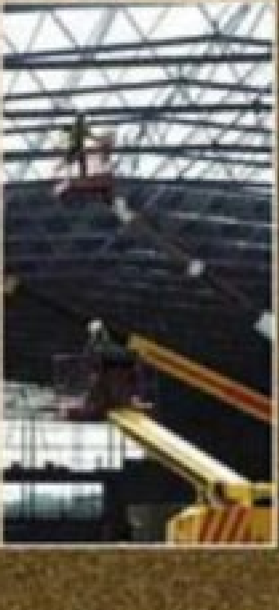
Construction Building Envelope and Interior Finishes DATABOOK



- Building Structures
- Interior Framing
- Wall, Ceiling, Floor Finishes
- Material Standards and Specifications
- How-To Tips

Sidney M. Levy

Construction Building Envelope and Interior Finishes Databook

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Introduction

The *Construction Building Envelope and Interior Finishes Databook* provides the project manager, construction superintendent, design consultant and facility managers with a one-source reference guide to building envelope and roofing systems, interior partition work, and floor, wall and ceiling finish installations, components and material specifications.

Sprinkled through-out are handy "Tips" and checklists.

Valuable information including ADA guidelines, "soft" and "hard" metrification conversion charts along with useful tables and formulas also resides within the covers of this book.

How many times during project meetings or visits to the field, or in conversations with subcontractors or design consultants is it convenient to have a concise source of construction details, materials or specifications at your fingertips? The *Construction Building Envelope and Interior Finishes Databook* was written with those needs in mind.

I selected those components that, in my forty years in the construction industry, appear to be those for which reference material is so often required, and, of course, always needed "yesterday."

Much of the material in this book has been gleaned from manufacturer's sources and from the many trade organizations that are only to willing to assist in disseminating valuable information. Some of this information is proprietary in nature, but much is generic and varies just slightly from producer to producer.

For those experienced construction professionals the *Construction Building Envelope and Interior Finishes Databook* may serve as a "refresher course" and for those new to the industry, it offers a simple way to become familiar with the complex and often bewildering array of materials and installation techniques that make up today's structures.

I hope you find this book a worthwhile addition to your construction library.

Sidney M. Levy

About the Author

Sidney M. Levy is a construction consultant with more than 40 years of experience in the industry. The author of 11 books, including several devoted to international construction and the renowned *Project Management in Construction,* published in both English and Spanish editions, he travels widely from his office in Chestertown, Maryland.

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Concrete

Contents

1.0.0 History

Concrete is an ancient material of construction, first used during the Roman Empire, which extended from about 20 B.C. to 200 A.D. The word concrete is derived from the Roman *concretus*, meaning to grow together. Although this early mixture was made with lime, cement, and a volcanic ash material called *pozzolana,* concrete today is a sophisticated material to which exotic constitutents can be added and, with computer-controlled batching, can produce a product capable of achieving 50,000 psi compressive strength.

The factors contributing to a successful batch of concrete are

- Precise measurement of water content;
- Type, size, and amount of cement and aggregate;
- Type, size, and location of reinforcement within the concrete pour to compensate for the lack of tensile strength basic in concrete;
- Proper curing procedures during normal hot or cold weather conditions.

1.1.1 General Properties

With some exceptions, the two most widely used concrete mixtures are

- Normal-weight (stone) concrete with a dry weight of 145 psf (6.93 kPa);
- Lightweight concrete (LWC) with a weight of approximately 120 psf (5.74 kPa). Extra light concrete, with weights as low as 80 psf (3.82 kPa), an be achieved with the use of special aggregates.

Other Types of Concrete

- *Lightweight Insulating* Containing perlite, vermiculite, and expanded polystyrene, which is used as fill over metal roof decks, in partitions, and in panel walls.
- *Cellular* Contains air or gas bubbles suspended in mortar and either no coarse aggregates or very limited quantities are included in the mixture. Use where high insulating properties are required.
- *Shot-crete or Gunite* The method of placement characterizes this type of concrete, which is applied via pneumatic equipment. Typical uses are swimming pools, shells, or domes, where formwork would be complicated because of the shape of the structure.
- *Ferrocement* Basically a mortar mixture with large amounts of light-gauge wire reinforcing. Typical uses include bins, boat hulls, and other thin, complex shapes.

1.2.0 Portland Cement as a Major Component

Different types of portland cement are manufactured to meet specific purposes and job conditions.

- Type I is a general-purpose cement used in pavements, slabs, and miscellaneous concrete pads and structures.
- Type IA is used for normal concrete, to which an air-entraining admixture is added.
- Type II creates a moderate sulfur-resistant product that is used where concrete might be exposed to groundwater that contains sulfates.
- Type IIA is the same as Type II, but is suited for an air-entrainment admixture.
- Type III is known as *high early strength* and generates high strength in a week or less.
- Type IIIA is high early, to which an air-entrainment admixture is added.
- Type IV cement produces low heat of hydration and is often used in mass pours, such as dam construction or thick mat slabs.
- Type V is a high sulfate-resistant cement that finds application in concrete structures exposed to high sulfate-containing soils or groundwater.
- White Portland cement is generally available in Type I or Type III only and gains its white color from the selection of raw materials containing negligible amounts of iron and magnesium oxide. White cement is mainly used as a constituent in architectural concrete.

1.2.1 High Early Cement

High early cement does exactly what its name implies: it provides higher compressive strength at an earlier age. Although Type III or Type IIIA cement can produce high early strength, there are other ways to achieve the same end result:

- Add more cement to the mixture [600 lb (272 kg) to 1000 lb (454 kg)];
- Lower the water content (0.2 to 0.45) by weight;
- Raise the curing temperature after consultation with the design engineer;
- Introduce an admixture into the design mix;
- Introduce microsilica, also known as *silica fume*, to the design mix;
- Cure the cast-in-place concrete by autoclaving (steam curing);
- Provide insulation around the formed, cast-in-place concrete to retain heat of hydration.

1.2.2 How Cement Content Affects Shrinkage

When low slumps, created in conjunction with minimum water requirements, are used with correct placement procedures, the shrinkage of concrete will be held to a minimum. Conversely, high water content and high slumps will increase shrinkage. A study at the Massachusetts Institute of Technology, as reported by the Portland Cement Association, indicated that for every 1% increase in mixing water, shrinkage of concrete increased by 2%. This study produced the following chart, showing the correlation of water and cement content to shrinkage.

1.2.2.1 Effect of Cement/Water Content on Shrinkage

Cement Content Bags/cubic yard	Concrete composition							
	Cement	Water	Air	Aggregate	Water + air	Water cement ratio by weight	Slump (inches)	Shrinkage (av. 3 × 3 × 10* prism)
4.99	0.089	0.202	0.017	0.692	0.219	0.72	3.3	0.0330
5.99	0.107	0.207	0.016	0.670	0.223	0.62	3.6	0.330
6.98	0.124	0.210	0.014	0.652	0.224	0.54	3.8	0.0289
8.02	0.143	0.207	0.015	0.635	0.223	0.46	3.8	0.0300

1.3.0 Control Joints

Thermal shrinkage will occur and the object of control joints, sometimes referred to as construction joints is to avoid the *random cracking* that often comes about when a concrete slab dries and produces excess tensile stress. Control joint spacing depends upon the slab thickness, aggregate size, and water content, as reported by the Portland Cement Association in their articles "Concrete Floors on Concrete," second edition, 1983.

1.3.0.1 Maximum Spacing of Control Joints

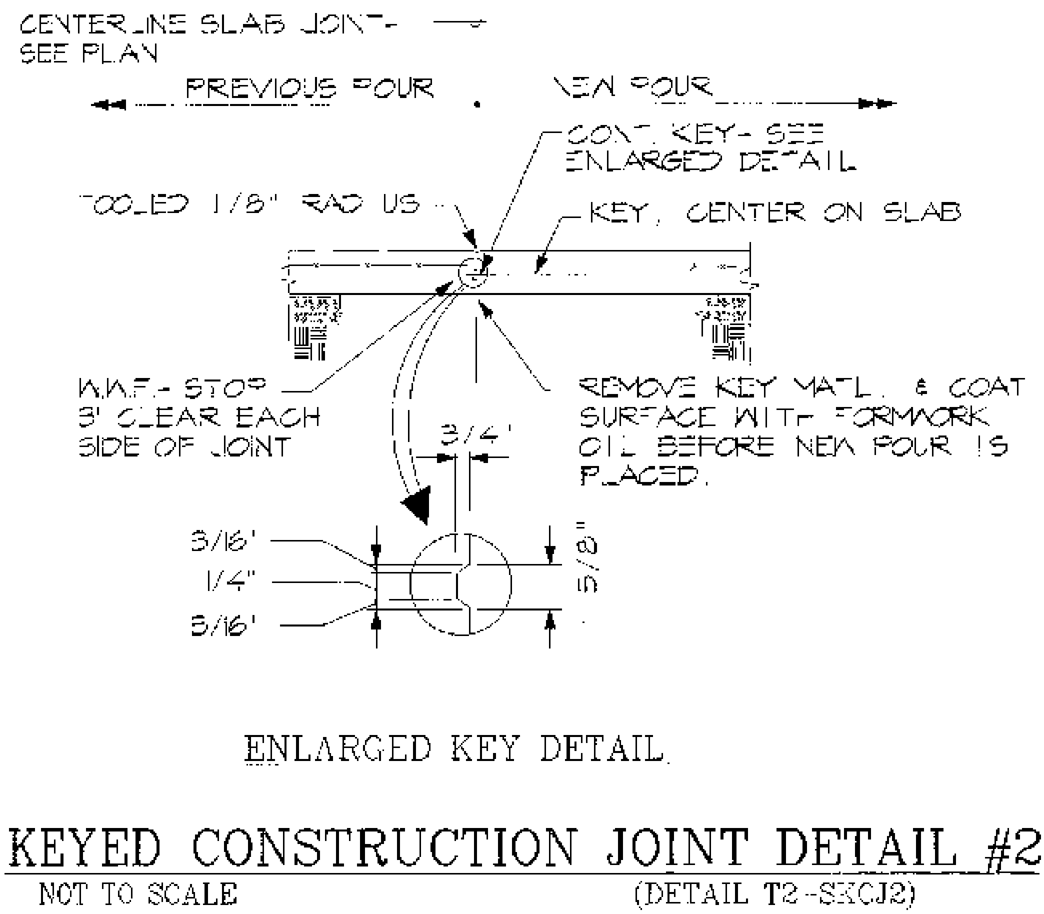
	Slump of 4–6 inches (101.6 mm–152.4 mm)		
Slab Thickness	Max. size aggregate less than ¾ inches (19.05 mm)	Max. size aggregate larger than ¾ inches	Slump less than 4 inches (101.6 mm)
4" (101.6 mm)	8' (2.4 m)	10' (3.05 m)	12' (3.66 m)
5" (126.9 mm)	10' (3.05 m)	13' (3.96 m)	15' (4.57 m)
6" (152.4 mm)	12' (3.66 m)	15' (4.57 m)	18' (5.49 m)
7" (177.8 mm)	14' (4.27 m)	18' (5.49 m)	21' (6.4 m)
8" (203.1 mm)	16' (4.88 m)	20' (6.1 m)	24' (7.32 m)
9" (228.6 mm)	18' (5.49 m)	23' (7.01 m)	27' (8.23 m)
10" (253.9 mm)	20' (6.1 mm)	25' (7.62 m)	30' (9.14 m)

The term *control joint* is often used as being synonymous with *construction joint,* however, there is a difference between the two. A *control joint* is created to provide for movement in the slab and induce cracking at that point, whereas a *construction joint* is a bulkhead that ends that day's slab pour. When control joints are created by bulkheading off a slab pour, rather than saw-cutting after the slab has been poured, steel dowels are often inserted in the bulkhead to increase load transfer at this joint.

1.3.0.2 Dowel spacing.

Slab Depth in. (mm)	Diameter (bar number)	Total length in. (mm)	Spacing in. (mm) center to center
5" (126.9 mm)	#5	12 in. (304.8 mm)	12 in. (304.8 mm)
6" (152.4 mm)	#6	14 in. (355.6 mm)	12 in. (304.8 mm)
7" (177.8 mm)	#7	14 in. (355.6 mm)	12 in. (304.8 mm)
8" (203.1 mm)	#8	14 in. (355.6 mm)	12 in. (304.8 mm)
9" (228.6 mm)	#9	16 in. (406.4 mm)	12 in. (304.8 mm)
10" (253.9 mm)	#10	16 in. (406.4 mm)	12 in. (304.8 mm)

1.3.0.3 Keyed Construction Joint



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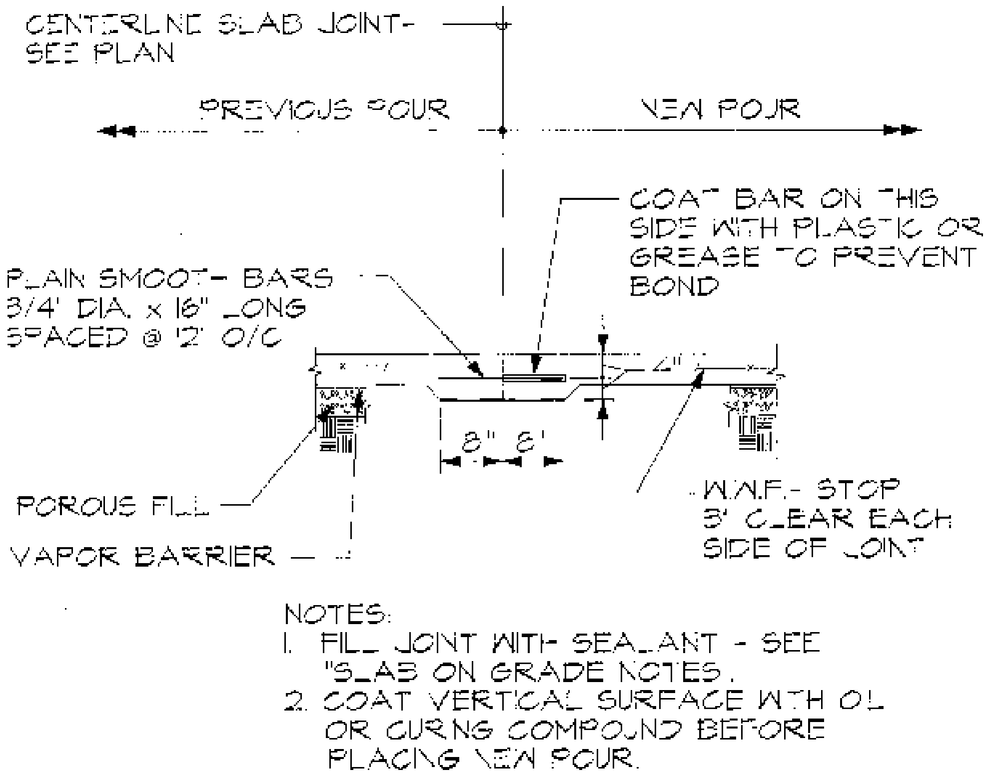
1.3.0.4 Doweled Construction Joint Detail



DOWELED CONSTRUCTION JOINT DETAIL

NOT TO SCALE (DETAIL T2 SDCJ)

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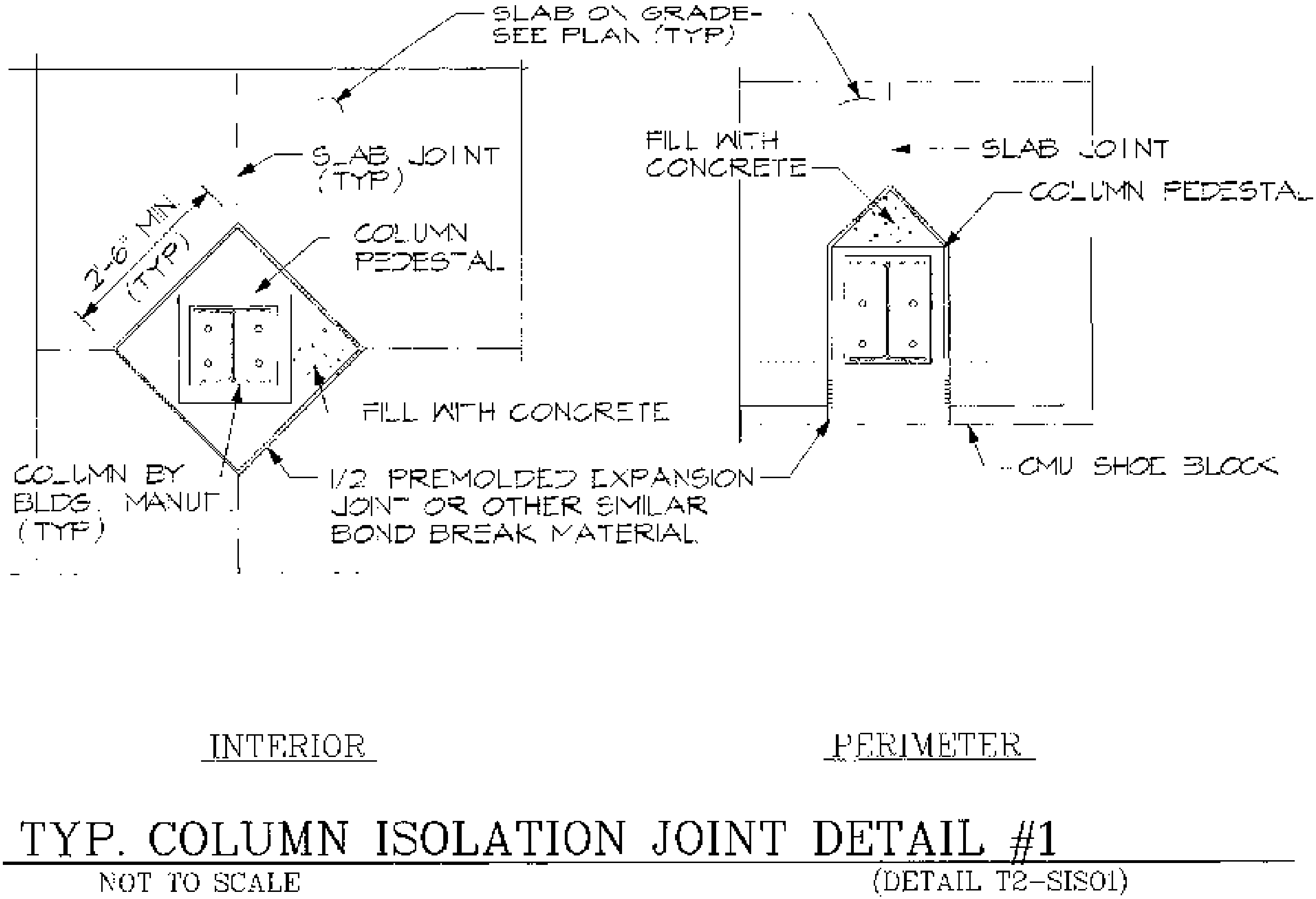
1.3.0.5 Typical Column Isolation Joint Detail #1



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1.4.0 Admixtures

Although concrete is an extremely durable product, it faces deterioration from various sources: chemical attack, permeation by water and/or gases from external sources, cracking because of the chemical reaction (known as *heat of hydration*), corrosion of steel reinforcement, freeze/thaw cycles, and abrasion. Much of the deterioration caused by these internal and external factors can be drastically delayed by the addition of a chemical admixture to the ready-mix concrete.

Admixtures are chemicals developed to make it easier for a contractor to produce a high-quality concrete product. Some admixtures retard curing, some accelerate it; some create millions of microscopic bubbles in the mixture; others allow a substantial reduction in water content, but still permit the concrete to flow like thick pea soup.

- *Water-reducing admixtures* Improve strength, durability, workability of concrete. Available in normal range and high range.
- *High-range water-reducing admixture* Also known as superplasticizer, it allows up to 30% reduction in water content with no loss of ultimate strength, but it creates increased flowability. It is often required where reinforcing steel is placed very close together in intricate forms.
- *Accelerating admixtures* They accelerate the set time of concrete, thereby reducing the protection time in cold weather, allowing for earlier stripping of forms. Accelerating admixtures are available in both chloride- and nonchloride-containing forms. Nonchloride is required if concrete is to be in contact with metal and corrosion is to be avoided.
- *Retarder admixtures* Retards the setting time, a desirable quality during very hot weather.
- *Air-entraining admixtures* Creates millions of microscopic bubbles in the cured concrete, allowing for expansion of permeated water, which freezes and is allowed to expand into these tiny bubbles, thereby resisting hydraulic pressures caused by the formation of ice.
- *Fly ash* When added to the concrete mixture, it creates a more dense end product, making the concrete extremely impermeable to water, which affords more protection to steel reinforcement contained in the pour. The addition of fly ash can increase ultimate strength to as much as 6500 psi (44.8 MPa), in the process, making the concrete more resistant to abrasion.
- *Silica fume* Also known as microsilica, it consists of 90 to 97% silicon dioxide, containing various amounts of carbon that are spherical in size and average about 0.15 microns in size. These extremely fine particles disperse into the spaces around the cement grains and create a uniform dense microstructure that produces concrete with ultra-high compressive strengths, in the nature of 12,000 (82.73 MPa) to 17,000 psi (117.20 MPa).
- *Multifilament or fibrillated fibers* This material is not a chemical admixture per se, but several manufacturers of concrete chemical additives also sell containers of finely chopped synthetic fibers, generally polypropylene, which, when added to the ready-mix concrete, serve as secondary reinforcement and prevent cracks.

1.5.0 Chloride Content in the Mixing Water

Excessive chloride ions in mixing water can contribute to accelerated reinforcing-steel corrosion and should be a concern when evaluating a mix design. Maximum water-soluble chloride ions, in various forms of concrete (as a percentage), should not exceed the following:

• Prestressed concrete	0.06%
• Reinforced concrete exposed to chloride in service (e.g., garbage slab)	0.15%
• Reinforced concrete that will be dry and/or protected from moisture infiltration	1.00%
• Other reinforced concrete	0.30%

1.6.0 Guidelines for Mixing Small Batches of Concrete (by Weight)

Max. size aggregate	Cement (lb/kg)	Wet-fine aggregate (lb/kg)	Wet-coarse aggregate (lb/kg)	Water (lb/kg)
⅜" (9.52 mm)	29 lb (13.15 kg)	59 lb (26.76 kg)	46 lb (20.87 kg)	11 lb (4.99 kg)
½" (12.6 mm)	27 lb (12.25 kg)	53 lb (24.04 kg)	55 lb (24.95 kg)	11 lb (4.99 kg)
¾" (19.05 mm)	25 lb (11.34 kg)	47 lb (21.32 kg)	65 lb (29.66 kg)	10 lb (4.54 kg)
1" (25.39 mm)	24 lb (10.89 kg)	45 lb (20.41 kg)	70 lb (31.75 kg)	10 lb (4.54 kg)
1½" (37.99 mm)	23 lb (10.43 kg)	43 lb (19.50 kg)	75 lb (34.02 kg)	9 lb (4.08 kg)

Guidelines for Mixing Small Batches of Concrete (by Volume)

Max. size aggregate	Cement	Wet-fine aggregate	Wet-coarse aggregate	Water
⅜" (9.52 mm)	1	2½	1½	½
½" (12.6 mm)	1	2½	2	½
¾" (19.05 mm)	1	2½	2½	½
1" (25.39 mm)	1	2½	2¾	½
1½" (37.99 mm)	1	2½	3	½

1.7.0 Recommended Slumps

The Portland Cement Association recommends the following slumps:

Component	Max. slump (inches	Min. slump (inches)
Footings (reinforced or not)	3	1
Foundation walls	3	1
Substructure walls	3	1
Caissons	3	1
Beams and reinforced walls	4	1
Building columns	4	1
Pavements and slabs	3	1
Mass concrete	2	1

1.7.1 The Slump Test

Slump, as it relates to concrete, is a measure of consistency equal to the decrease in height, measured to the nearest ¼ inch (6 mm) of the molded mass immediately after it has been removed from this molded mass created by the "slump cone."

The mold is in the form of a frustum (part of a solid cone intersected by the use of parallel lines) 12 inch (2.5 cm) high with a base diameter of 8 inches (2 cm) and a top diameter of 4 inches (1 cm).

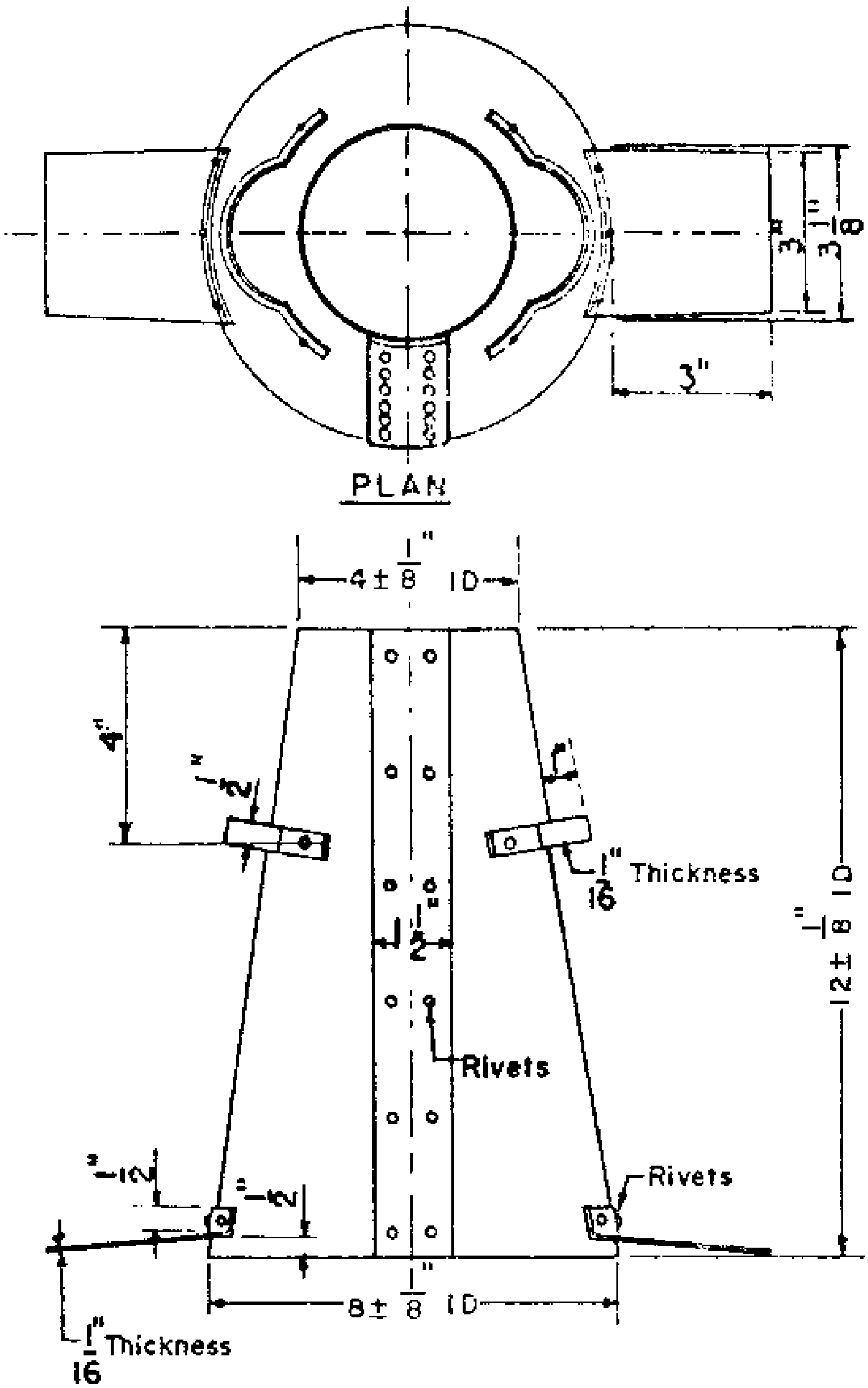
This mold (slump cone) is filled with freshly mixed concrete in 3 layers, each being rodded with a ⅝ inch (15.9 mm) bullet-shaped rod 25 times. When the mold has been filled, the top is struck off and the mold is lifted. The amount by which the mass settles after mold removal is referred to as "slump." A small slump is an indication of a very stiff mix and a very large slump is indicative of a very wet consistency.

Recommended slumps are:

Type of construction	Maximum slump (inches)	Minimum slump (inches)
Reinforced walls/footings	3 (76.2 mm)	1 (25.4 mm)
Caissons, substructure walls	3	1
Beams, reinforced walls	4 (102 mm)	1
Building columns	4	1
Pavements, slabs	3	1
Mass concrete	2 (50.8 mm)	1

Rule of Thumb: To raise the slump 1 inch (25.4 mm), add 10 pounds of water for each cubic yard of concrete. (One gallon of water equals 8.33 pounds.)

1.7.1.1 The Slump Cone



Metric Equivalents

in	1/16	1/8	1/2	1	1 1/2	3	3 1/8	4	8	12
mm	1.6	3.2	12.7	25.4	38.1	76.2	79.4	102	203	305

1.8.0 Forms for Cast-in-Place Concrete

Many different types of forms are on the market: wood, steel, aluminum, and fiberglass. Each has its advantage and disadvantage; however, some items (form ties and form-release materials) are common to all forms. Also, numerous types and configurations of form liners are available, primarily for architectural concrete use.

1.8.1 Maximum Allowable Tolerances for Form Work

The American Concrete Institute (ACI), in their ACI 347 Manual, include recommended maximum allowable tolerances for various types of cast-in-place and precast concrete, for example:

- *Maximum variations from plumb* In column and wall surfaces in any 10 feet (3.05 m) of length: ¼ inch (6.35 mm)
- *Maximum for entire length*
  ½ inch (12.7 mm)
- *Maximum variations from established position in plan shown in drawings—walls*
  ¾ inch (19.05 mm)
- *Variations in cross-sectional dimensions of beams/slab-wall thickness*
  Minus: ⅛ inch (3.175 mm)
  Plus: ¼ inch (6.35 mm)

1.8.2 Release Agents for Forms

A number of commercially available form release agents are on the market and some contractors use their own formula, but precautions (as seen below) are necessary, in some instances, to protect the form material.

Form face material Release agent comments and precautions.

Wood forms Oils penetrate wood and extend its life.

Unsealed plywood Apply a liberal amount of release agent several days before using, then wipe off, so only a thin layer remains prior to placing concrete.

Sealed/overlaid plywood Do not use diesel oil or motor oil on HDO/MDO plywood. Products containing castor oil can discolor concrete.

Steel Use a product with a rust inhibitor.

Aluminum Avoid products that contain wax or paraffin.

Glass-fiber reinforced Follow the form manufacturer's recommendations to avoid damage to forms.

Rigid plastic forms Follow the form manufacturer's recommendations to avoid damage to forms.

Elastomeric liners These often do not require release agents, but using the proper agent can prolong life. When deep textures are required, release agents should be used. Follow the manufacturer's recommendations to avoid damage to forms.

Foam expanded plastic liners Petroleum-based agents can dissolve the foam. These liners are generally "one-time" use only.

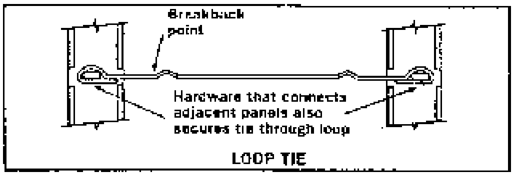
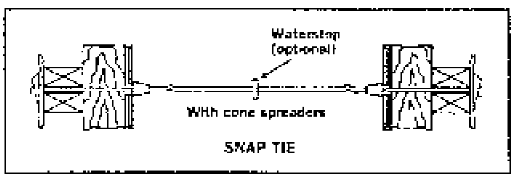
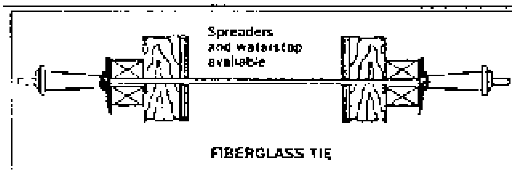
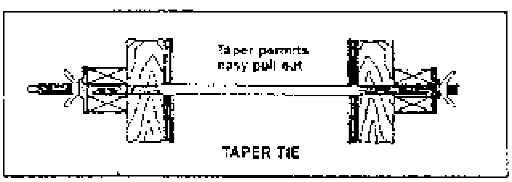
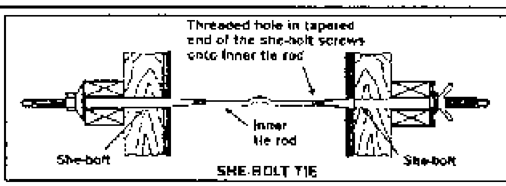
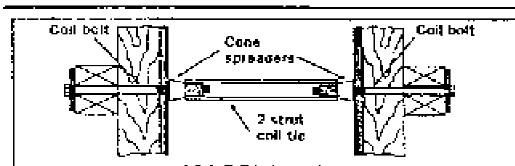
Rubber liners/molds Do not use petroleum, mineral oil, or solvent-based form oils to avoid damage to liner.

Concrete molds Avoid chemically active release agents and avoid match-cast or slab-on-slab work when the casting surface used as the form is only a few days old.

Controlled-permeability forms No release agent required.

Plaster waste molds Pretreat the mold with shellac or some other type of waterproof coating. Yellow cup grease (thinned) is an effective release agent.

1.8.3 Principal Types of Commercially Available Form Ties

	Type of Tie	Typical Working Loads In Tension* (lb)	Notes/Comments
One-Piece Ties	 LOOP TIE	Standard: 2,250 Heavy: 3,000	Shown with manufactured panel; also used with combination lock and bearing-plate hardware in job-built forms.
One-Piece Ties	 FLAT TIE	Standard: 2,250 Heavy: 3,000	Also available for 1,500-pound loads.
One-Piece Ties	 SNAP TIE	Standard: 2,250 Heavy: 3,000-3,200	Shown with cone spreaders; also available with washer spreaders.
One-Piece Ties	 FIBERGLASS TIE	3,000; 7,500; and 25,000, with diameters of 0.3, 0.5, and 1 inch, respectively	Available in 10- and 12-foot pieces for cutting to any desired length. Spreaders available.
One-Piece Ties	 TAPER TIE	7,500-64,000, depending on diameter and grade of steel	Completely reusable; grease before installation to facilitate removal. No spreaders included.
	 THREADED BAR TIE	7,000-69,000, with diameters from ½ inch to 1½ inches	Stock up to 50 feet long can be cut to required length. Plastic sleeve makes it removable.
Internally Disconnecting Ties	 SHE-BOLT TIE	5,000-64,000	No internal spreader. External spreader bracket available.
Internally Disconnecting Ties	 COIL TIE WITH BOLTS	Two-strut: 4,500-64,000 Four-strut: 18,000-27,000	Shown with cone spreader, but can be used as combination tie/spreader where it is not necessary to keep the tie ends at the back of the wall face.

*Based on manufacturers' data, using a 2:1 factor of safety. Wide working-load ranges indicate a range of form-tie diameters and grades of steel.

1.9.0 Curing of Concrete

To attain design strength, curing is a crucial part of the cast-in-place concrete process in order that the proper amount of moisture content and ambient temperature is maintained immediately following the placement of the concrete. The optimum curing cycle will take into account the prevention or replenishment of moisture content from the concrete and the maintenance of a favorable temperature for a specific period of time. During winter months, temporary protection and heat is required in conjunction with the curing process, and, during summer months, moisture replenishment becomes an integral part of the curing process.

1.9.1 Curing Procedures

1. Apply a membrane-curing compound—either by spraying or rolling on the surface immediately after the troweling process on slabs has ceased, or on walls, columns, beams, after the forms have been removed.
2. Curing by water in other than cold-weather conditions is acceptable, as long as it is continuous.
3. Waterproof paper, applied directly over the concrete surface after it has received a spray of water, is often effective.
4. Damp burlap, free of foreign substances that could leach out and stain the concrete, is also a proven curing procedure, as long a the burlap is kept moist.
5. Polyethylene sheets can be used as a blanket in much the same manner as waterproof paper, as long as its edges are lapped and sealed properly.
6. Damp sand or straw is also used on occasion, when nothing else is available. These materials must also be sprayed from time to time to maintain the moisture content.

The length of curing depends upon a number of factors, including the type of cement used and ambient temperatures. The following can be used as a guideline to determine the length of curing time.

1.9.2 Curing Times

At 50°F

Percentage design strength required	Type cement used in mix		
	I	II	III
50%	6	9	3
65%	11	14	5
85%	21	28	16
95%	29	35	26

At 70°F (21°C) Days

Percentage design strength required	Type cement used in mix		
	I	II	III
50%	6	9	3
65%	11	14	5
85%	21	28	16
95%	29	35	26

1.10.0 Concrete Reinforcing Bar Size/Weight Chart

Because of concrete's low resistance to shear and tensile strength, the type configuration and placement of reinforcement is crucial to achieve the project's design criteria. The most common form of concrete reinforcement is the deformed reinforcing bar and welded wire fabric. The most commonly used reinforcing bars are set forth in the following chart.

BAR SIZE DESIGNATION	WEIGHT POUNDS PER FOOT	NOMINAL DIMENSIONS—ROUND SECTIONS DIAMETER INCHES	CROSS-SECTIONAL AREA-SQ INCHES	PERIMETER INCHES
#3	.376	.375	.11	1.178
#4	.668	.500	.20	1.571
#5	1.043	.625	.31	1.963
#6	1.502	.750	.44	2.356
#7	2.044	.875	.60	2.749
#8	2.670	1.000	.79	3.142
#9	3.400	1.128	1.00	3.544
#10	4.303	1.270	1.27	3.990
#11	5.313	1.410	1.56	4.430
#14	7.650	1.693	2.25	5.320
#18	13.600	2.257	4.00	7.090

1.10.0 Concrete-reinforcing Bar Size/Weight Chart

1.10.1 ASTM Standards Including Soft Metric

Soft metric size	Nom dia mm	Area mm²	Weight factors		Standard size	Nom dia inches	Area in²	Weight factors	
			kg/m	kg/ft				lb/ft	lb/m
10	9.5	71	.560	.171	3	.375	.11	.376	1.234
13	12.7	129	.994	.303	4	.500	.20	.668	2.192
16	15.9	199	1.552	.473	5	.625	.31	1.043	3.422
19	19.1	284	2.235	.681	6	.750	.44	1.502	4.928
22	22.2	387	3.042	.927	7	.875	.60	2.044	6.706
25	25.4	510	3.973	1.211	8	1.000	.79	2.670	8.760
29	28.7	645	5.060	1.542	9	1.128	1.00	3.400	11.155
32	32.3	819	6.404	1.952	10	1.270	1.27	4.303	14.117
36	35.8	1006	7.907	2.410	11	1.410	1.56	5.313	17.431
43	43.0	1452	11.384	3.470	14	1.693	2.25	7.650	25.098
57	57.3	2581	20.239	6.169	18	2.257	4.00	13.600	44.619

Comparison of Steel Grades

Soft metric			Imperial		
Grade	MPa	psi	Grade	MPa	psi
300	300	43,511	40	257.79	40,000
420	420	60,716	60	413.69	60,000
520	520	75,420	75	517.11	75,000

1.10.2 Recommended End Hooks—All Grades

Soft metric size	mm				Imperial size	inches			
	D	90° Hooks	180° Hooks			D	90° Hooks	180° Hooks	
		A or G	A or G	J			A or G	A or G	J
10	60	150	125	80	3	2.25	6	5	3
13	80	200	150	105	4	3.0	8	6	4
16	95	250	175	130	5	3.75	10	7	5
19	115	300	200	155	6	4.50	12	8	6
22	135	375	250	180	7	5.25	14	10	7
25	155	425	275	205	8	6.0	16	11	8
29	240	475	375	300	9	9.50	19	15	11.75
32	275	550	425	335	10	10.75	22	17	13.25
36	305	600	475	375	11	12.0	24	19	14.75
43	465	775	675	550	14	18.25	31	27	21.75
57	610	1050	925	725	18	24.0	41	36	28.50

1.10.3 Stirrup and Tie Hooks—All Grades (General)

Soft size	mm				Imperial size	inches			
	D	90° Hooks	135° Hooks			D	90° Hooks	135° Hooks	
		A or G	A or G	H approx.			A or G	A or G	H approx
10	40	105	105	65	3	1.50	4	4	2.5
13	50	115	115	80	4	2.00	4.5	4.5	3
16	65	155	140	95	5	2.50	6	5.5	3.75
19	115	305	205	115	6	4.50	12	8	4.5
22	135	355	230	135	7	5.25	14	9	5.25
25	155	410	270	155	8	6.00	16	10.5	6

1.10.3.1 Stirrup and tie Hooks—All Grades (Seismic)

Soft metric size	mm			Imperial size	inches		
	D	135° Seismic			D	135° Seismic	
		A or G	H approx			A or G	H approx
10	40	110	80	3	1.50	4.25	3
13	50	115	80	4	2.00	4.5	3
16	65	140	95	5	2.50	5.5	3.75
19	115	205	115	6	4.50	8	4.5
22	135	230	135	7	5.25	9	5.25
25	155	270	155	8	6.00	10.5	6

1.10.4 Welded Wire Fabric (WWF)

Cross-sectional area and weight of welded wire fabric

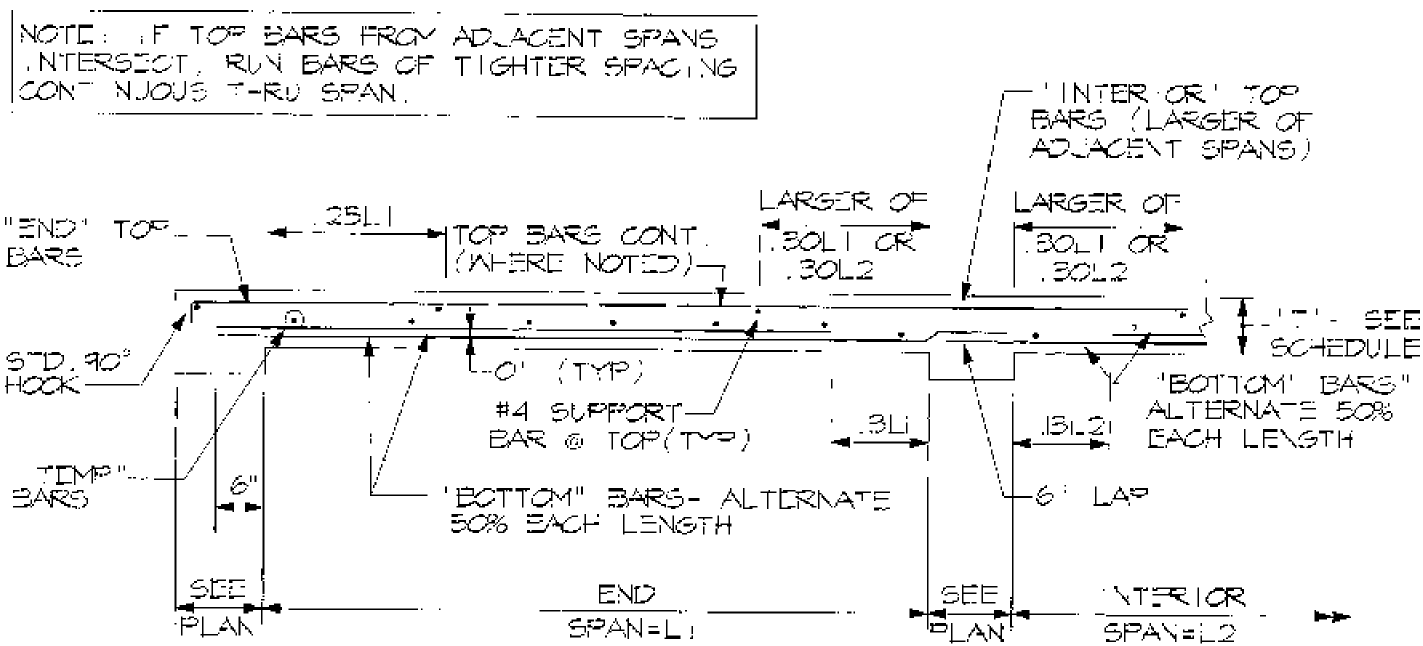
Wire size number		Nominal diameter, in	Nominal weight, lb/ft	Area per width (in.^{2}/ft) for various spacings (in)						
Plain	Deformed			2	3	4	6	8	12	16
W45	D45	0.757	1.53	2.70	1.80	1.35	0.90	0.68	0.45	0.34
W31	D31	0.628	1.05	1.86	1.24	0.93	0.62	0.47	0.31	0.23
W20	D20	0.505	0.680	1.2	0.80	0.60	0.40	0.30	0.20	0.15
W18	D18	0.479	0.612	1.1	0.72	0.54	0.36	0.27	0.18	0.14
W16	D16	0.451	0.544	0.96	0.64	0.48	0.32	0.24	0.16	0.12
W14	D14	0.422	0.476	0.84	0.56	0.42	0.28	0.21	0.14	0.11
W12	D12	0.391	0.408	0.72	0.48	0.36	0.24	0.18	0.12	0.09
W11	D11	0.374	0.374	0.66	0.44	0.33	0.22	0.17	0.11	0.08
W10.5		0.366	0.357	0.63	0.42	0.32	0.21	0.16	0.11	0.08
W10	D10	0.357	0.340	0.60	0.40	0.30	0.20	0.15	0.10	0.08
W9.5		0.348	0.323	0.57	0.38	0.29	0.19	0.14	0.095	0.07
W9	D9	0.338	0.306	0.54	0.36	0.27	0.18	0.14	0.090	0.07
W8.5		0.329	0.289	0.51	0.34	0.26	0.17	0.13	0.085	0.06
W8	D8	0.319	0.272	0.48	0.32	0.24	0.16	0.12	0.080	0.06
W7.5		0.309	0.255	0.45	0.30	0.23	0.15	0.11	0.075	0.06
W7	D7	0.299	0.238	0.42	0.28	0.21	0.14	0.11	0.070	0.05
W6.5		0.288	0.221	0.39	0.26	0.20	0.13	0.097	0.065	0.05
W6	D6	0.276	0.204	0.36	0.24	0.18	0.12	0.090	0.060	0.05
W5.5		0.265	0.187	0.33	0.22	0.17	0.11	0.082	0.055	0.04
W5	D5	0.252	0.170	0.30	0.20	0.15	0.10	0.075	0.050	0.04
W4.5		0.239	0.153	0.27	0.18	0.14	0.090	0.067	0.045	0.03
W4	D4	0.226	0.136	0.24	0.16	0.12	0.080	0.060	0.040	0.03
W3.5		0.211	0.119	0.21	0.14	0.11	0.070	0.052	0.035	0.03
W3		0.195	0.102	0.18	0.12	0.090	0.060	0.045	0.030	0.02
W2.9		0.192	0.099	0.17	0.12	0.087	0.058	0.043	0.029	0.02
W2.5		0.178	0.085	0.15	0.10	0.075	0.050	0.037	0.025	0.02
W2.1		0.162	0.070	0.13	0.84	0.063	0.042	0.031	0.021	0.02
W2		0.160	0.068	0.12	0.080	0.060	0.040	0.030	0.020	0.02
W1.5		0.138	0.051	0.090	0.060	0.045	0.030	0.022	0.015	0.01
W1.4		0.134	0.048	0.084	0.056	0.042	0.028	0.021	0.014	0.01

1.10.4.1 Common Types of Welded Wire Fabric

Style designation (W = Plain, D = Deformed)	Steel area (in^2/ft)		Approximate weight (lb per 100 sq ft)
	Longitudinal	Transverse	
4 x 4-W1.4 x W1.4	0.042	0.042	31
4 x 4-W2.0 x W2.0	0.060	0.060	43
4 x 4-W2.9 x W2.9	0.087	0.087	62
4 x 4-W/D4 x W/D4	0.120	0.120	86
6 x 6-W1.4 x W1.4	0.028	0.028	21
6 x 6-W2.0 x W2.0	0.040	0.040	29
6 x 6-W2.9 x W2.9	0.058	0.058	42
6 x 6-W/D4 x W/D4	0.080	0.080	58
6 x 6-W/D4.7 x W/D4.7	0.094	0.094	68
6 x 6-W/D7.4 x W/D7.4	0.148	0.148	107
6 x 6-W/D7.5 x W/D7.5	0.150	0.150	109
6 x 6-W/D7.8 x W/D7.8	0.156	0.156	113
6 x 6-W/D8 x W/D8	0.160	0.160	116
6 x 6-W/D8.1 x W/D8.1	0.162	0.162	118
6 x 6-W/D8.3 x W/D8.3	0.166	0.166	120
12 x 12-W/D8.3 x W/D8.3	0.083	0.083	63
12 x 12-W/D8.8 x W/D8.8	0.088	0.088	67
12 x 12-W/D9.1 x W/D9.1	0.091	0.091	69
12 x 12-W/D9.4 x W/D9.4	0.094	0.094	71
12 x 12-W/D16 x W/D16	0.160	0.160	121
12 x 12-W/D16.6 x W/D16.6	0.166	0.166	126

*Many styles may be obtained in rolls.

1.10.5 Typical One-way Concrete Slab Reinforcing Detail



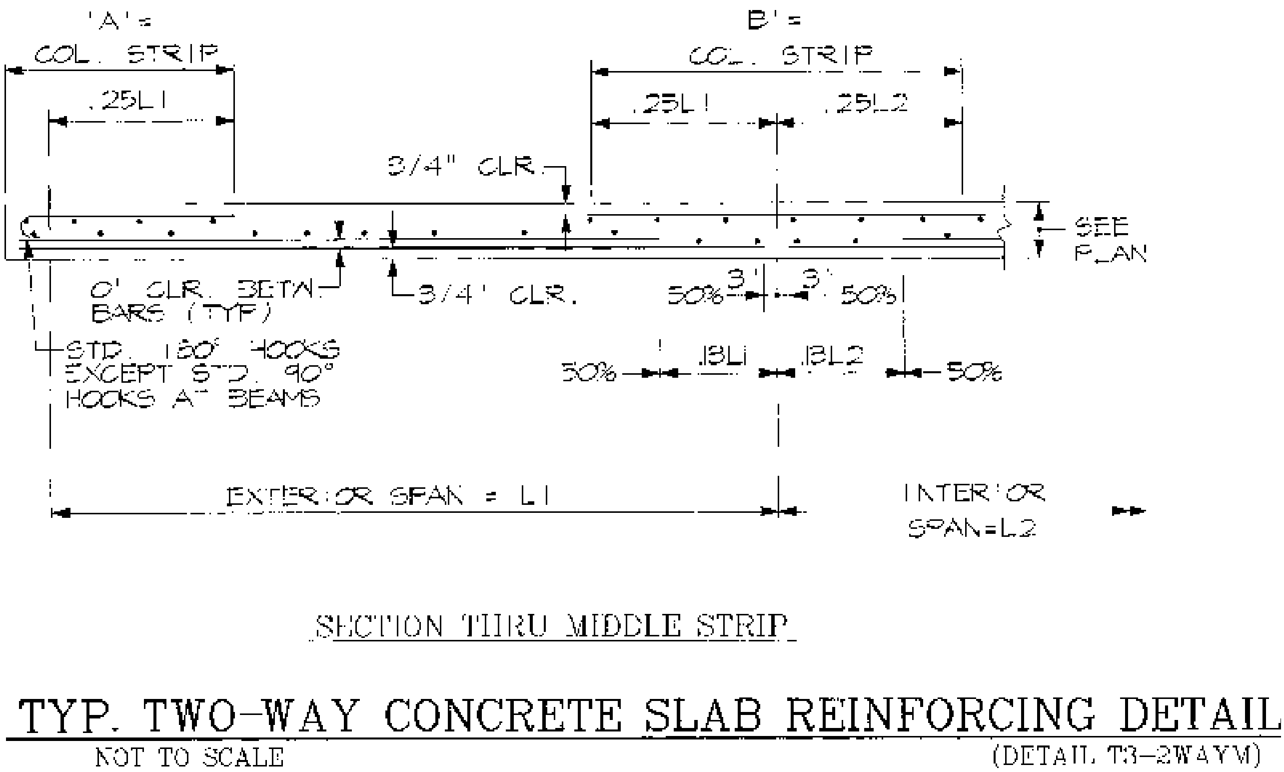
TYP. ONE-WAY CONCRETE SLAB REINFORCING DETAIL

NOT TO SCALE

(DETAIL T3-SLAB1)

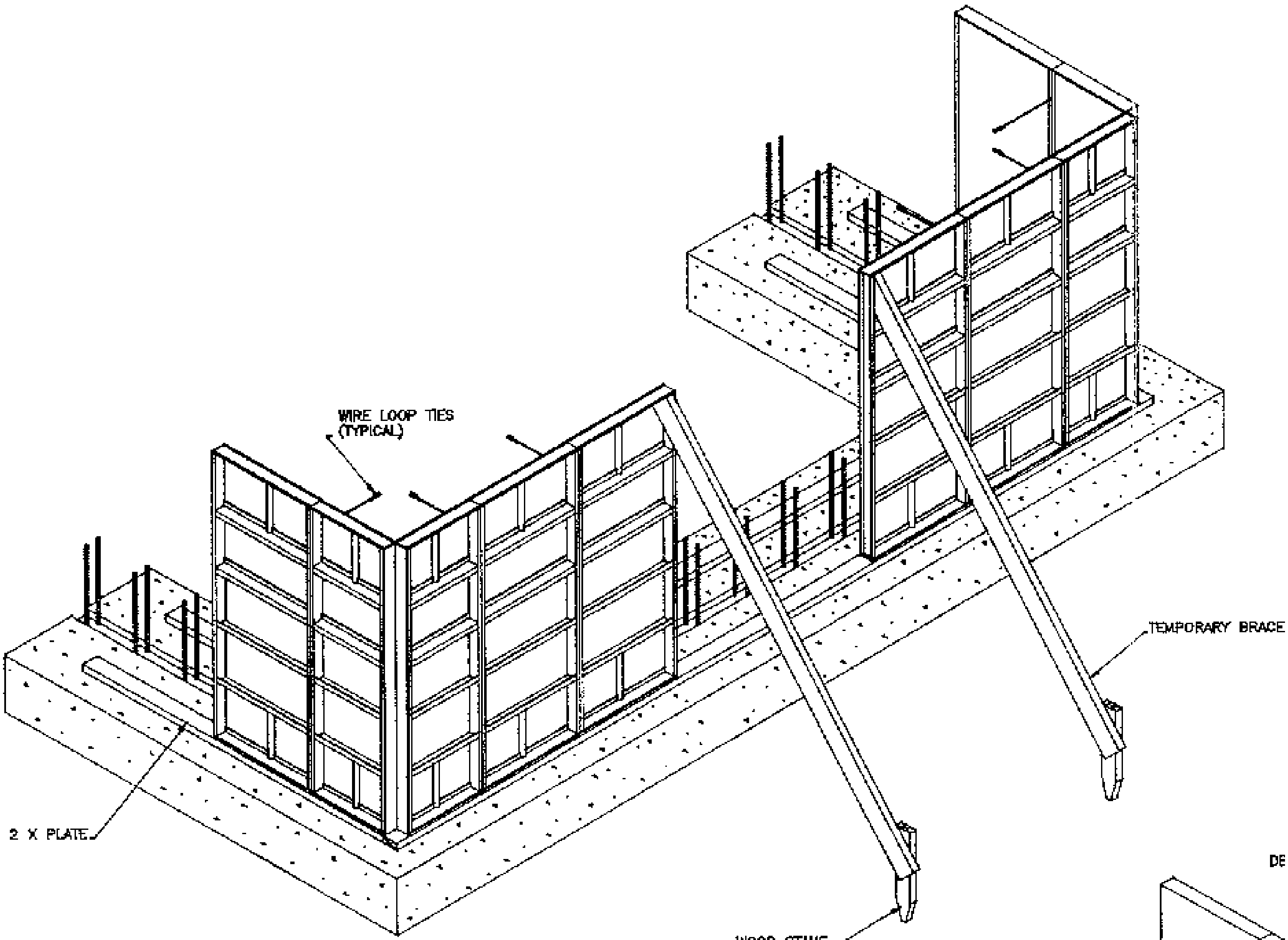
(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

1.10.6 Typical Two-Way Concrete Slab Reinforcing Detail

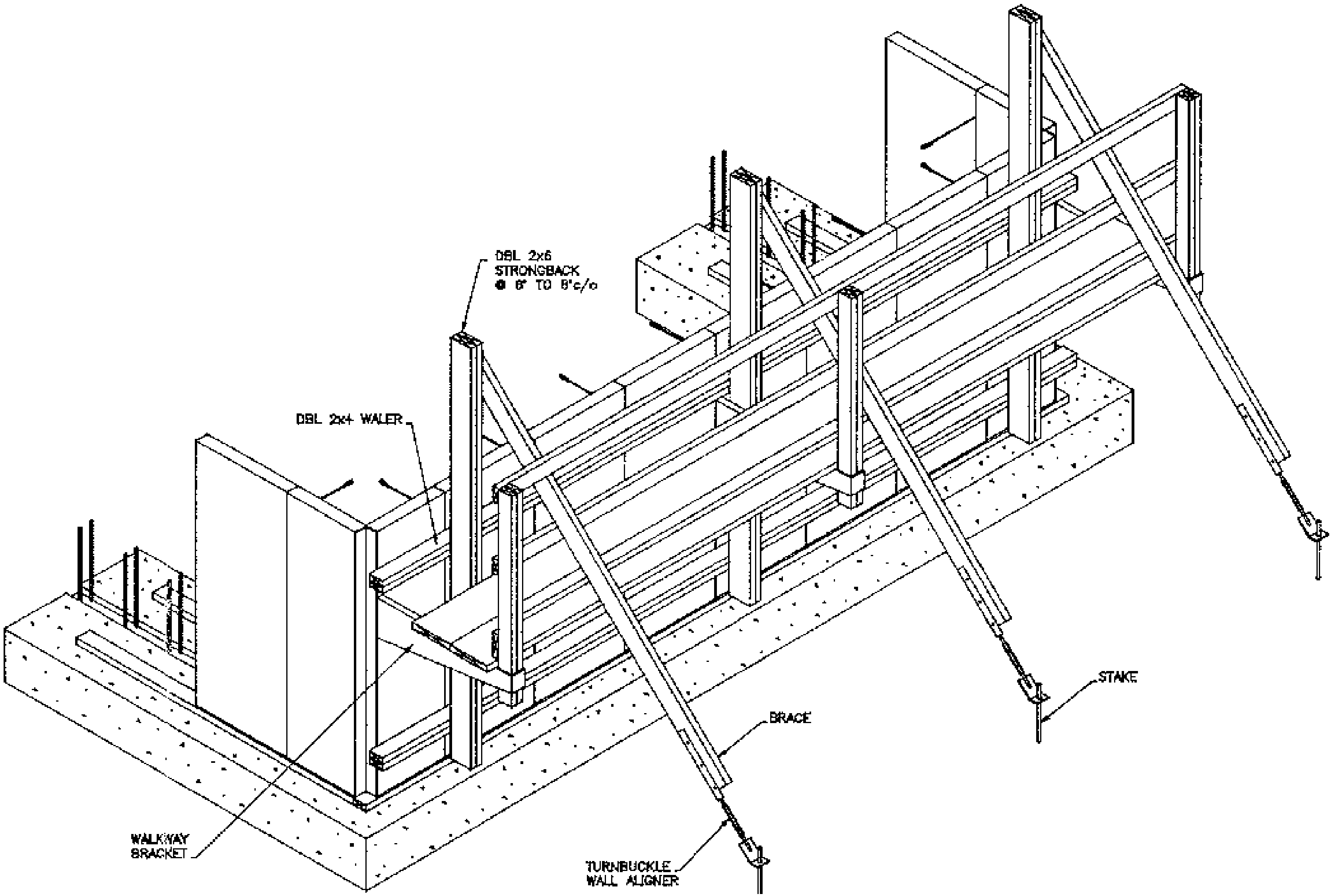


(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

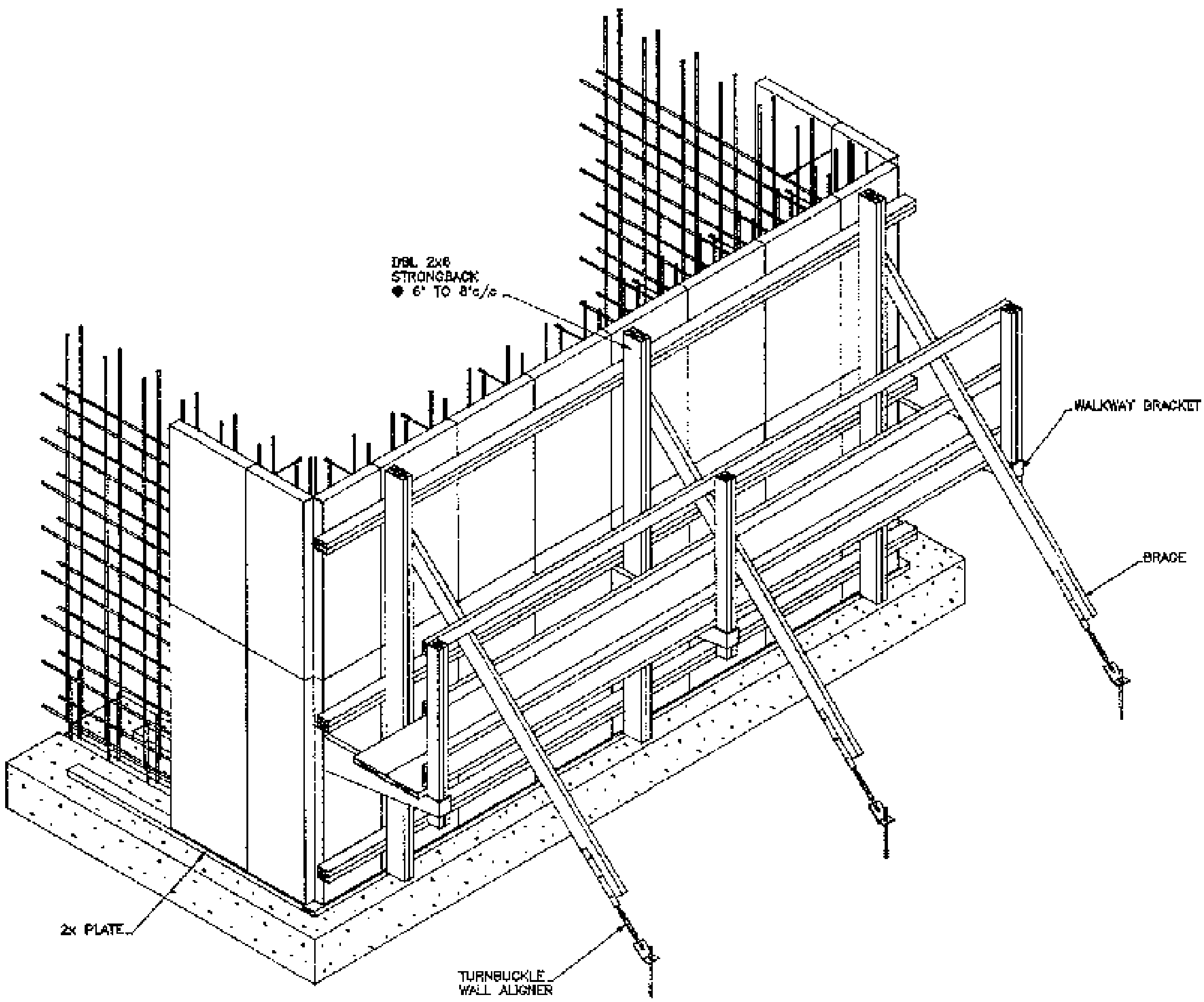
1.10.7 Typical Concrete Wall Form Schematic—One Side in Place



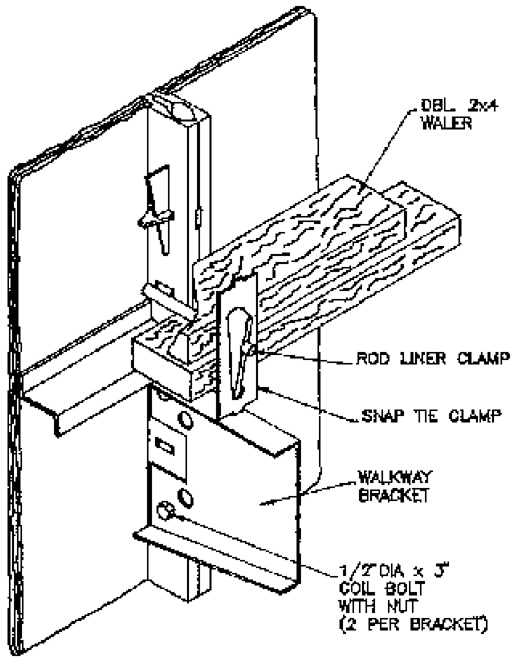
1.10.7.1 Typical Concrete Wall Form Schematic With Walkway Bracket Installed—One Side in Place



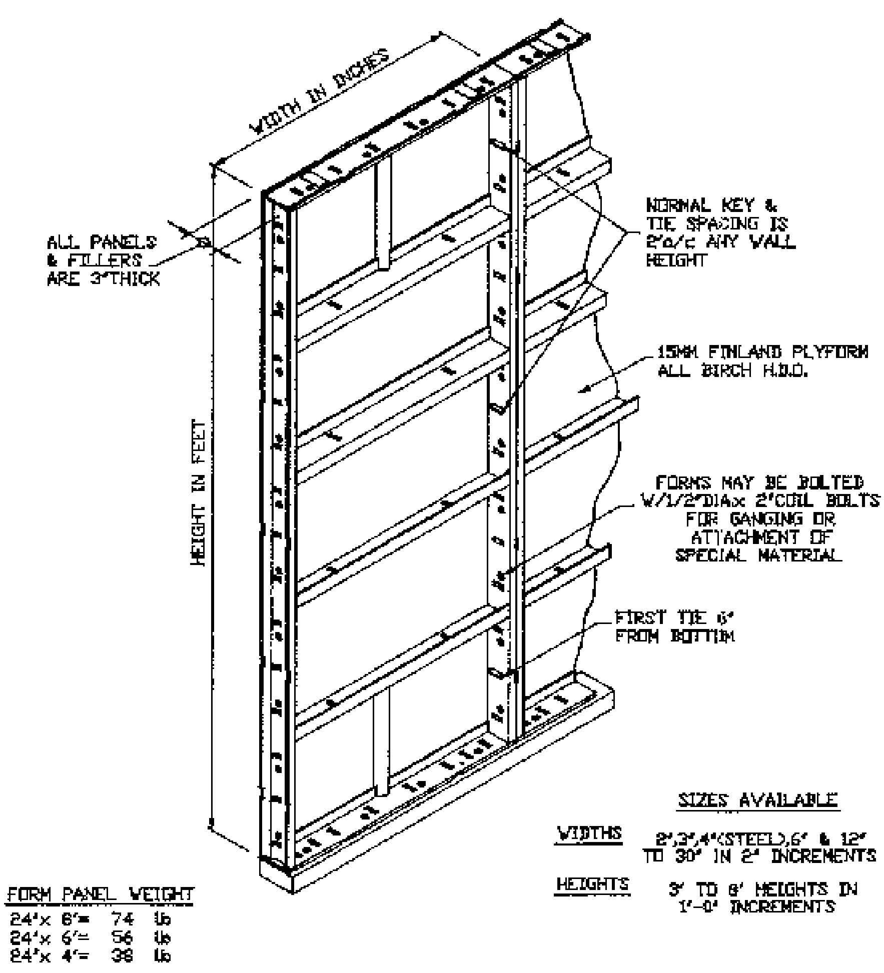
1.10.7.2 Typical Concrete Wall Form Schematic—Rebar in Place—Ready to be Buttoned up



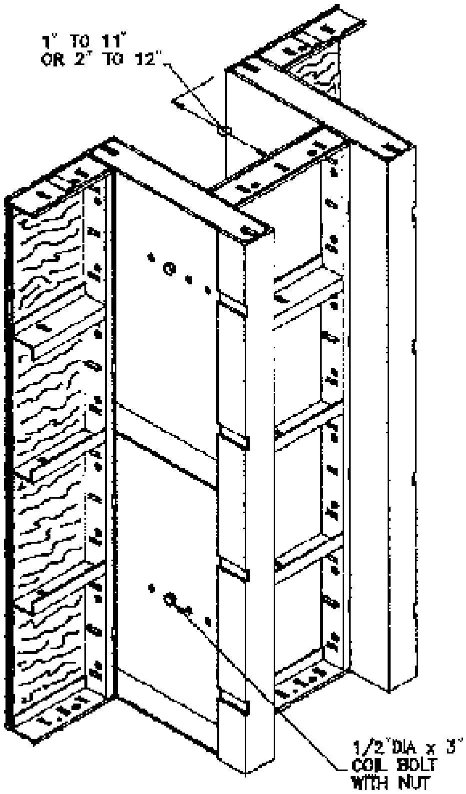
1.10.7.3 Typical Waler and Walkway Bracket Attachment



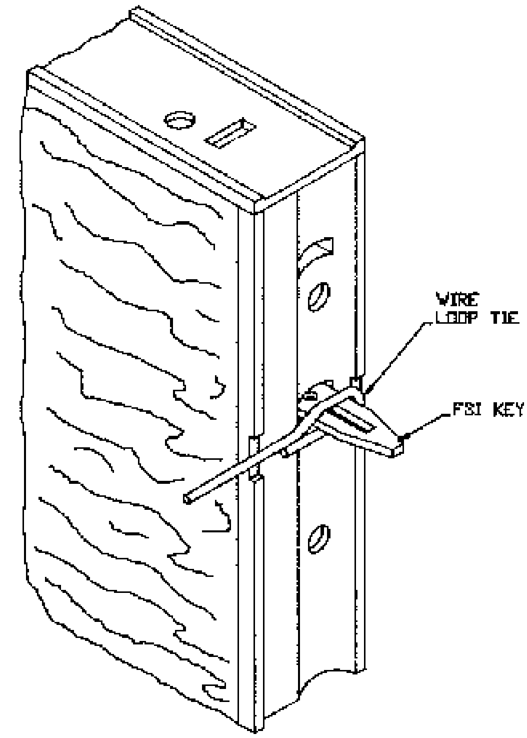
1.10.8 Typical Concrete Wall Form



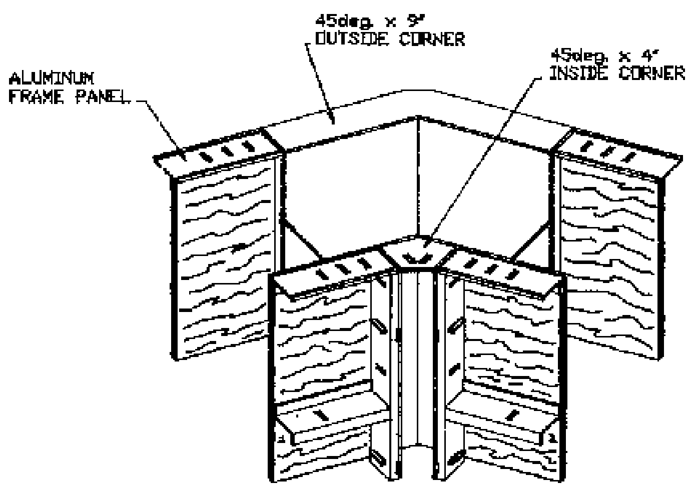
1.10.8.1 Typical Pilaster, 45 Degree Corner, 90 Degree Inside and Outside Corner Form Details



TYPICAL PILASTER FORM

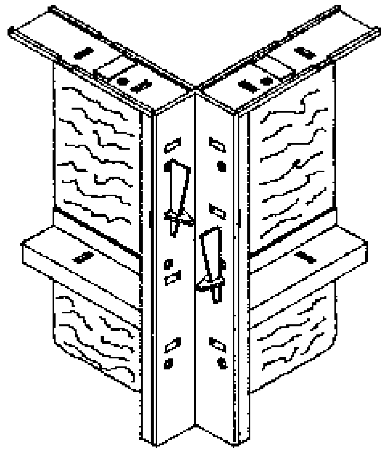


TYPICAL TIE CONNECTION

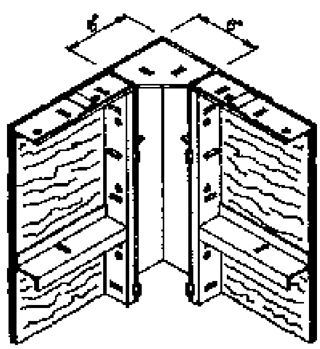


TYPICAL 45° CORNER

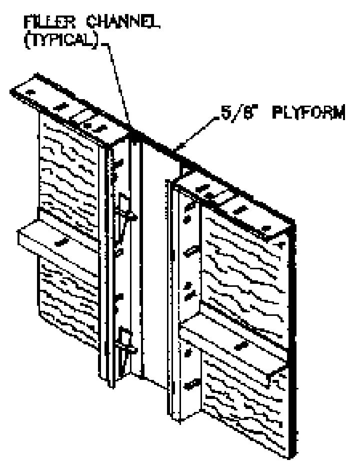
(AS SHOWN FOR 12" WALL)



TYPICAL 90° OUTSIDE CORNER



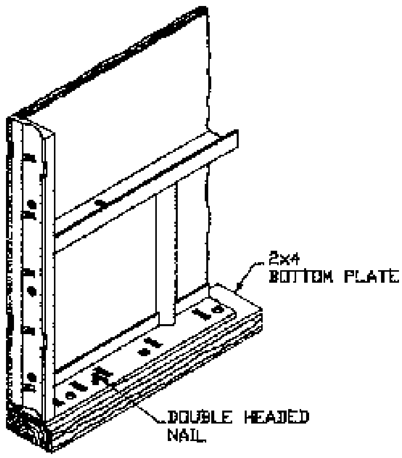
TYPICAL 90° INSIDE CORNER



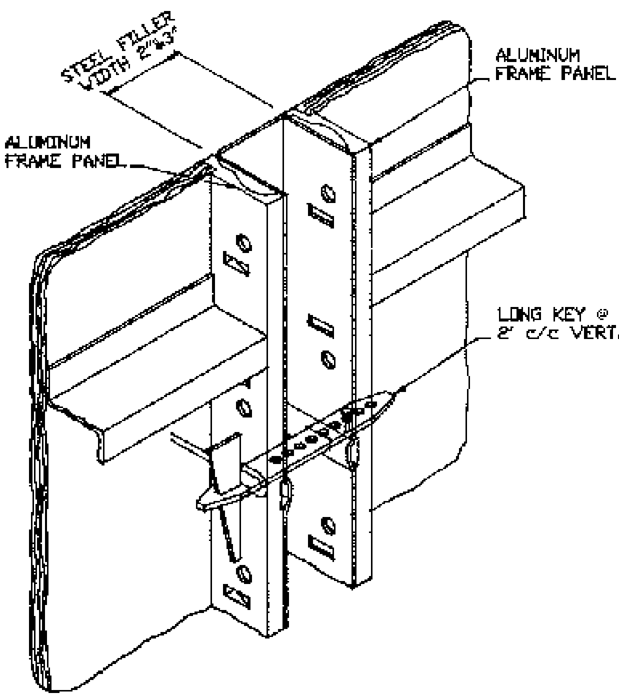
TYPICAL WOOD FILLER

Continued

1.10.8.2 Typical Attachment of Form to Plate and Long Key Installation

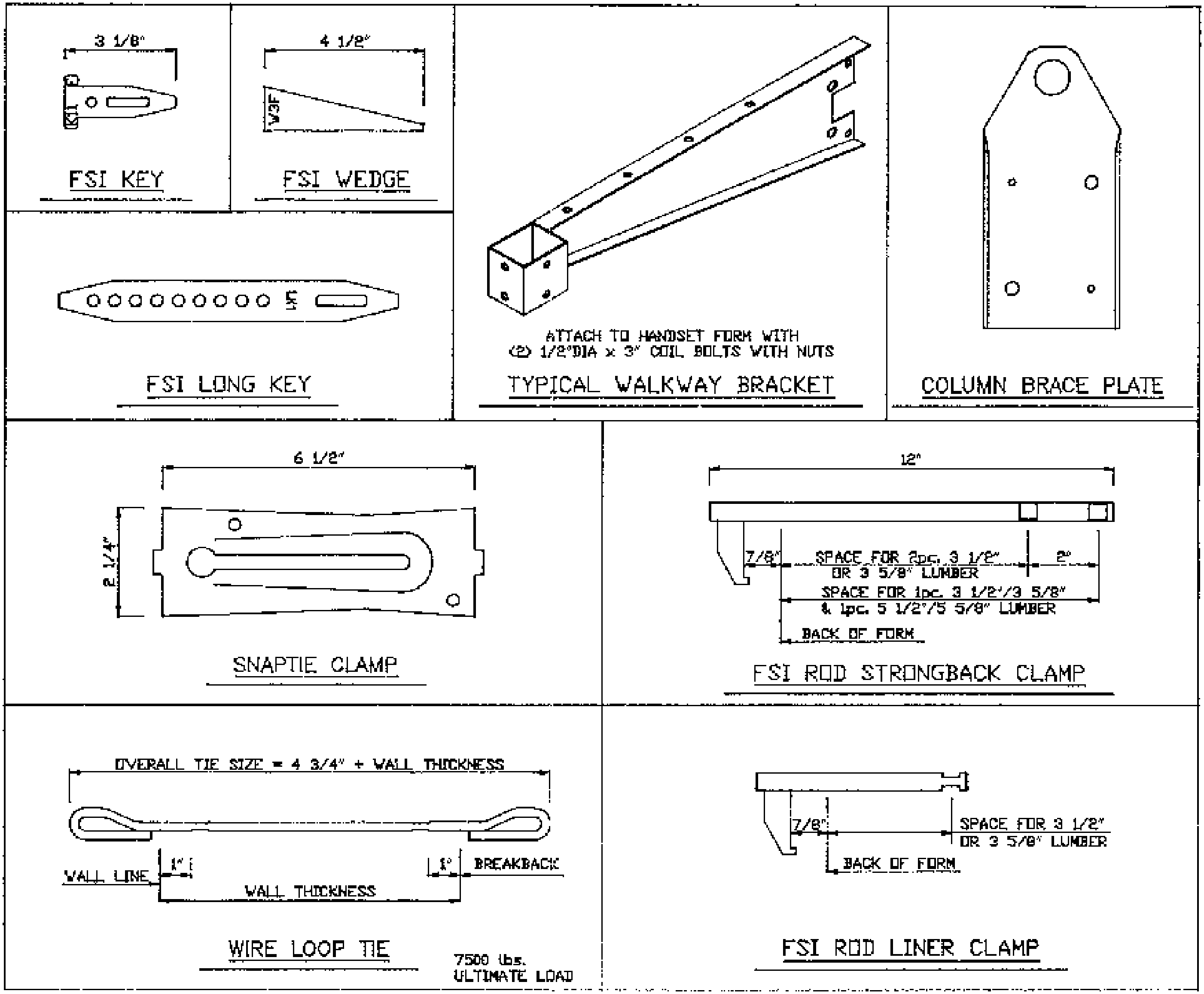


ATTACHMENT OF FORM TO PLATE
USING DOUBLE-HEADED NAILS

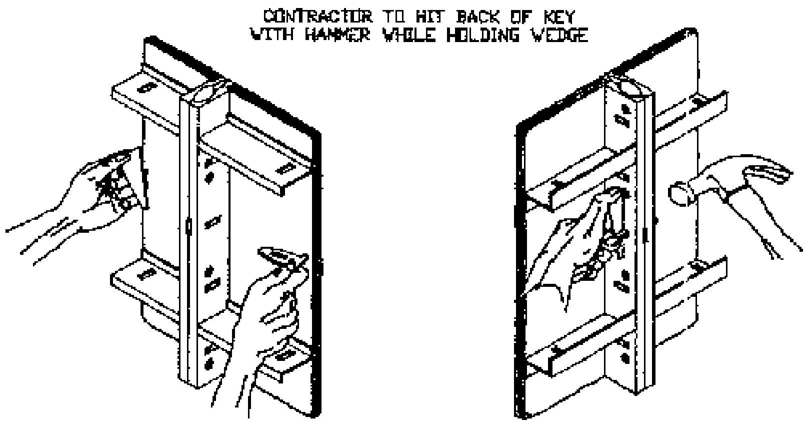


LONG KEY INSTALLATION

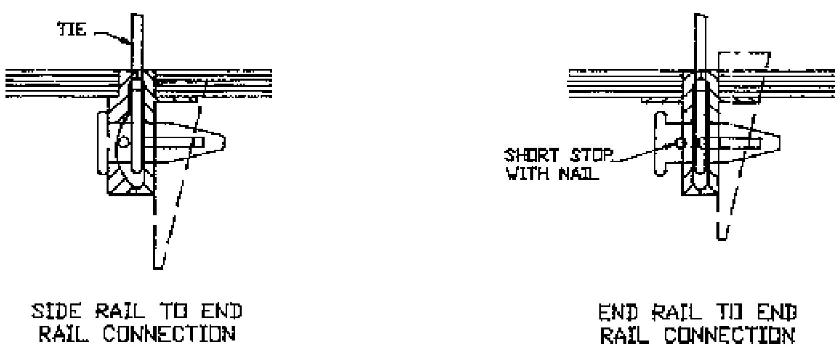
1.10.9 Form Installation Accessories



1.10.10 Proper Key and Wedge Connections and Installation Diagrams



PROPER KEY & WEDGE INSTALLATION



TYPICAL KEY & WEDGE CONNECTION

1.11.0 Notes on the Metrification of Reinforcing Steel

Drawing Scales

Metric drawing scales are expressed in nondimensional ratios. Nine scales are preferred (1 : 1, 1 : 5, 1 : 10, 1 : 20, 1 : 50; 1 : 100, 1 : 200, 1 : 500, and 1 : 1000). Three others have limited usage (1 : 2, 1 : 25, and 1 : 250). A comparison between inch-foot and metric scales follows:

1.11.0.1 Drawing Scales

Inch-foot scale	Ratio	Metric scale Preferred	Metric scale Other	Remarks
FULL SIZE	1:1	1:1		No change
HALF SIZE	1:2		1:2	No change
4" = 1'-0"	1:3			
3" = 1'-0"	1:4			
		1:5		Close to 3" scale
2" = 1'-0"	1:6			
1-1/2" = 1'-0"	1:8			
		1:10		Between 1" and 1½" scale
1" = 1'-0"	1:12			
3/4" = 1'-0"	1:16			
		1:20		Between 1/2" and 3/4" scales
1/2" = 1'-0"	1:24			
			1:25	Very close to 1/2" scale
3/8" = 1'-0"	1:32			
1/4" = 1'-0"	1:48			
		1:50		Close to 1/4" scale
1" = 5'-0"	1:60			
3/16" = 1'-0"	1:64			
1/8" = 1'-0"	1:96			
		1:100		Very close to 1/8" scale
1" = 10'-0"	1:120			
3/32" = 1'-0"	1:128			
1/16" = 1'-0"	1:196			
		1:200		Very close to 1/16" scale
1" = 20'-0"	1:240			
			1:250	Very close to 1" = 20'-0" scale
1" = 30'-0"	1:360			
1/32" = 1'-0"	1:384			
1" = 40'-0"	1:480			
		1:500		Very close to 1" = 40'-0" scale
1" = 50'-0"	1:600			
1" = 60'-0"	1:720			
1" = 1 chain	1:792			
1" = 80'-0"	1:960			
		1:1000		Very close to 1" = 80'-0" scale

Metric Units Used on Drawings

- Use only one unit of measure on a drawing. Except for large scale site drawings, the unit should be the millimeter (mm).
- Delete unit symbols but provide an explanatory note ("All dimensions are shown in millimeters," or "All dimensions are shown in meters.").
- Whole numbers should indicate millimeters; decimal numbers taken to three places should indicate meters.
- Where modules are used, the recommended basic module is 100 mm, which is similar to the 4-inch module in building construction (4 inches = 101.6 mm).

Drawing Sizes

The ISO "A" series drawing size are preferred metric size for design drawings. There are five "A" series sizes:

A0 = 1189 × 841 mm (46.8 × 33.1 in.)

A1 = 841 × 594 mm (33.1 × 23.4 in.)

A2 = 594 × 420 mm (23.4 × 16.5 in.)

A3 = 420 × 297 mm (16.5 × 11.7 in.)

A4 = 297 × 210 mm (11.7 × 8.3 in.)

A0 is the basic drawing size with an area of one square meter. Smaller sizes are obtained by halving the long dimension of the previous size. All "A" series sizes have a height to width ratio of one to the square root of 2.

Of course, metric drawings may be made on any size paper.

Rounding and Conversion

- When converting numbers from inch-pounds to metric, round the metric value to the same number of digits as there were in the inch-pound number (11 miles equals 17.699 km, which rounds to 18 km).
- Convert mixed inch-pound units (feet and inches, pounds and ounces) to the smaller inch-pound unit before converting to metric and rounding.
- "Rounding down" from multiples of 4 inches to multiples of 100 mm makes dimensions exactly 1.6 percent smaller and areas about 3.2 percent smaller. About $\frac{3}{16}$ inch is lost in every linear foot.
- In a "soft" conversion, an inch-pound measurement is mathematically converted to its exact (or nearly exact) metric equivalent. With "hard" conversion, a new rounded, rationalized metric number if created that is convenient to work with and remember [1 inch = 25.4 mm (soft) = 25 mm (hard)].

1.12.0 Tilt-Up Construction

General

The very nature of tilt-up construction dictates the need for thorough preconstruction planning. Much of the economy of tilt-up construction is realized by the ability to establish an efficient on-site production operation. The success of each construction sequence depends on the success of the preceding construction event. Errors are literally cast in concrete. Successful production of any tilt-up project requires careful organization and planning. The following may be used as a planning guide for the average tilt-up project but is not all-inclusive.

Site Access and Jobsite Conditions

Location of a jobsite may be such that special permits will be required to gain access to the site for the heavy equipment needed for earth work, large cranes for panel erection, and the large trucks that deliver roof members, not to mention ready mix concrete trucks. As an example, special permits are a common requirement for schools and churches. These buildings are often built in residential areas where tonnage restriction could exist.

It is advisable to investigate restrictions on early daily start up times. Also, noise and dust control regulations are becoming more prevalent. Fencing around a project should be considered to reduce vandalism and prevent unauthorized access and possible injury.

Scheduling

Construction sequences and scheduling must be constantly monitored and tightly controlled. Subcontractors and other trades have a certain specified time slot in which to perform their function. If a subcontractor performs a function out of sequence it almost always involves costly delays and prevents the next construction sequence from progressing.

The typical construction sequence for a normal tilt-up project is as follows:

- Site preparation;
- Underslab plumbing and electrical;
- Cast and cure interior column footings;
- Cast and cure floor slab;
- Form, cast and cure exterior footings
- Form, cast and cure tilt-up panels;
- Erect and brace panels;
- Construct the roof structure/diaphragm;
- Place concrete in the pour strip between the floor slab and the panels;
- Remove braces;
- Schedule other trades for painting, landscaping, interior framing, and interior finish.

The above is not a fixed sequence of events as there can be many exceptions. A common occurrence that would cause this sequence to change is a specification requiring the floor slab to be placed after the roof structure/diaphragm is completed. In this case, temporary casting slabs located outside the building perimeter are necessary for panel construction. Also, deadmen will be needed for the panel bracing.

The Slab as a Work Platform

Initial grading of the site should include completing all subgrade work for the building floor, parking and truck areas. At the same time, a road bed and ramp to the subgrade of the building for accessibility of equipment and material delivery should be installed.

Consideration should be given, at this time, to providing a well compacted subbase in the areas to be paved later. Too much emphasis cannot be placed on having a strong, well compacted subbase. Regardless of how much care goes into providing a good slab, that slab will only be as good as its subbase, not only for the early heavy construction loads that it will be expected to support, but also for any loads the tenant may later apply.

The panel contractor should make plans for stubbing all electrical and plumbing items below the finish floor surface. This creates additional floor area for casting panels and also provides an obstacle free area for crane movement. Items projecting above the slab can interfere with screeding of the panels and can be a source of cracks in the floor slab as well.

The quality of the floor slab in tilt-up construction is doubly important. Panels are normally cast on the floor slab and any imperfections in the slab surface will be mirrored on the downside face of the panel. For best results, the floor slab should have a hard, dense, steel trowel surface. As a general rule of thumb - if the total square footage of the panel area does not exceed 75% of the available floor slab area, then the panels can usually be individually cast on the floor slab without having to stack cast panels or use temporary outside casting slabs.

The panel contractor should try to lay out the panel forms in such a manner that the panels will not be cast over any floor slab construction or control joints. Should panels need to be cast over these joints, there are numerous ways to minimize the transfer of the joint image to the panel. The most popular is to fill the joint with drywall compound. Drywall compound readily disintegrates after the panels are lifted and leaves a relatively clean joint that can be blown free of residue for later sealing, if required. It must be pointed out that no known technique will completely eliminate the joint image, however it can be minimized to the point where sacking and patching might be omitted and a coat of paint will hide it.

Floor area at column blockouts can be made available for casting by filling the blockout with sand to within about 3" of the top and then placing a temporary filling of concrete finished the same as the floor. The blockout image will transfer to the panel, so choose a panel to cast over the blockout that is not as architecturally critical as others might be.

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Bondbreaker and Curing Compounds

Combination curing compounds and bondbreakers are some of the most critical materials that will be used on a tilt-up project. The product selected should meet ASTM C-309 requirements for curing concrete. Most projects require a cure and bondbreaker that will perform multiple tasks and allow future trades to work on the concrete surface. Generally a contractor is looking for these characteristics in his bondbreaker:

- Good curing qualities;
- Good bondbreaking qualities;
- Good drying qualities;
- Clean appearance;
- Compatibility with subsequent floor treatments and/or floor coverings;
- Compatibility with panel finishes such as paint, sealants, and adhesives.

There are four basic bondbreaker types:

- Synthetic petroleum, hydrocarbon, resin solutions;
- Solutions of waxes with metallic soaps;
- Solutions of organic esters and silicones;
- Water based – V.O.C. compliant.

Since resins and wax-soaps rely on physical films for performance, possibilities exist for residue on both the panels and the slab. Although resins are designed to oxidize off in 30 to 90 days under normal exposure, varying conditions may result in residue being present beyond that time. Wax-soap types resist oxidation, leaving residue, particularly with excessive application. Residues discolor and can prevent the adhesion of paint, sealers, adhesives, and other treatments. Silicone-ester types leave little or no residue. Basically, resin and wax soap cures and bondbreakers provide a membrane between the casting surface and the panel that prevents matrix migration from the panel to the slab. Silicone-esters are known as reactive bondbreakers that work with the excess lime in the slab matrix to provide a moisture barrier. In some areas, water-based V.O.C. compliant bondbreakers are now required.

It is important the curing compound be compatible with the bondbreaker. There is a wide variety of commercially available compounds that perform both functions. There are instances where special sealers are specified for the floor slab. Manufacturers' representatives should know if certain products are not compatible, otherwise specific testing or other evaluation may be required. When the concrete mix design contains fly ash, it is desirable to check with the manufacturer of the cure and bondbreaker for any special precautions that may be needed.

The application of the cure coat on the floor slab is by far the most important step in ensuring a successful lift. The application of the cure coat **should immediately** follow the final hard steel trowel just as the slab is losing the shine and turning a slate grey. A cure coat application applied at too late a time period could result in a porous slab surface that will soak up a bondbreaker coat, rendering it ineffective.

Shop Drawings

If complete shop drawings are not part of the plans prepared by the engineer, the panel contractor should prepare drawings detailing each panel completely. These shop drawings should include:

- Panel identification;
- All dimensions;
- All physical characteristics including weight;
- Reinforcing steel;
- Location and identification of all embedded items;
- Finishes and textures;
- Rigging and bracing information.

A complete set of shop drawings should be submitted to the engineer of record for their approval. Preparing these shop drawings on 8 1/2" x 11" stock that can be kept in a 3 ring loose leaf binder is one common procedure. Some contractors provide standard forms for their personnel so the detailing practice is made easier.

Panel Casting Layout

The panel contractor should consult with the erection contractor to help develop the proper casting layout. To ensure an efficient construction procedure, two important criteria must be met:

1) the panels must be located for efficient casting and
2) the panels must be located for safe and efficient erection.

The casting sequence should have as one of its main criteria the accessibility to the panel forms of the ready mix trucks so they may discharge concrete directly via their chutes without the expense of pumps or conveyor systems.

A typical panel erection sequence takes into consideration a number of factors. The contractor should watch for special bracing situations, particularly at corners and other interruptions of a straight building line. At corners, braces will be required to pass over or under bracing of a previously erected panel. Consideration of brace locations prior to casting of the panels can often reduce the time involved in placing panels in these situations.

In determining the panel erection sequence, plan to eliminate "fill-in" panels wherever possible. Panels should, if feasible, be erected consecutively, beginning at the corner of a building.

Panels should be cast as near as possible to their final location in the structure with as many placed side by side as possible. Panels that cannot be cast near their final location should be carefully located so they can be "walked" the shortest practical distance to their final position in the structure. It is good construction practice to cast panels so that "walking" the panels can be avoided.

A casting layout and erection sequence plan should be made by drawing the floor plan and placing on it cut-outs of the panels in their proposed casting locations. Use the cut-outs to evaluate the erection sequence by lifting each panel cut-out by hand to insure that the erection sequence is compatible with the layout. This planning should be done with the erection contractor.

Continued

1.12.1 Panel Construction

Panel Construction

Once the floor slab is in place and cleaned, the panels are outlined directly on the slab with chalk lines. Chalk lines should be sprayed with a coat of bondbreaker so weather will not wash them away. Then panel edge forms and/or any opening forms are erected.

It is recommended that the casting area be fogged with water to a point of saturation, but without standing water, prior to applying the bondbreaker coat. The bondbreaker should be applied using two applications. The first half of the material should be sprayed in an east–west direction and the second half sprayed in a north–south direction. This helps to ensure a uniform coat. As with any such procedure, the previous coat must be dry before applying any additional coats.

Check the casting slab before placing any concrete. The surface should be slightly tacky with a soapy feeling. Suitability of the bondbreaker can be checked by cleaning a small area of the casting surface to make it dust-free. Drop a small amount of water on the slab from a height of about 24" so it can splatter. If the bondbreaker coat is doing its job, the water should bead up and form droplets just as it would on a newly waxed car. If the water does not bead up, have the slab checked by the manufacturer's representative.

After the panels are formed, the bondbreaker applied and tested, chamfer strips installed, the reinforcing steel, lifting and bracing inserts and other embeds are securely in place — there is still one final recommended procedure for the panel contractor to consider. Just prior to casting the panel, the contractor should fog the casting surface with water, avoiding any standing or puddled water. By following this procedure, the contractor will be certain that the pores of the casting surface have been properly saturated.

The panel concrete must be properly consolidated using an appropriate vibrator. The vibrator is most effective if it is prodded straight up and down. Laying the vibrator horizontally and dragging it along the reinforcing steel will often leave the reinforcing steel pattern visible on the downside face of the panel. Avoid overvibration as it will cause segregation of the aggregate and bring excess water to the surface.

Preparation for Lifting

Clean the surface of all panels as well as all exposed surfaces of the floor slab. Locate and prepare all embedded items that are accessible. Do any necessary dressing and patching of the panel now. Remember, work on the ground is less expensive and safer than working on the panel after it is erected. This is also the time to install the strongbacks, if any are required, and to attach the pipe braces.

Each panel should be clearly identified with its number placed in a spot where it will not be exposed when the structure is finished. Also, the footing should have the appropriate panel number spray painted on it to give the riggers a clear indication where each panel goes. The footing should also have the location marks of the panel outlined on it to give the riggers guidelines for panel positioning on the footing.

All lifting inserts should be uncovered, cleaned out, and tested with a hardware unit several days prior to erection day so any needed repairs or adjustments can be made and not hold up the expensive crane and crew on erection day.

Equipment should include, rotary hammers, drills, leveling shims, cutting torch, steel wedges, pry bars, level and plumb bob. In addition, a full set of small hand tools should be available. It is a prudent contractor who anticipates material requirements and prepares for emergency breakdowns. Spreader bars and other lifting-related equipment are furnished by the erection contractor.

Panel Erection Techniques

The following panel erection techniques are suggested as an aid for the safe and efficient erection of tilt-up wall panels.

- **Layout** — Prior to the day of erection, the panels should be laid out on the exterior foundations and the exterior wall line established.
- **Alignment** — One method of alignment is to mark the limits of each panel, then drill ⅝" holes into the foundation approximately 5" deep. Install two #5 rebars (approximately 10" long) on each side of each panel.
- **Leveling** — Prior to day of erection, install leveling shims with a level so that the top of all panels are in line. Grout should be installed around the shims to hold them in position.
- **Grout** — After panels are erected and aligned, grout as specified should be placed under each panel. Grouting should be accomplished as early as possible after panel erection. Care should be taken to make certain the grout fills the void between bottom of panel and top of footing.

After the Lift

When casting the floor slab, a perimeter strip 3 to 5 feet wide is often left out between the floor slab and the panel. This portion of the slab is not yet cast in order to facilitate excavating for the footings. Backfilling of this pour strip is not done until after the panels have been erected. The excavated area may be as deep as 5 or 6 feet depending on the design of the building. It must be backfilled and compacted very carefully to avoid moving or bending of the panels. Usually, there are dowels projecting from the floor slab into this pour strip and they overlap with the dowels that project from the panel. If the structure is a *dock-high* building, it may be prudent to weld the floor dowels and panel dowels together prior to backfilling. After the backfill is in place and properly compacted, concrete is cast in this perimeter strip connecting the floor slab to the panel.

Braces should **NOT** be removed even temporarily, until **ALL** structural connections are complete. The pour strip between the floor slab and the tilt-up panel is considered a structural connection.

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1.12.2 Lifting Stresses and Concrete Design

Tilting a wall panel into position creates stresses not encountered in conventional cast-in-place construction. These stresses are very important, for they can range up to several times the magnitude of the stresses the panel has been designed for as a wall in the building frame. These high stresses also occur when the tensile strength of the concrete in the panel is relatively low.

The maximum stresses imposed upon a precast tilt-up wall panel will generally occur as the horizontally cast panel is tilted into its intended vertical position. Furthermore, the event usually takes place early in the life of the panel before the concrete has attained its full strength and capabilities.

As the panel is lifted or tilted, the dead weight of the panel induces a flexural moment, causing stresses to develop in the panel. These stresses can often become very high, depending on the size of the panel, number of openings, number of inserts used, and type of rigging. High lifting stresses can normally be offset with proper design of insert locations, strongbacking, special reinforcing techniques, or higher concrete strengths.

Since it is desirable to prevent cracking, the resistance to lifting stresses is generally dependent upon the homogeneous, uncracked section of concrete. The contribution of reinforcing steel to the properties of the panel cross section can usually be ignored, since the normal reinforcement is located at the center of the panel structural thickness or its Neutral Axis.

As concrete is weak in tension, it is sufficient to calculate the maximum induced tensile stress and to limit it to an acceptable value below the tensile resistance of the concrete. The tensile resistance of normal weight concrete made from sand and aggregate is about $7.5\sqrt{f'_c}$. However, to account for creep, shrinkage or other incidental buildups of tensile stress a somewhat lower value is generally accepted as the safe limit. Lightweight aggregate concrete tensile stresses are limited to 75 or 85% of the normal weight safe limit. The chart below lists the various safe tensile stress limits.

Concrete Weight	Allowable Tensile Stress
150 PCF	$5\sqrt{f'_c}$
Less Than 150 PCF	$.85 \times 6\sqrt{f'_c}$
110 PCF	$.75 \times 6\sqrt{f'_c}$

Note! f'_c refers to the actual concrete compressive strength at time of lift.

SWL Reduction Factors for Lightweight Concrete

Safe working loads for the inserts shown in this handbook were derived from analysis and testing of Dayton Superior's inserts when used in normal weight concrete. The safe working load of the insert is dependent upon the tensile strength of the concrete in which it is embedded. The American Concrete Institute standard "Building Code Requirements for Reinforced Concrete" has recognized that the tensile strength of lightweight concrete is less than that of normal weight concrete. When Dayton Superior's tilt-up inserts are used in lightweight concrete panels, the safe working load of such inserts must be recalculated by multiplying the safe working loads listed in this handbook by a reduction factor to compensate for the reduction in tensile strength. The following chart shows the various reduction factors which Dayton Superior recommends.

Concrete Type	SWL Reduction Factor
Normal Weight	1.0
Sand and Lightweight Aggregates	.7
All Lightweight Materials with a weight of 110 PCF or more	.6
All Lightweight Materials with a weight of 110 PCF or less	Verify by Testing

Interested readers are referred to section 11.2 of the American Concrete Institute's "Building Code Requirements for Reinforced Concrete (ACI 318)" for additional information.

(By permission from Dayton/Richmond, a Dayton Superior company, Miamisburg, Ohio.)

1.12.3 During the Lift

Precautions

Wind conditions must be considered prior to lifting a panel. A 40-ton panel will easily move in a slight breeze when hanging from a crane. All spectators should be kept well away from the lift and not allowed to interfere with the proceedings.

Panels should be inspected prior to lifting for any reinforcing steel and/or ledgers that may be projecting beyond the panel edges that will create interference when the panel is being plumbed next to a previously erected panel. This happens most often at corners.

After all attachments are made to the panel, and as the rigging is being raised to take the slack out of the cables, but prior to initial loading of the inserts, all rigging gear must be inspected for proper alignment and be free of snags. If non-swivel type sheaves are used, make certain the sheaves are properly aligned. As cables are being tensioned, they invariably tend to twist and possibly rotate the lifting hardware causing side loading on the hardware. The rigger foreman should be alert for this condition and if it does happen, SHOULD HALT THE LIFT AND REALIGN THE HARDWARE.

It is the rigger foreman's responsibility to be alert to all obstacles in the path of the crane and crew. He should be alert for panels that may be stuck to the casting surface. Under such conditions, loads transferred to the lifting inserts could be more than doubled causing possible insert failure. Carefully positioned pry bars and wedges can often be successful in helping the crane release the panel from the casting surface. Any wedges that are applied to help release the panel should be positioned at the insert lines.

Braces are almost always attached to the panel prior to lifting. Caution must be taken to be certain the braces will not be trapped by the rigging when the panel is in the upright position.

Plumbing the Panels

Precautions

Be alert when plumbing panels to their final upright position. Caution must be taken to make certain the panel being plumbed does not strike a previously erected panel. All personnel should be cleared of those critical areas around a panel when plumbing is being done. If the panel being plumbed is a closure panel, measurements should be taken prior to lifting to make certain the panel will fit.

Tilt-up panels should be as plumb as possible prior to attaching the brace to the floor attachment anchor. Temporary out-of-plumbness SHOULD NOT EXCEED 4" measured at the top of the panel. It is generally more practical to "fine tune" the panel plumbness with the pipe braces after the lift is completed.

There are two commonly occurring conditions that dictate that the panels be braced perfectly plumb prior to releasing the crane:

1) If the panel is going to support an adjacent spandrel or lintel panel, the supporting panel should be in an accurate final position to prevent having to adjust it later when it is supporting another panel.

2) If the bracing design calls for a subsupport system of knee, lateral, and end or cross bracing, then the panel should be accurately plumbed prior to attaching the subsupport system. Panels requiring subsupport systems must not be plumbed later as the brace subsupport system, if not removed, must be at least loosened in order to adjust the main brace, thus placing the panel in a dangerous position.

Bracing

General

Do not release the crane load if, for any reason, the bracing does not appear adequate. Crane loads should always be released slowly, keeping an eye on the panel and bracing for any unusual activity. It is desirable that all bracing be complete before releasing the crane. That is, all knee, lateral, and end or cross bracing, if required, be in place. However, this is not always possible. You should always be able to install the knee bracing, however, the crane's position near the panel may prevent the lateral bracing from being attached.

Once the crane is clear of the area, the panel contractor must complete the lateral and end or cross bracing. He must complete this phase of the bracing while remaining no more than one panel behind the erection crew. All bracing should be completed on all erected panels at the end of the work day.

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1.12.4 Insert Capacity Theory

When a load is applied to an insert embedded in concrete, a corresponding resistive force is induced into the concrete. The stresses which are induced appear to be a combination of shear and diagonal tension. Although it is now possible to measure the tensile strength of concrete by the Split Cylinder Test (See ASTM C-496, Latest Revision), many engineers will find the relationship between the compressive strength and the tensile strength more convenient. This relationship may be expressed as $f_T = K\sqrt{f'_c}$ where

f_t = ultimate diagonal tension resistance resulting from a shear force,

f'_c = compressive strength of the concrete at time of lift, and

K = variable, depending upon aggregates, mix design, etc. Value of K for sand and gravel concrete generally used in tilt-up construction is approximately 4.

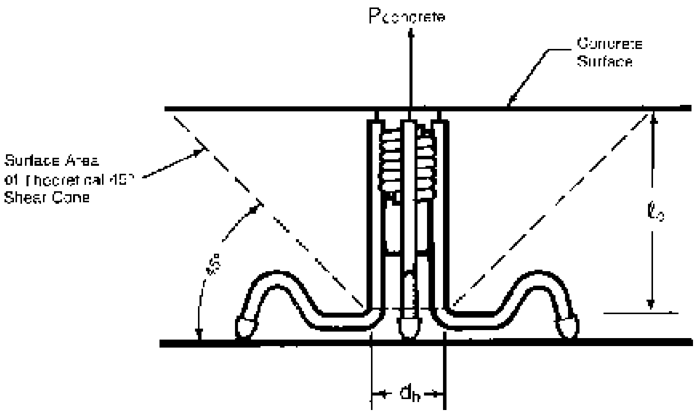
Insert concrete failures can be predicted with a reasonable degree of accuracy as punching shear failures, by using the following equation:

$$P_{concrete} = \frac{0.85 \times A_c \times 4 \times \lambda \times \sqrt{f'_c}}{\sqrt{2}} \text{ where}$$

$P_{concrete}$ = maximum tension load carried by concrete and

λ = reduction factor for use with lightweight concrete (see page 7)

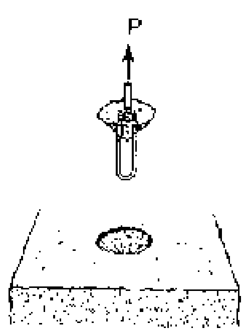
A_c = $\sqrt{2} \times \ell_e \times \pi (\ell_e + d_h)$ the surface area of a 45° shear cone.



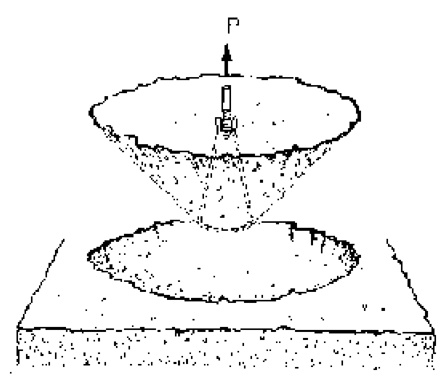
Warning! Adding re-bars to the horizontal portion of an insert will reduce the depth of the shear cone (ℓ_e) resulting in a reduced insert capacity. When re-bars are added for insert stability they should be placed against the vertical portion of the insert and at least 1" away from the horizontal portion.

Note! Maximum insert capacity may be controlled by insert's mechanical strength.

When the applied load P exceeds the pullout capacity of the insert, the insert will fail in one of four ways.



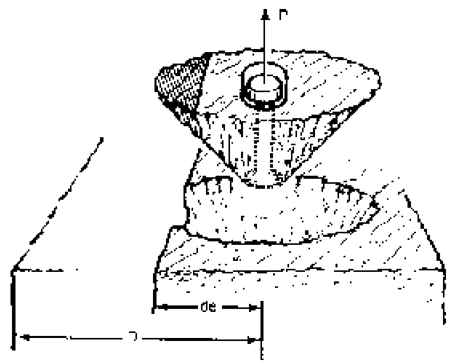
The entire insert may pull out of the concrete, with little apparent damage to the concrete. Such failures are rare and, when they do occur, are the result of bond failure between the concrete and insert. These failures usually occur in "green" or low strength concrete.



The entire insert may pull out of the concrete, bringing with it a cone of concrete having its apex slightly above the most deeply embedded part of the insert. Such failures usually occur in relatively low strength concrete in which the tensile strength of the shear cone surrounding the insert is not as great as the mechanical strength of the insert itself.

(By permission from Dayton/Richmond, a Dayton Superior company, Miamisburg, Ohio.)

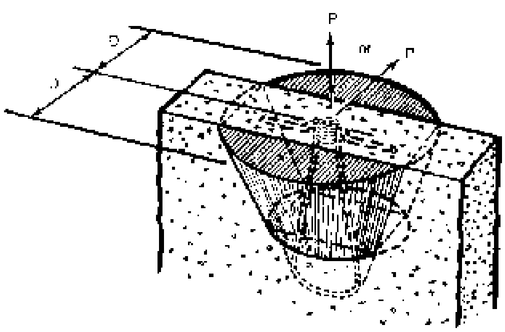
Insert Edge Distances



Embedment of inserts closer to any edge, construction joint, window or door opening than the minimum edge distances shown in this handbook will greatly reduce the effective area of the resisting concrete shear cone and thus reduce the inserts tension safe working load. The shaded area of the shear cone shown on the illustration shows the extent to which this area is reduced. Tension safe working loads of inserts near a free edge or corner must, therefore, be reduced in proportion to the reduction in effective shear cone area.

de — Actual Edge Distance
D — Minimum Edge Distance Required to Develop Insert's Maximum SWL.

Shear Loading



Another condition frequently encountered is that of an insert embedded near a free edge or corner and loaded in a transverse shear direction to the axis of the bolt, toward the free edge of the concrete. Contact Dayton Superior for safe working loads of inserts used in this condition.

D — Minimum Edge Distance Required to Develop Insert's Maximum SWL.

Condition of Loadings

All safe working loads shown in this handbook are for static load conditions only. If dynamic forces or impact loading conditions are anticipated, the safe working load must be reduced accordingly. Safe working loads shown in this handbook must never be exceeded.

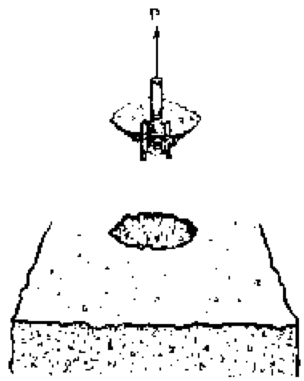
Care must be exercised to see that all inserts and hardware units are properly aligned, all lifting plates and bolts properly secured, all rigging is equalized, and properly sized crane cables utilized. In all cases the center line of the spreader bar and hook must be in line with the center of gravity line of the panel. Cable lengths must be of proper size and length.

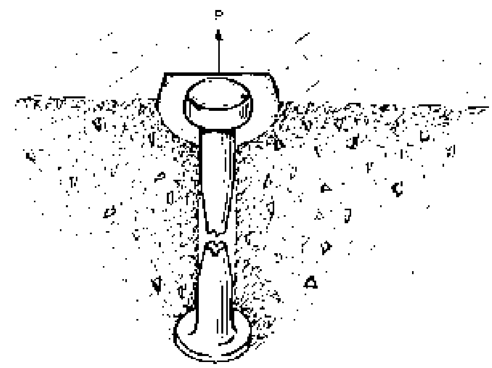
Continued

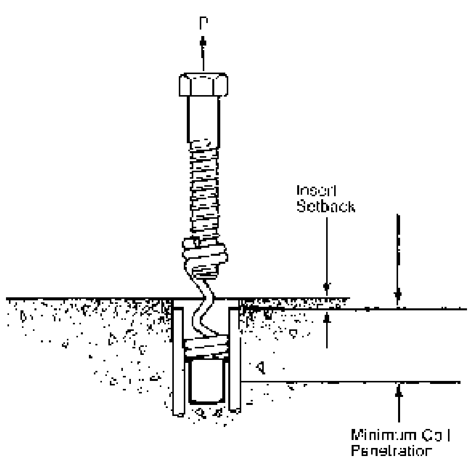
A failure may also occur through breakage of the insert. Coil type inserts will usually fail at a point just below the helically wound wire coil. A small cone of concrete will usually be pulled out of the concrete surface. This cone will have its apex at a point just below the coil. Its base diameter will be approximately twice its cone height. SLGR inserts will fail by fracturing of the shaft diameter of the insert.

These failures occur in high strength concrete when an insert is loaded beyond the mechanical strength of the insert.

Failures of this type are due to a definite overload being applied to the inserts. Such failures can be prevented by choosing inserts of capacity suitable to job conditions or by increasing the number of inserts used to lift the tilt-up panel.







When bolting coil type inserts, the bolt should always extend at least the proper amount beyond the bottom of the insert coil. Failure to do this causes the entire bolt load to be transferred to fewer turns of the coil, causing an increased load per weld contact point. The coil will then unwind much like a corkscrew, resulting in a premature failure.

Bolt Diameter	Minimum Coil Penetration
¾"	2¼"
1"	2¼"
1¼"	2½"
1½"	3"

Insert Placement

Tilt-up inserts which are positioned in the face of the panel are called FACE inserts; and those which position the inserts in the edge of the panel are called EDGE inserts. Inserts must be placed accurately because their safe working load decreases sharply if they are not perpendicular to the bearing surface, or if they are not in a straight line with the applied force.

Inserts lend themselves well to being located and held correctly (by tying to the reinforcing steel) before the casting operations begins. Failure to achieve proper insert placement is carelessness in field installation. It is equally important to place inserts so that the depth of thread is constant for the same size insert throughout a particular job. Otherwise an erection crew may make mistakes in the field by not always having the proper bolt engagement. Inserts should also be kept clean of dirt, ice or other debris.

Continued

1.12.5 Brace Length and Safe Working Loads

How to Calculate Brace Length

D = Elevation—top of panel above floor slab (not necessarily same as panel height).

W = Wall insert dimension – 2/3 D

F = Floor insert dimension = 3/4 W

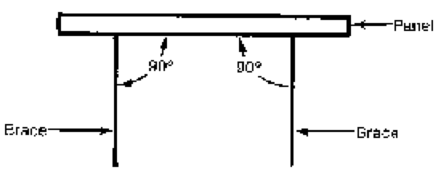
B = Brace length = 5/4 W

Danger! For safety, all braces must be installed at least 2′-0″ above the panels center of gravity.

Brace locations other than those shown may reduce the braces SWL drastically. Brace angles over 60° from the horizontal result in poor mechanical advantage and excessive vertical kick, while brace angles under 50° decrease brace buckling strength due to greater length and excessive sag.

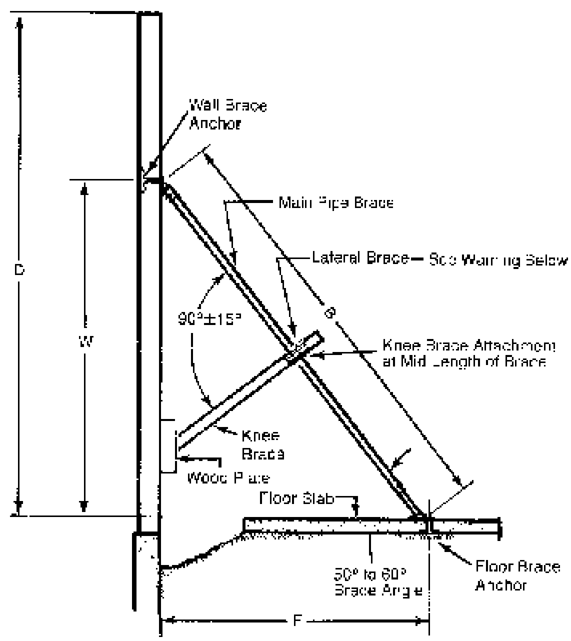
Without knee brace means that brace type can be adjusted for various lengths of "B" shown, and brace may be used without knee, lateral or end bracing.

With knee brace means that brace type can be adjusted for various lengths of "B" shown and requires the use of knee, lateral and end bracing to obtain the SWL listed.



Plan View

Danger! Bracing must be installed at 90° ± 5° to plane of panel or brace safe working load will be greatly reduced.



Note: End braces to ground and/or cross braces must be installed every 100 ft to prevent lateral movement of braces and to provide total brace stability.

WARNING! IT IS COMMON TO REFER TO THE SUBBRACING SUPPORT SYSTEM OF THE MAIN PIPE BRACES AS KNEE BRACING. HOWEVER, THE USER IS TO BE AWARE THAT WHEN KNEE BRACING IS REQUIRED, IT MEANS THAT LATERAL BRACING AND END BRACING MUST ALSO BE INCLUDED. THIS SUBBRACING SUPPORT SYSTEM IS NEEDED TO REDUCE THE BUCKLING LENGTH OF THE MAIN PIPE BRACES AND MUST HAVE FIRM CONNECTIONS AT ALL POINTS. THE KNEE BRACE MUST ALSO BE CONNECTED AT ITS BOTTOM END.

B-1 On-Site Pipe Brace				
				Safe Working Load
D	W	F	B	Without Knee Bracing
9′-0″	6′-0″	4′-6″	7′-6″	6,500 lb
9′-6″	6′-5″	4′-9″	7′ 11″	6,500 lb
10′-0″	6′-8″	5′-0″	8′-4″	6,500 lb
10′-6″	7′-0″	5′-3″	8′-9″	6,500 lb

SWL provides factor of safety of approximately 2 to 1.

(By permission from Dayton/Richmond, a Dayton Superior company, Miamisburg, Ohio.)

B-2 Regular Pipe Brace					
				Safe Working Load	
D	W	F	B	Without Knee Bracing	With Knee Bracing
16'-0"	10'-8"	8'-0"	13'-4"	5,800 lb	6,500 lb
17'-0"	11'-4"	8' 6"	14'-2"	4,800 lb	6,500 lb
18'-0"	12'-0"	9' 0"	15'-0"	4,200 lb	6,500 lb
19'-0"	12'-8"	9'-6"	15'-10"	3,550 lb	6,500 lb
20'-0"	13'-6"	10'-0"	16'-7"	3,150 lb	6,500 lb
21'-0"	14'-1"	10'-6"	17' 5"	2,800 lb	6,500 lb
22'-0"	14'-8"	11'-0"	18'-3"	2,500 lb	6,500 lb
23'-0"	15'-5"	11'-6"	19'-0"	2,275 lb	6,500 lb
24'-0"	16'-1"	12'-0"	19'-11"	1,975 lb	5,925 lb

SWL provides a minimum factor of safety of 1.5 to 1.

Danger! *With knee bracing* means that knee, lateral and end bracing must be installed in order to obtain SWL's shown.

B-3 Regular Pipe Brace With Extension				
				Safe Working Load
D	W	F	B	With Knee Bracing
26'-0"	17'-4"	13'-0"	21'-8"	6,500 lb
27'-0"	18'-0"	13'-6"	22'-6"	5,975 lb
28'-0"	18'-8"	14' 0"	23'-4"	5,325 lb
29'-0"	19'-4"	14'-6"	24'-2"	4,925 lb
30'-0"	20'-0"	15'-0"	25'-0"	4,550 lb
31'-0"	20'-8"	15'-6"	25'-10"	4,100 lb
32'-0"	21'-4"	16'-0"	26'-8"	3,800 lb
33'-0"	22'-0"	16'-6"	27' 6"	3,500 lb
34'-0"	22'-8"	17'-0"	28'-4"	3,225 lb
35'-0"	23'-4"	17'-6"	29'-2"	3,000 lb

SWL provides a minimum factor of safety of 1.5 to 1

Danger! This brace is not designed for use without knee, lateral and end braces.

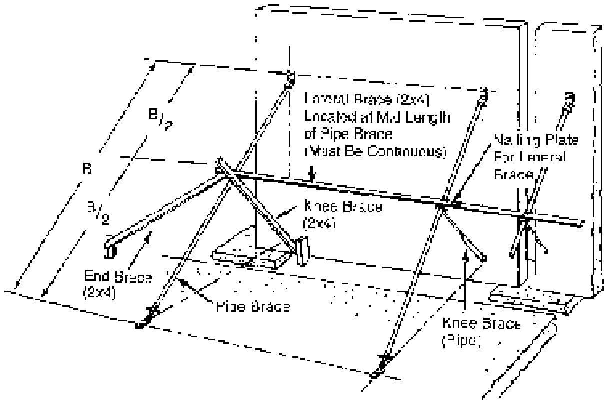
B-4 Heavy Duty Regular Pipe Brace					
				Safe Working Load	
D	W	F	B	Without Knee Bracing	With Knee Bracing
18'-0"	12'-0"	9' 0"	15'-0"	6,500 lb.	6,500 lb.
19'-0"	12'-8"	9'-6"	15' 10"	6,500 lb	6,500 lb
20'-0"	13'-4"	10'-0"	16'-8"	6,500 lb	6,500 lb
21'-0"	14'-0"	10'-6"	17'-6"	5,925 lb	6,500 lb
22'-0"	14'-8"	11'-0"	18'-4"	4,800 lb	6,500 lb
23'-0"	15'-4"	11'-6"	19'-2"	3,925 lb	6,500 lb
24'-0"	16'-0"	12'-0"	20'-0"	3,575 lb	6,500 lb
25'-0"	16'-8"	12'-6"	20'-10"	2,975 lb	6,500 lb
26'-0"	17'-4"	13'-0"	21'-8"	2,500 lb	6,500 lb
27'-0"	18'-0"	13'-6"	22'-6"	2,275 lb	6,500 lb
28'-0"	18'-8"	14'-0"	23'-4"	1,950 lb	6,500 lb.

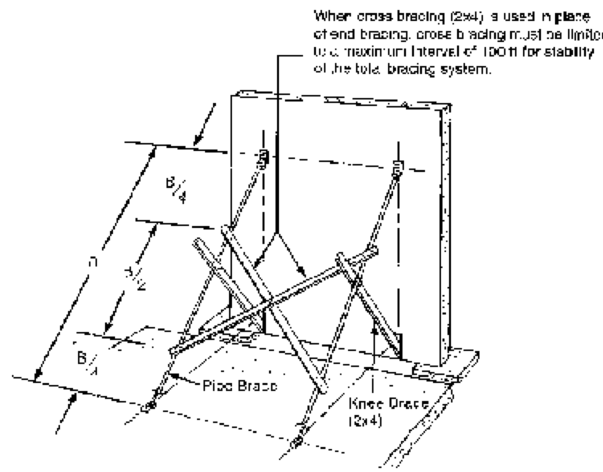
SWL provides a minimum factor of safety of 1.5 to 1.

Danger! *With knee bracing* means that knee, lateral and end bracing must be installed in order to obtain SWL's shown.

Continued

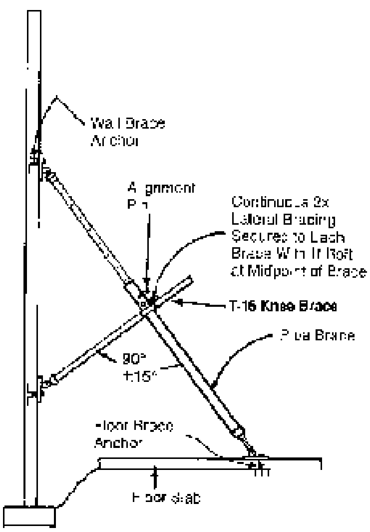
Knee, Lateral and End Bracing





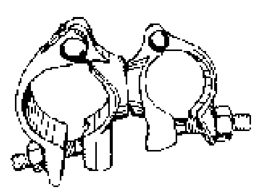
In order to properly strengthen the main pipe brace, knee bracing, lateral bracing and end bracing must be installed at the mid-point of the main pipe brace.

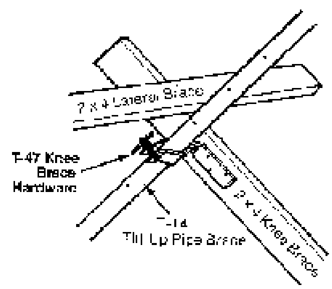
Cross bracing is an acceptable alternative to lateral bracing and end bracing. This method system provides excellent panel stability when the erection sequence dictates that there are no adjacent panels that would make continuous lateral bracing possible.



T-17 Swivel Coupler (#3)

Used to connect 1½" I.D. pipe knee brace to 2" or 2½" I.D. pipe brace





Danger! After winds of 15 mph or more have been experienced at the job site, the tilt-up contractor must check the tightness of the bolts that secure the wall and foot plates to the concrete. Retightening of such bolts to the proper torque will assure that the pipe braces are secure.

Safety Notes

- Panel should be plumb with braces and knee braces installed before crane releases panel.
- Lateral bracing should be installed as soon as crane and crew are clear and should not be more than one panel behind the last panel erected.
- Lateral bracing must be continuous, connected at each brace, and tied off with end brace at the end of each line.
- All members of the brace system must always be in place and secured at the end of each day.
- Knee and lateral bracing must be located at mid-length of pipe brace.
- Panels require a minimum of two braces per panel.
- Do not erect panels or continue working during excessive windy or adverse weather conditions.
- All brace inserts should be a minimum of 12" from any panel edge, opening, control joint or construction joint.
- Knee brace must be firmly fixed at bottom end to prevent possible upward buckling of main brace.
- Panel bracing is designed to withstand specified windloads until panels are connected to the structural system of the building. Do not remove any members of the bracing system until all structural connections are completed.
- Welding or bolting the precast or tilt-up elements in place might preclude the use of braces.
- For special conditions contact Dayton Superior for recommendations.
- T-14 Tilt-up Braces are not recommended for bracing concrete block, brick or other types of masonry walls.

Continued

1.12.6 Rigging and the Crane

General

The most important phase during the construction of a tilt-up building is the erection of the wall panels. It is extremely important for the designers and contractors to plan and re-plan this portion of the job. They should direct their efforts to ensure that this important phase of construction is performed safely and efficiently.

Since there must be a close, cooperative relationship between the panel contractor and the erection subcontractor, it is advisable to select an erection subcontractor during the early days of the project. The erection subcontractor and crew should be well experienced in tilt-up, as panel tilting and handling is a very specialized skill.

Prior to Construction

Prior to the actual start of construction, an inspection of the site should be made by the contractor. The location of the jobsite may be such that special permits will be required to gain access to the site for heavy equipment such as the crane. As an example, permits are a common requirement for schools and church projects. These projects are usually built in residential areas where weight and size restrictions may exist.

It is advisable for the contractor to investigate restrictions on early daily start-up times. Many areas have noise abatement and dust control regulations. Also, the panel contractor and erection contractor should walk the site and determine a suitable location for the crane assembly and rigging make-up. Some local governments will not allow this activity on public streets.

It is also advisable that any problems with uneven terrain be noted at this time and dealt with prior to bringing the crane onto the jobsite.

The panel contractor and the erection contractor should always agree on a location for both the crane entrance onto the floor slab as well as the exit ramp off the floor slab. If necessary, plans should be made to thicken the floor slab at these ramp locations so the crane weight will not damage the edge of the slab.

Underground tunnels, trenches and sewer lines are a very common occurrence and can create problems. It is necessary to know the location of these underground hazards and to avoid those that may need strengthening in order to support the crane's weight. We have often found that the location of these underground hazards is not always noted on the architect/engineer's plans. Further investigation by the panel contractor should be made in an effort to discover these types of unknown hazards.

Overhead electric or telephone wires can be a common problem on both urban and rural job sites. It may be necessary to shut off the power in some overhead wires in order to safely operate the crane during panel erection. Most safety regulations dictate that cranes will not be allowed to work closer than ten feet to power lines.

The quality of the floor slab on a tilt-up project cannot be overemphasized due to the heavy weights that the slab will be expected to support early in its life. Equally as important as the slab, is the subbase under the floor slab. When it comes to supporting the combined weight of the crane and tilted panel, the floor slab is no better than its subbase. Even a thick, properly engineered floor slab with two curtains of reinforcing steel will not support the weight of the crane if the subbase is unstable.

To insure an efficient construction procedure, careful consideration must be given to the casting location of the panels. The following two important criteria must be met if the contractor expects to have a successful project:

- Panels must be located for efficient CASTING.
- Panels must be located for efficient LIFTING

The panel contractor should work with the erection subcontractor in developing the panel casting layout. The erector's advice should be sought so that the panels are cast in such a position that a properly sized crane can safely reach and erect them.

Crane selection should not be looked on as merely routine. General rules for sizing the crane state that the crane capacity should be a minimum of two to three times that of the heaviest panel including the weight of the rigging gear. However, in the final analysis not only the panel weight, but also the crane's position relative to the panel must be considered. The following questions must be answered before final determination of crane size can be established:

- How far must the crane reach to lift the panel?
- How far will the crane have to travel with the panel?
- How far will the crane have to reach to set the panel?

Crane Certification

The crane that is finally selected for the project should be properly certified. Many, if not all, states have standards with which erection subcontractors must comply. Prudent contractors make certain they have available at the jobsite documentation attesting to the crane's certification. The contractor should also obtain a certificate of liability insurance from the erection subcontractor.

(By permission from Dayton/Richmond, a Dayton Superior company, Miamisburg, Ohio.)

1.12.7 Problem Areas

Over the years, Dayton Superior has found that the following areas are most often overlooked and can create costly problems for the beginning tilt-up contractor.

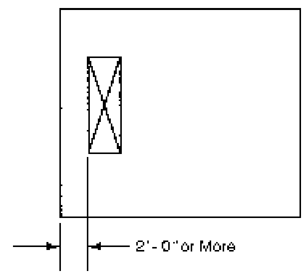
Panel Widths

Familiarize yourself with field conditions and equipment available for tilt-up erection. Crane capacity should be a minimum of two times the maximum panel weight. Available crane capacity may determine maximum panel width.

For maximum rigging and lifting efficiency Dayton Superior recommends the following:
Panel heights of 24 ft or less – widths to 36 ft or panel heights greater than 24 ft – widths to 20 ft.

Window and Door Openings

Try to center in panel; if not possible, always have a 2'-0" or more keg of concrete. Legs less than 2'-0" usually will require the use of a strong-back or additional reinforcing steel.



Pier Heights

When pier heights vary, always keep bottom of panel parallel with horizon (Fig. 1); avoid panel design such as (Fig. 2 and Fig. 3). These designs will require a strongback/shore to prevent undue twisting during tilt-up and possible spalling of the concrete.

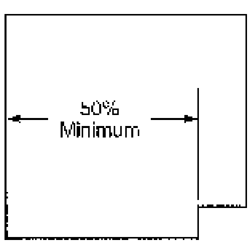


Fig. 1

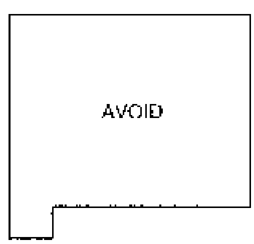


Fig. 2

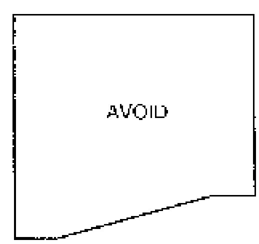


Fig. 3

Header Openings

Avoid panel designs that have large center of gravity shifts. If design is a must, try something like that shown on right.

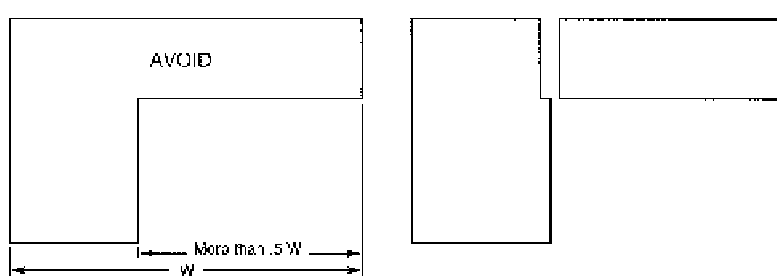


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Figure 1.12.8 Safety Notes and Product Application

In its continued development of hardware for the tilt-up industry, Dayton Superior has placed increasing emphasis on ensuring that material supplied from its manufacturing plants meets or exceeds the safety requirements for the erection of tilt-up wall panels. Tests on the products shown in this handbook have been conducted by Dayton Superior with the assistance of several independent testing laboratories. The safe working loads listed in this handbook were determined from these tests and were established with the following factors in mind:

1. All safe working loads shown in this handbook are based upon the item being new or in "as new" condition. Safe working loads are considered to be the greatest load that will be applied to an item.
2. The insert is correctly embedded in sound concrete and shall be firmly bolted or wired in place so that the vertical axis of the insert is perpendicular to the lifting surface.
3. Concrete compressive strength (f'c) at time of initial lift is at least that strength as listed in the insert selection chart.
4. All bolted hardware shall have full bearing on the concrete surface and all attachment bolts shall bear fully on the hardware. Caution must be used so that the hardware is not subjected to a side loading that will cause an additional and unintended loading.
5. Erection and attachment bolts shall be of proper length and are to be well tightened to prevent hardware slippage and bolt bending.
6. Coil bolts shall have minimum coil penetration through the insert coil, but must not bear on concrete at the bottom of the void.
7. Inserts are properly located in relation to edges, corners and openings and at such distances as to permit the development of a full concrete shear cone. These minimum edge distances are shown on other pages of this handbook.
8. The tensile load on the insert is calculated to include the effect of both axial and transverse loads as transmitted by the crane lines to the hardware.
9. Impact wrenches must not be used to tighten bolts that are used for lifting, handling, transporting, connecting or bracing precast elements.
10. When inserts are electroplated they must be properly baked to relieve embrittlement. Failure to do so may result in premature failure.
11. Do not use cast inserts (castings) for lifting of tilt-up panels.
12. Do not weld rebars to any portion of an insert. Do not weld to lifting hardware units. Welding causes embrittlement at the load point and can result in a sudden, brittle failure. It is necessary to have a good working knowledge of materials, heat treatment and welding procedures before welding of any item is to be considered. Since Dayton Superior is not able to control field conditions or field workmanship, Dayton Superior DOES NOT GUARANTEE any of its products altered in any way after leaving the factory.

Safety Factors

The safety factor to be applied to a particular product is a variable, depending on the degree of hazard or risk involved in the application of that product. In tilt-up construction various conditions can often increase the loadings as well as the degree of risk involved. Adhesion of the panel to the casting surface, jerking of the panel during lifting, use of a crane not adequate for the job, bouncing of the wall panel after it has been lifted, handling the panel more than anticipated, transporting panel over rough surfaces, under or over booming, etc., all have high risk factors. Safety factors should be increased accordingly by the user to reduce these risks.

Dayton Superior recommends that the following minimum safety factors be used when determining a product's safe working load and that the provisions of OSHA (Occupational Safety and Health Administration Act, Part 1910) and American National Standards Institute (ANSI 10.9) be strictly followed when considering safety factors:

Safety Factor	Intended Use of Product
1.5 to 1	Tilt-up Wall Braces
1.5 to 1	Brace Anchors
2 to 1	Lifting Inserts
3 to 1	Permanent Panel Connections
4 to 1	Handling Panels Multiple Times
5 to 1	Lifting Hardware

If a different safety factor than the one shown in this handbook is required for any reason, a product's safe working load must be changed accordingly by the user. The following equation is used to reduce a safe working load when a different factor of safety is required:

$$\frac{\text{SWL} \times \text{Published Factor of Safety}}{\text{Required Factor of Safety}} = \text{New SWL}$$

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1.13.0 Prestressed Concrete

Concrete in which internal stresses (forces) are induced by means of prestressing steel tendons such that tensile stresses resulting from loads are counteracted to a desired degree is called prestressed concrete. There are two basic methods of prestressing concrete—pretensioning and posttensioning.

Pretensioned Concrete

In this process, which generally occurs in a factory environment, stressing strands are placed in tension in a concrete form prior to the placement of concrete in that form. After the concrete has cured to a specific strength, the steel stressing strands are "unloaded" so that the stresses are transferred to the concrete by the bond between the steel strands and the concrete. This process is most frequently used in the production of hollow core or solid precast plank.

1.13.1 Posttensioned Concrete

Posttensioned concrete is a field operation and, therefore, knowledgeable and experienced personnel are required in order to produce a structurally sound product in a safe environment.

Posttensioning is a method to produce structural concrete slabs, girders, and beams utilizing prestressing steel as part of a component referred to as a "tendon" which imparts prestressing forces to the concrete component. The tendons can be either encapsulated in flexible metal or plastic sheathing, or unbonded and pregreased, or mastic coated.

These tendons are individual wires as opposed to the stranded wires used in the prestressing process. Most tendons are shipped in bundles that are tied or banded and safety concerns begin even before any tendons are placed in the form. When the securing bands of the tendons are cut, the bundle becomes an uncoiled spring and care must be taken to avoid injury to those unloading the tendons prior to installation.

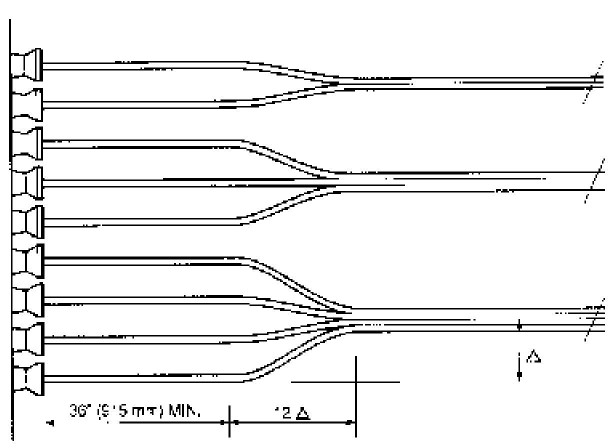
The banded tendons are usually bundled to form strand groups and not more than five ½ inch (12.7 mm) diameter tendons and not more than four 0.6 inch (15.2 mm) diameter strand tendons should be banded in one group.

When banding tendons together, care must be taken to avoid damaging the plastic sheathing.

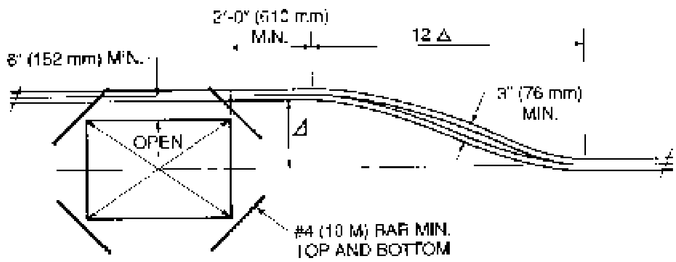
The tendons are smoothly splayed out at the anchorage as illustrated in Fig. 1.13.2. The design engineer will usually specify the procedures for installing tendons around small openings in a slab (Fig. 1.13.3). It is possible to splice tendons that may be too short by using tendon couplers (Fig. 1.13.4).

Dead end anchorages are generally attached at the posttensioning supplier's plant. A typical jacking device is shown in Figure 1.13.5.

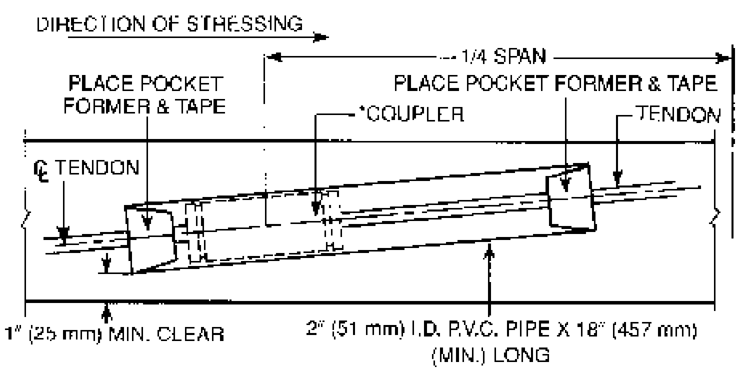
1.13.2 Typical Tendon Layout



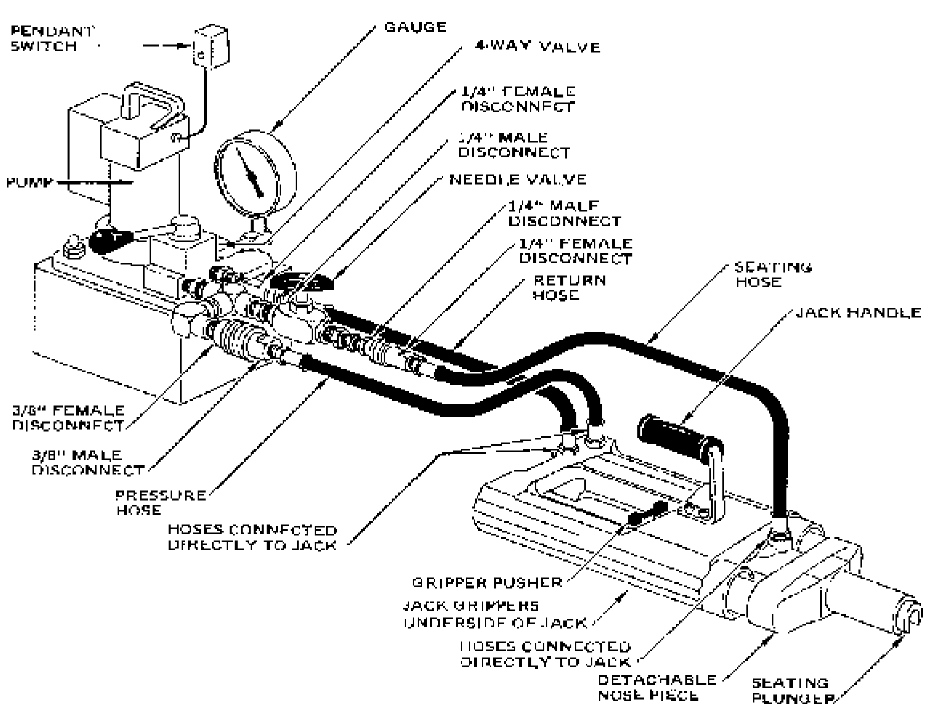
1.13.3 Tendon Layout to Avoid Small Openings



1.13.4 Tendon Coupler



1.13.5 Typical Jack and Pump Details with Manual Seating Valve or Sequencing Valve



1.13.6 Some Posttensioning Do's and Don'ts

During concrete placement:

1. Any chloride bearing chemicals in the concrete must be avoided for obvious reasons.
2. Concrete should not be placed until all tendons and reinforcing steel have been inspected and are in compliance with the design criteria and approved shop drawings.
3. During the placement of concrete, care must be taken to avoid moving the tendons out of their designated positions.
4. When truck dumping, do not place too much concrete in one location to avoid excessive spreading which may effect the placement of the tendons.
5. When pumping concrete do not rest the hose on the tendons, and move the hose nozzle in such a manner so as to avoid displacement of the tendons.
6. When placing concrete by crane and bucket, release the concrete at an elevation that avoids displacement of the tendons.
7. Do not place the vibrator on the tendons; avoid contact between the vibrator and the concrete as much as possible.

Tendon Stressing

1. Do not begin tendon stressing until break tests of concrete cylinders indicate that the concrete has attained the minimum compressive strength as specified by the design engineer.
2. Edge forms should be removed as quickly as possible to make it easier to clean out the anchor cavity while the concrete is still "green."
3. Check the integrity of the concrete, both inside the pocket and on all exposed surfaces. If there is evidence of honeycomb in the concrete, or there are voids or cracks or other signs that the concrete is substandard, DO NOT STRESS IT. One way of determining the existence of honeycombing is to tap the suspected area with a hammer. If a hollow sound is detected, notify the structural engineer for further instructions.
4. Check the tendon to ensure that it is perpendicular to the anchor and the anchor is parallel to the face of the concrete, unless design dictates otherwise.
5. Remove any excess corrosion inhibiting coatings, any dirt, sand, or concrete slurry from the tendon tails.
6. Inspect the wedges to ensure that they have been installed evenly and have been seated properly.
7. Each jack should have its own 30-amp protected circuit and all electrical circuits must be grounded.
8. Check all hose connections and make sure that a pressure gauge is installed and functioning.
9. The pump and jack should be started and checked in both extended and retracted positions. Are they any hydraulic leaks? Is the seating plunger functioning properly?

Stressing the Tendons

1. Although stressing should not commence until the proper design strength of the concrete has been achieved, it is advisable to begin stressing as soon as design strength is verified.
2. A safe, clear area must be created for the stressing crew.
3. Qualified inspection personnel must be present to measure elongations and if any variations between calculated and actual elongations consistently exceed tolerance, stressing should cease and not start up again until the cause has been determined.
4. When stressing above grade, jacks and pumps need to be secured to a fixed object to prevent equipment from being thrown off the elevated platform should a tendon fail during stressing.
5. The pump should be operated by a pendant switch, which will allow the operator to stand away from the pump should a tendon or jack gripper fail.

The Don'ts of Stressing

1. Don't stress any tendons that contain concrete slurry inside the anchor cavity. The slurry will prevent proper seating of the wedges.
2. Don't use the jack when it does not seat properly on the face of the anchor.
3. Don't overstress tendons to achieve proper elongation.
4. Don't allow obstructions in the path of the jack extension.
5. Don't use extension cords longer than 100 feet (30 meters). All extension cords must be three wire, 12 gauge, minimum.
6. Don't continue stressing if it appears that something is not working properly.
7. Don't detension with loose plates, spacing shims, or piggy backing.
8. Don't stand close to the jack or between the jack and the pump while in operation.
9. Don't permit workers to stand in the immediate area of the jack.
10. If unsure of any operation or procedure—STOP and get professional instructions.

1.13.7 Glossary of Terms

Anchorage A device used to anchor the tendon to the concrete member. In pretensioning, this device is used to anchor the tendon during hardening of the concrete.

Bonded tendons Tendons that are bonded to the concrete by grouting or other means and are therefore not free to move relative to the concrete.

Initial prestress The stress (force) in the tension immediately after transferring the prestressing force to the concrete. This occurs after the wedges (pieces of tapered metal with teeth that bite into the prestressing steel during transfer of the prestressing force) have been seated in the anchor.

Prestress To place a material (e.g., concrete) in a state of compression prior to the application of loads.

Prestressing steel High strength steel used in the process, most frequently made up of seven wire strands or single wires, bars, or groups of wires or bars.

Posttensioning A method of prestressing in which the tendons are tensioned after the concrete has hardened.

Sheath An enclosure in which the prestressing steel is placed to prevent bonding during concrete placement and also to protect the tendons from corrosion if the tendons are to remain unbonded.

Tendon The complete assembly that consists of the prestressing steel, sheathing, and associated anchorages.

Unbonded tendons Tendons in which the prestressing steel is permanently free to move relative to the concrete to which they are applying their prestressing forces.

The Posttensioning Institute (PCI) in Phoenix, Arizona, has developed guidelines for field personnel involved in installation, stressing, and finishing of unbonded single-strand tendons. Their guidelines represent generally accepted industry practices, but each posttensioned concrete installation may vary according to specific engineering demands.

1.14.0 Precast Concrete

Precast concrete can be produced at the job site, which is the case in tilt-up construction or it can be factory produced in an indoor, controlled environment where it is often autoclaved, a process involving high-pressure steam to accelerate early strength. The design of connections of the various components of a precast concrete structural system is of utmost importance in order to assure that loads are transferred from one member to another and overall system stability is achieved.

A well-designed connection also takes into account practicality in both manufacture and installation. The designer must always consider cost-effectiveness since contractors are most likely to compare a precast system to other structural designs during the project's genesis and design development.

Architectural precast panels often prove cost-effective and allow a designer considerable latitude in surface treatment and overall design.

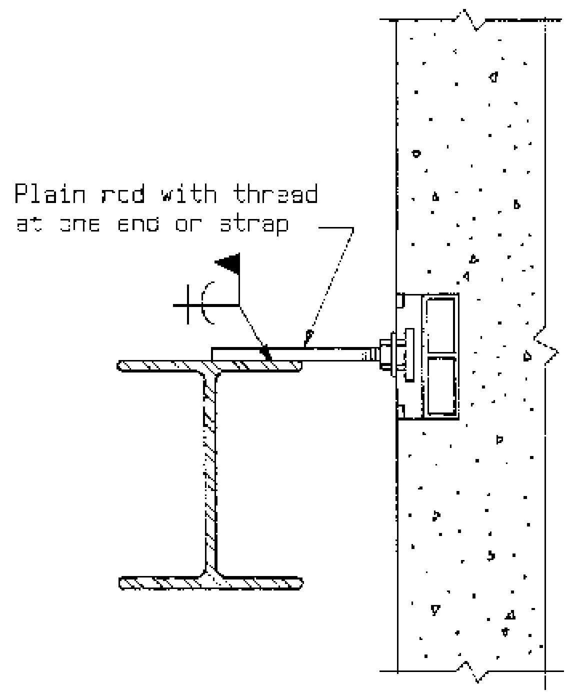
Typical beam-to-column connections, precast-to-steel frame connections, precast plank, column–to–cast-in-place and other connections are shown in the following detail drawings, which are to be considered guidelines only and are not meant to be replicated as part of any precast concrete system.

1.14.1 Precast Welded Tieback Connections

Design
- if strap is used, volume change restraint in the plane of panel must be considered
- slenderness ratio must be considered for compression load

Production
- simple

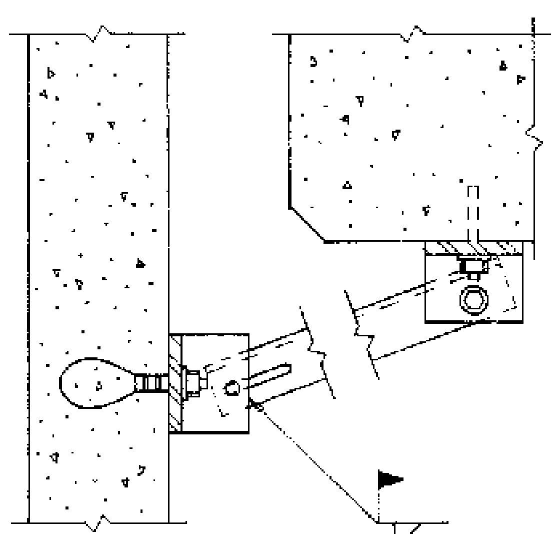
Erection
- requires bracing until welded; bracing may be achieved by another connection
- threaded rod should not be overtightened if future movement at slotted insert is expected



Design
- live load deflection of superstructure must be considered
- if bracing angle is designed as axial member, then the vertical component of force must be accounted for in the design of other connections on the same panel

Production
- simple

Erection
- slots and bolts are used for temporary erection connection
- weld after final alignment



(By permission from the Prestressed Concrete Institute (PCI), Chicago, Illinois.)

Design

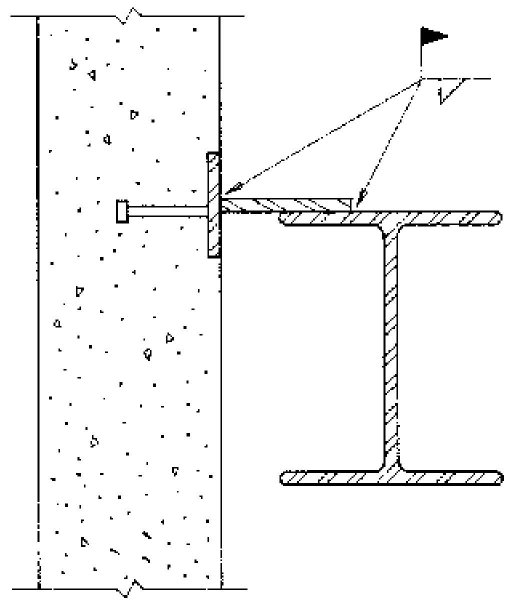
- volume change of panel and live load deflection of steel beam must be considered
- consider staggering studs to minimize magnification of the force on headed stud due to misalignment of plate
- rigid connection

Production

- simple

Erection

- requires bracing until welded; bracing may be achieved by another connection
- ample adjustment allowance



Design

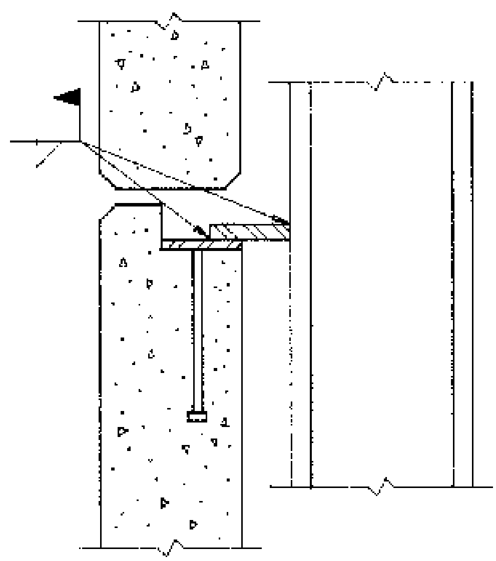
- rigid connection
- possible volume change restraint problems
- connection is difficult to inspect

Production

- simple

Erection

- requires bracing until welded; bracing may be achieved by another connection
- ample adjustment allowance
- alignment and welding must be completed before panel above is erected



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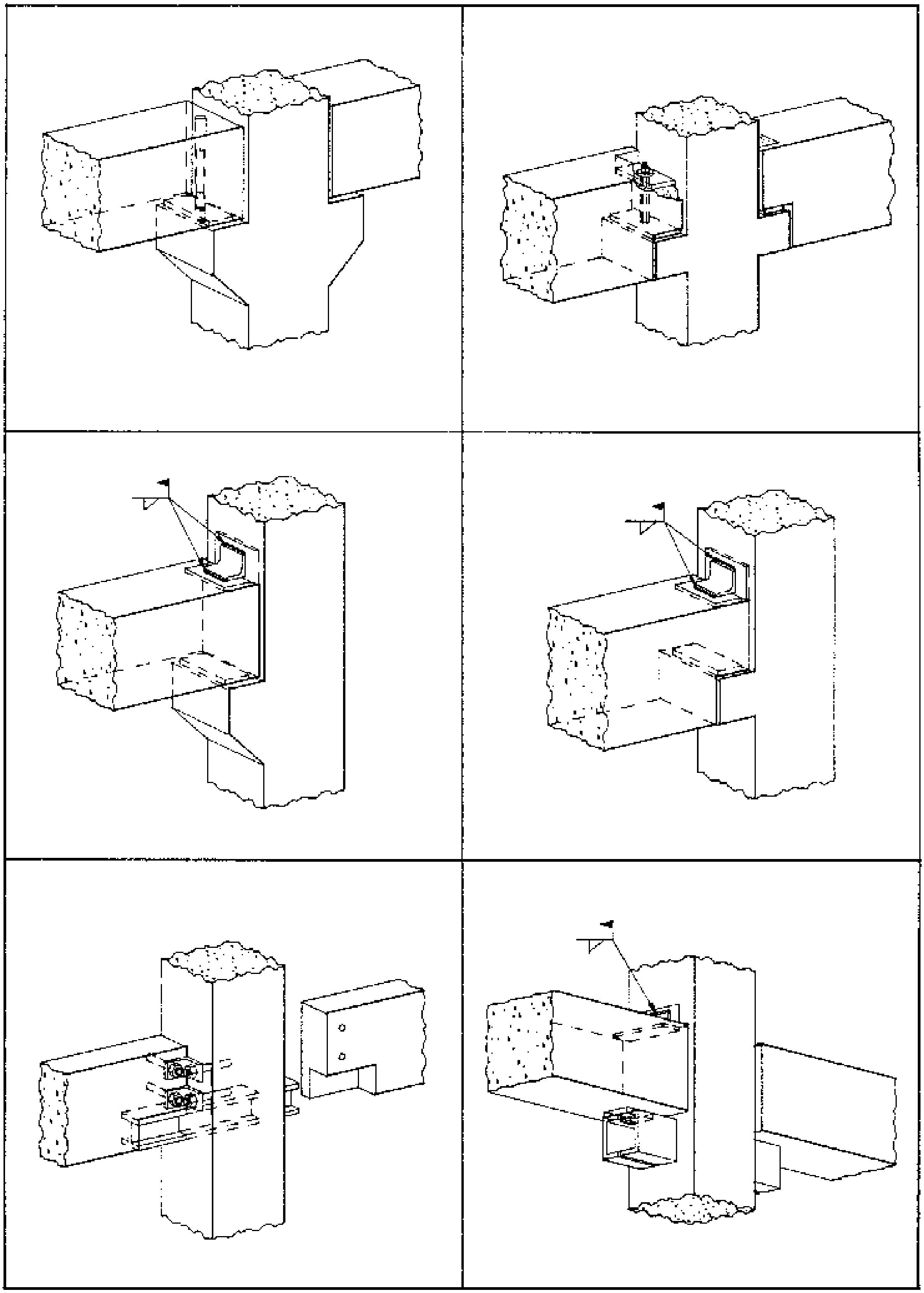
1.14.2 Precast—Column-to-Beam Connections



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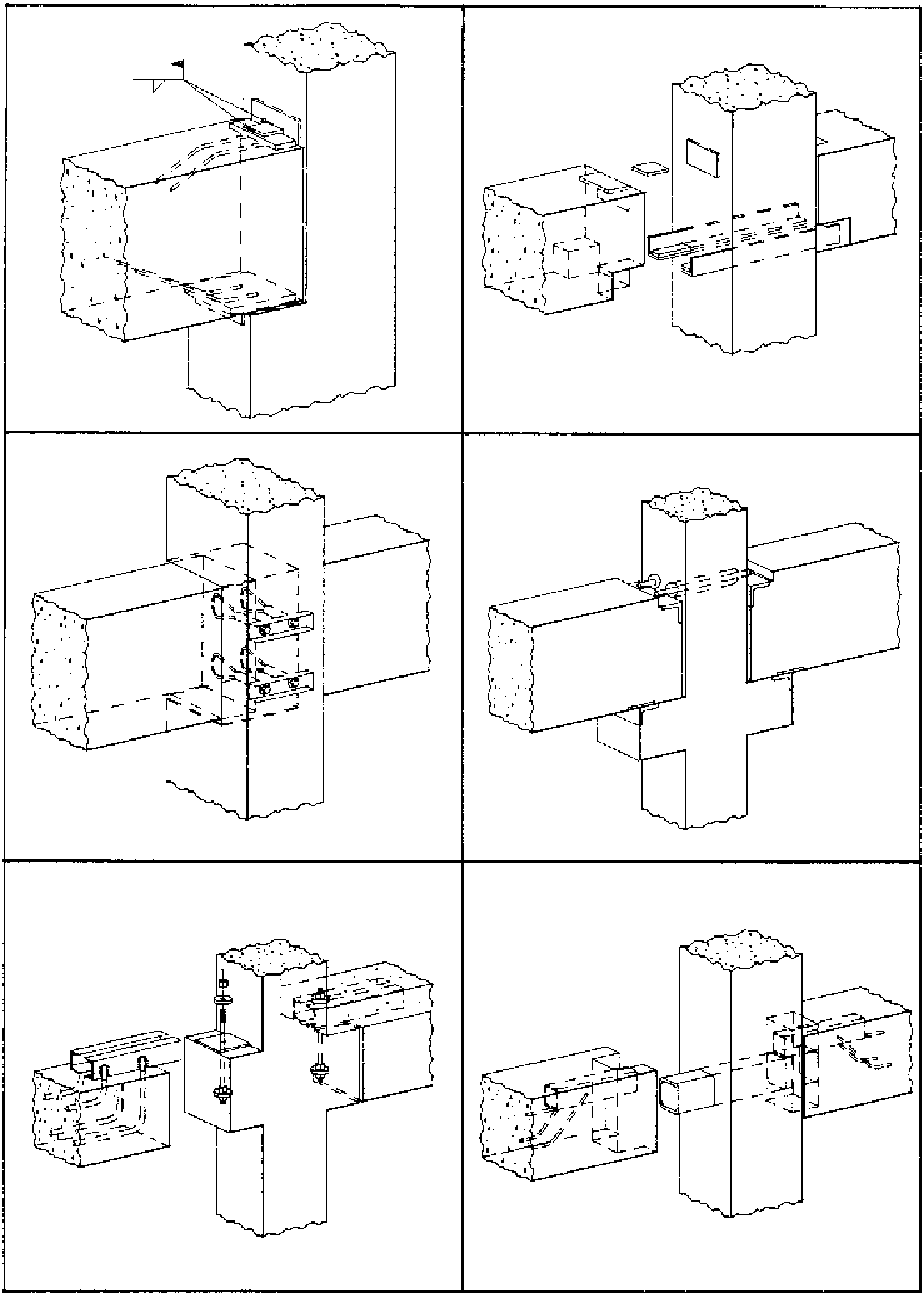

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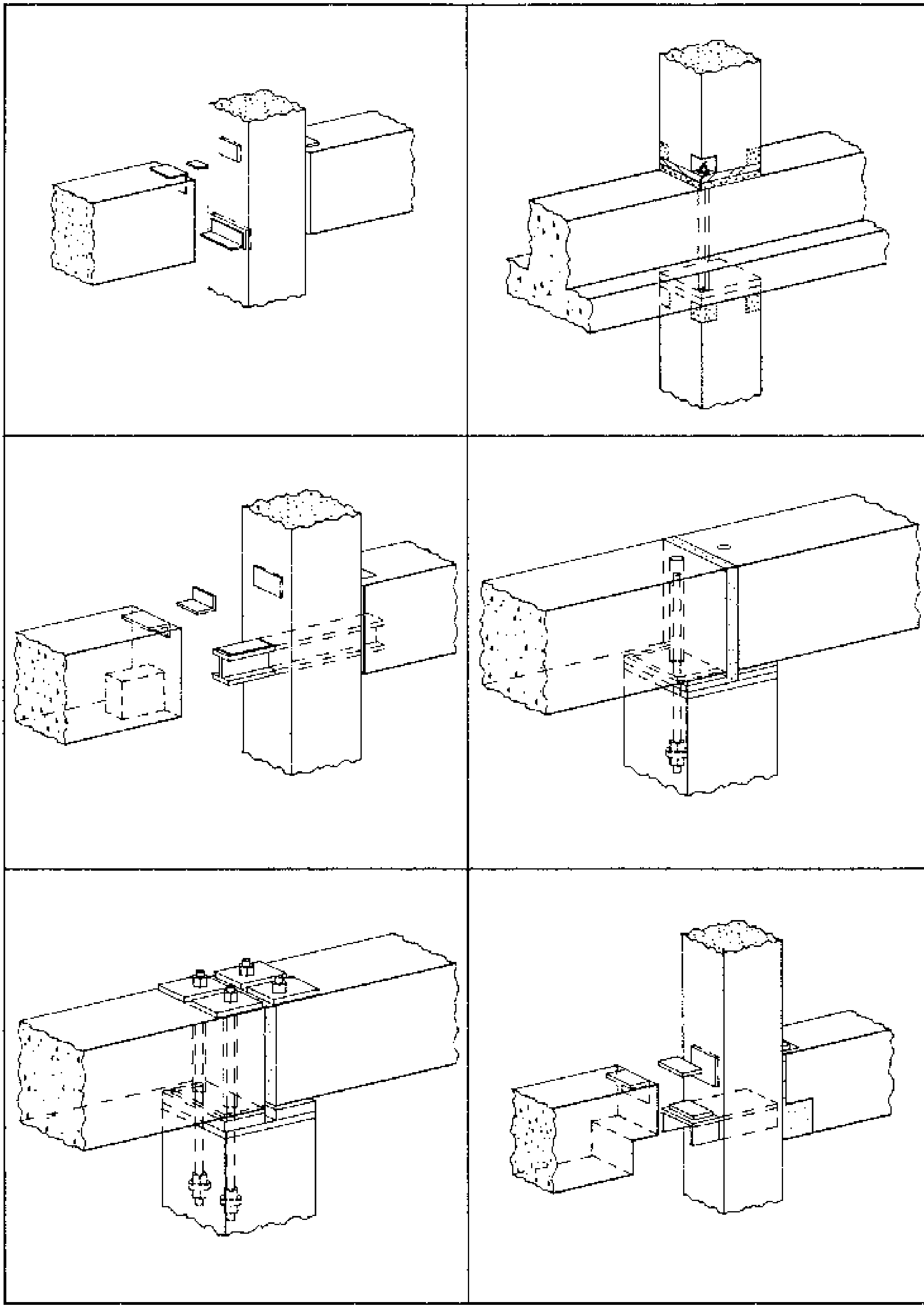

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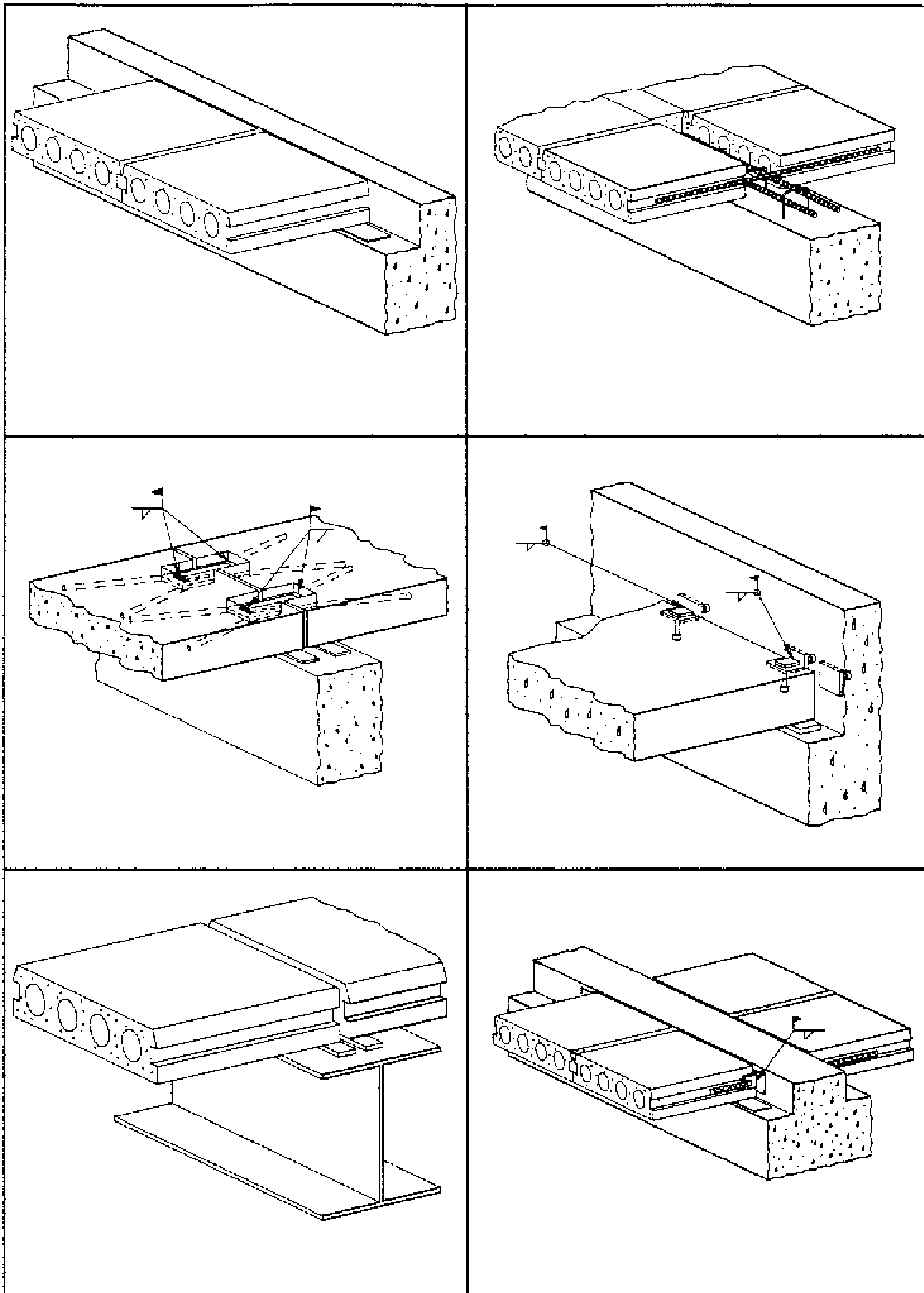
1.14.3 Precast—Plank-to-Precast, Plank-to-Steel Beam Connections



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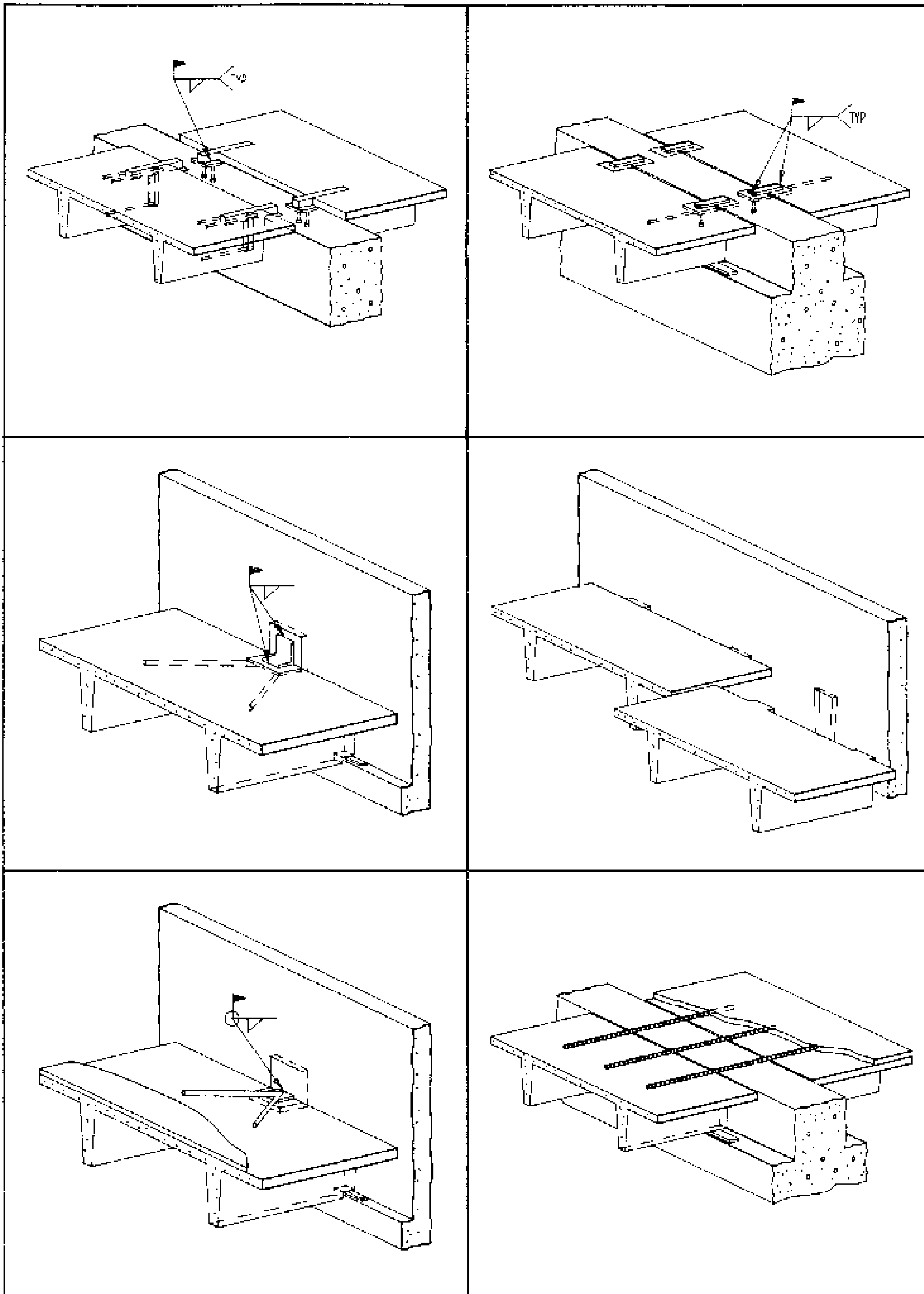

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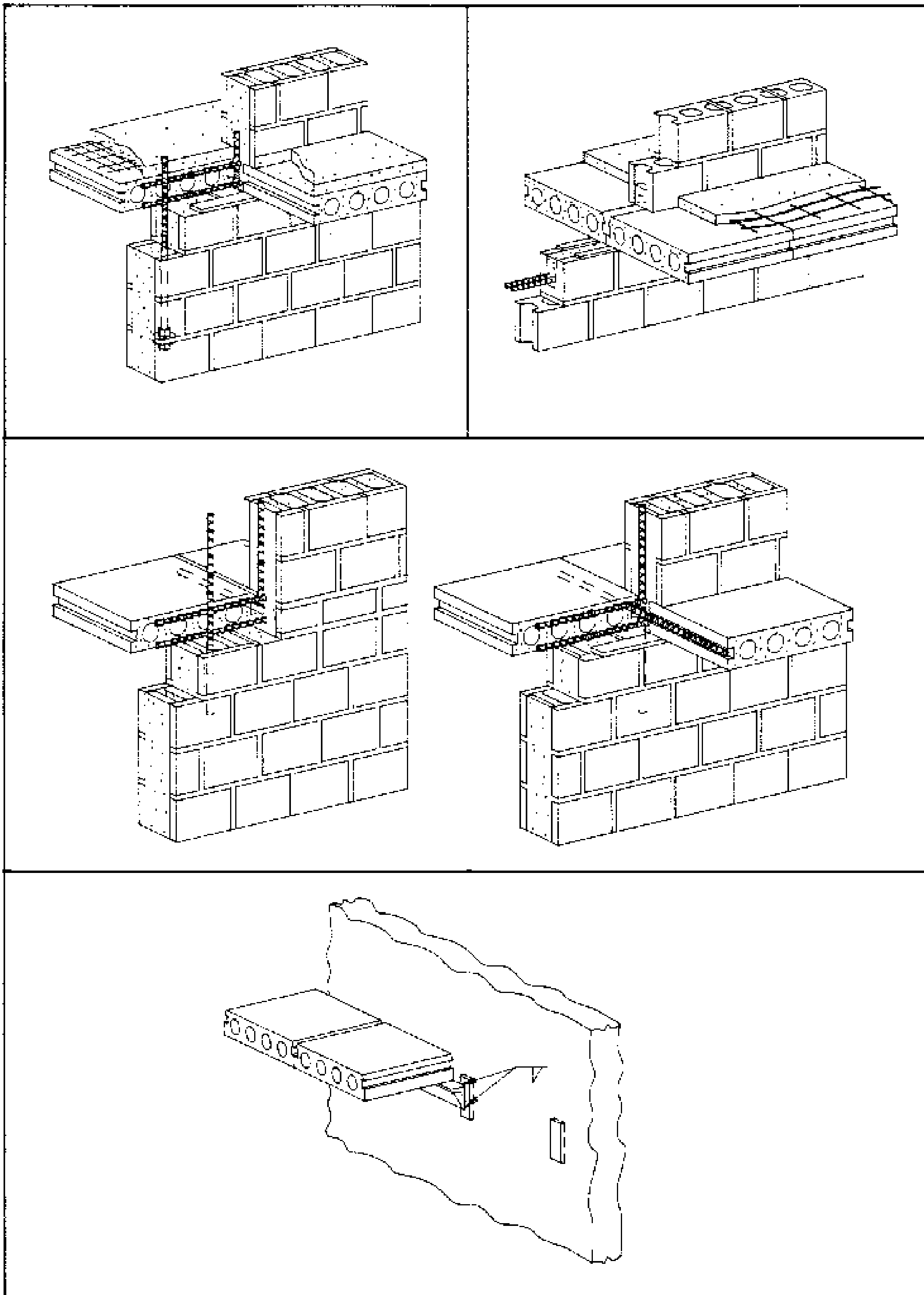
1.14.3.1 Precast—Plank-to-CMU Wall Connections



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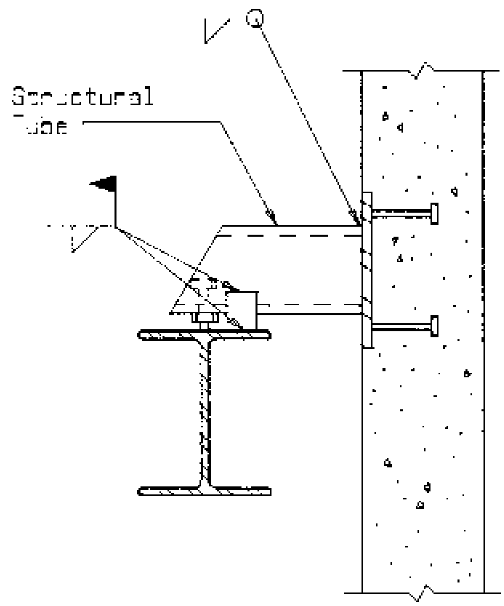
1.14.3.2 Eccentric Bearing Details

Design
- weld all around may not be required
- keep bearing at centerline of beam to avoid torsion
- safety and sequence may dictate blockout to embed bracket in floor slab

Production
- simple
- substantial shop fabrication
- leveling bolt is costly

Erection
- simple
- leveling bolt saves time

Variations
- different tieback connection may be used in lieu of weld plate
- shims may be used in lieu of leveling bolt
- location and configuration of weld plate may vary

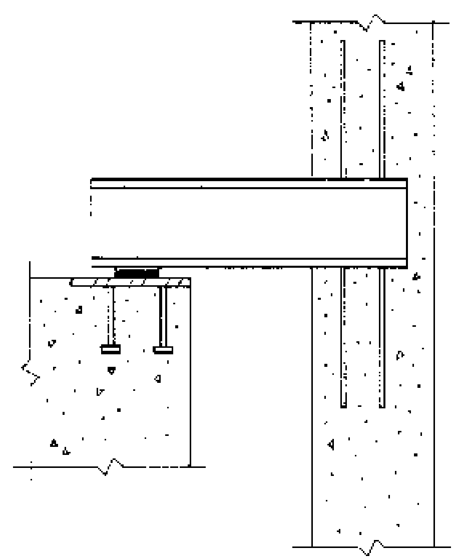


Design
- hardware layout drawing required for G.C.
- consider torque on projecting element if unsymmetrical section used

Production
- simple
- requires early coordination with G.C.
- requires additional space for storage and shipping

Erection
- simple

Variations
- W, I, channel, ST, flat bars, angle or TS may be used



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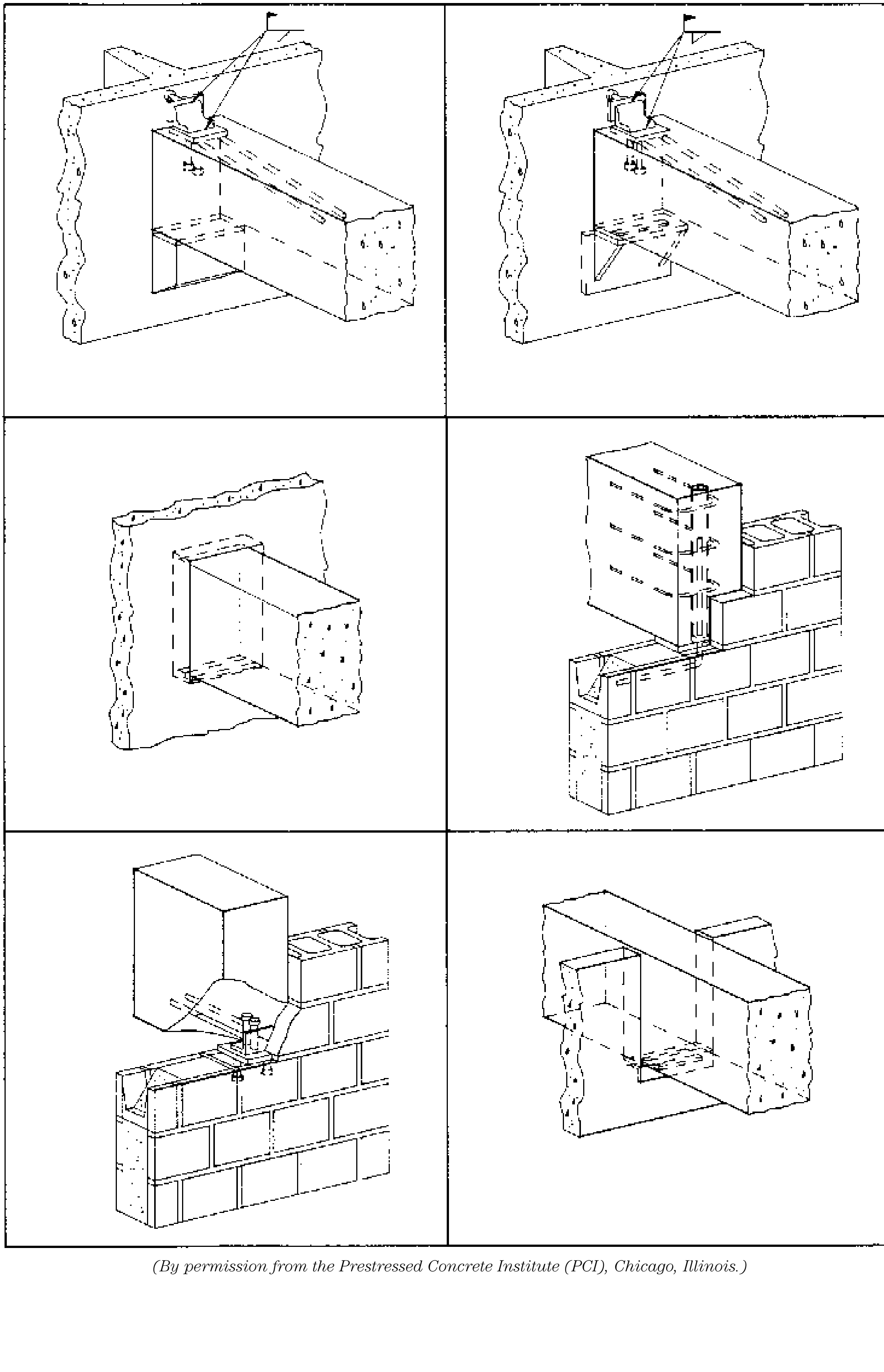
1.14.3.3 Beam-to-Wall Connections



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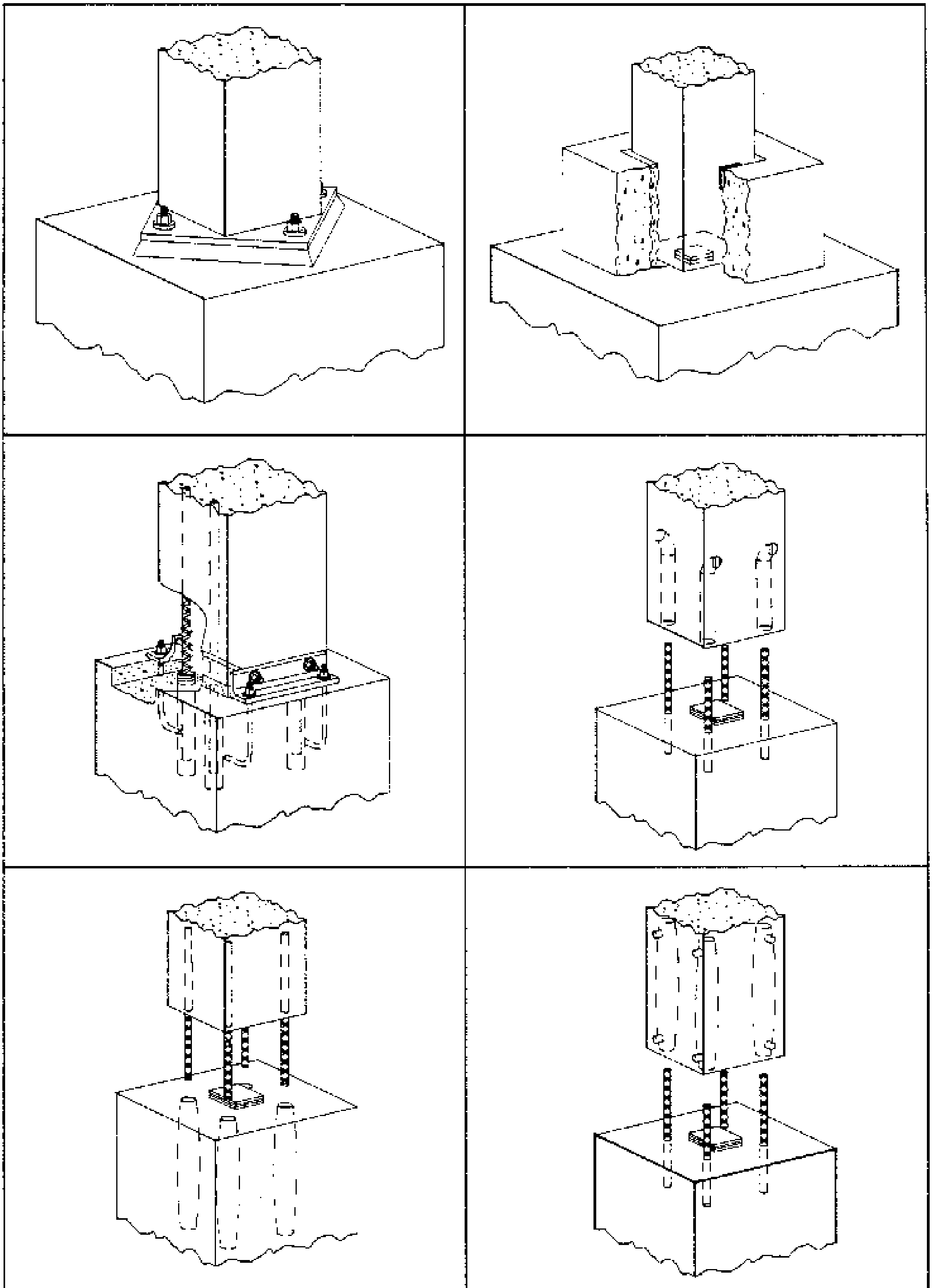
1.14.3.4 Column-to-Footing Connections



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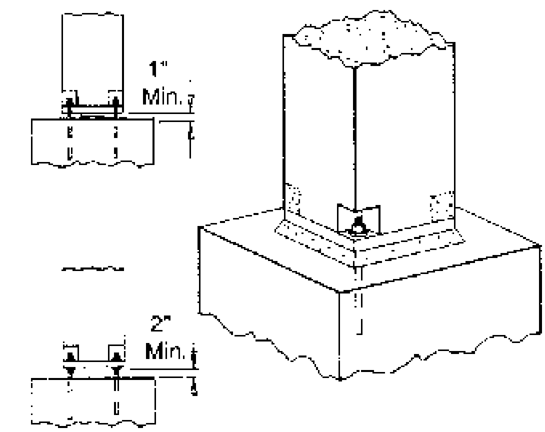
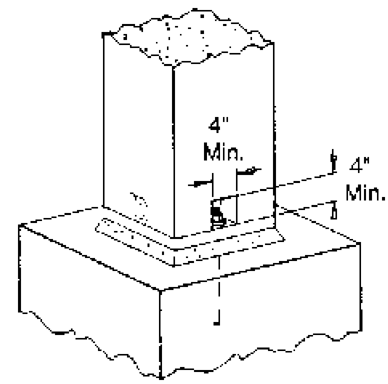


CF1



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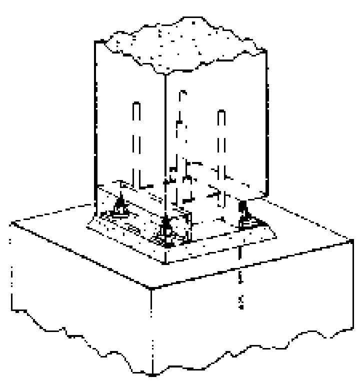

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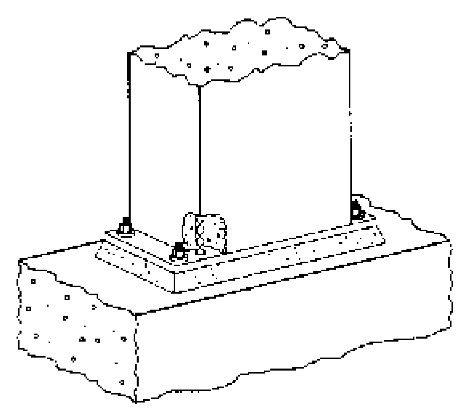

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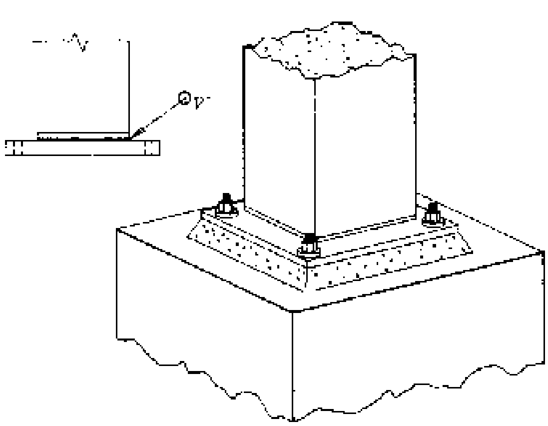
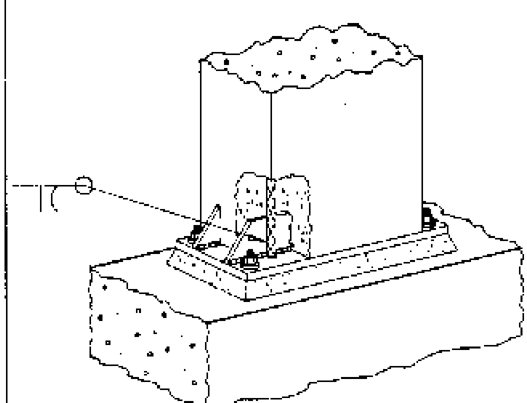


CF5



CF6

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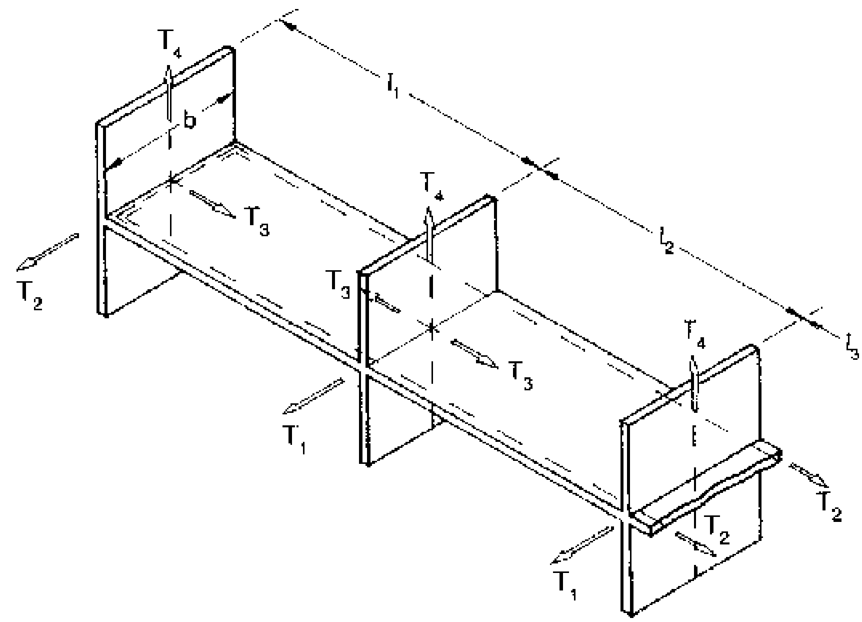
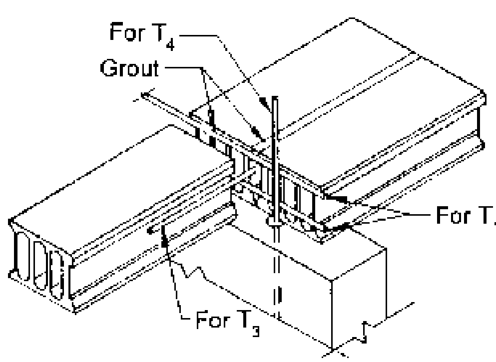
1.14.3.5 Tie Forces and Typical Tie Arrangements



Recommended Tie Forces in Precast Concrete Bearing Wall Buildings



Typical Tie Arrangement

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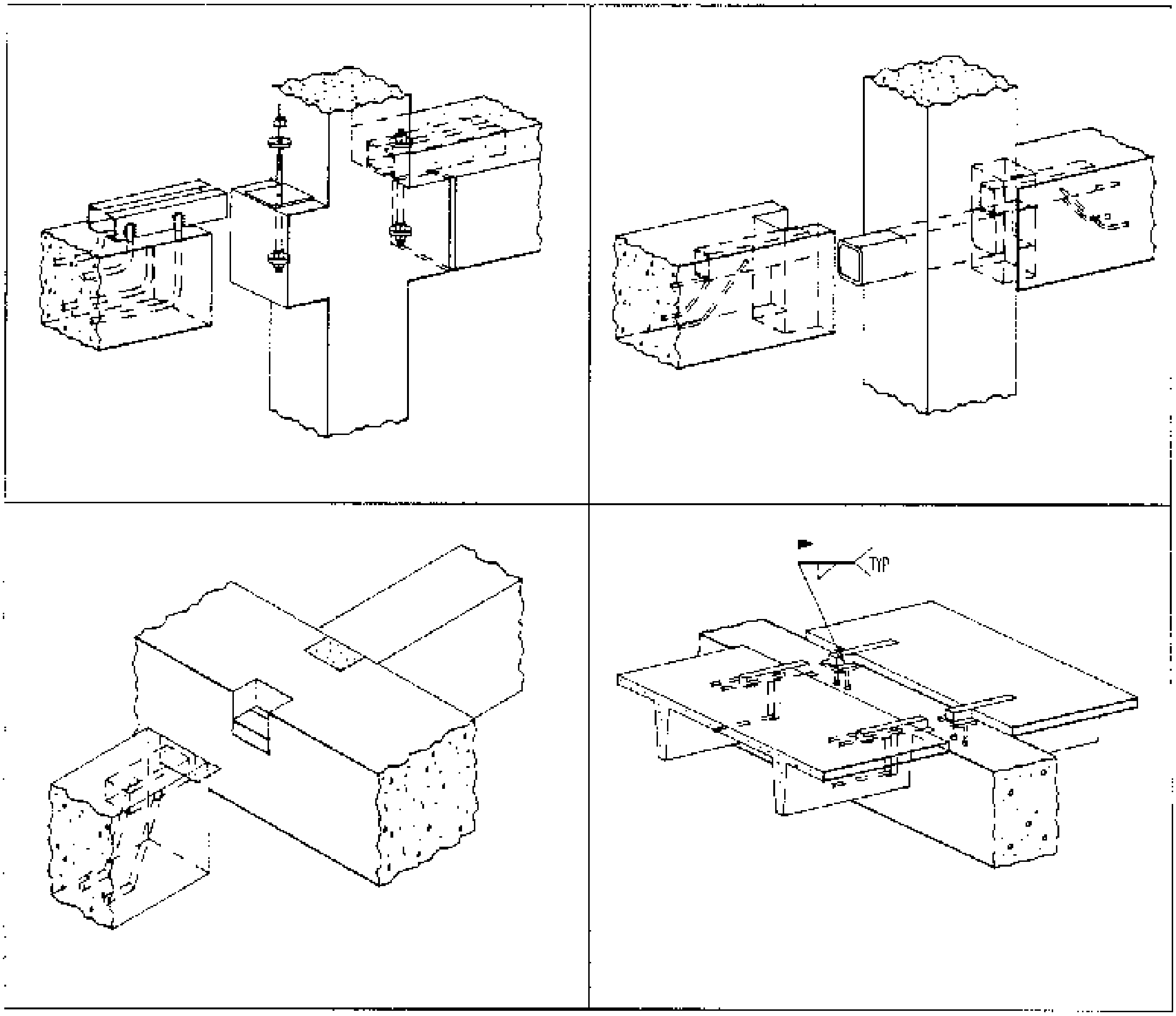
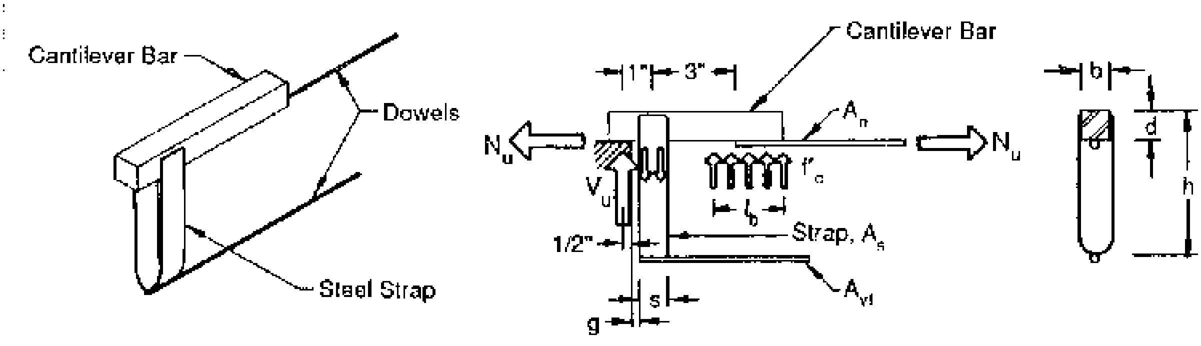
1.14.3.6 Hanger Connections



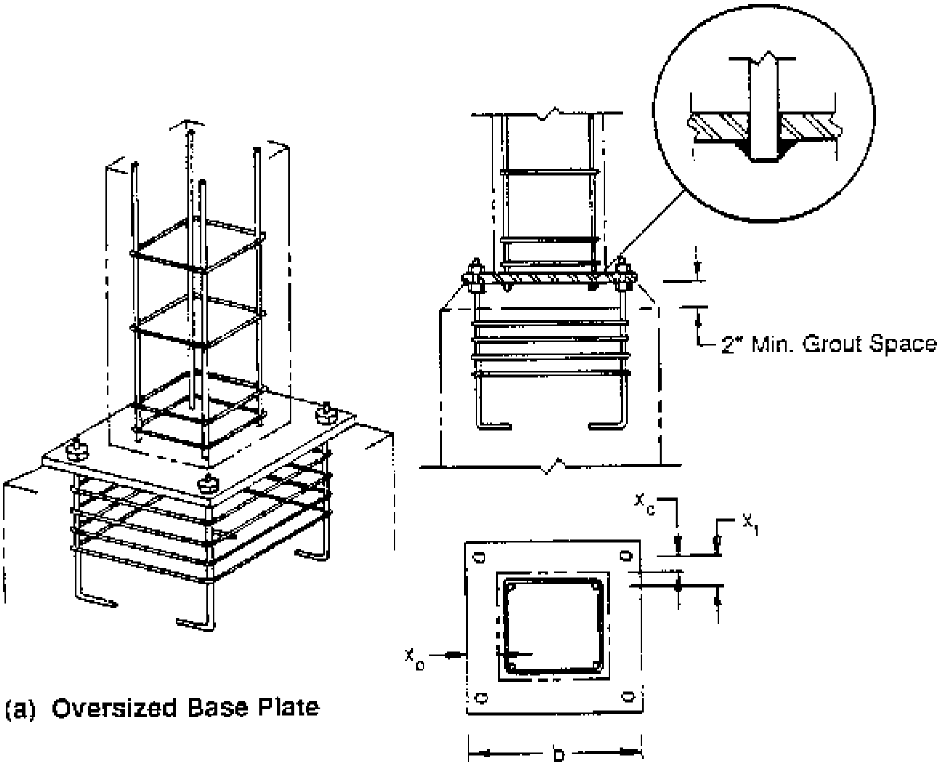


(a) Basic Components (b) Design Assumptions

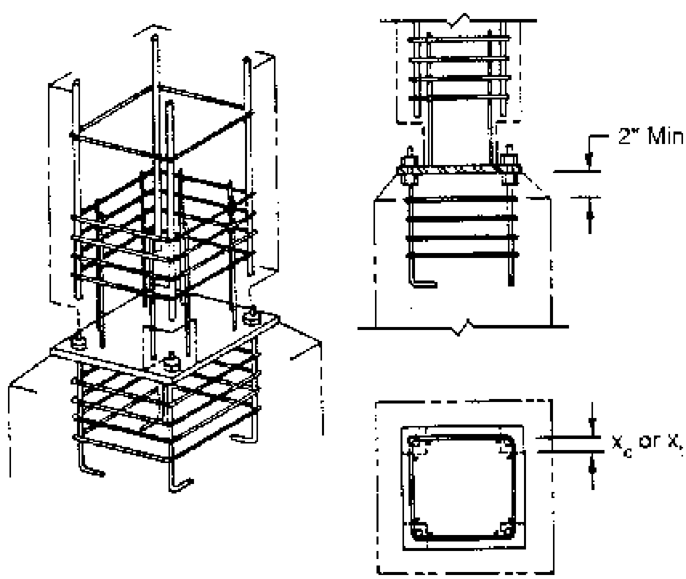
Cazaly Hanger

(By permission from the Prestressed Concrete Institute (PCI), Chicago, Illinois.)

1.14.3.7 Column Base Connections



(a) Oversized Base Plate



(b) Flush Base Plate

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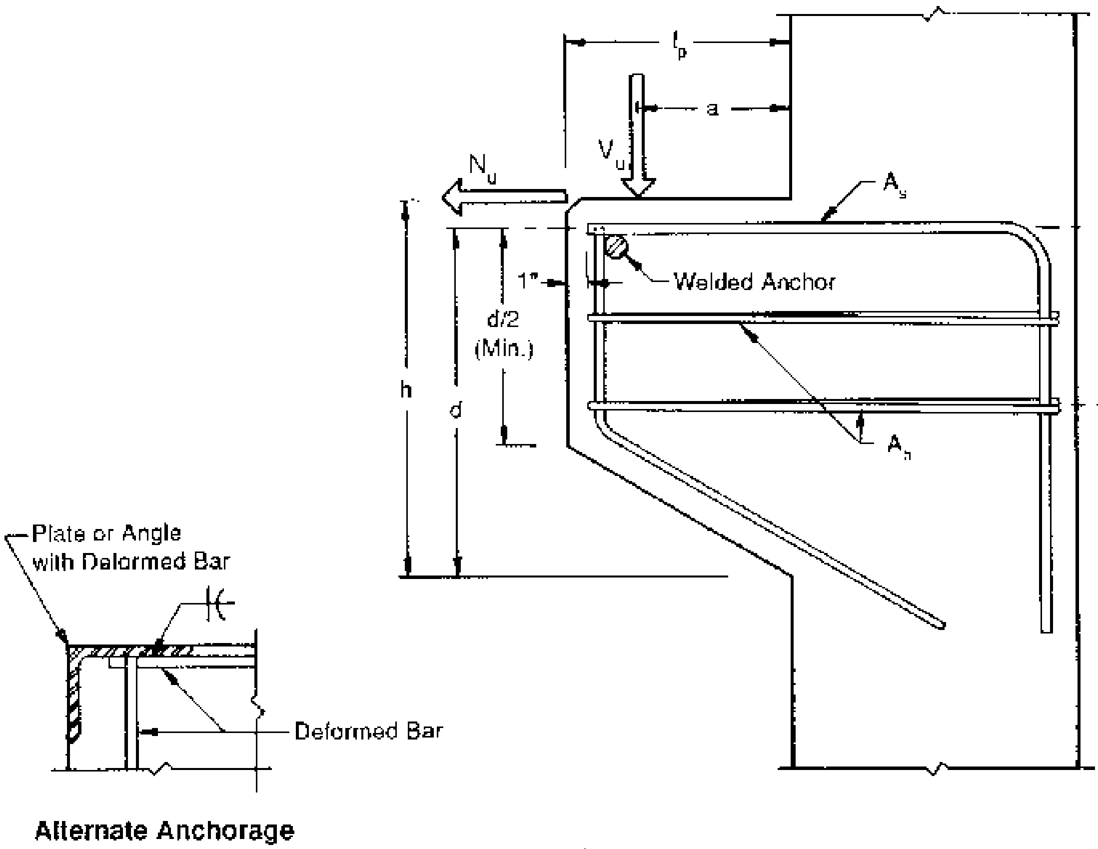
1.14.3.8 Corbel Design



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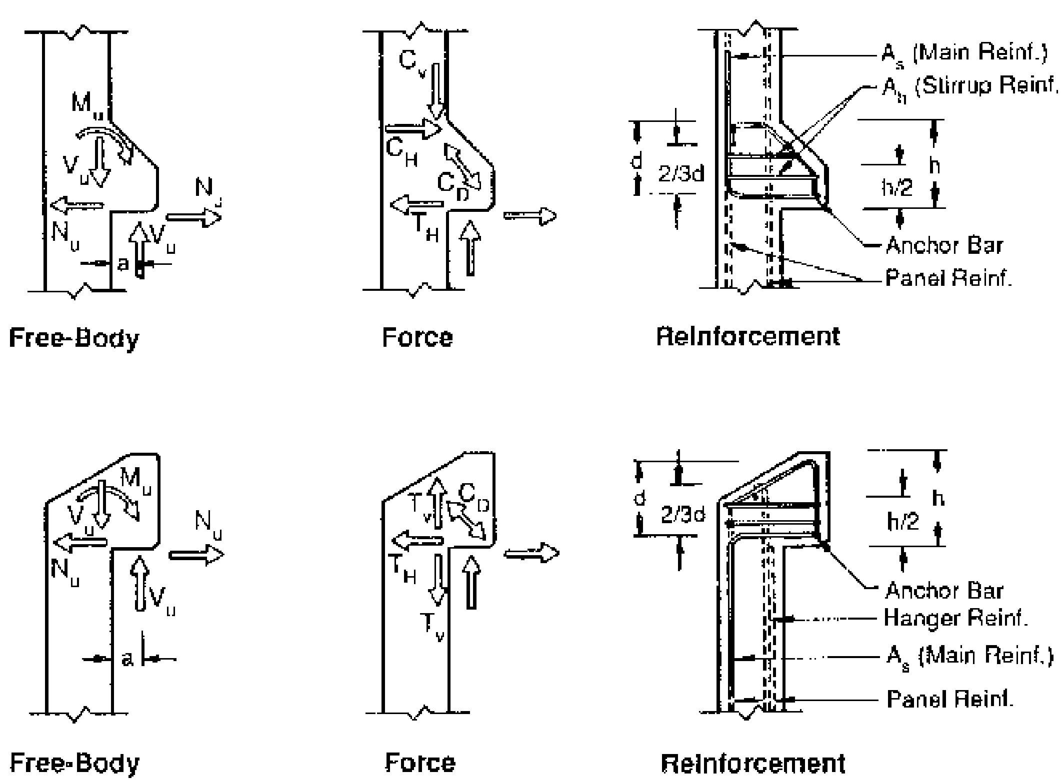
1.14.3.9 Corbel Force Diagrams and Typical Reinforcement



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1.14.3.10 Keyed Joint Connections

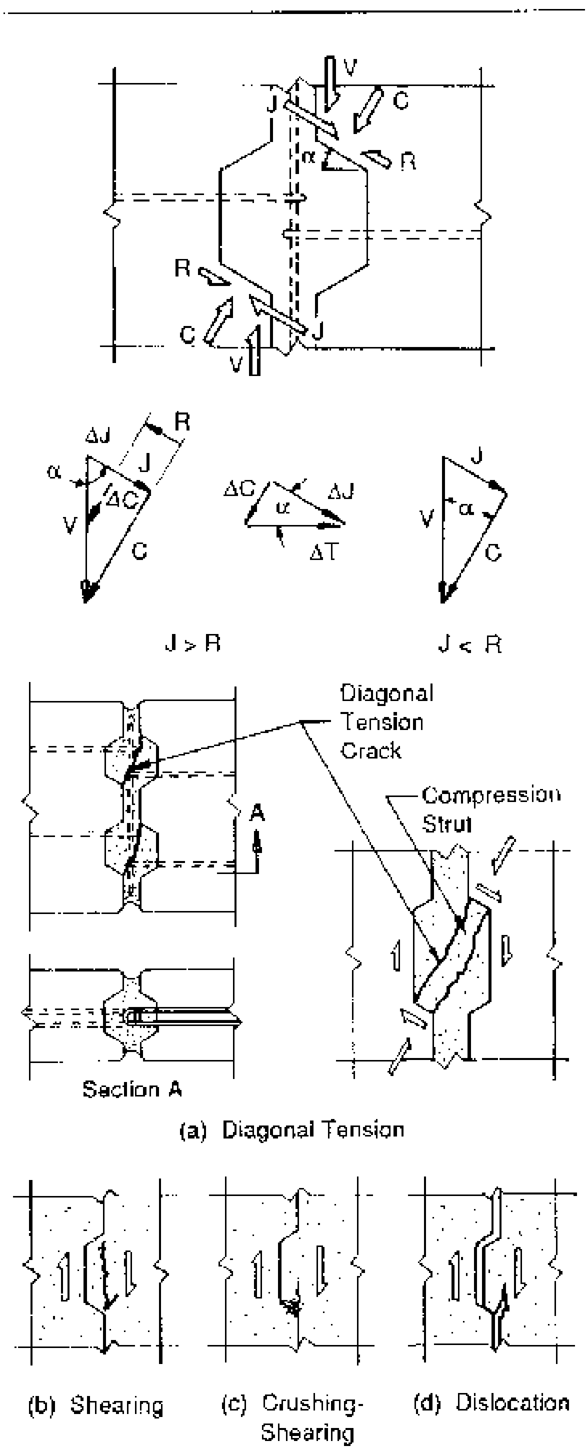

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Figure 1.15.0 Protection of Residential Concrete Exposed to Freeze–Thaw Cycles

SECTION 1928 — GENERAL

1928.1 Purpose. The purpose of this appendix is to provide minimum standards for the protection of residential concrete exposed to freezing and thawing conditions.

1928.2 Scope. The provisions of this appendix apply to concrete used in buildings of Groups R and U Occupancies that are three stories or less in height.

1928.3 Special Provisions. Normal-weight aggregate concrete used in buildings of Groups R and U Occupancies three stories or less in height which are subject to de-icer chemicals or freezing and thawing conditions as determined shall comply with the requirements of Table A-19-A.

TABLE A-19-A—MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE[1]

TYPE OR LOCATION OF CONCRETE CONSTRUCTION	MINIMUM SPECIFIED COMPRESSIVE STRENGTH[2] (f'_c) × 6.89 for kPa — Weathering Potential		
	Negligible	Moderate	Severe
Basement walls and foundations not exposed to the weather	2,500	2,500	2,500[3]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[3]
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	2,500	3,000[4]	3,000[4]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	2,500	3,000[4]	3,500[4]

[1]Increases in compressive strength above those used in the design shall not cause implementation of the special inspection provisions of Section 1701.5, Item 1.

[2]At 28 days, pounds per square inch (kPa).

[3]Concrete in these locations which may be subject to freezing and thawing during construction shall be air-entrained concrete in accordance with Footnote 5.

[4]Concrete shall be air entrained. Total air content (percentage by volume of concrete) shall not be less than 5 percent or more than 7 percent.

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1.15.1 Special Exposure Requirements for Concrete

TOTAL AIR CONTENT FOR FROST-RESISTANT CONCRETE

NOMINAL MAXIMUM AGGREGATE SIZE (inches) × 25.4 for mm	AIR CONTENT, PERCENTAGE Severe Exposure	Moderate Exposure
3/8	7 1/2	6
1/2	7	5 1/2
3/4	6	5
1	6	4 1/2
1 1/2	5 1/2	4 1/4
2[1]	5	4
3[1]	4 1/2	3 1/2

[1]These air contents apply to total mix, as for the preceding aggregate sizes. When testing this concrete, however, aggregate larger than 1 1/2 inches (38 mm) is removed by hand picking or sieving, and air content is determined on the minus 1 1/2-inch (38 mm) fraction.

REQUIREMENTS FOR SPECIAL EXPOSURE CONDITIONS

EXPOSURE CONDITION	MAXIMUM WATER-CEMENTITIOUS MATERIALS RATIO, BY WEIGHT, NORMAL-WEIGHT AGGREGATE CONCRETE	MINIMUM f'_c, NORMAL-WEIGHT AND LIGHTWEIGHT AGGREGATE CONCRETE, psi × 0.00689 for MPa
Concrete intended to have low permeability when exposed to water	0.50	4,000
Concrete exposed to freezing and thawing in a moist condition or to deicing chemicals	0.45	4,500
For corrosion protection for reinforced concrete exposed to chlorides from deicing chemicals, salt, saltwater, brackish water, seawater or spray from these sources	0.40	5,000

REQUIREMENTS FOR CONCRETE EXPOSED TO DEICING CHEMICALS

CEMENTITIOUS MATERIALS	MAXIMUM PERCENT OF TOTAL CEMENTITIOUS MATERIALS BY WEIGHT[1]
Fly ash or other pozzolans conforming to ASTM C 618	25
Slag conforming to ASTM C 989	50
Silica fume conforming to ASTM C 1240	10
Total of fly ash or other pozzolans, slag and silica fume	50[2]
Total of fly ash or other pozzolans and silica fume	35[2]

[1]The total cementitious materials also includes ASTM C 150, C 595 and C 845 cement.
[2]Fly ash or other pozzolans and silica fume shall constitute no more than 25 and 10 percent, respectively, of the total weight of the cementitious materials.
The maximum percentages above shall include:
1. Fly ash or other pozzolans present in Type IP or I(PM) blended cement in accordance with ASTM C 595.
2. Slag used in the manufacture of a IS or I(SM) blended cement in accordance with ASTM C 595.
3. Silica fume, ASTM C 1240, present in a blended cement.

REQUIREMENTS FOR CONCRETE EXPOSED TO SULFATE-CONTAINING SOLUTIONS

SULFATE EXPOSURE	WATER-SOLUBLE SULFATE (SO_4) IN SOIL, PERCENTAGE BY WEIGHT	SULFATE (SO_4) IN WATER, ppm	CEMENT TYPE	MAXIMUM WATER-CEMENTITIOUS MATERIALS RATIO, BY WEIGHT, NORMAL-WEIGHT AGGREGATE CONCRETE[1]	MINIMUM f'_c, NORMAL-WEIGHT AND LIGHTWEIGHT AGGREGATE CONCRETE, psi × 0.00689 for MPa
Negligible	0.00-0.10	0-150	—	—	—
Moderate[2]	0.10-0.20	150-1,500	II, IP(MS), IS (MS)	0.50	4,000
Severe	0.20-2.00	1,500-10,000	V	0.45	4,500
Very severe	Over 2.00	Over 10,000	V plus pozzolan[3]	0.45	4,500

[1]A lower water-cementitious materials ratio or higher strength may be required for low permeability or for protection against corrosion of embedded items or freezing and thawing (Table 19-A-2).
[2]Seawater.
[3]Pozzolan that has been determined by test or service record to improve sulfate resistance when used in concrete containing Type V cement.

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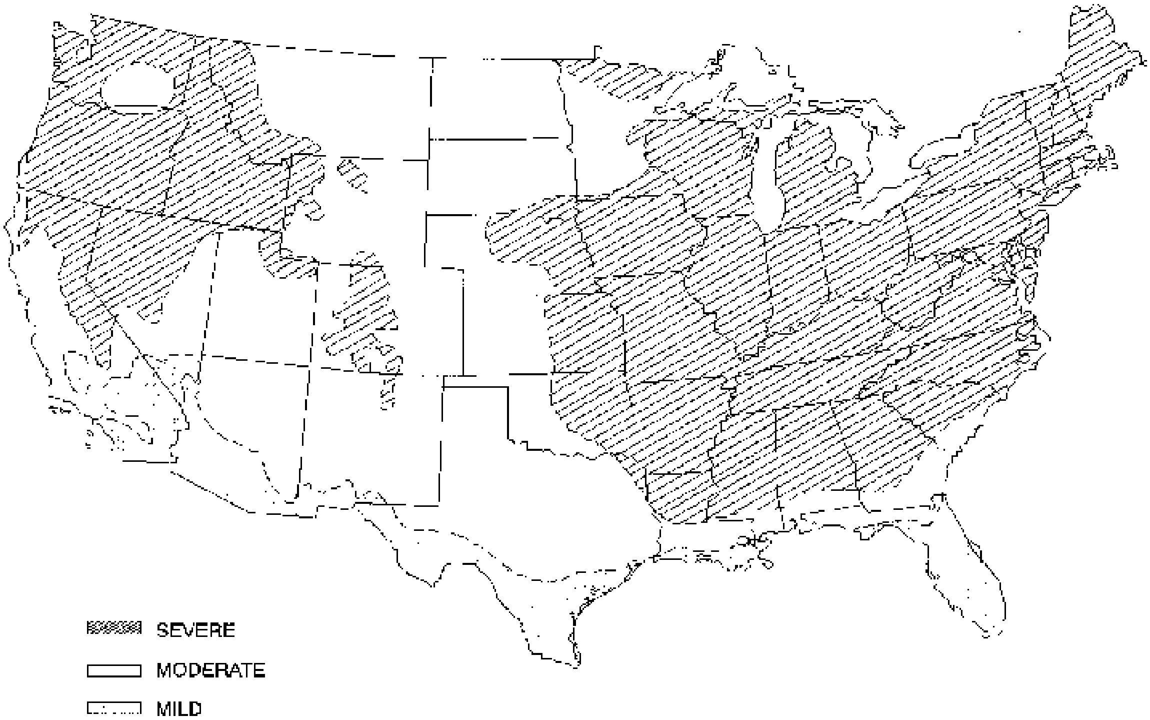
1.16.0 Weathering Regions and Weathering Index



WEATHERING REGIONS (WEATHERING INDEX)

NOTES:

[1]The three exposures are:

A. Severe—Outdoor exposure in a cold climate where concrete may be exposed to the use of de-icing salts or where there may be a continuous presence of moisture during frequent cycles of freezing and thawing. Examples are pavements, driveways, walks, curbs, steps, porches and slabs in unheated garages. Destructive action from de-icing salts may occur either from direct application or from being carried onto an unsalted area from a salted area, such as on the undercarriage of a car traveling on a salted street but parked on an unsalted driveway or garage slab.

B. Moderate—Outdoor exposure in a climate where concrete will not be exposed to the application of de-icing salts but will occasionally be exposed to freezing and thawing.

C. Mild—Any exposure where freezing and thawing in the presence of moisture is rare or totally absent.

[2]Data needed to determine the weathering index for any locality may be found or estimated from the tables of Local Climatological Data, published by the Weather Bureau, U.S. Department of Commerce.

[3]The weathering regions map provides the location of severe, moderate and mild winter weathering areas as they occur in the United States (Alaska and Hawaii are classified as severe and mild, respectively). The map cannot be precise. This is especially true in mountainous areas where conditions change dramatically within very short distances. It is intended to classify as severe any area in which weathering conditions may cause de-icing salt to be used, either by individuals or for street or highway maintenance. These conditions are significant snowfall combined with extended periods during which there is little or no natural thawing. If there is any doubt about which of two regions is applicable, the more severe exposure should be selected.

[4]The Weathering Index:

Severe—As a guideline, the number of days during which the temperature does not rise above 32°F (0°C) is multiplied by the inches of snowfall. An index of 150 or more is classified as severe. Cold, humid climates may be more severe than cold, dry climates for a given index.

Moderate, Mild—Multiply the inches of precipitation times the number of days the temperature registers below 32°F (0°C). Use the occurrence between the first day in the fall and the last day in the spring that the temperature registers below 32°F (0°C). An index above 200 is moderate. An index below 200 is mild.

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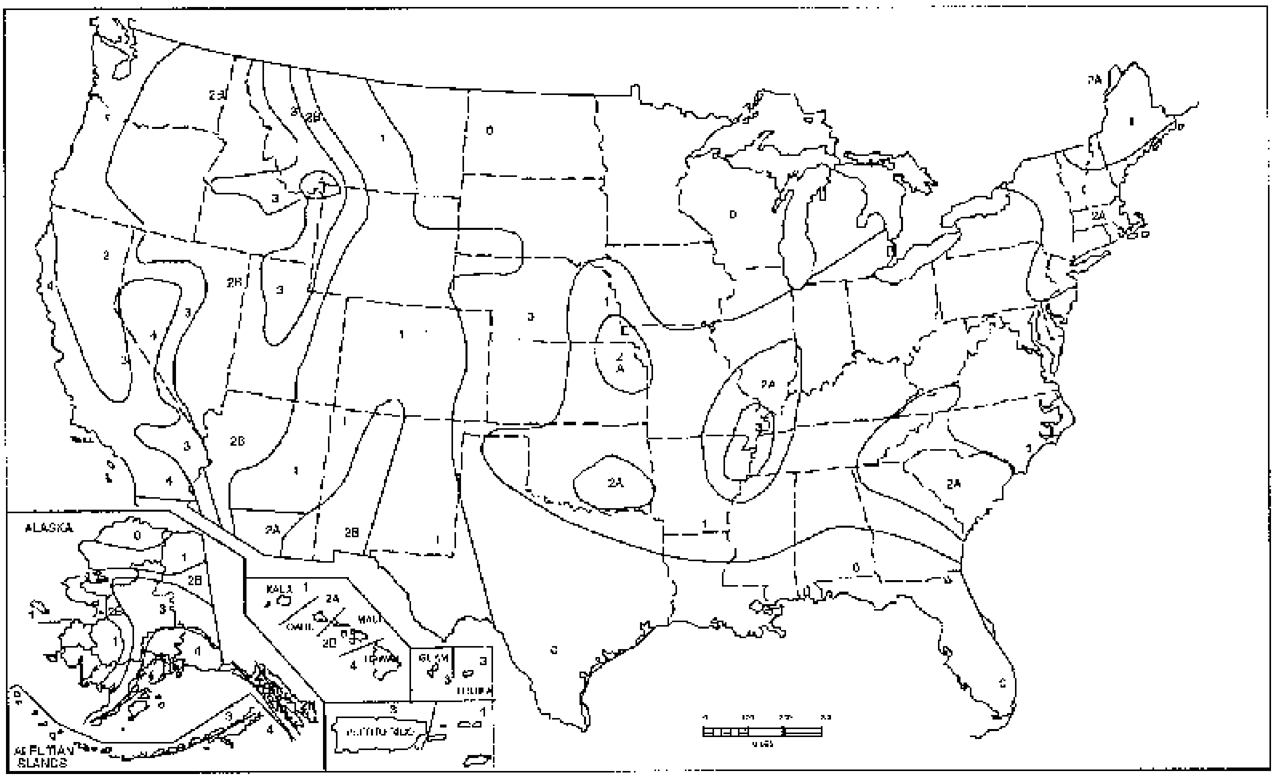
1.17.0 Seismic Map of the United States



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1.18.0 Minimum Cover for Reinforcement in Cast-in-Place Concrete

Cast-in-place concrete (nonprestressed). The following minimum concrete cover shall be provided for reinforcement:

		MINIMUM COVER, inches (mm)
1.	Concrete cast against and permanently exposed to earth	3 (76)
2.	Concrete exposed to earth or weather:	
	No. 6 through No. 18 bar	2 (51)
	No. 5 bar, W31 or D31 wire, and smaller	$1^1/_2$ (38)
3.	Concrete not exposed to weather or in contact with ground:	
	Slabs, walls, joists:	
	No. 14 and No. 18 bar	$1^1/_2$ (38)
	No. 11 bar and smaller	$^3/_4$ (19)
	Beams, columns:	
	Primary reinforcement, ties, stirrups, spirals	$1^1/_2$ (38)
	Shells, folded plate members:	
	No. 6 bar and larger	$^3/_4$ (19)
	No. 5 bar, W31 or D31 wire, and smaller	$^1/_2$ (12.7)
4.	*Concrete tilt-up panels cast against a rigid horizontal surface, such as a concrete slab, exposed to the weather:*	
	No. 8 and smaller	*1 (25)*
	No. 9 through No. 18	*2 (51)*

Precast concrete (Manufactured under plant control conditions). The following minimum concrete cover shall be provided for reinforcement:

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1.18.1 Minimum Cover for Reinforcement in Precast Concrete

		MINIMUM COVER, Inches (mm)
1.	Concrete exposed to earth or weather:	
	Wall panels:	
	No. 14 and No. 18 bar	$1^1/_2$ (38)
	No. 11 bar and smaller	$^3/_4$ (19)
	Other members:	
	No. 14 and No. 18 bar	2 (51)
	No. 6 through No. 11 bar	$1^1/_2$ (38)
	No. 5 bar W31 or D31 wire, and smaller	$1^1/_4$ (32)
2.	Concrete not exposed to weather or in contact with ground:	
	Slabs, walls, joists:	
	No. 14 and No. 18 bar	$1^1/_4$ (32)
	No. 11 bar and smaller	$^5/_8$ (16)
	Beams, columns:	
	Primary reinforcement	d_b but not less than $^5/_8$ (16) and need not exceed $1^1/_2$ (38)
	Ties, stirrups, spirals	$^3/_8$ (9.5)
	Shells, folded plate members:	
	No. 6 bar and larger	$^5/_8$ (16)
	No. 5 bar, W31 or D31 wire, and smaller	$^3/_8$ (9.5)

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1.18.2 Minimum Cover for Reinforcement in Prestressed Concrete

Prestressed concrete.

The following minimum concrete cover shall be provided for prestredded and nonprestressed reinforcement, ducts and end fittings, except as provided in Sections 1907.7.3.2 and 1907.7.3.3.

		MINIMUM COVER, Inches (mm)
1.	Concrete cast against and permanently exposed to earth	3 (76)
2.	Concrete exposed to earth or weather:	
	Wall panels, slabs, joists	1 (25)
	Other members	$1^1/_2$ (32)
3.	Concrete not exposed to weather or in contact with ground:	
	Slabs, walls, joists	$^3/_4$ (19)
	Beams, columns:	
	Primary reinforcement	$1^1/_2$ (38)
	Ties, stirrups, spirals	1 (25)
	Shells, folded plate members:	
	No. 5 bars, W31 or D31 wire, and smaller	$^3/_8$ (9.5)
	Other reinforcement	d_b but not less than $^3/_4$ (19)

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1.19.0 Concrete—Quality Control Checklist

Quality Control Checklist

Project no.

Section

Concrete

No.

03301

Accepted By

Date

1. Shop drawings are approved and on site.
2. Verify approval of forms and rebar prior to pour
3. Requirements for tests, mix design, ingredients, etc.
4. Test lab notified prior to pour and tests are performed (cylinder, sump, etc.)
5. Testing is arranged at plant and site.
6. Previously placed conc. properly prepared for new.
7. Vibrators are used during pour.
8. Temporary form openings, tremies, chutes, provided.
9. Sub base and capillary fills compacted.
10. Arrange for specified curing and sawed joints.
11. Arrange for cold weather protection if needed.
12. Bolts and loose items properly located and installed. Verify contractor has coordinated.
13. Date and location of pours is recorded.
14. Verify finishes. smooth, exposed aggregate, colored.
15. No troweling while bleed water is on surface.
16. Curing compounds compatible with finishes have been verified.
17. Slopes are provided for proper drainage.
18. Wet spray or moist curing is adequately performed.
19. Loading and traffic are controlled over surfaces.
20. Methods of repairing provided as soon as possible.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

1.20.0 Concrete Reinforcement—Quality Control Checklist

Quality Control Checklist

Project no.

Section: Concrete Reinforcement

No. 03200

Date

1. Shop drawings are approved and on site.
2. Grade of steel delivered as required.
3. Spacing coordinated to suit masonry units.
4. Required clearance of steel from forms provided.
5. Length of splices, and staggering splices as required.
6. Bends within radii and tolerance are uniformly made.
7. Additional bars at intersects, openings, and corners.
8. Bars cleaned of material that might reduce bond.
9. Dowels for marginal bars at openings.
10. Bars tied and supported to prevent displacement.
11. Spacers, tie wires, chairs as required.
12. Conduits are separated 3 conduit diameters minimum.
13. No conduit or pipe place below rebar mat except where approved.
14. No contact of bars is made with dissimilar metals.
15. Bars not near surfaces that allow rusting.
16. Adequate clearance provided for deposit of conc.
17. Verify that contractor has coordinated and reviewed drawings for anchors, piping, sleeves, boxes.
18. Verify that contractor has resolved conflicts between embedded items and reinf.
19. Special coating as required.
20. Cantilever – proper placement.
21. No bent bars and tension members are installed except where approved.
22. No conduit or piping is placed below rebar mat in suspended slabs unless approved by three conduit diameters minimum.
23. Unless approved, boxing out is not allowed for subsequent grouting-in.
24. Rules of thumb for bar splices:
    For 24d lap: multiply bar size by 3 = lap in inches.
    For 32d lap: multiply bar size by 4 = lap in inches.
    For 40d lap: multiply bar size by 5 = lap in inches.
25. Avoid bending rebar excessively ("hickeying"). Max slope = 1:6. Field bending of partially embedded bar should be done with consultant's approval.
26. Agency inspection is performed if required.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

1.21.0 Concrete Form Removal—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Concrete Form Removal

No.
03801

Date

1. Method of patching approved and applied early.
2. No troweling while bleed water is on surface.
3. Overtroweling is to be avoided.
4. Finishing method provides surface within tolerance.
5. Slopes provide proper drainage.
6. Check edges are finished and match.
7. Moist curing is adequately performed.
8. Protective covers have sufficient lap and seal.
9. Methods to repair defects are applied early.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

2

Masonry

Contents

2.0.0 History of Masonry

The first recorded brick masonry units were made by the Egyptians in 10,000 B.C. and the Romans used brick in many of their structures 2000 years go. The Great Pyramid of Giza in Egypt is the first recorded use of mortar. Brick manufacture and use occurred in the mid-1600s and was patterned on English methods and practices. It was not until 1930, however, that cavity wall construction (as we know it today) was introduced into the United States from Europe as a means of controlling moisture. This method provides a physical separation between the inner and outer wythes to serve as a drainage cavity for water, which would be expelled through weep holes in the outer wythe.

Masonry today is primarily devoted to the construction of brick, block, structural clay products, and natural and cast stone. Walls can be basically categorized as load-bearing or non-load-bearing walls, cavity walls, veneer walls, and solid walls. No matter the type of material used or the method by which the masonry wall is constructed, two components remain crucial: mortar and wall reinforcement.

2.1.0 Mortar

Mortar is the bonding agent that holds all of the masonry units together. Bond strength is the crucial element that differs from its close relative concrete, where compressive strength is the most important physical property.

Mortar serves four functions:

1. It bonds the masonry units together and seals the space between them.
2. It allows for dimensional variations in the masonry units while still maintaining a high degree of levelness.
3. It bonds to the reinforcing steel in the wall.
4. It provides an added decorative effect to the wall inasmuch as various colors or tooled joints can be introduced.

2.1.1 Mortar Types

- *Type M* High compressive strength (2500 psi average), containing greater durability than other types. Therefore, it is generally recommended for unreinforced masonry walls below grade.
- *Type S* Reasonable high compressive strength (1800 psi average) and having great tensile bond strength. It is usually recommended for reinforced masonry walls, where maximum flexural strength is required.
- *Type N* Midrange compressive strength (750 psi average) and suitable for general above-grade masonry construction for parapets and chimneys.
- *Type O* Load compressive strength (350 psi average) and suitable for interior non-load-bearing masonry walls.
- *Type K* Very low compressive strength (75 psi average) and occasionally used for interior non-load-bearing walls, where permitted by local building codes.

Workability or plasticity of the mortar is an essential characteristic of proper mortar mixes. The mortar must have both cohesive and adhesive qualities when it makes contact with the masonry units. Hardness or high strength is not necessarily a measure of durability. Mortar that is stronger than the masonry units to which it is applied might not "give," thereby causing stress to be relieved by the masonry units. This could result in these units cracking or spalling.

2.1.2 Mortar Additives

Like concrete, mortar admixtures can be added for many reasons:

- *Accelerators* To speed up the setting time by 30 to 40% and increase the 24-hour strength. Some accelerators contain calcium chloride and are not acceptable to the architect/engineer.

- *Retarders* Extends the board life of the mortar by as much as 4 to 5 hours. it slows down the set time of mortar when temperatures exceed 70°F.
- *Integral water repellents* It reduces water absorption and is useful when a single wythe wall will be exposed to the elements.
- *Bond modifiers* Improves adhesion to block. It is particularly useful when glass block walls are being built.
- *Corrosion inhibitors* Used in marine environments where salt air could penetrate the mortar and begin to corrode any wall reinforcement.

2.1.3 Mortar Testing

Mortar testing is performed by the "prism" test method, in accordance with ASTM E 447, Method B. The compressive strength is the average strength of three prisms.

2.1.4 Compressive Strength of Masonry, Based on Types of Mortar

Net area compressive strength of concrete masonry units, psi (MPa)		Net area compressive strength of masonry, psi[1] (MPa)
Type M or S mortar	Type N mortar	
1250 (8.6)	1300 (9.0)	1000 (6.9)
1900 (13.1)	2150 (14.8)	1500 (10.3)
2800 (19.3)	3050 (21.0)	2000 (13.8)
3750 (25.8)	4050 (27.9)	2500 (17.2)
4800 (33.1)	5250 (36.2)	3000 (20.1)

[1]For units of less than 4 in. (102 mm) height, 85 percent of the values listed.

2.1.5 Compressive Strength of Mortars Made with Various Types of Cement

Type of cement	Minimum compressive strength, psi				ASTM designation
	1 day	3 days	7 days	28 days	
Portland cements					C150-85
I	—	1800	2800	4000*	
IA	—	1450	2250	3200*	
II	—	1500	2500	4000*	
	—	1000†	1700†	3200*†	
IIA	—	1200	2000	3200*	
	—	800†	1350†	2560*†	
III	1800	3500	—	—	
IIIA	1450	2800	—	—	
IV	—	—	1000	2500	
V	—	1200	2200	3000	
Blended cements					C595-85
I(SM), IS, I(PM), IP	—	1800	2800	3500	
I(SM)-A, IS-A I(PM)-A, IP-A	—	1450	2250	2800	
IS(MS), IP(MS)	—	1500	2500	3500	
IS-A(MS), IP-A(MS)	—	1200	2000	2800	
S	—	—	600	1500	
SA	—	—	500	1250	
P	—	—	1500	3000	
PA	—	—	1250	2500	
Expansive cement					C845-80
E-1	—	—	2100	3500	
Masonry cements					C91-83a
N	—	—	500	900	
S	—	—	1300	2100	
M	—	—	1800	2900	

*Optional requirement.

†Applicable when the optional heat of hydration or chemical limit on the sum of C2S and C3A is specified.

Note: When low or moderate heat of hydration is specified for blended cements (ASTM C595), the strength requirements is 80% of the value shown.

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2.1.6 Allowable Compressive Stresses for Masonry

Construction; compressive strength of unit, gross area, psi (MPa)	Allowable compressive stresses[1] gross cross-sectional area, psi (MPa)	
	Type M or S mortar	Type N mortar
Solid masonry of brick and other solid units of clay or shale; sand-lime or concrete brick:		
8000 (55.1) or greater	350 (2.4)	300 (2.1)
4500 (31.0)	225 (1.6)	200 (1.4)
2500 (17.2)	160 (1.1)	140 (0.97)
1500 (10.3)	115 (0.79)	100 (0.69)
Grouted masonry, of clay or shale; sand-lime or concrete:		
4500 (31.0) or greater	225 (1.6)	200 (1.4)
2500 (17.2)	160 (1.1)	140 (0.97)
1500 (8.3)	115 (0.79)	100 (0.69)
Solid masonry of solid concrete masonry units:		
3000 (20.7) or greater	225 (1.6)	200 (1.4)
2000 (13.8)	160 (1.1)	140 (0.97)
1200 (8.3)	115 (0.79)	100 (0.69)
Masonry of hollow load bearing units:		
2000 (13.8) or greater	140 (0.97)	120 (0.83)
1500 (10.3)	115 (0.79)	100 (0.69)
1000 (6.9)	75 (0.52)	70 (0.48)
700 (4.8)	60 (0.41)	55 (0.38)
Hollow walls (noncomposite masonry bonded)		
Solid units:		
2500 (17.2) or greater	160 (1.1)	140 (0.97)
1500 (10.3)	115 (0.79)	100 (0.69)
Hollow units	75 (0.52)	70 (0.48)
Stone ashlar masonry:		
Granite	720 (5.0)	640 (4.4)
Limestone or marble	450 (3.1)	400 (2.8)
Sandstone or cast stone	360 (2.5)	320 (2.2)
Rubble stone masonry		
Coursed, rough, or random	120 (0.83)	100 (0.69)

Net area compressive strength of units, psi (MPa)	Moduli of elasticity[1] E, psi $\times 10^6$ (MPa $\times 10^3$)	
	Type N mortar	Type M or S mortar
6000 (41.3) and greater	—	3.5 (24)
5000 (34.5)	2.8 (19)	3.2 (22)
4000 (27.6)	2.6 (18)	2.9 (20)
3000 (20.7)	2.3 (16)	2.5 (17)
2500 (17.2)	2.2 (16)	2.4 (17)
2000 (13.8)	1.8 (12)	2.2 (15)
1500 (10.3)	1.5 (10)	1.6 (11)

[1]Linear interpolation permitted.

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2.1.7 Mortar Proportions for Unit Masonry

MORTAR	TYPE	PROPORTIONS BY VOLUME (CEMENTITIOUS MATERIALS): Portland Cement or Blended Cement	Masonry Cement[1] M	Masonry Cement[1] S	Masonry Cement[1] N	Mortar Cement[2] M	Mortar Cement[2] S	Mortar Cement[2] N	Hydrated Lime or Lime Putty	AGGREGATE MEASURED IN A DAMP, LOOSE CONDITION
Cement-lime	M	1	—	—	—	—	—	—	1/4	Not less than 2 1/4 and not more than 3 times the sum of the separate volumes of cementitious materials.
	S	1	—	—	—	—	—	—	over 1/4 to 1/2	
	N	1	—	—	—	—	—	—	over 1/2 to 1 1/4	
	O	1	—	—	—	—	—	—	over 1 1/4 to 2 1/2	
Mortar cement	M	1	—	—	—	—	—	1	—	
	M	—	—	—	—	1	—	—	—	
	S	1/2	—	—	—	—	—	1	—	
	S	—	—	—	—	—	1	—	—	
	N	—	—	—	—	—	—	1	—	
Masonry cement	M	1	—	—	1	—	—	—	—	
	M	—	1	—	—	—	—	—	—	
	S	1/2	—	—	1	—	—	—	—	
	S	—	—	1	—	—	—	—	—	
	N	—	—	—	1	—	—	—	—	
	O	—	—	—	1	—	—	—	—	

[1]Masonry cement conforming to the requirements of UBC Standard 21-11.

[2]Mortar cement conforming to the requirements of UBC Standard 21-14.

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2.1.8 Specified Compressive Strength of Masonry Based on Compressive Strength of Masonry Units

COMPRESSIVE STRENGTH OF CLAY MASONRY UNITS[1,2] (psi)	SPECIFIED COMPRESSIVE STRENGTH OF MASONRY, f'_m: Type M or S Mortar[3] (psi) × 6.89 for kPa	Type N Mortar[3] (psi)
14,000 or more	5,300	4,400
12,000	4,700	3,800
10,000	4,000	3,300
8,000	3,350	2,700
6,000	2,700	2,200
4,000	2,000	1,600

COMPRESSIVE STRENGTH OF CONCRETE MASONRY UNITS[2,4] (psi)	SPECIFIED COMPRESSIVE STRENGTH OF MASONRY, f'_m: Type M or S Mortar[3] (psi) × 6.89 for kPa	Type N Mortar[3] (psi)
4,800 or more	3,000	2,800
3,750	2,500	2,350
2,800	2,000	1,850
1,900	1,500	1,350
1,250	1,000	950

[1]Compressive strength of solid clay masonry units is based on gross area. Compressive strength of hollow clay masonry units is based on minimum net area. Values may be interpolated. When hollow clay masonry units are grouted, the grout shall conform to the proportions in Fig. 2.1.10.

[2]Assumed assemblage. The specified compressive strength of masonry f'_m is based on gross area strength when using solid units or solid grouted masonry and net area strength when using ungrouted hollow units.

[3]Mortar for unit masonry, proportion specification, as specified in Fig. 2.1.7. These values apply to portland cement-lime mortars without added air-entraining materials.

[4]Values may be interpolated. In grouted concrete masonry, the compressive strength of grout shall be equal to or greater than the compressive strength of the concrete masonry units.

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2.1.9 Allowable Tension for Embedded Anchor Bolts for Clay and Concrete Masonry

f'_m (psi) × 6.89 for kPa	EMBEDMENT LENGTH, l_b, or EDGE DISTANCE, l_{be} (inches) × 25.4 for mm, × 4.45 for N: 2	3	4	5	6	8	10
1,500	240	550	970	1,520	2,190	3,890	6,080
1,800	270	600	1,070	1,670	2,400	4,260	6,660
2,000	280	630	1,120	1,760	2,520	4,500	7,020
2,500	310	710	1,260	1,960	2,830	5,030	7,850
3,000	340	770	1,380	2,150	3,100	5,510	8,600
4,000	400	890	1,590	2,480	3,580	6,360	9,930
5,000	440	1,000	1,780	2,780	4,000	7,110	11,100
6,000	480	1,090	1,950	3,040	4,380	7,790	12,200

[1]The allowable tension values in Fig. 2.1.9 are based on compressive strength of masonry assemblages.
[2]Values are for bolts of at least A 307 quality. Bolts shall be those specified in Section 2106.2.14.1.
[3]Values shown are for work with or without special inspection.

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2.1.10 Grout Proportions by Volume

TYPE[1]	PARTS BY VOLUME OF PORTLAND CEMENT OR BLENDED CEMENT	PARTS BY VOLUME OF HYDRATED LIME OR LIME PUTTY	AGGREGATE MEASURED IN A DAMP, LOOSE CONDITION: Fine	Coarse
Fine grout	1	0 to $1/10$	$2^1/4$ to 3 times the sum of the volumes of the cementitious materials	
Coarse grout	1	0 to $1/10$	$2^1/4$ to 3 times the sum of the volumes of the cementitious materials	1 to 2 times the sum of the volumes of the cementitious materials

[1]Grout shall attain a minimum compressive strength at 28 days of 2,000 psi (13.8 MPa). The building official may require a compressive field strength test of grout made in accordance with UBC Standard 21-18.

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2.1.11 Grouting Limitations

GROUT TYPE	GROUT POUR MAXIMUM HEIGHT (feet)[1] × 304.8 for mm	MINIMUM DIMENSIONS OF THE TOTAL CLEAR AREAS WITHIN GROUT SPACES AND CELLS[2,3] × 25.4 for mm: Multiwythe Masonry	Hollow-unit Masonry
Fine	1	$3/4$	$1^1/2 \times 2$
Fine	5	$1^1/2$	$1^1/2 \times 2$
Fine	8	$1^1/2$	$1^1/2 \times 3$
Fine	12	$1^1/2$	$1^3/4 \times 3$
Fine	24	2	3×3
Coarse	1	$1^1/2$	$1^1/2 \times 3$
Coarse	5	2	$2^1/2 \times 3$
Coarse	8	2	3×3
Coarse	12	$2^1/2$	3×3
Coarse	24	3	3×4

[1]See also Section 2104.6.
[2]The actual grout space or grout cell dimensions must be larger than the sum of the following items: (1) The required minimum dimensions of total clear areas in this figure; (2) The width of any mortar projections within the space; and (3) The horizontal projections of the diameters of the horizontal reinforcing bars within a cross section of the grout space or cell.
[3]The minimum dimensions of the total clear areas shall be made up of one or more open areas, with at least one area being $3/4$ inch (19 mm) or greater in width.

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2.1.11.1 Grouting Masonry—Explained and Illustrated

SCOPE

This Construction Guide presents information on grouting masonry walls. The intent of this guide is to provide general information on grouting methods and procedures. Knowledge of applicable codes and standards, in conjunction with acceptable field practices, is required to assure successful grouting results.

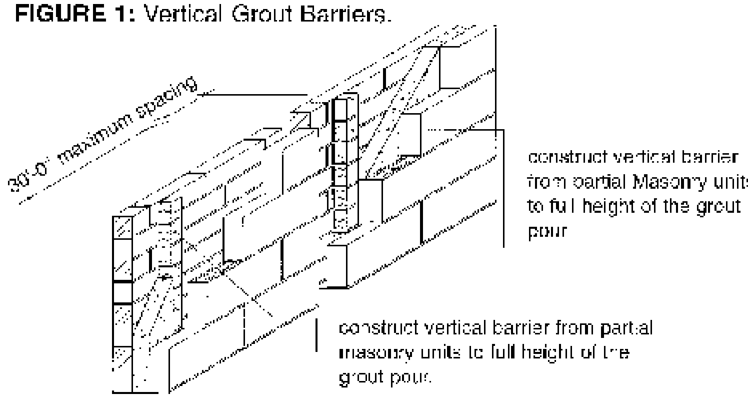
INTRODUCTION

Masonry can be grouted and reinforced to produce efficient load-resistant structures. Reinforced masonry is used to produce taller, thinner and more economical walls. Most grouted masonry walls include reinforcing steel to provide additional lateral strength. Walls constructed in certain seismic zones are required to be reinforced and grouted to resist the dynamic forces of an earthquake.

Placing Grout

Grout is placed in lifts either between two wythes of masonry or into the cells of masonry units. Lifts should be poured in increments not to exceed 5 feet. If it is demonstrated that the grout space can be properly filled, it might be allowable to place grout in increments greater than 5 feet. One or more lifts constitute a grout pour, which is the total height of grout placed in a masonry wall prior to the construction of additional masonry. For example, if a wall is constructed to a height of 10 feet, the total grout pour would be 10 feet, with the grout being placed in two 5-foot lifts. The

FIGURE 1: Vertical Grout Barriers.



maximum height of a grout pour is restricted by the size and type of grout space and the type of grout mix (fine or coarse) listed in Table 1.

GROUTING METHODS

There are two methods of placing grout: low-lift grouting and high-lift grouting. In low-lift grouting, 5 feet or less of wall height is grouted in one day. The grout is usually placed with buckets. In high-lift grouting, grout can be placed up to a full story height in one day. Grout is usually placed with a grout pump.

The method for placing grout is usually determined by the contractor. However, the specifications can require a particular grouting method. Each of the two basic methods for placing grout—low lift grouting and high lift grouting—has its advantages. The method ultimately selected depends upon the type of masonry wall, the size of the project, the equipment available, and the experience of the contractor.

Low-lift Grouting

The primary benefit of low lift grouting is that cleanouts are not required. Since the total grout pour cannot exceed 5 feet in one day, all visual inspections of the grout space can be made from the top of the wall. Also, low-lift grouting is better suited to smaller projects and multi-wythe construction and when construction sequencing prevents the use of high-lift grouting.

There are two procedures for low-lift grouting:

Pours 12 inches or less - This method involves grouting the masonry as the wall is being constructed. The grout is placed in the grout space in lifts not to exceed six times the width of the space or a maximum of 8 inches. The grout lift should be terminated approximately 1 inch below the top of the uppermost units. When grout is placed between multi-wythe walls, vertical barriers must be constructed to contain grout flow. Designed to prevent excessive flowage, which can cause segregation of grout materials, vertical barriers should be constructed in grout spaces at a maximum spacing of 30 feet. These barriers can be comprised of partial masonry units constructed to the full height of the wall (See Figure 1). Consolidate the grout shortly after it is placed. Masonry units must not be displaced or dislodged while consolidating grout (See Figure 2).

TABLE 1: Grout Pour Heights and Space Requirements

Specified Grout Type	Maximum Grout Pour Height (ft)	Minimum Width of Grout Space Between Wythes (in.)	Minimum Grout Space Dimensions for Grouting Cells of Hollow Units (in. x in.)	Cleanout Requirement
Fine	1	3/4	1 1/2x2	No
Fine	5	2	2 x 3	No
Fine	12	2 1/2	2 1/2x3	Yes
Fine	24	3	3x3	Yes
Coarse	1	1 1/2	1 1/2x3	No
Coarse	5	2	2 1/2 x 3	No
Coarse	12	2 1/2	3x3	Yes
Coarse	24	3	3x4	Yes

NOTES: The minimum grout space dimension is the distance between any masonry protrusion and shall be increased by the width of horizontal bars installed within the space.

(By permission from the Brick Industry Association, Reston, Virginia.)

Pours greater than 12 inches and up to 5 feet - For multi-wythe walls, first construct the masonry to a height of 4 or 5 feet. The wythes must be bonded together with wire ties or joint reinforcement to prevent bulging or blowouts; and the masonry must be allowed to cure for approximately 12 to 18 hours prior to grouting to withstand hydrostatic grout pressure. A minimum 3/4 inch grout space is required between the wythes. Vertical barriers must be constructed to contain grout flow. Next, install vertical reinforcement (if required); then place grout in two or three lifts, evenly distributing the grout throughout the space in each lift. Consolidate the grout shortly after it is placed and reconsolidate after initial water loss and settlement have occurred (See Figure 2).

For single-wythe walls, first construct the masonry to height of 4 or 5 feet with vertical cells sufficiently aligned and clear of debris and mortar obstructions. Lay units with cross webs bedded with mortar to contain grout. Next install vertical reinforcement (if required); then pour grout into the cells of units, terminating the grout approximately 1 to 2 inches below the top of the upper most unit. Consolidate the grout shortly after it is placed and reconsolidate after initial water loss and settlement has occurred (See Figure 2).

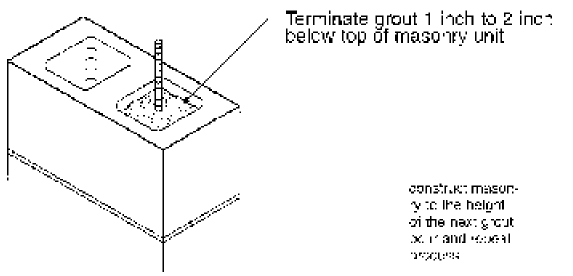


FIGURE 3D: Grout shear key

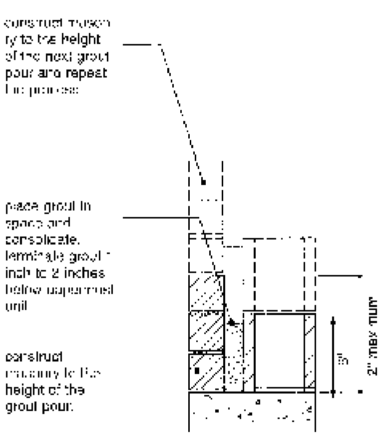


FIGURE 2A. Grout pours 12 inch or less for multi-wythe wall

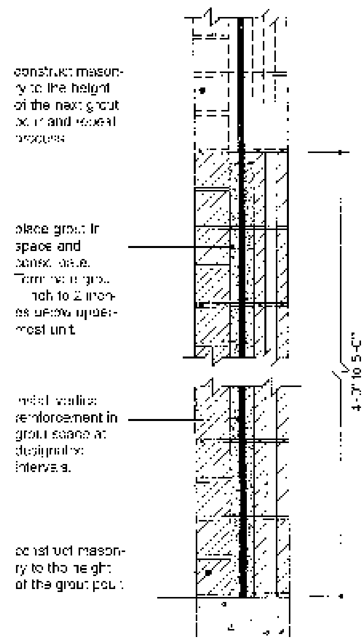


FIGURE 2B: Grout pours up to 5 feet for multi-wythe wall

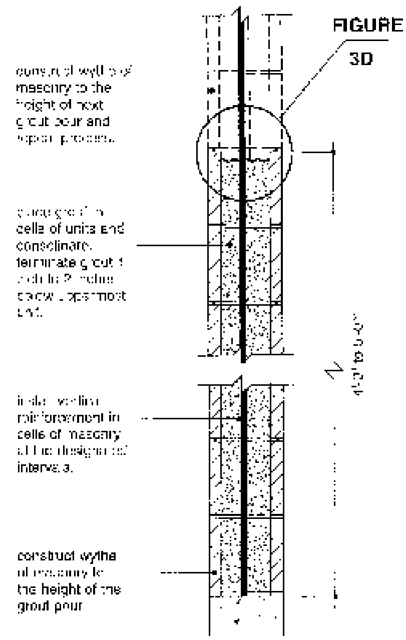


FIGURE 2C: Grout pours up to 5 feet for single-wythe wall

FIGURE 2: Methods of low-lift grouting.

High-lift Grouting

Grouting masonry walls that have been constructed to a full story height has several advantages. Reinforcement bars are placed after the masonry wall has been constructed. Productivity is increased because the mason does not have to lift and place the unit over the reinforcement bar for single-wythe grouting. Large amounts of grout can be placed at one time, which also increases productivity and produces more consistent workmanship.

Cleanout openings are required at the base of the wall for high-lift grouting. Used to remove mortar droppings and debris from the grout space, cleanouts also can be used to inspect the placement of reinforcing steel. These openings are formed by removing face shells from units, cutting holes in face shells or by deleting entire units, and should be a minimum of 3 inches long by 3 inches high. Cleanouts should be located at the base of the wall every 32 inches or less in a multi-wythe wall and at each vertical bar location when grouting cells of masonry units. Cleanouts must be covered prior to grouting - with a face shell or a form board that is braced or anchored to the wall (See Figure 3).

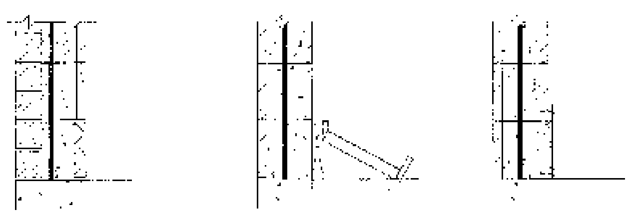


FIGURE 3A. Reinstall face shell or CMU scap

FIGURE 3B. Install 2x10 braced against masonry

FIGURE 3C. Install plywood form board mechanically fastened to masonry

FIGURE 3: Methods for sealing cleanout openings.

Continued. (By permission from the Brick Industry Association, Reston, Virginia.)

PRECAUTIONARY MEASURES

Certain precautions must be taken to assure successful grouting of masonry.

Keeping Grout Space Clean

Certain provisions must be met to keep the grout space clear of mortar while the masonry is being constructed. In multi-wythe walls, beveling the mortar bed joints back and upward slightly from the grout space eliminates most mortar extrusions. If the grout space is wide enough, the mason can pick out excess mortar extrusions with his trowel. When the cells of masonry units are to be grouted, mortar extrusions (mortar fins) in the cells should be removed with a trowel while the masonry is being constructed, or the mortar fins should be knocked off with a piece of wood or rebar down to the base of the cell shortly after the mortar begins to set. Also, it is good practice to clean the grout space with high-pressure air or water to remove mortar build-up.

Preventing Blowouts

Blowouts of mortar joints occur when the hydrostatic grout pressure exceeds the strength of the mortar joint. These blowouts can be prevented by providing proper curing time for the masonry prior to placing grout—at least 24 hours when grouting cells of masonry units and at least 72 hours when grouting multi-wythe walls.

Additional precautions against blowouts should be taken for grouting multi-wythe walls.

- Bond wythes of masonry together with a 9-gauge rectangular wall tie and a 3/16 inch diameter wire tie, or joint reinforcement. Place a minimum of one rectangular tie, one-tie or one cross-wire of joint reinforcement every 2 square feet of wall.
- Sufficiently embed masonry ties to ensure proper bonding of the wythes. Masonry ties and joint reinforcement should be at least 2 inches less in width than the actual thickness of the wall.
- Consolidate grout properly to help prevent build-up of highpressure. Do not continue to grout at one location, forcing the grout to flow throughout the space. Shift grout placement to other locations.

INSTALLING REINFORCEMENT

Methods for installing rebar are dictated by code requirements. Some codes require reinforcement to be installed prior to units being laid.

Grout Consolidation

Grout must be consolidated (vibrated) as it is being placed to minimize the voids that are left when water is absorbed by the masonry units. Grout consolidation, which usually takes place 5 to 10 minutes after placement, can be accomplished by puddling the grout with a piece of rebar or a 1 x 2 inch board if grout lifts do not exceed 12 inches. Lifts greater than 12 inches must be consolidated with a mechanical vibrator fitted with a small diameter vibrator head (3/4 inch to 1 inch diameter). Mechanically vibrate grout placed in cells of masonry units for only several seconds at a given location. Leaving the vibrator head stationary at one location may cause mortar or face-shell blowouts.

The grout should be reconsolidated within 1/2 hour after it has been consolidated to assure proper bond. Reconsolidation prevents separations from developing between the grout and masonry by eliminating water build-up between the two materials.

Given this requirement, the only productive way to construct masonry would be with open-ended units (A- or H-shaped), so that the units would not have to be lifted and placed over the reinforcement.

If the code allows for reinforcement after wall construction, there are two installation methods available to the contractor. One method is to install full-length reinforcement bars into masonry after the units have been laid. Rebar positioners can be installed into the masonry units during construction to assure proper bar location.

Reinforcement bars also can be installed in shorter lengths as the wall is being constructed. In this method, masonry can be constructed to a height of 4 feet and allowed to cure properly. Then, a 6-foot reinforcement bar can be inserted into the masonry and grouted to an approximate height of 4 feet, leaving an adequate length of reinforcement bar exposed to provide a lap splice. This process is repeated until the wall is complete.

PARTIAL GROUTING

Single-wythe masonry walls may be partially grouted, confining grout to areas of the wall containing vertical or horizontal reinforcement. Place hardware cloth or plastic mesh material below and sometimes above bond beam units containing horizontal reinforcement to confine grout to the units or cells that form the bond beam. Bed cross-webs with mortar to confine grout only to those areas that contain vertical reinforcement.

WEATHER PROTECTION

When constructing and grouting masonry under adverse conditions, follow recommendations and procedures stated within the applicable masonry code. However, consider additional means of protection when grouting masonry under the following conditions:

- When the climatic conditions are extremely hot and arid, moisten the exterior of the masonry with water prior to grouting. This will cool down the wall and help prevent the grout from setting prematurely.
- When climatic conditions are extremely cold, construct and grout the masonry within an adequately heated enclosure to assure that all excessive water is extracted from the grout. Keeping the newly constructed masonry warm will allow proper curing and prevent the masonry from freezing. Heat the masonry until it has thoroughly dried and cured.

DISCLAIMER

This document is intended to assist the industry in avoiding design and construction problems sometimes associated with masonry construction. It is intended for mason contractors, field personnel, architects, engineers, building officials, general contractors, construction managers, students, suppliers, manufacturers and other industry representatives. It is not the intent of this report to cover every aspect of masonry construction, but to focus on issues that may lead to problems. This document should not be used as the sole guide for designing and constructing masonry. It is imperative to refer to relevant codes and standards and other industry-related documents. As such, the IMI assumes no liability for any consequences that may follow from the use of this document.

Continued

2.1.12 Foundation Wall Construction (Depth of Unbalanced Back Fill)

Wall construction	Nominal wall thickness, in. (mm)	Maximum depth of unbalanced backfill, ft (m)
Hollow unit masonry	8 (203)	5 (1.53)
	10 (254)	6 (1.83)
	12 (305)	7 (2.14)
Solid unit masonry	8 (203)	5 (1.53)
	10 (254)	7 (2.14)
	12 (305)	7 (2.14)
Fully grouted masonry	8 (203)	7 (2.14)
	10 (254)	8 (2.44)
	12 (305)	8 (2.44)

(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

2.1.12.1 Exterior Foundation Requirements—6- and 8-inch-Thick Walls

Wood or Steel Framing
Width of Footings in Inches[1,2]

		ONE-STORY BUILDINGS Roof Live Load × 0.0479 for kN/m²			TWO-STORY BUILDINGS Roof Live Load (psf) × 0.0479 for kN/m² Plus Floor Live Load (psf) × 0.0479 for kN/m²					
					20		30		40	
WALL HEIGHT (feet) × 304.8 for mm	SPAN TO BEARING WALLS (feet)	20 psf (inches)	30 psf (inches)	40 psf (inches)	50	100	50	100	50	100
					Minimum Width of Footing (inches) × 25.4 for mm					
8	8	12			12	12	12	12	12	12
	16				12	14	12	14	12	14
	24				14	18	14	18	16	18
	32				16	20	18	20	18	20
10	8	12			12	12	12	12	12	12
	16				14	16	14	16	14	16
	24				16	20	16	18	16	20
	32				20	24	20	22	20	24
12	8	12	12	12	12	14	12	14	12	14
	16	12	12	12	16	18	16	16	14	16
	24	12	12	14	18	20	18	20	18	20
	32	12	14	16	20	22	22	22	22	24

[1] For buildings with under-floor space or basements, footing thickness is to be a minimum of 12 inches (305 mm). It shall be reinforced with No. 4 bars at 24 inches (610 mm) on center when its width is required to be 18 inches (457 mm) or larger and it supports more than the roof and one floor.

[2] Footings are a minimum of 10 inches (254 mm) thick for a one-story building and 12 inches (305 mm) thick for a two-story building. Bottom of footing to be 18 inches (457 mm) below grade or the frost depth, whichever is deeper. Footing to be reinforced with No. 4 bars at 24 inches (610 mm) on center when supporting more than the roof and one floor.

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2.1.12.2 Interior Foundation Requirements—6- and 8-inch-Thick Walls

Wood or Steel Framing
Width of Footings in Inches[1,2,3]

WALL HEIGHT (feet)	SPAN TO BEARING WALLS (feet)	ONE-STORY BUILDINGS Roof Live Load[4] × 0.0479 for kN/m²: 20 psf (inches)	30 psf (inches)	40 psf (inches)	TWO-STORY BUILDINGS Roof Live Load[4] (psf) × 0.0479 for kN/m²: 20 — Plus Floor Live Load[5] (psf) × 0.0479 for kN/m²: 50	20: 100	30: 50	30: 100	40: 60	40: 100
× 304.8 for mm					Minimum Width of Footing (inches) × 25.4 for mm					
8	8	12	12	12	12	14	12	14	12	14
	16	12	12	12	16	20	18	20	18	22
	24	12	12	14	20	26	22	28	22	28
	32	14	14	16	24	28	26	32	28	34
10	8	12	12	12	14	16	14	16	14	16
	16	12	12	12	20	24	20	22	20	22
	24	12	14	14	22	28	22	28	22	28
	32	14	14	16	26	34	26	32	28	34
12	8	12	12	12	14	16	16	18	16	18
	16	12	14	16	20	24	20	22	20	22
	24	14	14	16	24	28	22	28	24	28
	32	16	16	18	28	30	28	32	28	34

[1]For buildings with under-floor space or basements, footing thickness is to be a minimum of 12 inches (305 mm). It shall be reinforced with No. 4 bars at 24 inches (610 mm) on center when its width is required to be 18 inches (457 mm) or larger and it supports more than the roof and one floor.
[2]Footings are 10 inches (254 mm) thick for up to 24 inches (610 mm) wide and 12 inches (305 mm) thick for up to 34 inches (864 mm) wide. Footings shall be reinforced with No. 4 bars at 24 inches (610 mm) on center when supporting more than the roof and one floor.
[3]These interior footings support roof-ceiling or floors or both for a distance on each side equal to the span length shown. A tributary width equal to the span length may be used.
[4]From local snow load tables. For areas without snow loads use 20 pounds per square foot (0.96 kN/m²).
[5]For intermediate floor loads go to next higher value.

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2.1.12.3 Empirical Design—Wall Lateral Support Requirements

CONSTRUCTION	MAXIMUM *l/t* or *h/t*
Bearing walls	
Solid or solid grouted	20
All other	18
Nonbearing walls	
Exterior	18
Interior	36

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2.1.12.4 Empirical Design—Thickness of Foundation Walls

FOUNDATION WALL CONSTRUCTION	NOMINAL THICKNESS (inches) × 25.4 for mm	MAXIMUM DEPTH OF UNBALANCED FILL (feet) × 304.8 for mm
Masonry of hollow units, ungrouted	8 10 12	4 5 6
Masonry of solid units	8 10 12	5 6 7
Masonry of hollow or solid units, fully grouted	8 10 12	7 8 8
Masonry of hollow units reinforced vertically with No. 4 bars and grout at 24″ o.c. Bars located not less than $4\frac{1}{2}$″ from pressure side of wall.	8	7

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2.1.12.5 Empirical Design—Allowable Shear on Bolts, Unburned Units

DIAMETER OF BOLTS (inches)	EMBEDMENTS (inches)	SHEAR (pounds)
× 25.4 for mm		× 4.45 for N
$\frac{1}{2}$		—
$\frac{5}{8}$	12	200
$\frac{3}{4}$	15	300
$\frac{7}{8}$	18	400
1	21	500
$1\frac{1}{8}$	24	600

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2.1.12.6 Empirical Design—Allowable Shear on Bolts for all Masonry Except Unburned Clay Units

DIAMETER BOLT (inches)	EMBEDMENT[1] (inches)	SOLID MASONRY (shear in pounds)	GROUTED MASONRY (shear in pounds)
× 25.4 for mm		× 4.45 for N	
$\frac{1}{2}$	4	350	550
$\frac{5}{8}$	4	500	750
$\frac{3}{4}$	5	750	1,100
$\frac{7}{8}$	6	1,000	1,500
1	7	1,250	1,850[2]
$1\frac{1}{8}$	8	1,500	2,250[2]

[1] An additional 2 inches of embedment shall be provided for anchor bolts located in the top of columns for buildings located in Seismic Zones 2, 3 and 4.
[2] Permitted only with not less than 2,500 pounds per square inch (17.24 MPa) units.

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2.1.12.7 Empirical Design—Allowable Compressive Stresses for Masonry

CONSTRUCTION: COMPRESSIVE STRENGTH OF UNIT, GROSS AREA × 6.89 for kPa	ALLOWABLE COMPRESSIVE STRESSES[1] GROSS CROSS-SECTIONAL AREA (psi) × 6.89 for kPa	
	Type M or S Mortar	Type N Mortar
Solid masonry of brick and other solid units of clay or shale; sand lime or concrete brick:		
8,000 plus, psi	350	300
4,500 psi	225	200
2,500 psi	160	140
1,500 psi	115	100
Grouted masonry, of clay or shale; sand-lime or concrete:		
4,500 plus, psi	275	200
2,500 psi	215	140
1,500 psi	175	100
Solid masonry of solid concrete masonry units:		
3,000 plus, psi	225	200
2,000 psi	160	140
1,200 psi	115	100
Masonry of hollow load-bearing units:		
2,000 plus, psi	140	120
1,500 psi	115	100
1,000 psi	75	70
700 psi	60	55
Hollow walls (cavity or masonry bonded)[2] solid units:		
2,500 plus, psi	160	140
1,500 psi	115	100
Hollow units	75	70
Stone ashlar masonry:		
Granite	720	640
Limestone or marble	450	400
Sandstone or cast stone	360	320
Rubble stone masonry Coarse, rough or random	120	100
Unburned clay masonry	30	—

[1] Linear interpolation may be used for determining allowable stresses for masonry units having compressive strengths which are intermediate between those given in the table.
[2] Where floor and roof loads are carried upon one wythe, the gross cross-sectional area is that of the wythe under load. If both wythes are loaded, the gross cross-sectional area is that of the wall minus the area of the cavity between the wythes.

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2.2.0 Brick Sizes (Nomenclature)

MODULAR BRICK SIZES

Unit Designation	Nominal Dimensions, in. w	h	l	Joint Thickness[2], in.	Specified Dimensions[3], in. w	h	i	Vertical Coursing
Modular	4	2⅔	8	⅜	3⅜	2¼	7⅝	3C = 8 in.
				½	3½	2¼	7½	
Engineer Modular	4	3⅕	8	⅜	3⅜	2¾	7⅝	5C = 16 in.
				½	3½	2 13/16	7½	
Closure Modular	4	4	8	⅜	3⅝	3⅝	7⅝	1C = 4 in.
				½	3½	3½	7½	
Roman	4	2	12	⅜	3⅝	1⅝	11⅝	2C = 4in.
				½	3½	1½	11½	
Norman	4	2⅔	12	⅜	3⅝	2¼	11⅝	3C = 8 in.
				½	3½	2¼	11½	
Engineer Norman	4	3⅕	12	⅜	3⅝	2¾	11⅝	5C = 16 in.
				½	3½	2 13/16	11½	
Utility	4	4	12	⅝	3⅝	3⅝	11⅝	1C = 4 in.
				½	3½	3½	11½	

NONMODULAR BRICK SIZES

Unit Designation	Nominal Dimensions, in. w	h	l	Joint Thickness[2], in.	Specified Dimensions[3], in. w	h	l	Vertical Coursing
Standard				⅜	3⅝	2¼	8	3C = 8 in.
				½	3½	2¼	8	
Engineer Standard				⅜	3⅝	2¾	8	5C = 16 in.
				½	3½	2$\frac{13}{16}$	8	
Closure Standard				⅜	3⅝	3⅝	8	1C = 4 in.
				½	3½	3½	8	
King				⅜	3	2¾	9⅝	5C = 16 in.
					3	3⅝	9¾	
Queen				⅜	3	2¾	8	5C = 16 in.

[1]1 in. = 25.4 mm; 1 ft = 0.3m
[2]Common joint sizes used with length and width dimensions. Joint thicknesses of bed joints vary based on vertical coursing and specified unit height.
[3]Specified dimensions may vary within this range from manufacturer to manufacturer.
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2.2.1 Other Brick Sizes

MODULAR BRICK SIZES

Nominal Dimensions, in.[1] w	h	l	Joint Thickness[2], in.	Specified Dimensions[3], in. w	h	l	Vertical Coursing
4	6	8	⅜	3⅝	5⅝	7⅝	2C = 12 in.
			½	3½	5½	7½	
4	8	8	⅜	3⅝	7⅝	7⅝	1C = 8 in.
			½	3½	7½	7½	
6	3⅕	12	⅜	5⅝	2¾	11⅝	5C = 16 in.
			½	5½	2$\frac{13}{16}$	11½	
6	4	12	⅜	5⅝	3⅝	11⅝	1C = 4 in.
			½	5½	3½	11½	
8	4	12	⅜	7⅝	3⅝	11⅝	1C = 4 in.
			½	7½	3½	11½	
8	4	16	⅜	7⅝	3⅝	15⅝	1C = 4 in.
			½	7½	3½	15½	
NONMODULAR BRICK SIZES							
			⅜	3	2¾	8¾	5C = 16 in.
				3	2⅝	8⅝	

[1]1 in. = 25.4 mm; 1 ft = 0.3 m
[2]Common joint sizes used with length and width dimensions. Joint thicknesses of bed joints vary based on vertical coursing and specified unit height.
[3]Specified dimensions may vary within this range from manufacturer to manufacturer.

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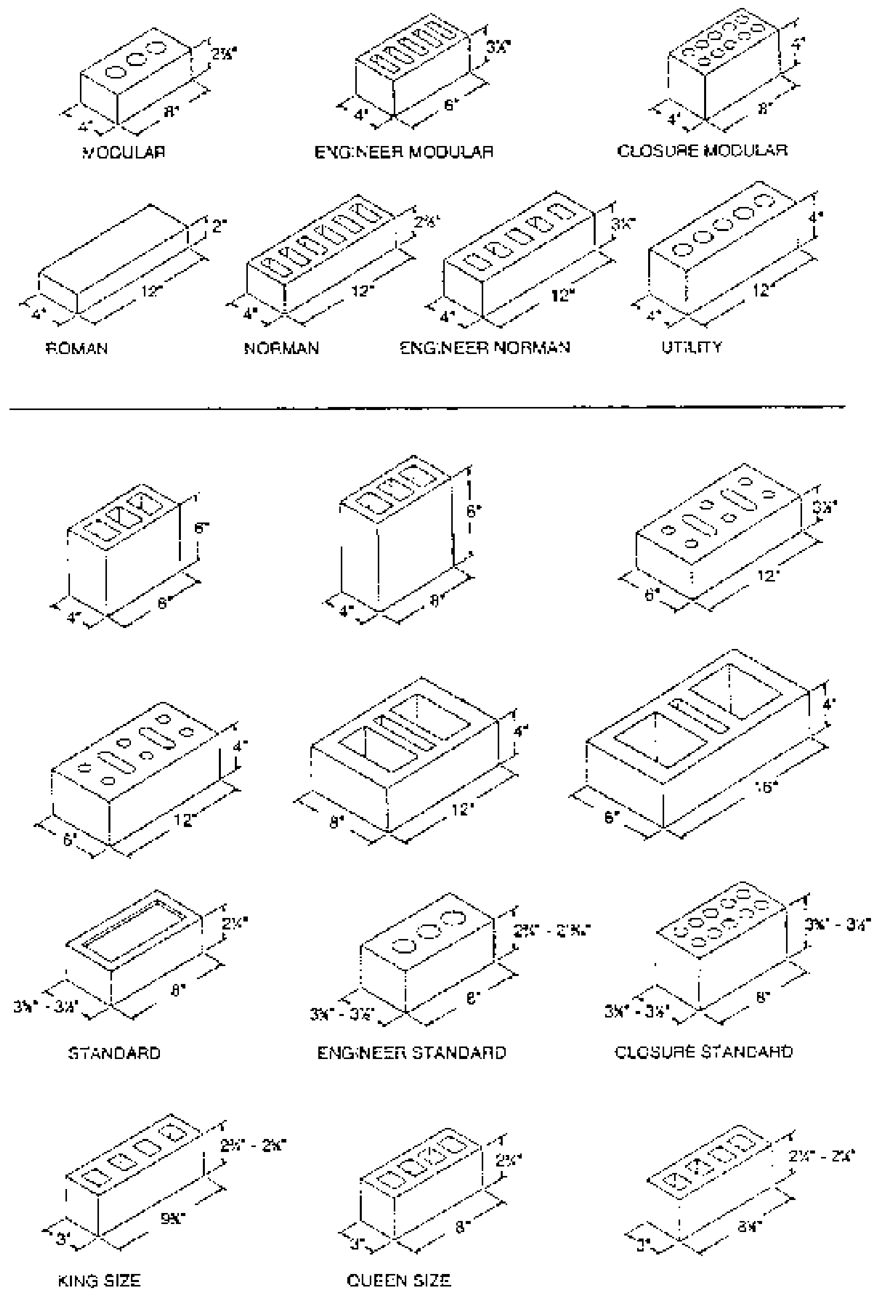
2.2.2 Modular and Nonmodular Brick Sizes



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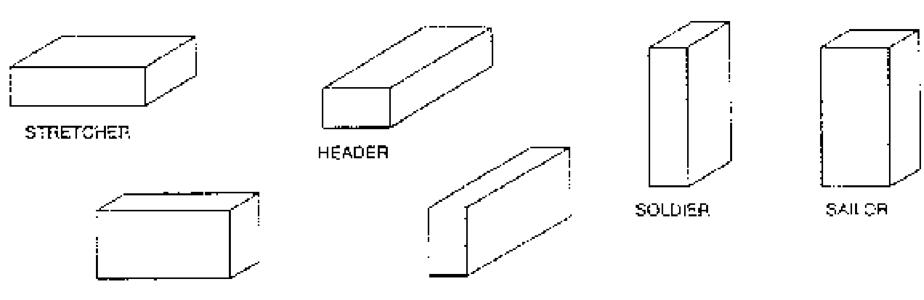
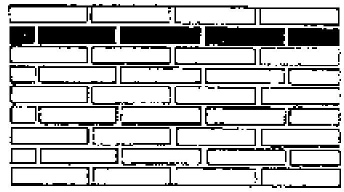
2.2.3 Brick Positions in a Wall

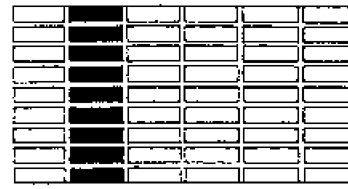


2.2.4 Traditional Bond Patterns (Illustrated)

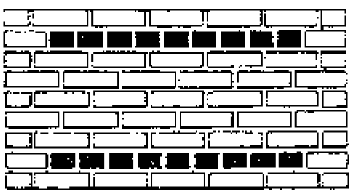
Running Bond



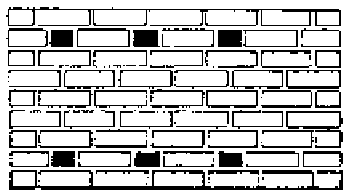
½ Running Bond



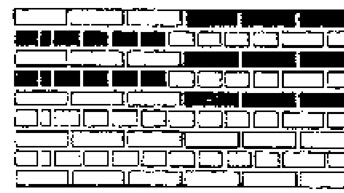
Stack Bond



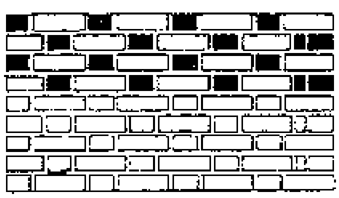
Common Bond
(6" Course Headers)



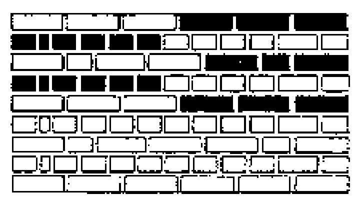
Common Bond
(8" Course Headers)



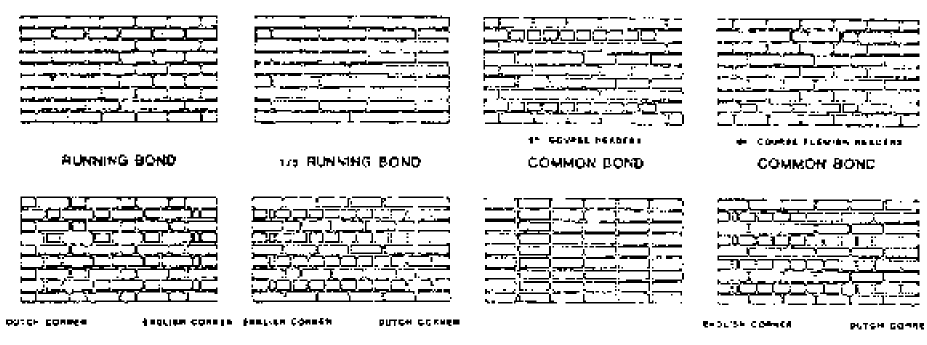
English Corner Dutch Corner
English Bond



Dutch Corner English Corner
Flemish Bond



English Corner Dutch Corner
English Cross or Dutch Bond



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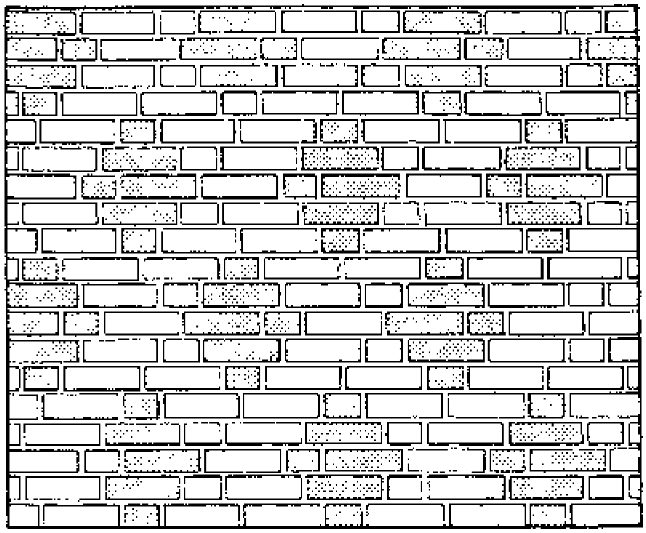
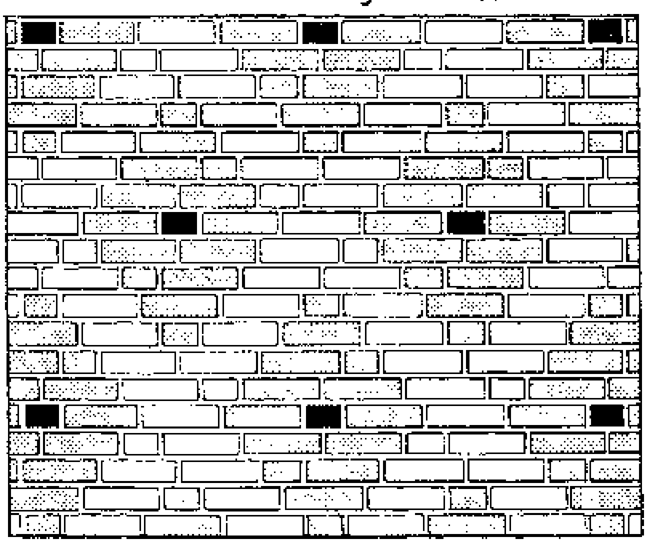
2.2.4 Traditional Bond Patterns (Illustrated)—Continued



Double Stretcher Garden Wall Bond
with Units in Diagonal Lines



Garden Wall Bond with Units in Dovetail Fashion

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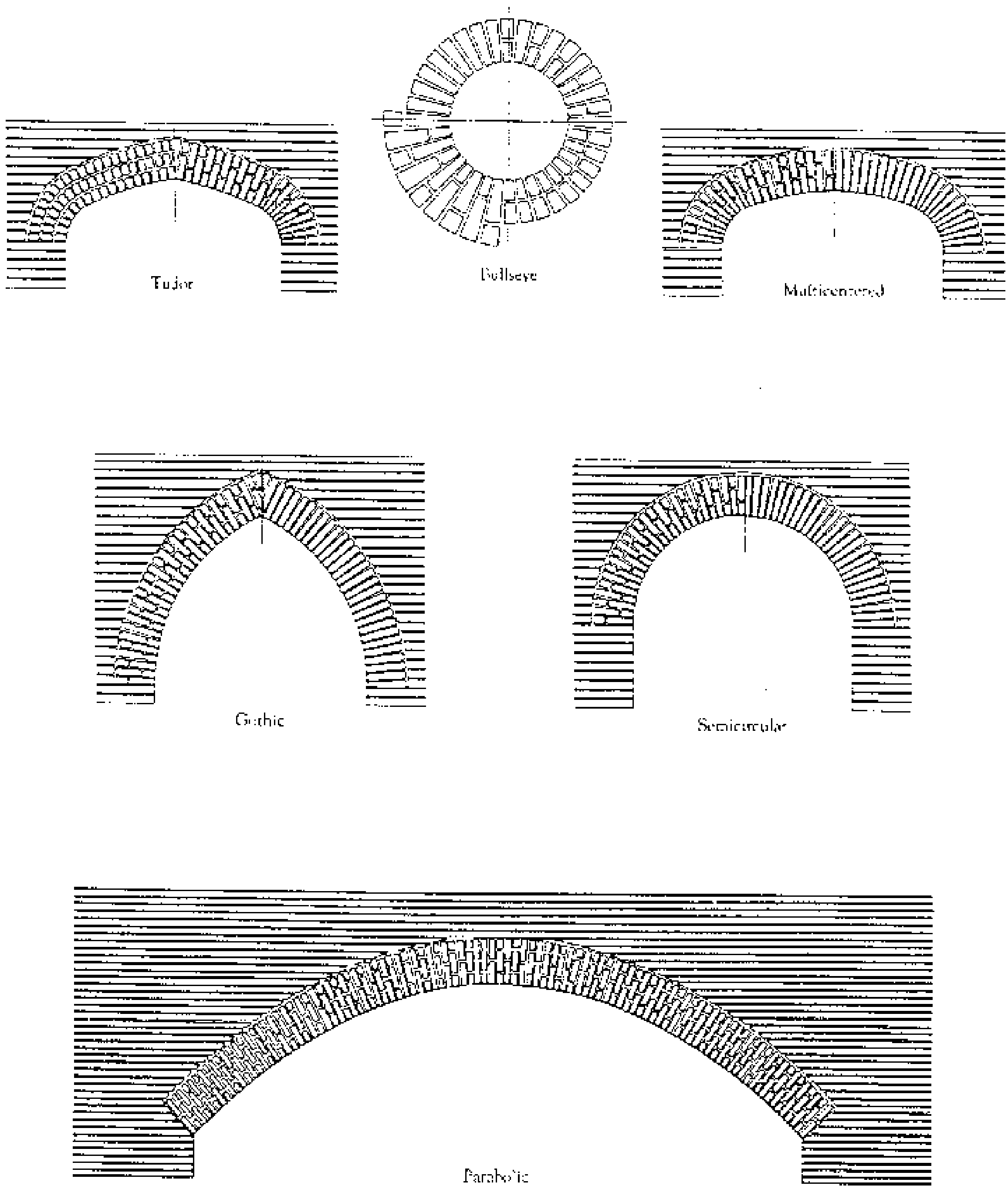
2.2.5 Traditional Bond Patterns Explained

Standard Patterns for brick walls are

- *Running bond* The simplest of all brick structures, this pattern consists of all stretchers. Metal ties are used when this type of wall is used in cavity-wall or veneer-wall construction.
- *Common or American bond* A variation of the running bond, this pattern introduces a course of full-length headers at regular intervals, generally every fifth, sixth, or seventh course.
- *English bond* This pattern consists of alternate courses of headers and stretchers. The headers are centered on the stretchers and joints between stretchers in all courses are aligned vertically.
- *English cross or Dutch bond* This is a variation on the English Bond, but it differs in that vertical joints between the stretchers in alternate courses do not align vertically.

- *Flemish bond* Each course of brick consists of alternate stretchers and headers. Headers in alternate courses are centered over the stretchers in the intervening courses. Half brick or "snapped" headers can be used where structural bonding between two wythes is not required.
- *Block or stacked bond* There is no overlapping of units because all vertical joints are aligned. Generally, this patterned wall is bonded to the backing with rigid steel ties and reinforcement in the horizontal mortar joints.

2.2.6 Brick Arches (Illustrated)



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2.3.0 Estimating Concrete Masonry

NOMINAL LENGTH OF CONCRETE MASONRY WALLS BY STRETCHERS

(Based on units 15⅝" long and half units 7⅝" long with ⅜" thick head joints)

LENGTH OF WALL	NO. OF UNITS	LENGTH OF WALL	NO. OF UNITS	LENGTH OF WALL	NO. OF UNITS	LENGTH OF WALL	NO. OF UNITS	LENGTH OF WALL	NO. OF UNITS	LENGTH OF WALL	NO. OF UNITS
0'-8"	½	20'-8"	15½	40'-8"	30½	60'-8"	45½	80'-8"	60½	100'-8"	75½
1'-4"	1	21'-4"	16	41'-4"	31	61'-4"	46	81'-4"	61	101'-4"	76
2'-0"	1½	22'-0"	16½	42'-0"	31½	62'-0"	46½	82'-0"	61½	102'-0"	76½
2'-8"	2	22'-8"	17	42'-8"	32	62'-8"	47	82'-8"	62	102'-8"	77
3'-4"	2½	23'-4"	17½	43'-4"	32½	63'-4"	47½	83'-4"	62½	103'-4"	77½
4'-0"	3	24'-0"	18	44'-0"	33	64'-0"	48	84'-0"	63	104'-0"	78
4'-8"	3½	24'-8"	18½	44'-8"	33½	64'-8"	48½	84'-8"	63½	104'-8"	78½
5'-4"	4	25'-4"	19	45'-4"	34	65'-4"	49	85'-4"	64	105'-4"	79
6'-0"	4½	26'-0"	19½	46'-0"	34½	66'-0"	49½	86'-0"	64½	106'-0"	79½
6'-8"	5	26'-8"	20	46'-8"	35	66'-8"	50	86'-8"	65	106'-8"	80
7'-4"	5½	27'-4"	20½	47'-4"	35½	67'-4"	50½	87'-4"	65½	107'-4"	80½
8'-0"	6	28'-0"	21	48'-0"	36	68'-0"	51	88'-0"	66	108'-0"	81
8'-8"	6½	28'-8"	21½	48'-8"	36½	68'-8"	51½	88'-8"	66½	108'-8"	81½
9'-4"	7	29'-4"	22	49'-4"	37	69'-4"	52	89'-4"	67	109'-4"	82
10'-0"	7½	30'-0"	22½	50'-0"	37½	70'-0"	52½	90'-0"	67½	110'-0"	82½
10'-8"	8	30'-8"	23	50'-8"	38	70'-8"	53	90'-8"	68	110'-8"	83
11'-4"	8½	31'-4"	23½	51'-4"	38½	71'-4"	53½	91'-4"	68½	111'-4"	83½
12'-0"	9	32'-0"	24	52'-0"	39	72'-0"	54	92'-0"	69	112'-0"	84
12'-8"	9½	32'-8"	24½	52'-8"	39½	72'-8"	54½	92'-8"	69½	112'-8"	84½
13'-4"	10	33'-4"	25	53'-4"	40	73'-4"	55	93'-4"	70	113'-4"	85
14'-0"	10½	34'-0"	25½	54'-0"	40½	74'-0"	55½	94'-0"	70½	114'-0"	85½
14'-8"	11	34'-8"	26	54'-8"	41	74'-8"	56	94'-8"	71	114'-8"	86
15'-4"	11½	35'-4"	26½	55'-4"	41½	75'-4"	56½	95'-4"	71½	115'-4"	86½
16'-0"	12	36'-0"	27	56'-0"	42	76'-0"	57	96'-0"	72	116'-0"	87
16'-8"	12½	36'-8"	27½	56'-8"	42½	76'-8"	57½	96'-8"	72½	116'-8"	87½
17'-4"	13	37'-4"	28	57'-4"	43	77'-4"	58	97'-4"	73	117'-4"	88
18'-0"	13½	38'-0"	28½	58'-0"	43½	78'-0"	58½	98'-0"	73½	118'-0"	88½
18'-8"	14	38'-8"	29	58'-8"	44	78'-8"	59	98'-8"	74	118'-8"	89
19'-4"	14½	39'-4"	29½	59'-4"	44½	79'-4"	59½	99'-4"	74½	119'-4"	89½
20'-0"	15	40'-0"	30	60'-0"	45	80'-0"	60	100'-0"	75	120'-0"	90

NOMINAL HEIGHT OF CONCRETE MASONRY WALLS BY COURSES

(Based on units 7⅝" high and ⅜" thick mortar joints)

HEIGHT OF WALL	NO. OF UNITS	HEIGHT OF WALL	NO. OF UNITS	HEIGHT OF WALL	NO. OF UNITS	HEIGHT OF WALL	NO. OF UNITS
0'-8"	1	8'-8"	13	16'-8"	25	24'-8"	37
1'-4"	2	9'-4"	14	17'-4"	26	25'-4"	38
2'-0"	3	10'-0"	15	18'-0"	27	26'-0"	39
2'-8"	4	10'-8"	16	18'-8"	28	26'-8"	40
3'-4"	5	11'-4"	17	19'-4"	29	27'-4"	41
4'-0"	6	12'-0"	18	20'-0"	30	28'-0"	42
4'-8"	7	12'-8"	19	20'-8"	31	28'-8"	43
5'-4"	8	13'-4"	20	21'-4"	32	29'-4"	44
6'-0"	9	14'-0"	21	22'-0"	33	30'-0"	45
6'-8"	10	14'-8"	22	22'-8"	34	30'-8"	46
7'-4"	11	15'-4"	23	23'-4"	35	31'-4"	47
8'-0"	12	16'-0"	24	24'-0"	36	32'-0"	48

HOW TO USE THESE TABLES

The tables on this page are an aid to estimating and designing with standard concrete masonry units. The following are examples of how they can be used to advantage.

Example:

Estimate the number of units required for a wall 76' long and 12' high.
From table: 76' = 57 units
12' = 18 courses
57 × 18 = 1026 = No. masonry units required

Example:

Estimate the number of units required for a foundation 24' × 30' = 11 courses high.
2 (24 + 30) = 108' = distance for a foundation
From table: 108' = 81 units
81 × 11 = 891 = No. masonry units required.

This table can also be useful in the layout of a building on a modular basis to eliminate cutting of units. Example: If design calls for a wall 41' long it can be found from the table that making this wall 41'-4", will eliminate cutting units and consequent waste. Example: If the distance between two openings has been tentatively established at 2'-9", consulting the table will show that 2'-8" dimension would eliminate cutting of units.

2.3.1 Horizontal Brick Coursing

Number of Units	Unit Length[1]					
	Nominal Dimensions, in.		Specified Dimensions, in.			
	8	12	8		8⅝	9⅝
			½ in. jt.	⅜ in. jt.	⅜ in. jt.	⅜ in. jt.
1	0'-8"	1'-0"	0'-8½"	0'-8⅜"	0'-9"	0'-10"
2	1'-4"	2'-0"	1'-5"	1'-4¾"	1'-6"	1'-8"
3	2'-0"	3'-0"	2'-1½"	2'-1⅛"	2'-3"	2'-6"
4	2'-8"	4'-0"	2'-10"	2'-9½"	3'-0"	3'-4"
5	3'-4"	5'-0"	3'-6½"	3'-5⅞"	3'-9"	4'-2"
6	4'-0"	6'-0"	4'-3"	4'-2¼"	4'-6"	5'-0"
7	4'-8"	7'-0"	4'-11½"	4'-10⅝"	5'-3"	5'-10"
8	5'-4"	8'-0"	5'-8"	5'-7"	6'-0"	6'-8"
9	6'-0"	9'-0"	6'-4½"	6'-3⅜"	6'-9"	7'-6"
10	6'-8"	10'-0"	7'-1"	6'-11¾"	7'-6"	8'-4"
11	7'-4"	11'-0"	7'-9½"	7'-8⅛"	8'-3"	9'-2"
12	8'-0"	12'-0"	8'-6"	8'-4½"	9'-0"	10'-0"
13	8'-8"	13'-0"	9'-2½"	9'-0⅞"	9'-9"	10'-10"
14	9'-4"	14'-0"	9'-11"	9'-9¼"	10'-6"	11'-8"
15	10'-0"	15'-0"	10'-7½"	10'-5⅝"	11'-3"	12'-6"
16	10'-8"	16'-0"	11'-4"	11'-2"	12'-0"	13'-4"
17	11'-4"	17'-0"	12'-0½"	11'-10⅜"	12'-9"	14'-2"
18	12'-0"	18'-0"	12'-9"	12'-6¾"	13'-6"	15'-0"
19	12'-8"	19'-0"	13'-5½"	13'-3⅛"	14'-3"	15'-10"
20	13'-4"	20'-0"	14'-2"	13'-11½"	15'-0"	16'-8"
21	14'-0"	21'-0"	14'-10½"	14'-7⅞"	15'-9"	17'-6"
22	14'-8"	22'-0"	15'-7"	15'-4¼"	16'-6"	18'-4"
23	15'-4"	23'-0"	16'-3½"	16'-0⅝"	17'-3"	19'-2"
24	16'-0"	24'-0"	17'-0"	16'-9"	18'-0"	20'-0"
25	16'-8"	25'-0"	17'-8½"	17'-5⅜"	18'-9"	20'-10"
26	17'-4"	26'-0"	18'-5"	18'-1¾"	19'-6"	21'-8"
27	18'-0"	27'-0"	19'-1½"	18'-10⅛"	20'-3"	22'-6"
28	18'-8"	28'-0"	19'-10"	19'-6½"	21'-0"	23'-4"
29	19'-4"	29'-0"	20'-6½"	20'-2⅞"	21'-9"	24'-2"
30	20'-0"	30'-0"	21'-3"	20'-11¼"	22'-6"	25'-0"
31	20'-8"	31'-0"	21'-11½"	21'-7⅝"	23'-3"	25'-10"
32	21'-4"	32'-0"	22'-8"	22'-4"	24'-0"	26'-8"
33	22'-0"	33'-0"	23'-4½"	23'-0⅜"	24'-9"	27'-6"
34	22'-8"	34'-0"	24'-1"	23'-8¾"	25'-6"	28'-4"
35	23'-4"	35'-0"	24'-9½"	24'-5⅛"	26'-3"	29'-2"
36	24'-0"	36'-0"	25'-6"	25'-1½"	27'-0"	30'-0"
37	24'-8"	37'-0"	26'-2½"	25'-9⅞"	27'-9"	30'-10"
38	25'-4"	38'-0"	26'-11"	26'-6¼"	28'-6"	31'-8"
39	26'-0"	39'-0"	27'-7½"	27'-2⅝"	29'-3"	32'-6"
40	26'-8"	40'-0"	28'-4"	27'-11"	30'-0"	33'-4"
41	27'-4"	41'-0"	29'-0½"	28'-7⅜"	30'-9"	34'-2"
42	28'-0"	42'-0"	29'-9"	29'-3¾"	31'-6"	35'-0"
43	28'-8"	43'-0"	30'-5½"	30'-0⅛"	32'-3"	35'-10"
44	29'-4"	44'-0"	31'-2"	30'-8½"	33'-0"	36'-8"
45	30'-0"	45'-0"	31'-10½"	31'-4⅞"	33'-9"	37'-6"
46	30'-8"	46'-0"	32'-7"	32'-1¼"	34'-6"	38'-4"
47	31'-4"	47'-0"	33'-3½"	32'-9⅝"	35'-3"	39'-2"
48	32'-0"	48'-0"	34'-0"	33'-6"	36'-0"	40'-0"
49	32'-8"	49'-0"	34'-8½"	34'-2⅜"	36'-9"	40'-10"
50	33'-4"	50'-0"	35'-5"	34'-10¾"	37'-6"	41'-8"
100	66'-8"	100'-0"	70'-10"	69'-8½"	75'-0"	83'-4"

[1] 1 in. = 25.4 mm; 1 ft = 0.3 m

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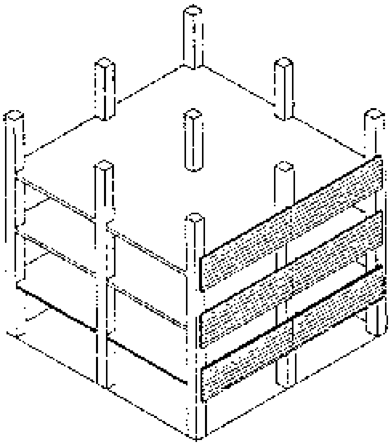
2.3.2 Nominal Height of Brick and Block Walls by Coursing

COURSES	REGULAR 4 2¼" bricks + 4 equal joints =					MODULAR 3 bricks + 3 joints =	CONCRETE BLOCKS	
	10" ¼" joints	10½" ⅜" joints	11" ½" joints	11½" ⅝" joints	12" ¾" joints	8"	3⅝" blocks ⅜" joints	7⅝" blocks ⅜" joints
1	2½"	2⅝"	2¾"	2⅞"	3"	2 11/16"	4"	8"
2	5"	5¼"	5½"	5¾"	6"	5 5/16"	8"	1'4"
3	7½"	7⅞"	8¼"	8⅝"	9"	8"	1'0"	2'0"
4	10"	10½"	11"	11½"	1'0"	10 11/16"	1'4"	2'8"
5	1'0½"	1'1⅛"	1'1¾"	1'2⅜"	1'3"	1'1 5/16"	1'8"	3'4"
6	1'3"	1'3¾"	1'4½"	1'5¼"	1'6"	1'4"	2'0"	4'0"
7	1'5½"	1'6⅜"	1'7¼"	1'8⅛"	1'9"	1'6 11/16"	2'4"	4'8"
8	1'8"	1'9"	1'10"	1'11"	2'0"	1'9 5/16"	2'8"	5'4"
9	1'10½"	1'11⅝"	2'0¾"	2'1⅞"	2'3"	2'0"	3'0"	6'0"
10	2'1"	2'2¼"	2'3½"	2'4¾"	2'6"	2'2 11/16"	3'4"	6'8"
11	2'3½"	2'4⅞"	2'6¼"	2'7⅝"	2'9"	2'5 5/16"	3'8"	7'4"
12	2'6"	2'7½"	2'9"	2'10½"	3'0"	2'8"	4'0"	8'0"
13	2'8½"	2'10⅛"	2'11¾"	3'1⅜"	3'3"	2'10 11/16"	4'4"	8'8"
14	2'11"	3'0¾"	3'2½"	3'4¼"	3'6"	3'1 5/16"	4'8"	9'4"
15	3'1½"	3'3⅜"	3'5¼"	3'7⅛"	3'9"	3'4"	5'0"	10'0"
16	3'4"	3'6"	3'8"	3'10"	4'0"	3'6 11/16"	5'4"	10'8"
17	3'6½"	3'8⅝"	3'10¾"	4'0⅞"	4'3"	3'9 5/16"	5'8"	11'4"
18	3'9"	3'11¼"	4'1½"	4'3¾"	4'6"	4'0"	6'0"	12'0"
19	3'11½"	4'1⅞"	4'4¼"	4'6⅝"	4'9"	4'2 11/16"	6'4"	12'8"
20	4'2"	4'4½"	4'7"	4'9½"	5'0"	4'5 5/16"	6'8"	13'4"
21	4'4½"	4'7⅛"	4'9¾"	5'0⅜"	5'3"	4'8"	7'0"	14'0"
22	4'7"	4'9¾"	5'0½"	5'3¼"	5'6"	4'10 11/16"	7'4"	14'8"
23	4'9½"	5'0⅜"	5'3¼"	5'6⅛"	5'9"	5'1 5/16"	7'8"	15'4"
24	5'0"	5'3"	5'6"	5'9"	6'0"	5'4"	8'0"	16'0"
25	5'2½"	5'5⅝"	5'8¾"	5'11⅞"	6'3"	5'6 11/16"	8'4"	16'8"
26	5'5"	5'8¼"	5'11½"	6'2¾"	6'6"	5'9 5/16"	8'8"	17'4"
27	5'7½"	5'10⅞"	6'2¼"	6'5⅝"	6'9"	6'0"	9'0"	18'0"
28	5'10"	6'1½"	6'5"	6'8½"	7'0"	6'2 11/16"	9'4"	18'8"
29	6'0½"	6'4⅛"	6'7¾"	6'11⅜"	7'3"	6'5 5/16"	9'8"	19'4"
30	6'3"	6'6¾"	6'10½"	7'2¼"	7'6"	6'8"	10'0"	20'0"
31	6'5½"	6'9⅜"	7'1¼"	7'5⅛"	7'9"	6'10 11/16"	10'4"	20'8"
32	6'8"	7'0"	7'4"	7'8"	8'0"	7'1 5/16"	10'8"	21'4"
33	6'10½"	7'2⅝"	7'6¾"	7'10⅞"	8'3"	7'4"	11'0"	22'0"
34	7'1"	7'5¼"	7'9½"	8'1¾"	8'6"	7'6 11/16"	11'4"	22'8"
35	7'3½"	7'7⅞"	8'0¼"	8'4⅝"	8'9"	7'9 5/16"	11'8"	23'4"
36	7'6"	7'10½"	8'3"	8'7½"	9'0"	8'0"	12'0"	24'0"
37	7'8½"	8'1⅛"	8'5¾"	8'10⅜"	9'3"	8'2 11/16"	12'4"	24'8"
38	7'11"	8'3¾"	8'8½"	9'1¼"	9'6"	8'5 5/16"	12'8"	25'4"
39	8'1½"	8'6⅜"	8'11¼"	9'4⅛"	9'9"	8'8"	13'0"	26'0"
40	8'4"	8'9"	9'2"	9'7"	10'0"	8'10 11/16"	13'4"	26'8"
41	8'6½"	8'11⅝"	9'4¾"	9'9⅞"	10'3"	9'1 5/16"	13'8"	27'4"
42	8'9"	9'2¼"	9'7½"	10'0¾"	10'6"	9'4"	14'0"	28'0"
43	8'11½"	9'4⅞"	9'10¼"	10'3⅝"	10'9"	9'6 11/16"	14'4"	28'8"
44	9'2"	9'7½"	10'1"	10'6½"	11'0"	9'9 5/16"	14'8"	29'4"
45	9'4½"	9'10⅛"	10'3¾"	10'9⅜"	11'3"	10'0"	15'0"	30'0"
46	9'7"	10'0¾"	10'6½"	11'0¼"	11'6"	10'2 11/16"	15'4"	30'8"
47	9'9½"	10'3⅜"	10'9¼"	11'3⅛"	11'9"	10'5 5/16"	15'8"	31'4"
48	10'0"	10'6"	11'0"	11'6"	12'0"	10'8"	16'0"	32'0"
49	10'2½"	10'8⅝"	11'2¾"	11'8⅞"	12'3"	10'10 11/16"	16'4"	32'8"
50	10'5"	10'11¼"	11'5½"	11'11¾"	12'6"	11'1 5/16"	16'8"	33'4"

2.4.0 Typical Atlas Brick Construction



1. PREFABRICATED* PANEL CURTAIN WALL SYSTEM

Description: Panels are "hung" from the structural frame to provide the curtain wall. All loads are transferred to the frame or load bearing system.

*The panels may be prefabricated, or laid-in-place.

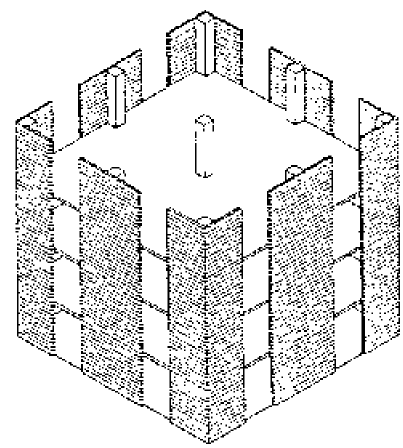
Advantages: 1) Essentially a veneer system, without expensive back-up or exposed supporting steel angles required.

2) Allows frame structure and curtain wall fabrication to proceed independently.

3) Prefabrication allows off-site masonry construction for "tight" jobsites.

Applications: Most economical where there is a significant amount of repetitive design elements (i.e., spandrels, soffits, lintels, or column cover elements). Brick panels can be the entire exterior cladding, or be used in conjunction with other systems where convenient (load bearing, structural skin, pre-cast concrete systems, etc.). Panels are adaptable to any construction form.

Prefabricated panels also allow a high degree of aesthetic flexibility.



2. STRUCTURAL "SKIN" (CURTAIN WALL)

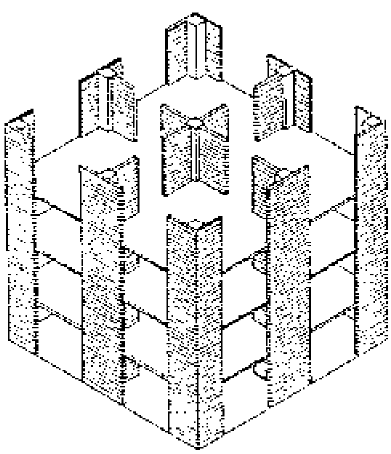
Description: The building structure is a load bearing moment-resisting space frame. Reinforced, grouted Atlas Brick is supported at the foundation, and tied laterally to the building frame.

Advantages: 1) Allows independent construction of the load bearing, moment frame and brick skin, requiring less trade coordination.

2) Eliminates traditional veneer support angles and back-up wall systems.

3) Provides a more structurally stable cladding system than traditional unreinforced masonry (particularly in earthquake areas).

Applications: Universally applied on single- or multi-story buildings, wherever a frame structure is used and the economic and aesthetic demands of exposed face brick is desired.



3. DUAL FRAMING SYSTEM

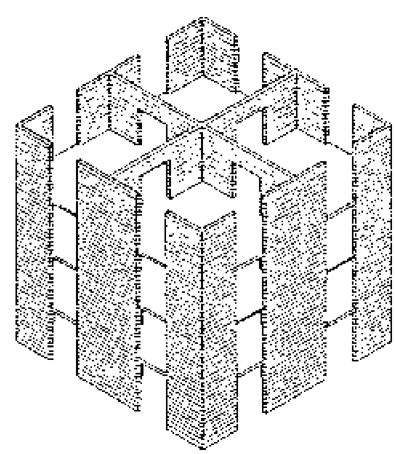
Description: This system uses a load bearing space frame that is designed to carry the gravity loads as well as 25% of the shear load.

Reinforced, grouted Atlas Brick walls serve as the shear resisting elements, and are designed to carry the full lateral load.

Advantages: 1) Allows independent construction of frame and shear wall systems. Amount of trade coordination is decreased.

2) The complexity of the frame construction is decreased since only 25% of the shear load is transferred through the frame connections.

Applications: Used on any structure where there is frame and shear wall construction acting together to resist design loads.



4. LOAD BEARING SHEAR WALL SYSTEM

Description. All gravity dead loads, live loads, and lateral loadings due to earthquake or wind are resisted by the reinforced grouted Atlas Brick walls, in conjunction with the structural floor diaphragm.

Advantages: Economy results from multiple use of structural elements. The brick walls serve as:

1) structure
2) space partitions (finished walls)
3) fire separations
4) sound partitions
5) exterior finish

Applications: Used on single & multi story structures where there are a number of walls that can carry the vertical and horizontal loads, especially apartment buildings, hotels, single story structures like warehouses, shopping centers, etc.

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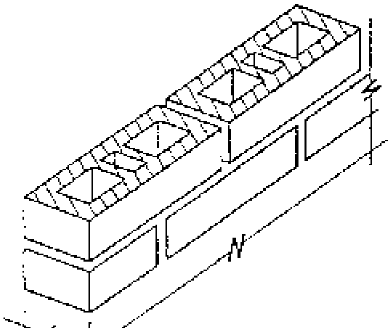
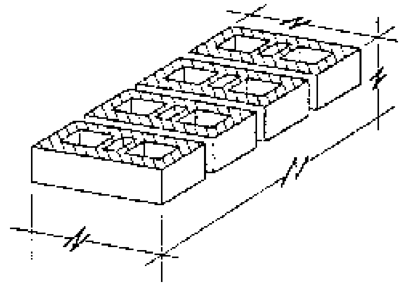
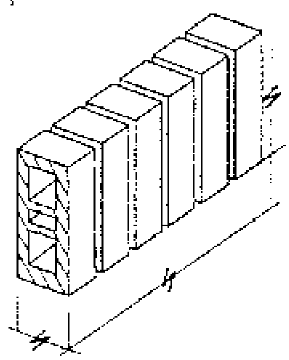
2.4.1 Brick Orientation (Illustrated)



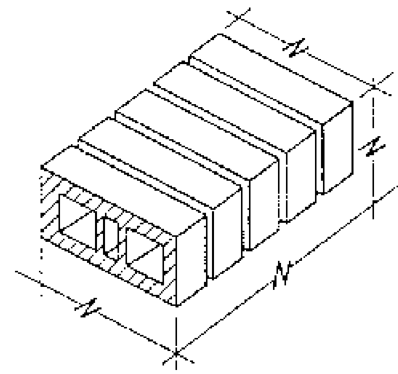
STRETCHER COURSE



HEADER COURSE

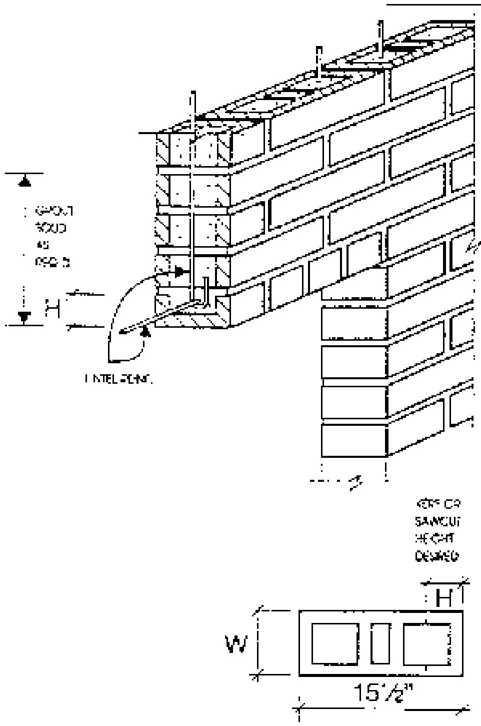


SOLDIER COURSE

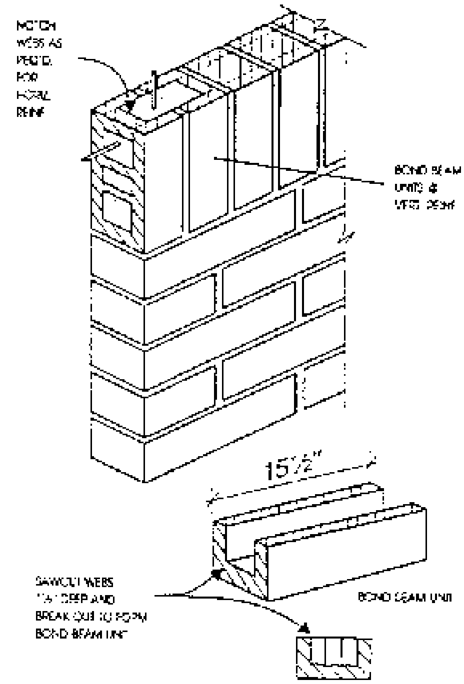


ROWLOCK COURSE

SPECIAL REINFORCING



LINTEL BEAM



SOLDIER COURSE

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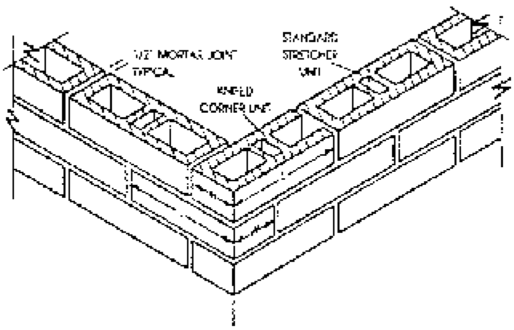
2.4.2 Corner, Beam, and Jamb Details

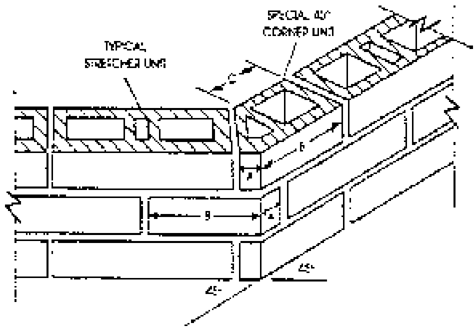
CORNER DETAILS

W (Wall Width)	L (Corner Unit Length)
3½"	11½"
5½"	15½"
7½"	15½" (Reg. Stretcher Unit, No Knifed Corner Req'd.)

W (Wall Width)	A	B	C
3½"	1¼"	9¾"	7¼"
5½"	2¼"	10¼"	7¼"
7½"	2¾"	10¾"	7¼"

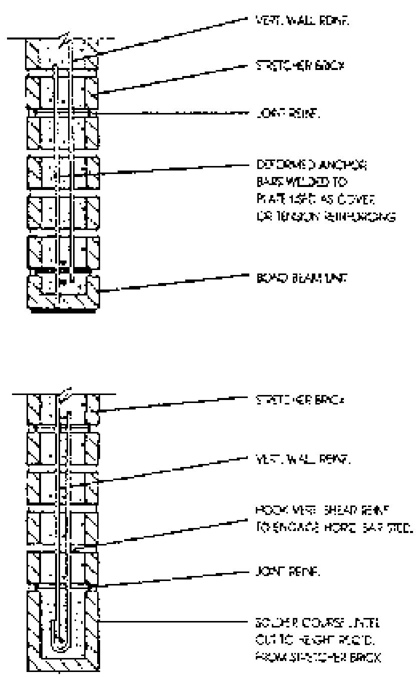


90° CORNER

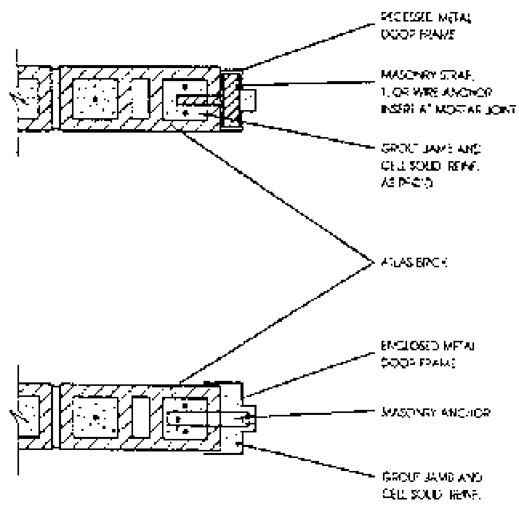


45° CORNER

BEAM AND JAMB OPTIONS



LINTEL BEAM OPTIONS



DOOR JAMB OPTIONS

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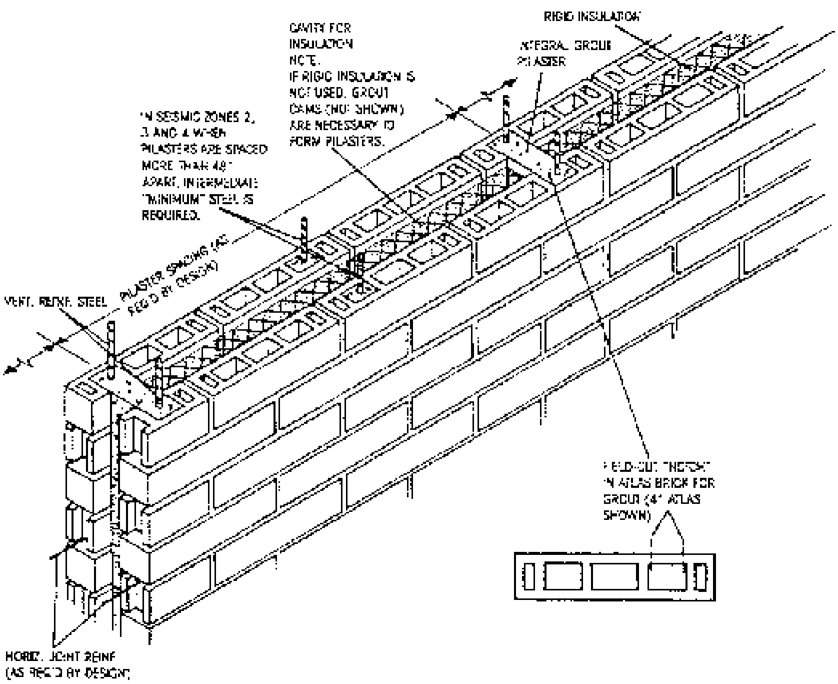
2.4.3 Pilaster and Parapet Wall Details

"INTEGRAL PILASTER" CONCEPT



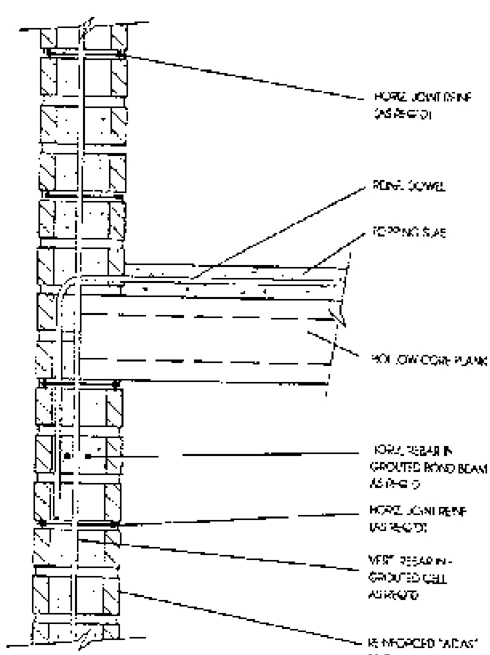
INTEGRAL PILASTER WALL

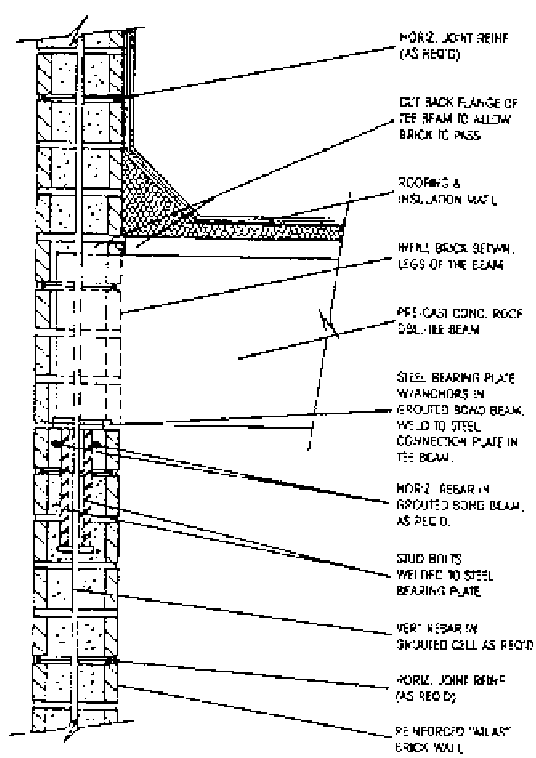
Description: a "Hybrid" system using a double wythe, insulated cavity wall and grouted pilasters or piers forming the structural tie between the brick wythes.

Advantages: Combines the appearance of two-faced brick construction while allowing a cavity of rigid board insulation to fulfill superior high insulation requirements. The interior and exterior brick mass also aids in the thermal performance of this wall system.

Applications: This wall system can be used in load bearing applications (gymnasium, auditoriums, etc.) or anywhere a highly insulated (high R value) double face, structural brick "sandwich" wall is required.

Note: This Atlas system requires a complete rational analysis to determine particular application acceptability. Local codes may or may not provide for this structural system. A complete detail of this wall is described in the paper "High, Thin Brick Walls That Can Beat The Energy Crunch," Donald A. Wakefield, P.E., 5th International Brick Masonry Conference, Washington, D.C., October, 1979.





SECTION @ ROOF

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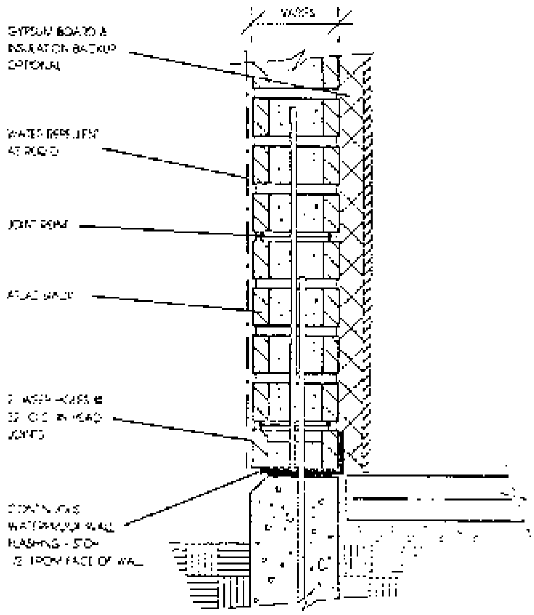
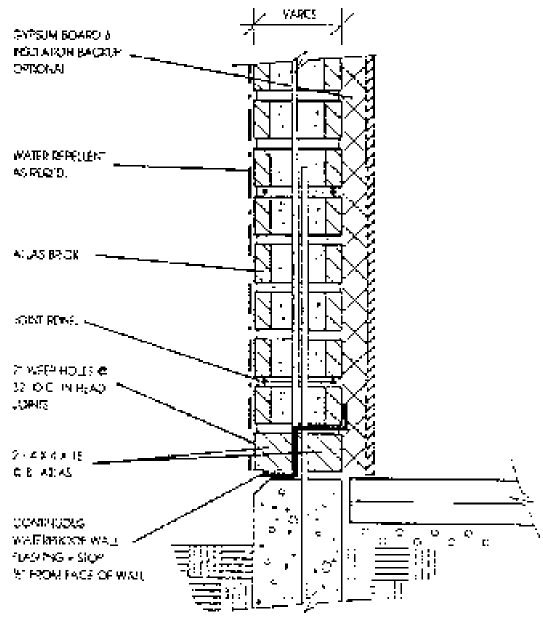
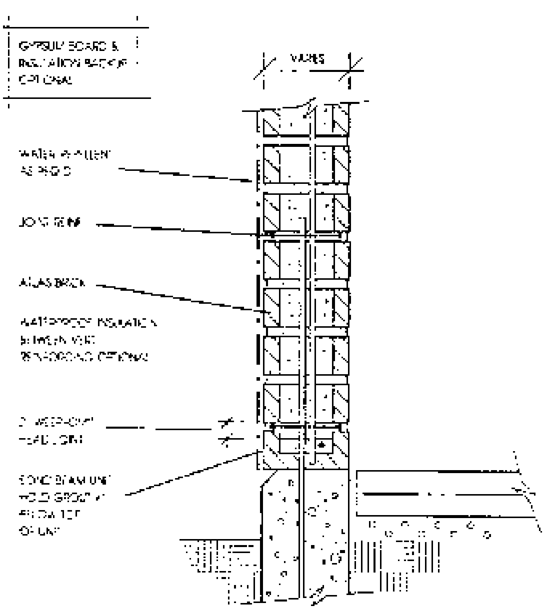
2.4.4 Flashing Details



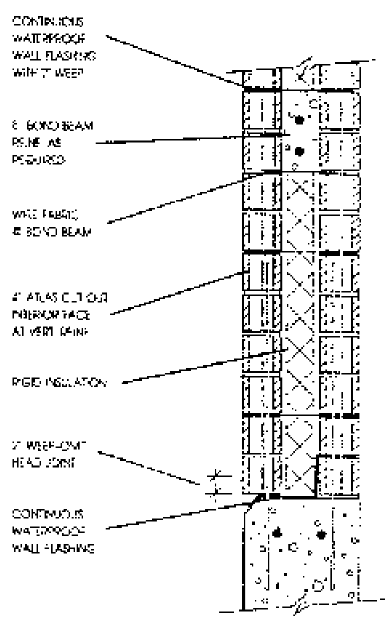
SINGLE UNIT BASE WITH FLASHING



DOUBLE UNIT BASE WITH FLASHING



SINGLE UNIT BASE W/O FLASHING



INTEGRAL PILASTER WITH FLASHING

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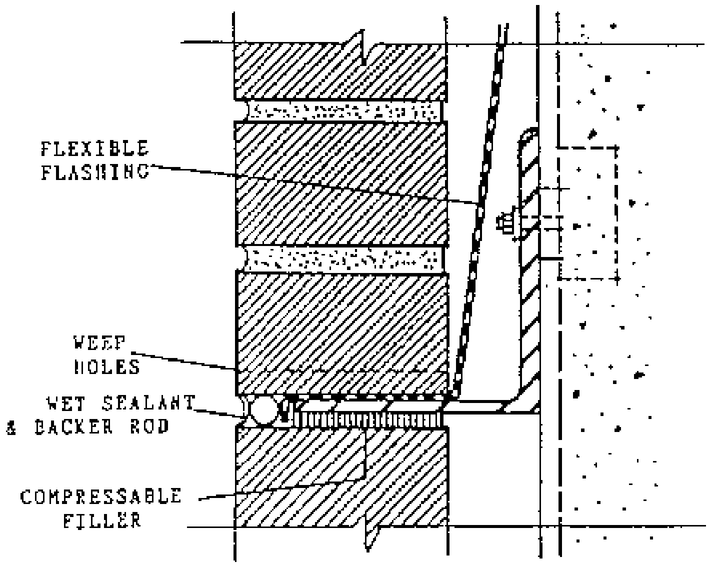
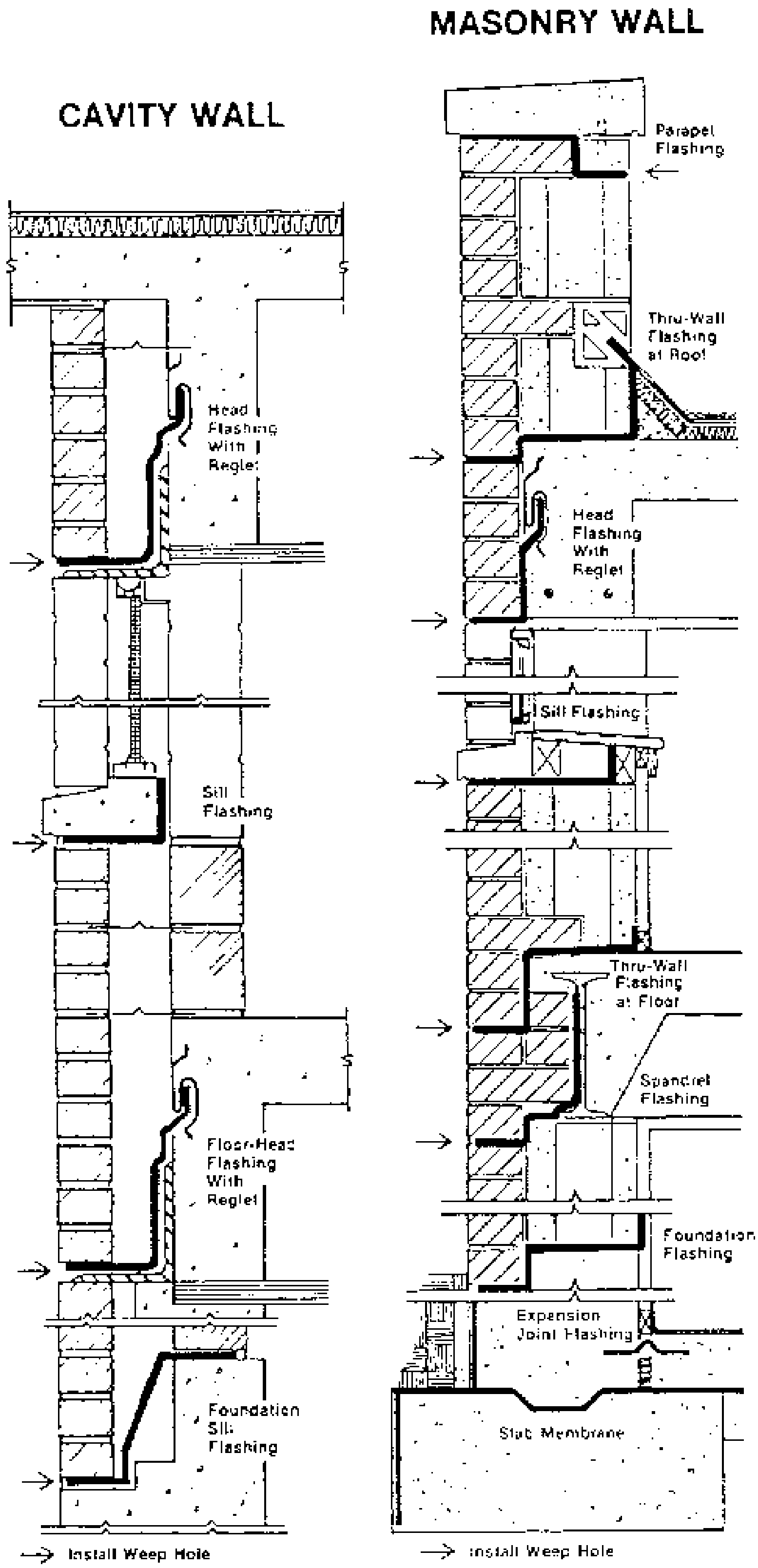
2.4.5 Flashing and Caulking Details at Brick-Relieving Angles



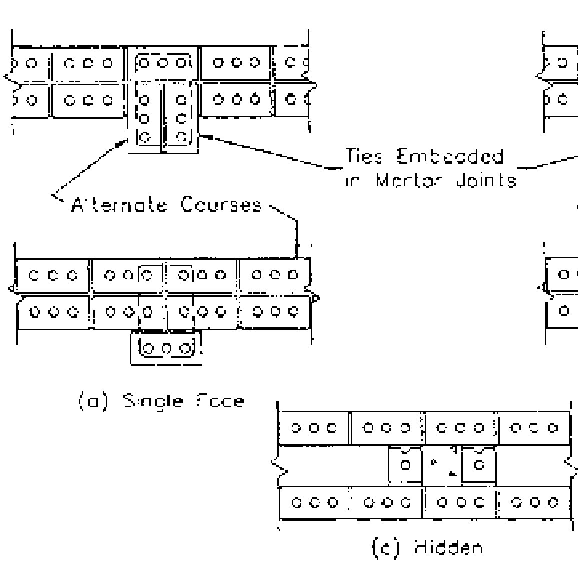
Flexible flashing terminated behind wet sealant & backer rod.

2.4.6 Miscellaneous Metal Flashing Details

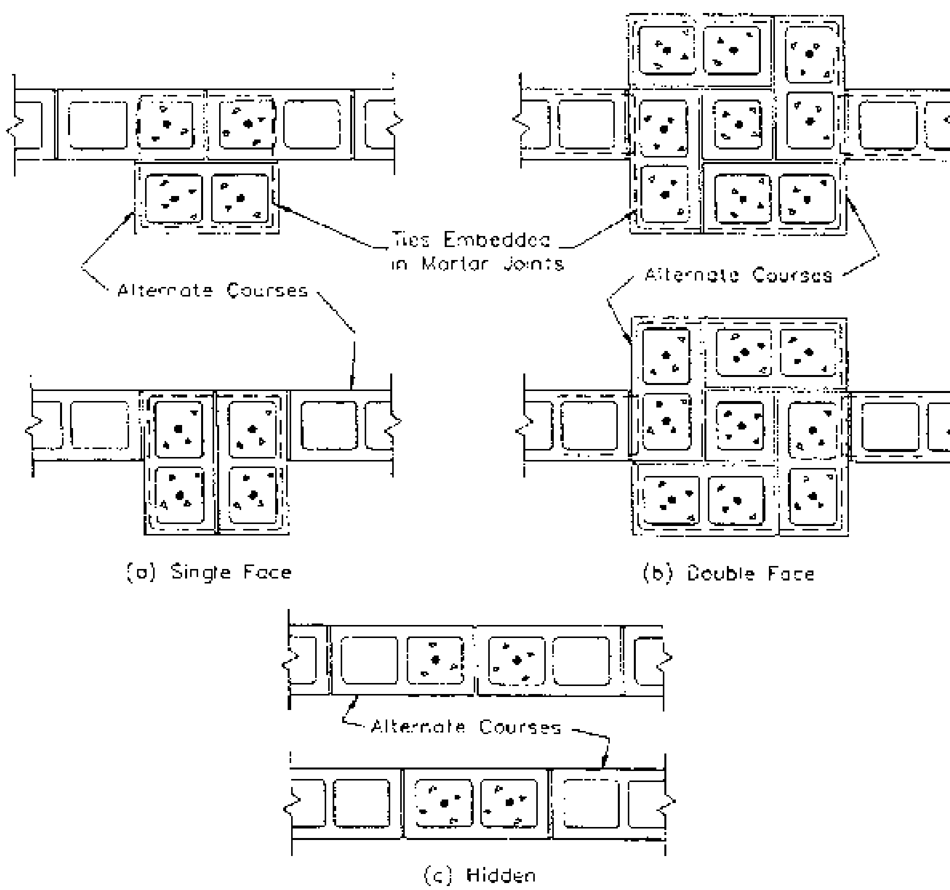
Metal flashing details for cavity and block back-up brick wall.



2.4.7 Pilaster Details



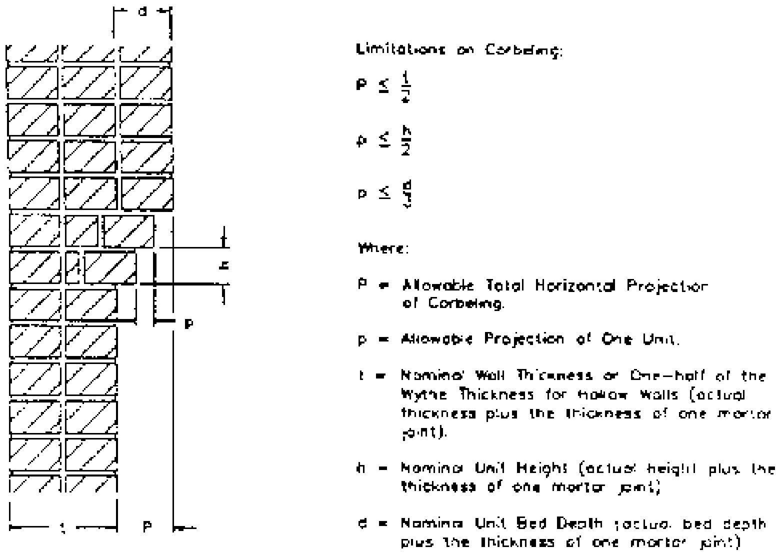
Brick Pilasters



Block Pilasters

(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

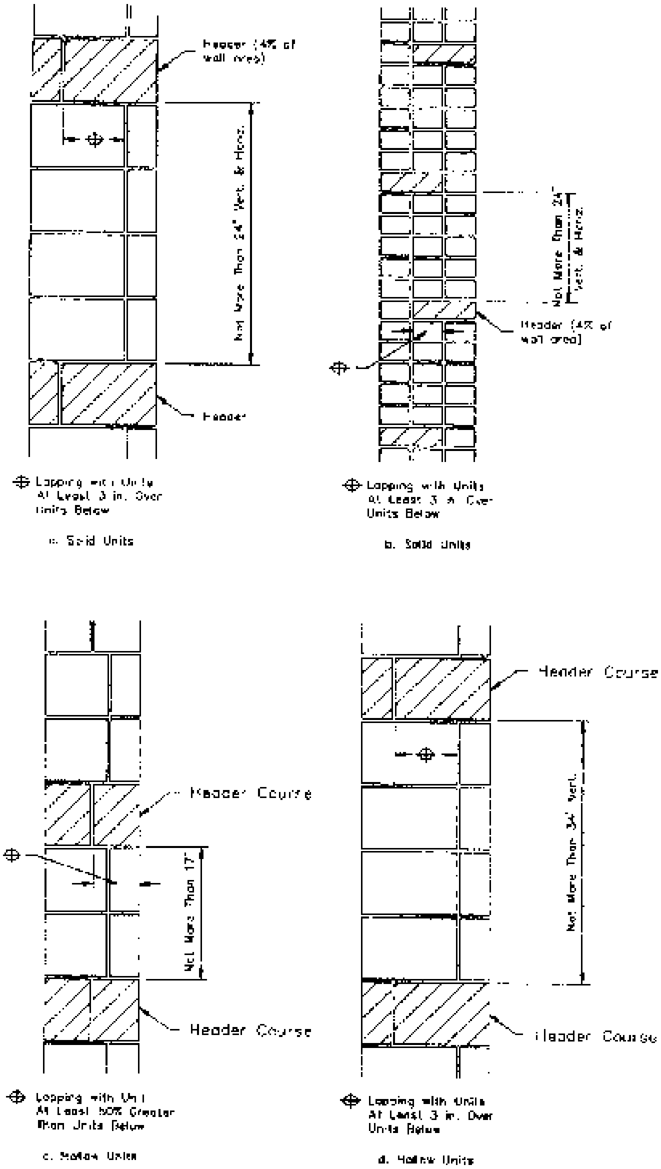
2.4.8 Corbeling Limitations



Limitations on corbeling

(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

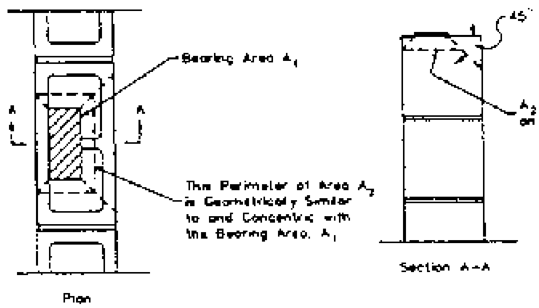
2.4.9 Wall-Elevation Sections



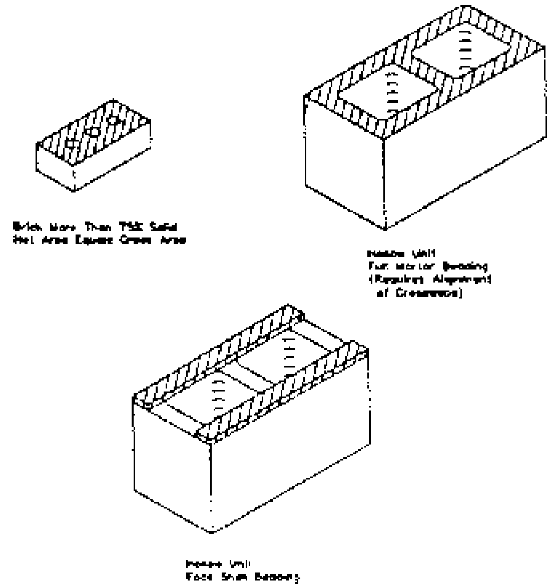
Cross section of wall elevations

(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

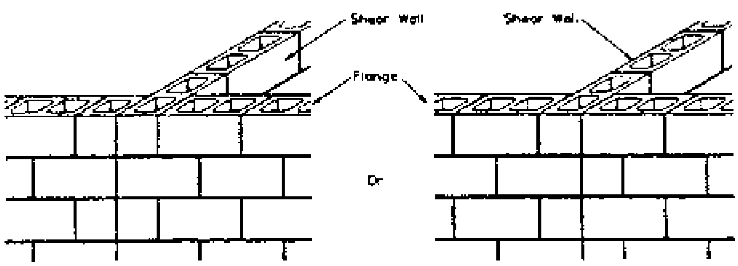
2.4.10 Bearing Areas, Running Bond at Intersections



Bearing areas



Net cross-sectional areas



Running bond lap at intersection

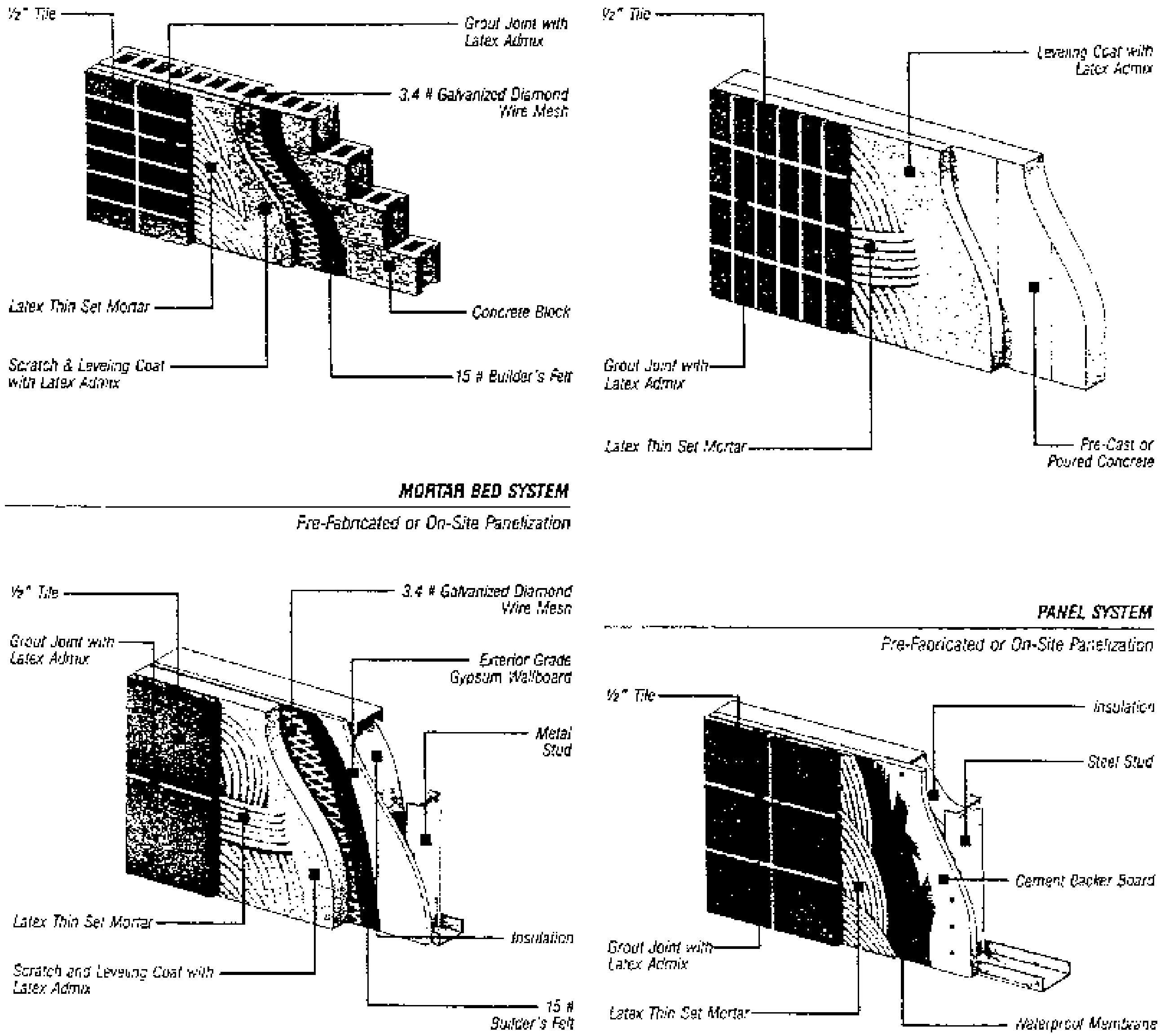
(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

2.5.0 Tile Wall Systems

Innovative wall systems, utilizing thin tile as wall coverings, provide exciting design opportunities in today's competitive building market. Various concepts (see schematics), either prefabricated as panels in the factory or set-in-place on site, offer numerous wall-system options. Design assistance and cost analysis are available through local tile contractors or panel fabricators.

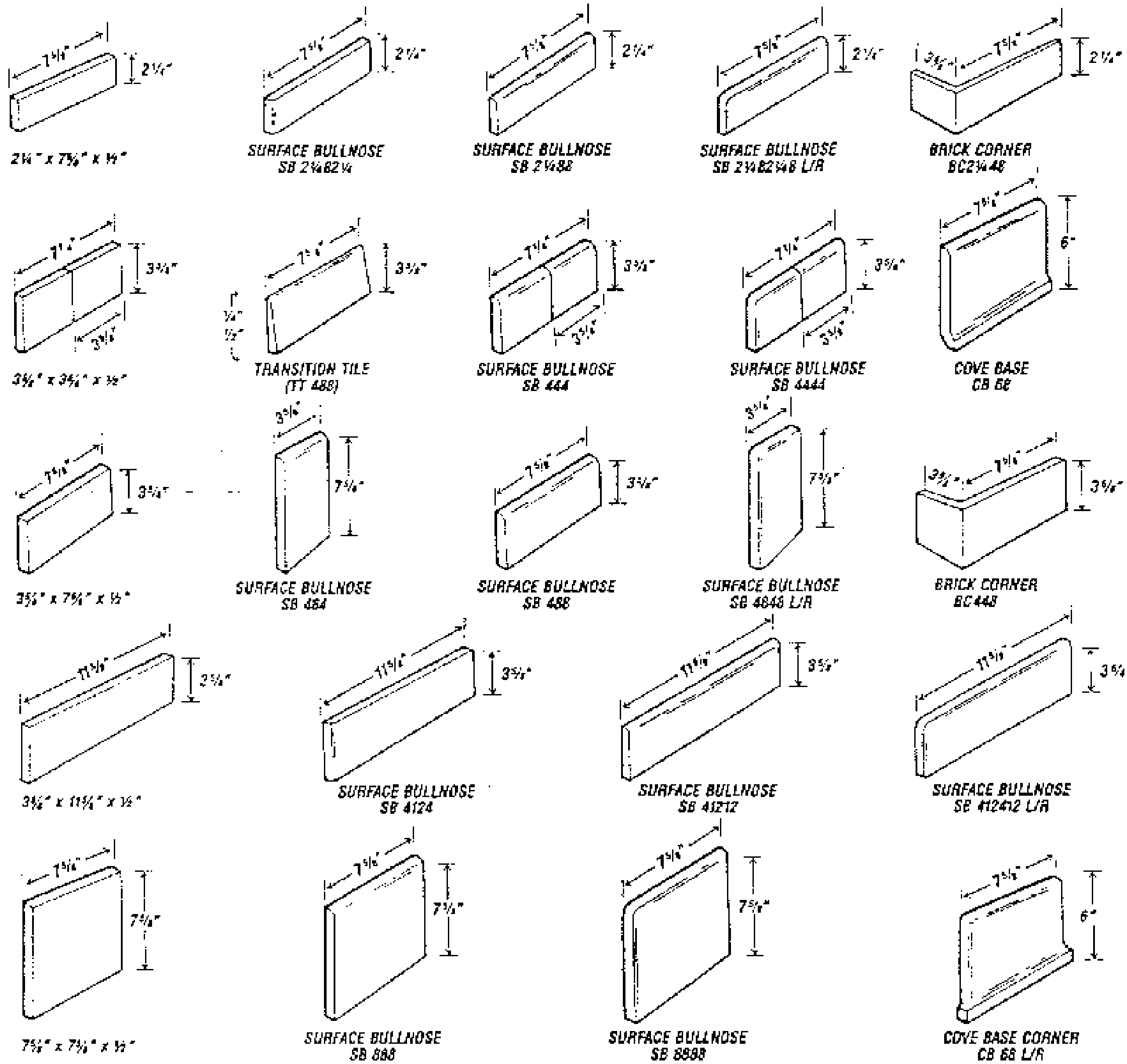
Tile Cladding Benefits:

- Design freedom
- Lightweight construction
- Quick installation
- Economical in-place cost
- Durability and fire resistance
- Increased insulation value
- All-weather construction



Tile wall systems. *(By permission of Endicott Clay Products Co., Fairbury, Nebraska.)*

2.5.1 Standard Tile-Cladding Shapes



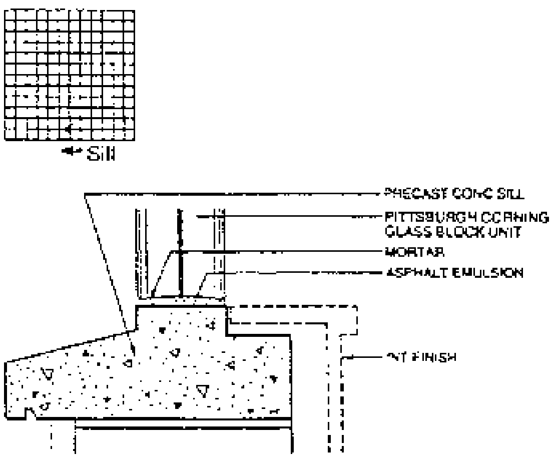
(By permission of Endicott Clay Products Co., Fairbury, Nebraska.)

2.6.0 Glass Block—Typical Sill Details

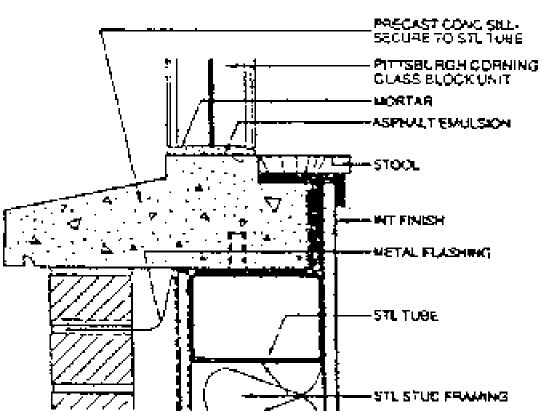
Glass block is often used in building construction; however, installation details vary considerably from brick- or block-wall construction.

2.6.0.1 Glass-Block—Typical Sill Details (Illustrated)

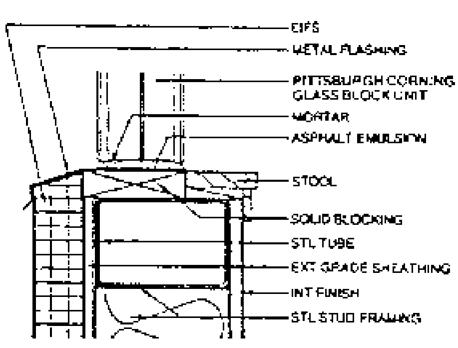
Typical Sill Details
Exterior Openings



Sill - Glass Block in CMU Wall (PCD 006) Fire Rated

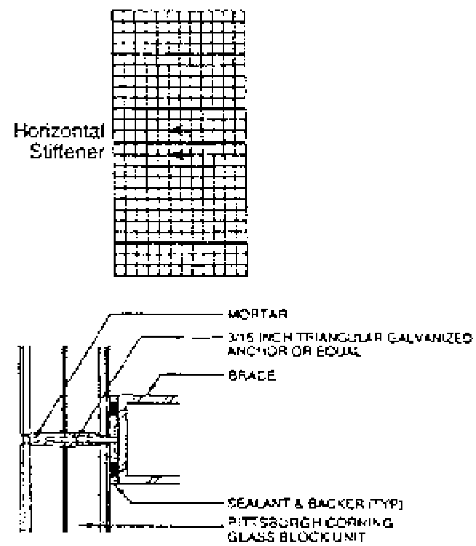


Sill - Glass Block in Steel Stud Wall with Brick Veneer (PCD 063)

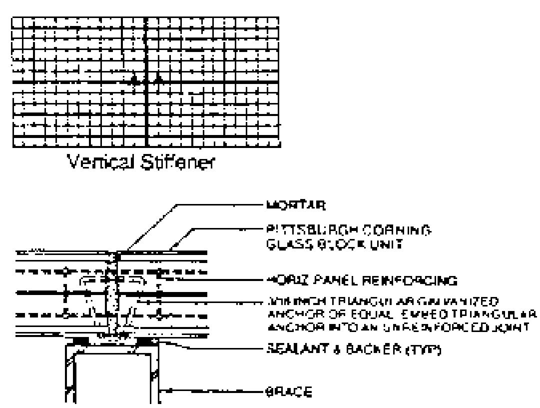


Sill - Glass Block in Steel Stud Wall with Synthetic Plaster Finish (PCD 033)

Typical Mortared Stiffener Details
250 Sq. Ft Panels



Intermediate Horizontal Brace in Glass Block Panel (PCD 089)

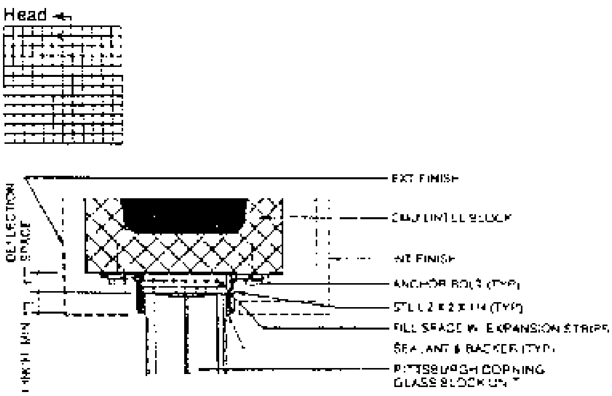


Intermediate Vertical Brace in Glass Block Panel (PCD 088)

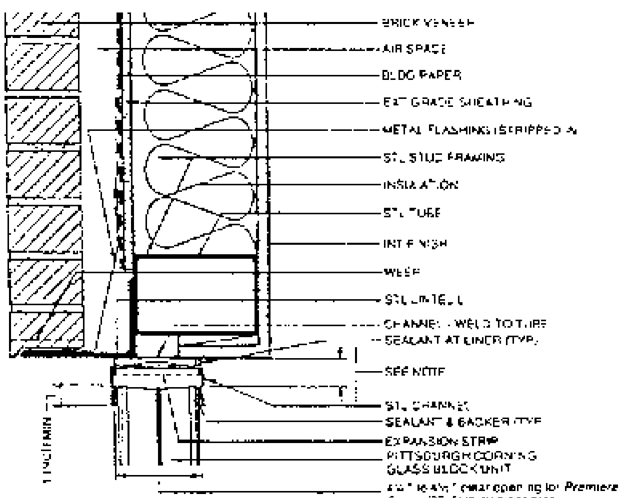
(By permission of Pittsburgh Corning Glass Block, Pittsburgh, Pennsylvania.)

2.6.1 Glass Block (Typical Head and Jamb Details)

Typical Head Details
Exterior Openings

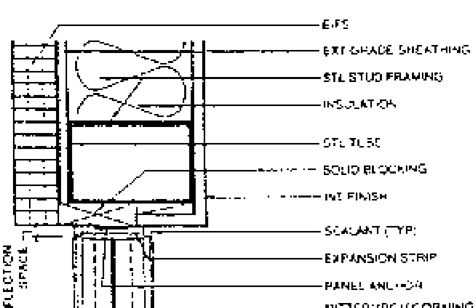


Head - Glass Block in CMU Wall (PCD 004) Fire Rated



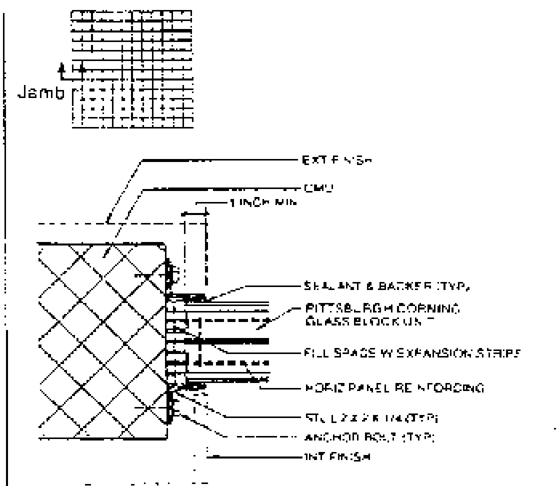
NOTE: This dimension is determined by the anticipated deflection of the structural member above the glass block.

Head - Glass Block in Steel Stud Wall with Brick Veneer (PCD 061)

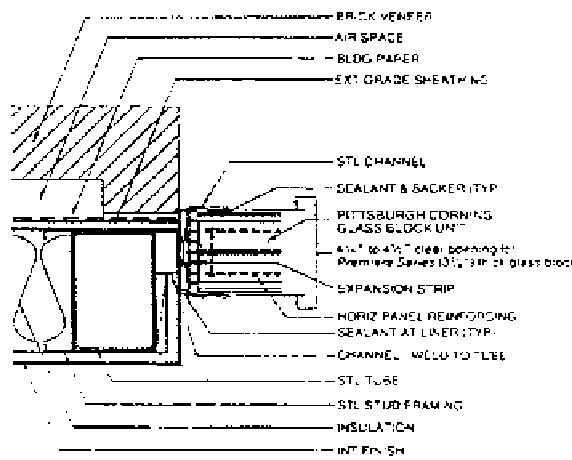


Head - Glass Block in Steel Stud Wall with Synthetic Plaster Finish (PCD 031)

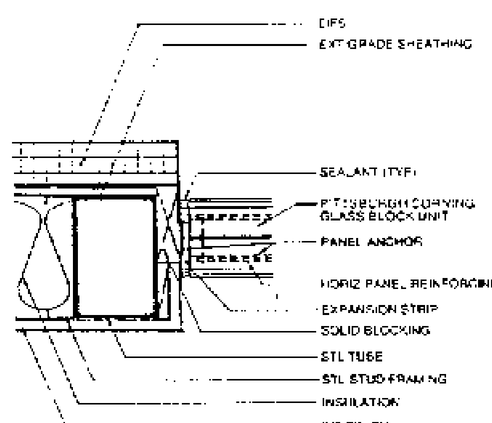
Typical Jamb Details
Exterior Openings



Jamb - Glass Block in CMU Wall (PCD 005) Fire Rated



Jamb - Glass Block in Steel Stud Wall with Brick Veneer (PCD 062)

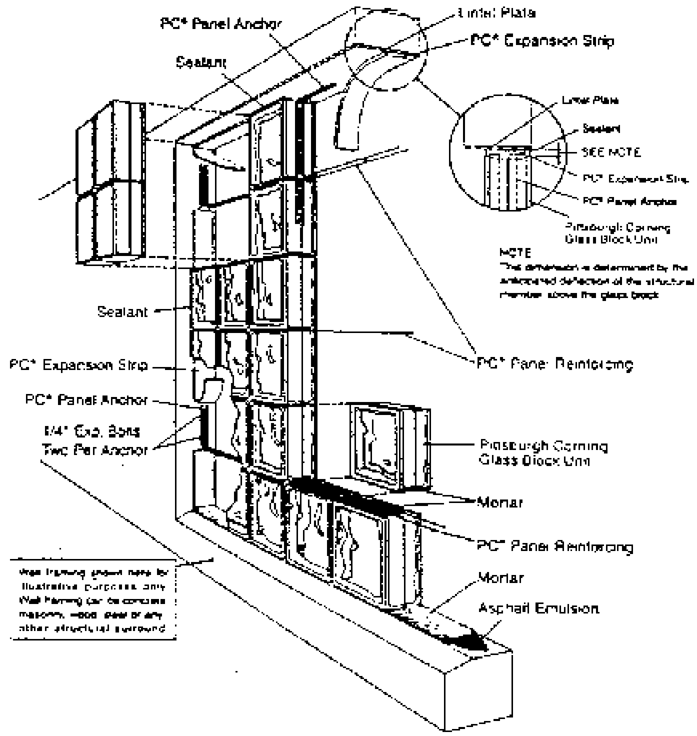


Jamb - Glass Block in Steel Stud Wall with Synthetic Plaster Finish (PCD 032)

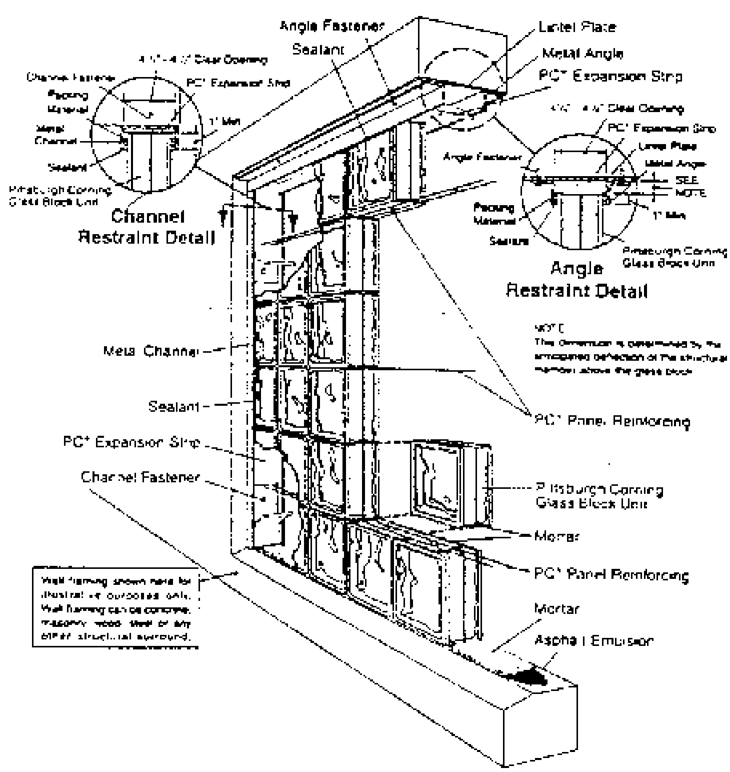
(By permission of Pittsburgh Corning Glass Block, Pittsburgh, Pennsylvania.)

2.6.2 Glass Block (Typical Panel Anchor Details)

Panel Anchor Construction



Channel-Type Restraint Construction



(By permission of Pittsburgh Corning Glass Block, Pittsburgh, Pennsylvania.)

2.6.3 Glass Block—Typical Installation Procedures

1. Cover the sill area with a heavy coat of asphalt emulsion. Allow emulsion to dry at least 2 hours before placing mortar.
2. Adhere expansion strips to jambs and head. Make certain expansion strip extends to the still.
3. Set a full mortar bed joint, applied to the sill.
4. Set the lower course of block, maintain a uniform joint width of ¼ inch (6.35 mm) to ⅜ inch (9.5 mm) plus or minus ⅛ inch (3.175 mm). All mortar joints must be full and not furrowed. Steel tools must not be used to tap block into position (place a rubber crutch tip on end of trowel to tap block into position). Do not realign, tap, or otherwise move block after initial placement. For some glass blocks a typical mortar joint is ⅜ inch (9.5 mm). It may be necessary to use wedges in the mortar joints of the lower courses to prevent the mortar from being squeezed out.
5. Install panel reinforcing every 16 inches (40.64 cm) on center (o.c.) maximum in the horizontal mortar joint and in the joints immediately above and below all openings with the panel. Where panel anchors are used at jambs and heads in lieu of channels or chase surrounds, install panel anchors in the same joints (16 inches o.c. maximum) as the panel reinforcing. *EXCEPT* that, at panel corners, anchors should be placed in each mortar joint, both at the jamb and head, 24 inches (50.8 cm) on each side of the corner. Install panel anchors across the head joint spaced 16 inches on center, maximum. Run reinforcing continuously from end to end of panels. Lap reinforcing not less than 6 inches (125.24 cm) whenever it is necessary to use more than one length.

   Install reinforcing as follows:

   Place lower half of mortar in bed joint. Do not furrow.

   Press reinforcing into place.

   Cover panel reinforcing with upper half of mortar bed and trowel smooth. Do not furrow.
6. Place full mortar bed for joints not requiring panel reinforcing—do not furrow. Maintain uniform joint width.
7. Set succeeding courses of block; space at head panel and jambs must remain free of mortar for caulking and sealants.
8. Use only wooden or rubber-tipped tools when tapping glass blocks into place.
9. Strike joints while mortar is still plastic and before final set. Remove surplus mortar from faces of glass blocks and wipe dry. Tool joints smooth and concave before mortar takes final set. Remove any edges from lower courses at this time and point up voids with mortar. At this time remove and clean all excess mortar from jamb, head, and other expansion joint locations.
10. After final mortar set (usually 24 hours) install packing tightly between glass panel and jamb and head locations. Leave space for sealants.
11. Apply sealant evenly to the full depth of recesses as indicated on the drawings and in accordance with the manufacturer's recommendations.

2.6.4 Cleaning the Glass Block Installation

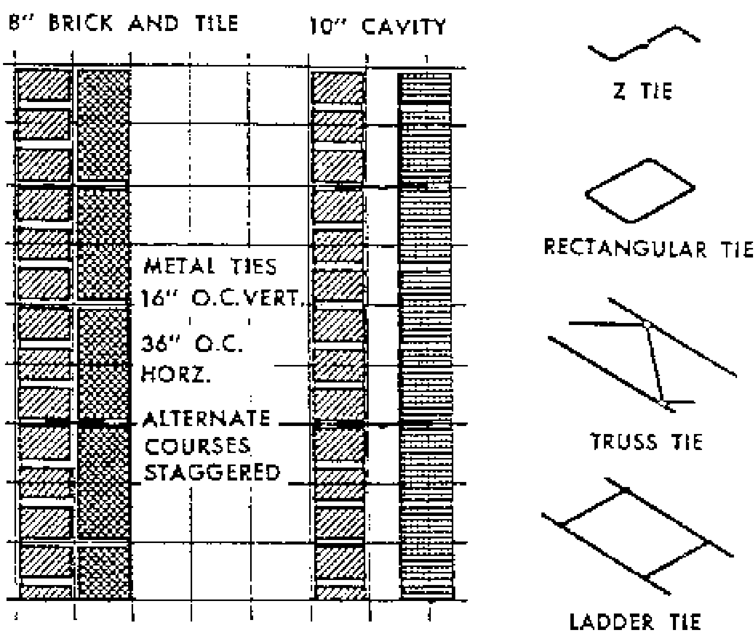
1. Remove surplus mortar from the cases of the glass block at the time the joints are struck or tooled. Mortar should be removed while it is still plastic using a clean, wet sponge or a normal household scrub brush with stiff bristles.
2. Do not use harsh cleaners, acids of any strength, abrasives, or alkaline materials when cleaning glass block. Never use steel wool or a wire brush to remove mortar from the face of the glass block.
3. Final mortar removal is accomplished with a clean, wet sponge or cloth. Rinse the sponge or cloth frequently in clean water to remove abrasive particles that could scratch the glass block. Allow any remaining film on the block to dry to a powder.

4. After all organic materials, caulking, etc., have been applied, remove any excess caulking or sealant materials with a commercial solvent such as xylene, toluene, mineral spirits, or naptha, followed by a normal wash and rinse. Be careful not to damage caulking materials by using too much solvent during this cleaning operation.
5. The final cleaning of the glass panel or wall should be done when the wall is not exposed to sunlight. Start at the top and wash with generous amounts of clean water. Dry all water from the block and change the cloth frequently to avoid picking up mortar particles which could scratch the glass. To remove dry powder from the glass surfaces, use a clean, dry, soft cloth. For stubborn or hard to remove powder or stains, the use of "extra fine" steel wool (grades 000 or 0000) is suggested, however this type of cleaning should be tried first in an unobtrusive area to ensure that scratching of the glass surface will not occur due to this abrasive action.

2.7.0 Masonry Reinforcement—Types of Ties

Whenever a double wythe wall is constructed or a cavity wall containing a masonry veneer is built, anchors, ties, or reinforcement is required to stabilize the two components. Seismic requirements add other components to the conventional masonry wall reinforcement to stabilize the structure in case of a seismic event.

2.7.0.1 Masonry Reinforcement—Types of Ties (Illustrated)



Metal-Tied Masonry Walls

(By permission from the Brick Institute of America, Reston, Virginia.)

2.7.1 Masonry Reinforcement (Materials and Physical Properties of Bars/Wire)

Reinforcement and metal accessories

ASTM specification	Material	Use	Yield strength, ksi (MPa)	ASTM yield stress, MPa
A 36	Structural steel	Connectors	36 (248)	250
A 82	Steel wire	Joint reinforcement, ties	70 (483)	485
A 167	Stainless steel	Bolts, reinforcement, ties	30 (207)	205
A 185	Steel wire	Wire fabric, ties	75 (517)	485
A 307	Carbon steel	Connectors	60 (414)	
A 366	Carbon steel	Connectors	—	
A 496	Steel wire	Reinforcement	75 (517)	485
A 497	Steel wire fabric	Reinforcement, wire fabric	70 (483)	485
A 615	Billet steel	Reinforcement	40,60 (276, 414)	300,400
A 616	Rail steel	Reinforcement	50,60 (345, 414)	350,400
A 617	Axle steel	Reinforcement	40,60 (276, 414)	300,400
A 706	Low alloy steel	Reinforcement	60 (414)	

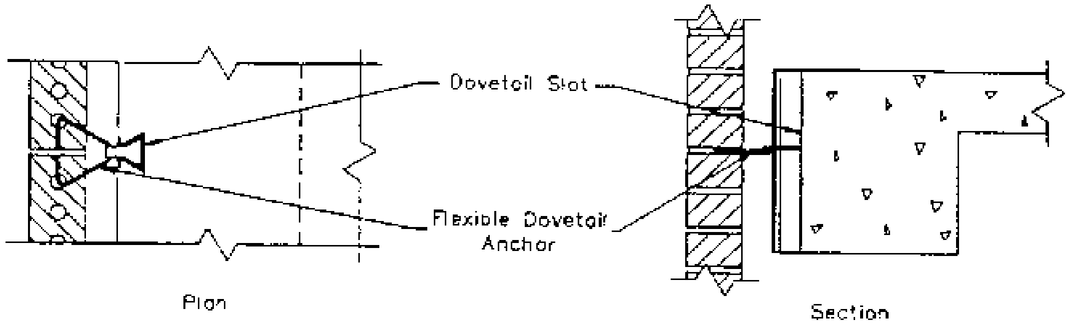
Physical properties of steel reinforcing wire and bars

Designation		Diameter, in (mm)	Area, in.^{2} (mm^2)	Perimeter, in (mm)
Wire				
W1.1 (11 gage)		0.121 (3.07)	0.011 (7.10)	0.380 (9.65)
W1.7 (9 gage)		0.148 (3.76)	0.017 (11.0)	0.465 (11.8)
W2.1 (8 gage)		0.162 (4.12)	0.020 (12.9)	0.509 (12.9)
W2.8 (3/16 wire)		0.187 (4.75)	0.027 (17.4)	0.587 (14.9)
W4.9 ($^1/_4$ wire)		0.250 (6.35)	0.049 (31.6)	0.785 (19.9)
Bars	Metric			
#3		0.375 (9.53)	0.11 (71.0)	1.178 (29.92)
	10	0.445 (11.3)	0.16 (100)	1.398 (35.5)
#4		0.500 (12.7)	0.20 (129)	1.571 (39.90)
#5	15	0.625 (15.9)	0.31 (200)	1.963 (49.86)
#6		0.750 (19.1)	0.44 (284)	2.456 (62.38)
	20	0.768 (19.5)	0.47 (300)	2.413 (61.3)
#7		0.875 (22.2)	0.60 (387)	2.749 (69.83)
	25	0.992 (25.2)	0.76 (500)	3.118 (79.2)
#8		1.000 (25.4)	0.79 (510)	3.142 (79.81)
#9		1.128 (28.7)	1.00 (645)	3.544 (90.02)
	30	1.177 (29.9)	1.09 (700)	3.657 (93.9)
#10		1.270 (32.2)	1.27 (819)	3.990 (101.3)
	35	1.406 (35.7)	1.55 (1000)	4.417 (112.2)
#11		1.410 (35.8)	1.56 (1006)	4.430 (112.5)

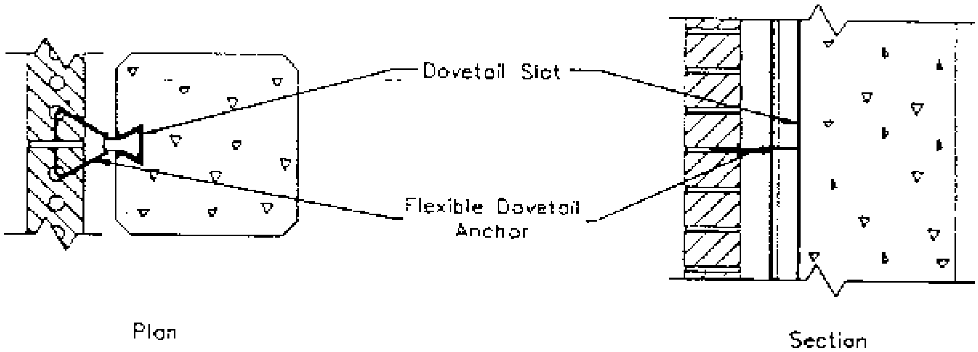
Wire size	*Minimum number of ties required*
W1.7	one wall tie per $2^2/_3$ ft^2 (0.25 m^2) of wall
W2.8	one wall tie per $4^1/_2$ ft^2 (0.42 m^2) of wall

(Reprinted by permission from the Brick Institute of America, Reston, Virginia.)

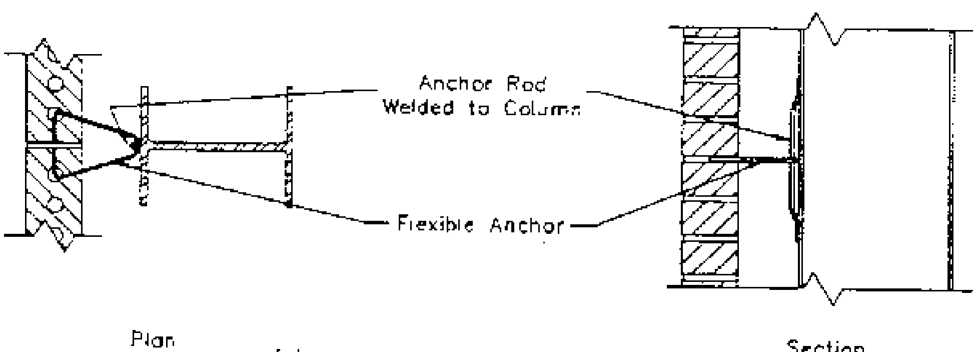
2.7.2 Wall Anchorage Details



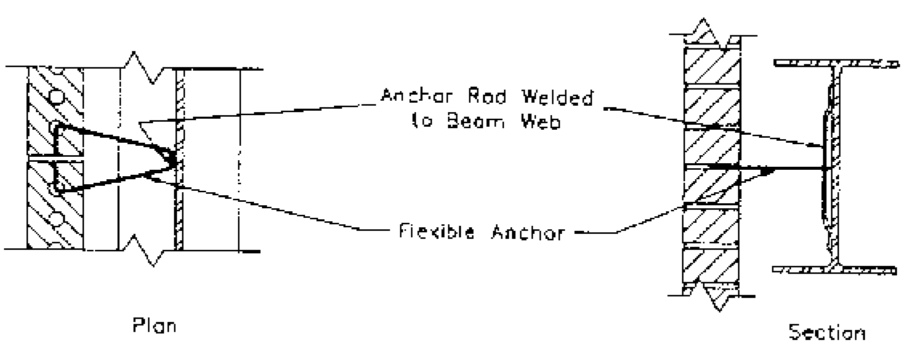
(a) Wall Anchorage to Concrete Beams



(b) Wall Anchorage to Concrete Columns



(c) Wall Anchorage to Steel Column

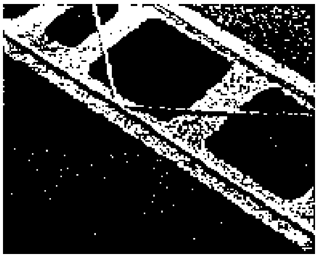


(d) Wall Anchorage to Steel Beam

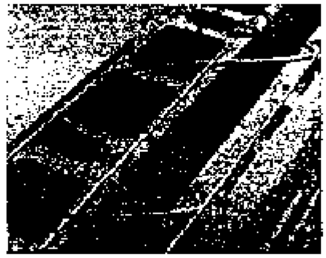
(By permission from the Masonry Society, ACI, ASCE from their manual Building Code Requirements for Masonry Structures.)

2.7.3 Truss and Ladur Reinforcement

DUR-O-WAR® TRUSS



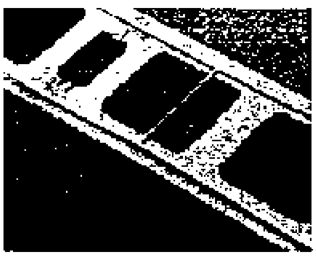
D/A 310 TRUSS



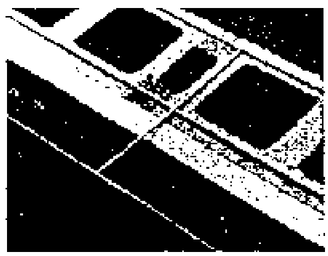
D/A 310 TR TRI-ROD

D/A 310 DSR DOUBLE SIDE ROD

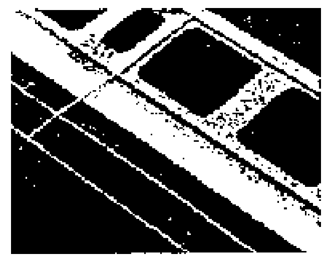
LADUR TYPE®



D/A 320 LADUR



D/A 320 TR TRI-ROD



D/A 320 DSR DOUBLE SIDE ROD

INSTALLATION – TRUSS AND LADUR

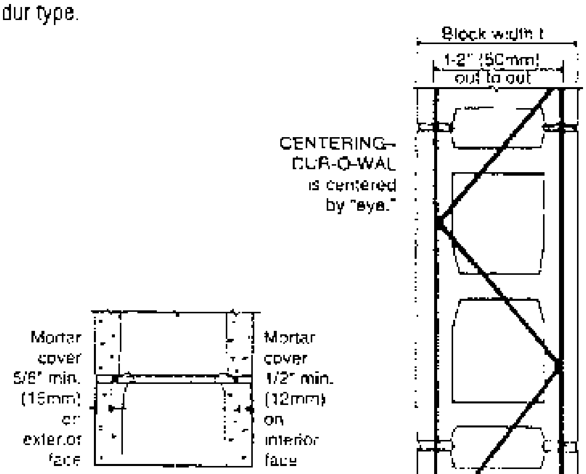
Use at least one longitudinal side rod for each bed joint. Out-to-out spacing of the side rods is approximately 2" (50mm) less than the nominal thickness of the wall or wythe in which the reinforcement is placed.

Splices

Side rods should be lapped 6" (150mm) at splices in order to provide adequate continuity of the reinforcement when subjected to normal shrinkage stresses.

Centering and Placement

Place joint reinforcement directly on masonry and place mortar over wire to form bed joint. This applies to both truss type (shown) and ladur type.

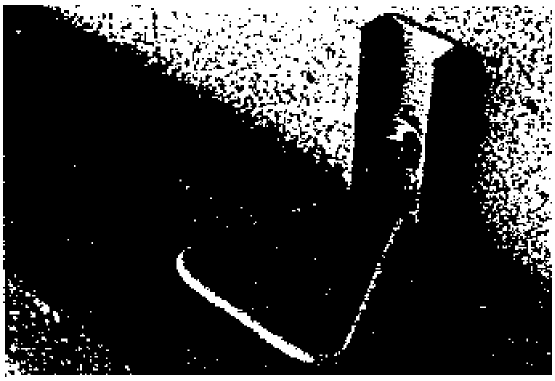


(By permission from Dur-O-Wall, Inc., Arlington Heights, Illinois.)

2.7.4 Masonry Wall Ties

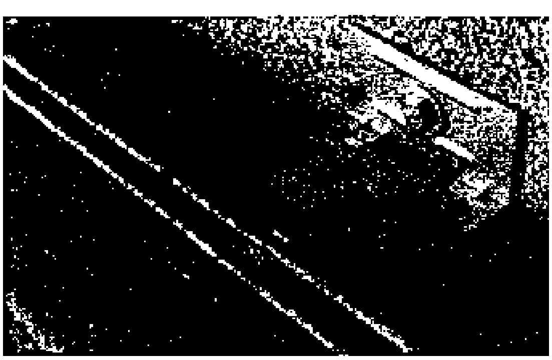
D/A 5801

Recommended for noninsulated cavity/walls. The channel base plate is secured to the back-up and has a 1-1/4" (30mm) slot for coursing adjustability. The 3/16" (5mm) triangular wire tie is mortared in the veneer. Hot dipped galvanized and stainless steel finishes are available.



D/A 5431

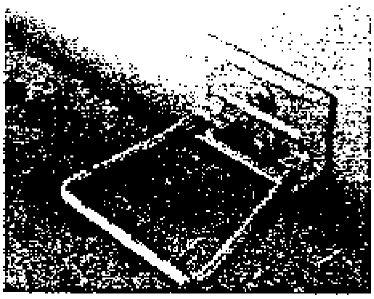
Recommended for reconstructing brick wythes of composite walls. The 14 gauge (1.9 mm) corrugated strap has a 1-1/4" (30mm) of adjustability. The tie is mortared in place with the new brick wythe. Shear lugs accommodate seismic ladur or pencil rod. Hot dipped galvanized and stainless steel finishes are available.



D/A 5213S with Seismic Ladur

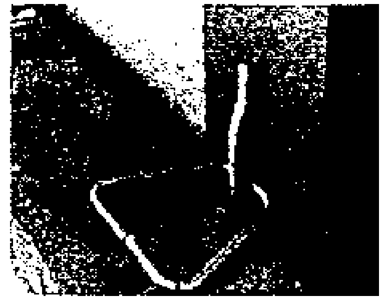
(By permission from Dur-O-Wall, Inc., Arlington Heights, Illinois.)

2.7.5 Masonry Veneer Anchors



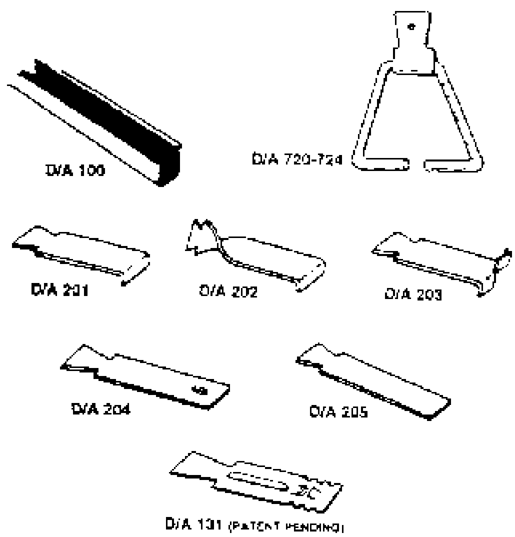
D/A 213

D/A 207 WITH D/A 701

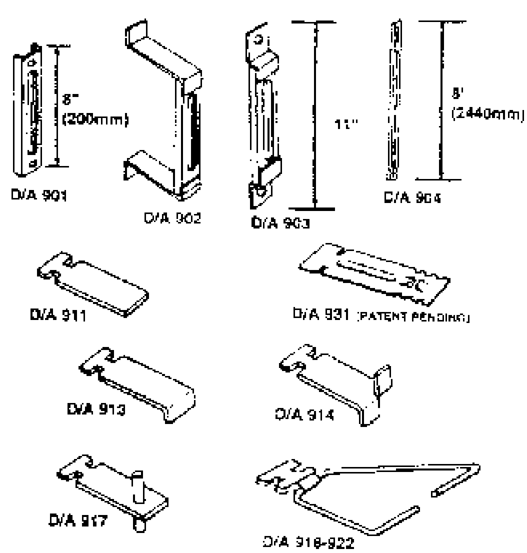


D/A 709 WITH D/A 701

Dovetail Slots and Anchors



Channel Slots and Anchors



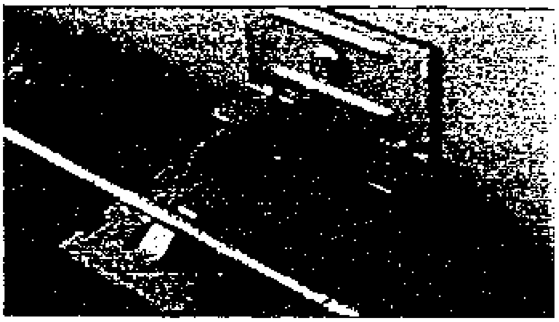
(By permission from Dur-O-Wall, Inc., Arlington Heights, Illinois.)

2.7.6 Seismic Masonry Veneer Anchors

Seismic Veneer Anchoring Application

DUR-O-WAL's seismic veneer anchors are designed to meet performance criteria as defined by building codes. These anchors can be used for tieing brick veneers to wood stud, steel studs, steel framing, masonry, brick and concrete. They are fabricated with shear lugs that accommodate 9 gauge veneer reinforcement. The connectors are individually mounted and are easily installed.

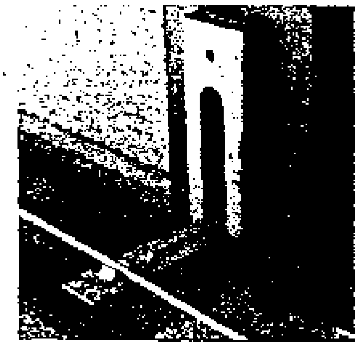
Seismic Veneer Anchors (patented)



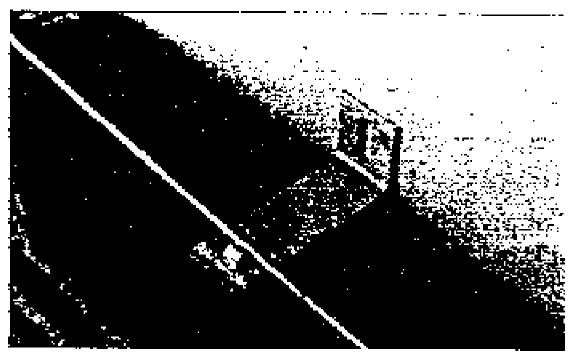
This anchor has the same plate and pintle design as Seismic Dur-O-Eye. The plate is engineered to be attached to the face of a CMU or concrete (D/A 5213) steel stud, wood stud or steel frame (D/A 213S) rather than embedded in mortar. The pintle shear lugs hold pencil rod or Seismic Ladur in place for greater pull out stress resistance and ductility. Adjusts 1-¼" (30mm) up or down to allow for different course heights and allows at least ½" (13mm) horizontal in-plane movement to accommodate expansion and contraction. A hot dipped galvanized finish (1.5 oz. zinc per sq. ft.) (456g/m^2) is standard, and 304 stainless steel is available. DUR-O-WAL recommends the use of two screws for stud applications, either the D/A 807 for steel, D/A 808 for wood, or D/A 995, or a special ¼' (6mm) expansion bolt for concrete or masonry retrofit applications (D/A 5213).

D/A 931 Seismic Channel Slot Anchor Assembly (patent pending)

Engineered for use with standard channel slots. Pencil rod or Seismic Ladur fits inside shear lug for positive placement without the need for special clips.



D/A 431 Seismic Strap Anchor (patent pending)



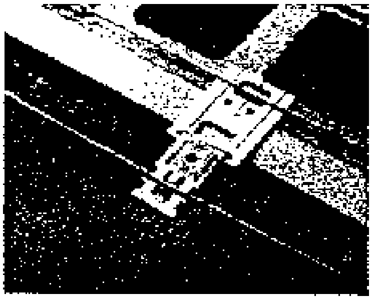
A special 14 ga. (1.9mm) adjustable seismic corrugated veneer anchor with two shear lugs, which is engineered for use with pencil rod or Seismic Ladur to resist out of plane movement and afford greater ductility in seismic zones 3 and 4 or Seismic Performance Categories D and E can be nailed or screwed to wood stud backup (D/A 808).

D/A 131 Seismic Dovetail Anchor Assembly (patent pending)

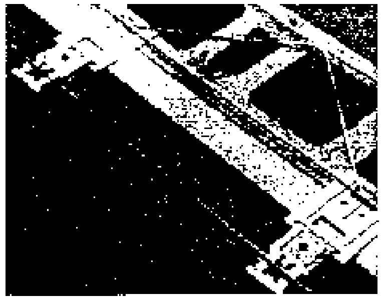
Specially designed tie with shear lug locks for pencil rod or Seismic Ladur to assure positive positioning and reinforcement without the need for special clips. Engineered to fit standard dovetail slots with ⅝" (16mm) throat opening.

(By permission from Dur-O-Wall, Inc., Arlington Heights, Illinois.)

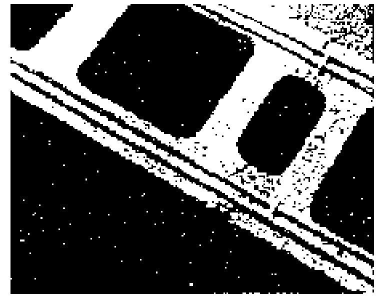
2.7.7 Seismic Masonry Ladur and Comb Reinforcement



D/A 360 S SEISMIC LADUR-EYE



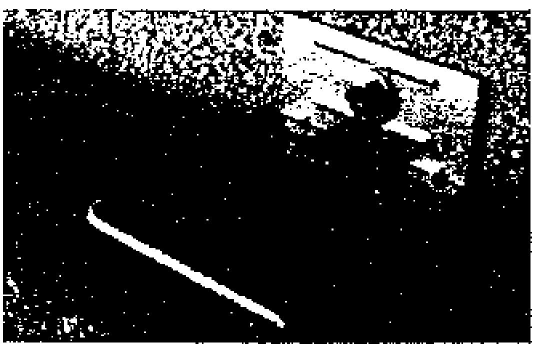
D/A 370 S SEISMIC DUR -O-EYE



D/A 320 S SEISMIC LADUR

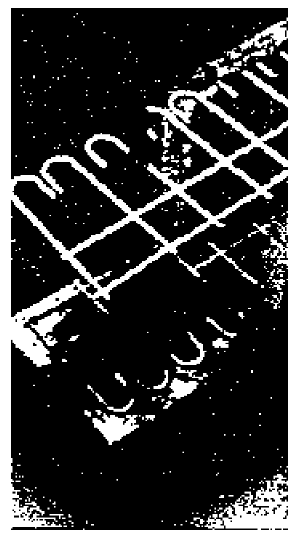
D/A 5213/Seismic 5213S

Recommenced for brick cavity walls with or without insulation. Dual leg 3/16" (5mm) pintle adjusts vertically 1-1/4" (30mm), up or down. The plate projects off the back-up wall to accommodate insulation or bridge cavities. Hot dip galvanized, and stainless steel finishes available.



Seismic Comb (patent pending)

Masonry confinement reinforcement located in horizontal mortar joint to improve seismic performance of shear walls. Provides the Vertical Rebar confinement requirements in Section 2108.2.5.6 (1994). Made with 3/16" diameter wire conforming to ASTM A82. A hot dipped galvanized finish (1.5 oz., 458 g/m^2, zinc per square foot), per ASTM A153, is standard. Available for 6" (150mm), 8" (200mm), 10" (250mm) and 12" (300mm) hollow masonry units.



(By permission from Dur-O-Wall, Inc., Arlington Heights, Illinois.)

2.8.0 Investigating Unstable Masonry Conditions to Prevent Failures

Although masonry walls are extremely durable, "old age" and neglect can take its toll on even the most durable structure. When inspecting a masonry facade for potential problems and restoration, a number of contributing factors must be considered. Often, it is necessary to cut out a small section of wall in the area/areas where failures are suspected.

The following checklist will aid in this investigation:

1. When initially built, were all ties and anchors installed as required?
2. Were the ties properly installed (e.g., embedded adequately in the bed joint and connected tot he backup correctly)
3. Does there appear to be excessive differential wall movement caused by thermal movement, settlement, or freeze/thaw conditions?

4. Were the proper size and type of ties/anchors used to avoid stresses that exceed the facade material's capacity?
5. Were the proper type of expansion and control joints installed at the proper distances?
6. Have the ties, anchors, fasteners, relieving angles, and lintels corroded because of moisture being trapped? Is there accelerated corrosion from chlorides or has galvanic action taken place because of a combination of carbon steel anchors in contact with dissimilar materials?
7. Has excessive water penetrated the wall system from any poorly maintained parapet flashings or roof-coping flashings?
8. Have the caulk joints been allowed to deteriorate?
9. Have the weep holes been caulked when maintenance caulking was performed and have the lintels been caulked at the point where brick is bearing on them?
10. Have the mortar joints deteriorated and not been tuckpointed during routine maintenance inspections?

2.8.1 Restabilizing, Reanchoring a Masonry Veneer Wall System

At times both new and old brick veneer walls may require reanchoring to provide structural stability and ensure watertight integrity.

In new construction, after the veneer wall has been built it may be determined that the desired quality level of construction had not been achieved and additional anchors may be required. Corrosion of the existing wall ties over the years may also call for restabilization of the brick veneer wall assembly. In order to establish the proper method to achieve stabilization in either new or older brick veneer wall assemblies, a structural engineer will most likely consider the following:

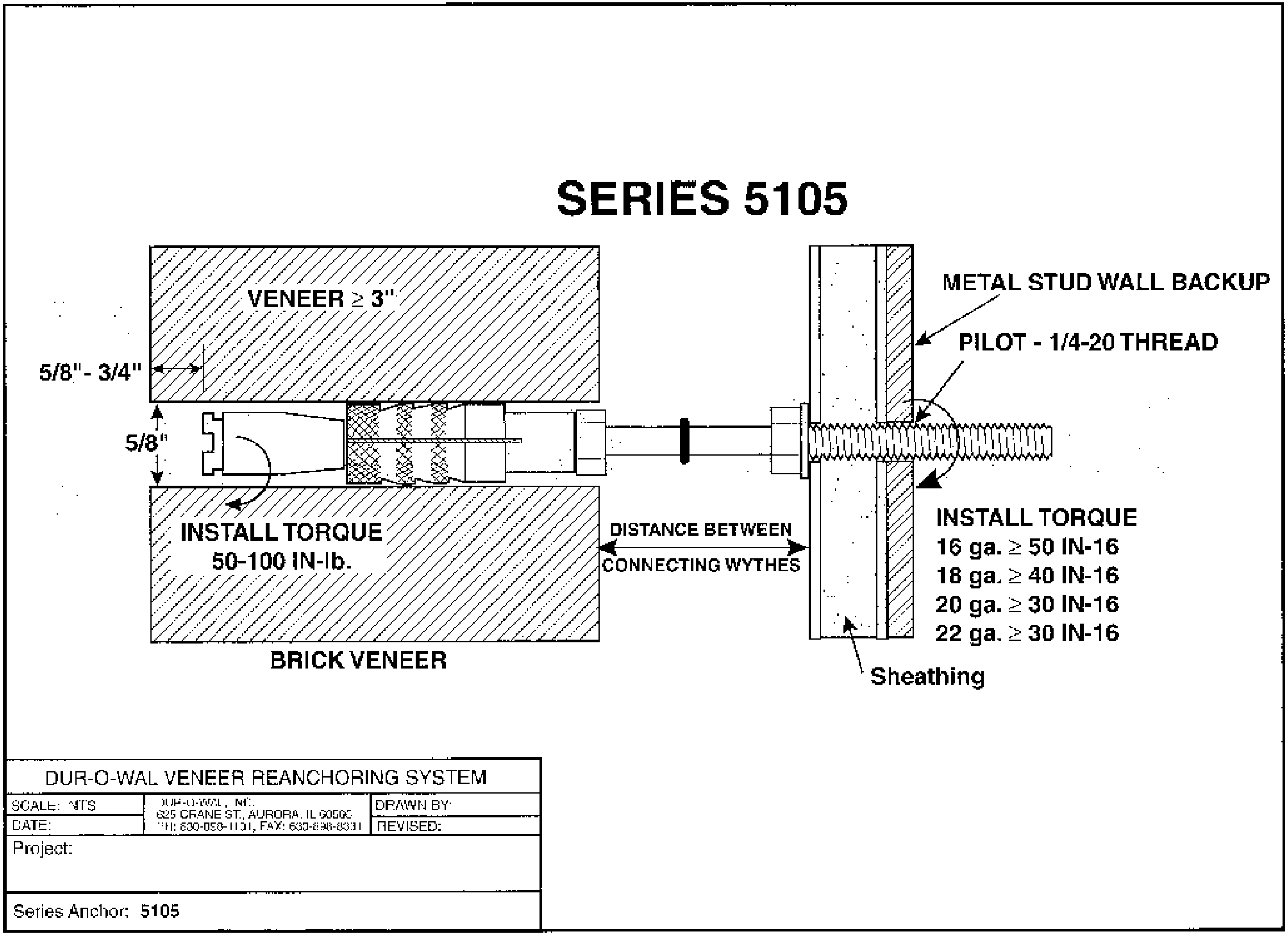
- Relative stiffness of the existing veneer;
- The construction of the veneer wall, i.e., CMU back-up, steel stud assembly;
- Whether the anchoring device should be a friction fit, mechanically activated, or an adhesive device;
- Load versus deflection characteristics of the anchoring device.

Changing seismic code requirements have made it necessary to reinforce existing brick veneer wall assemblies and stabilization anchors afford the contractor a relatively easy way to fulfill these code requirements.

Also, renewed interest in preserving old, historic, or architecturally important structures has been another impetus behind product development to aid restoration contractors.

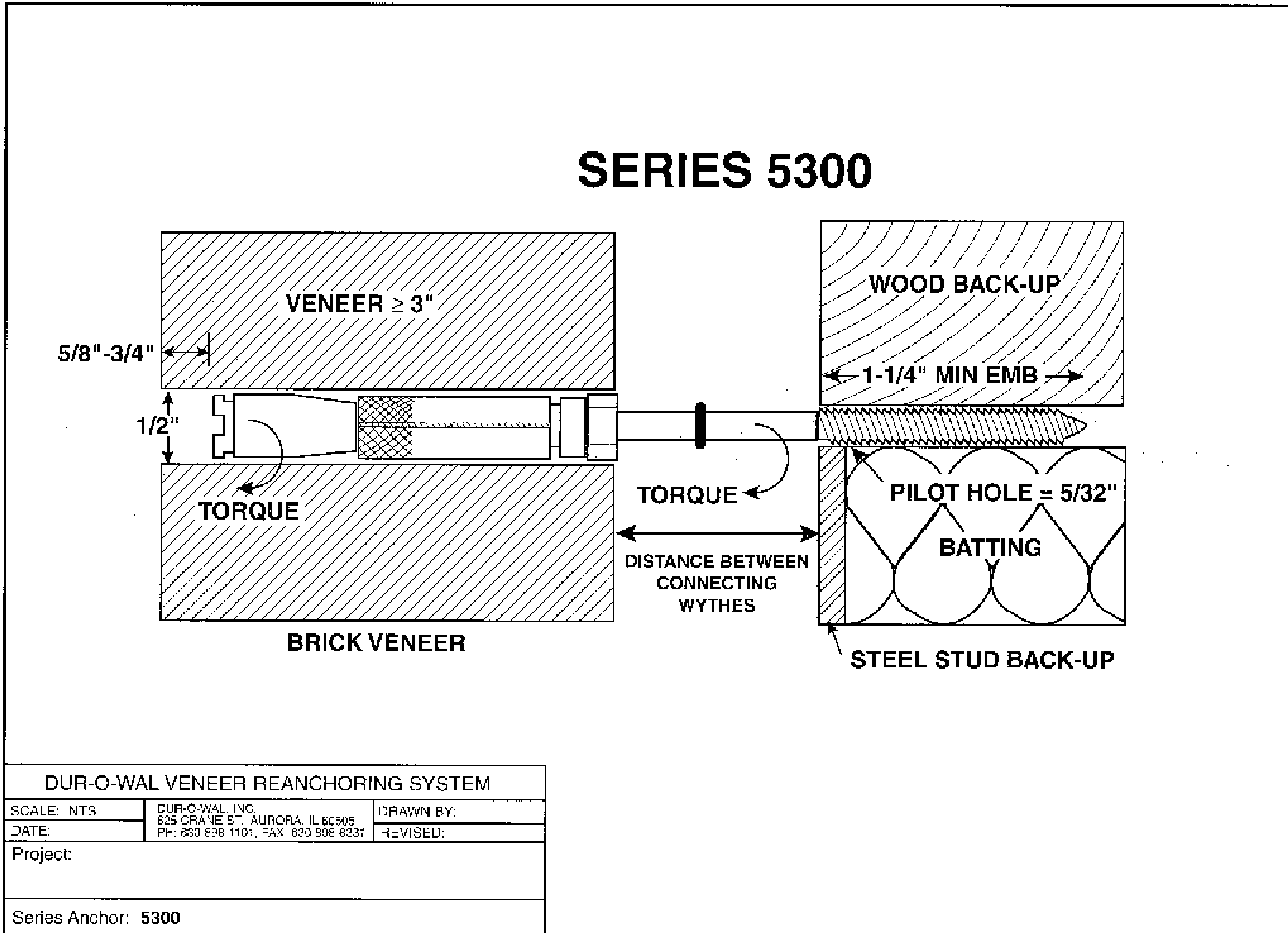
The various types of veneer anchors displayed on the following pages have been developed by the Dur-O-Wall Company, and several other leading masonry accessories manufacturers have also developed masonry restabilization products that basically function in a similar manner.

2.8.2 Reanchoring System for Brick-to-Metal Stud Wall



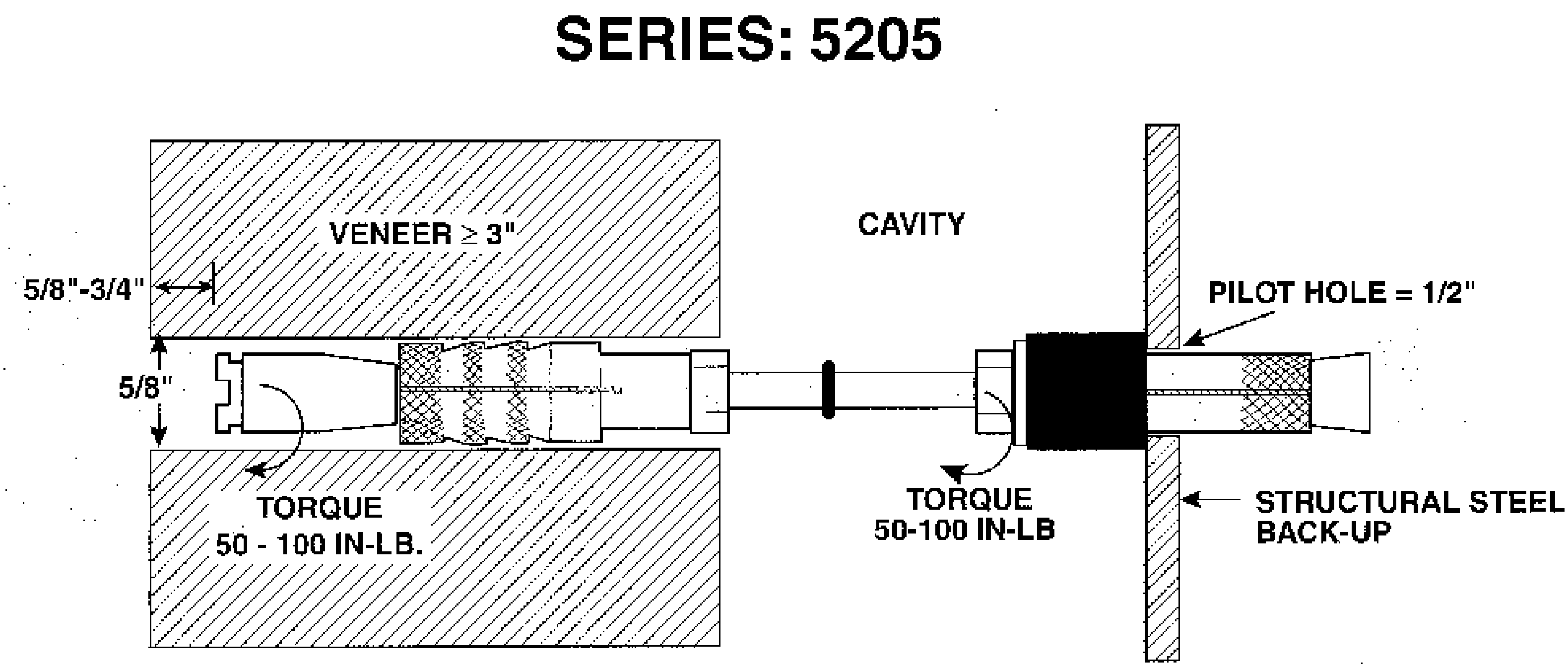
(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

2.8.3 Reanchoring System for Brick-to-Metal Stud with Wood Back-up



(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

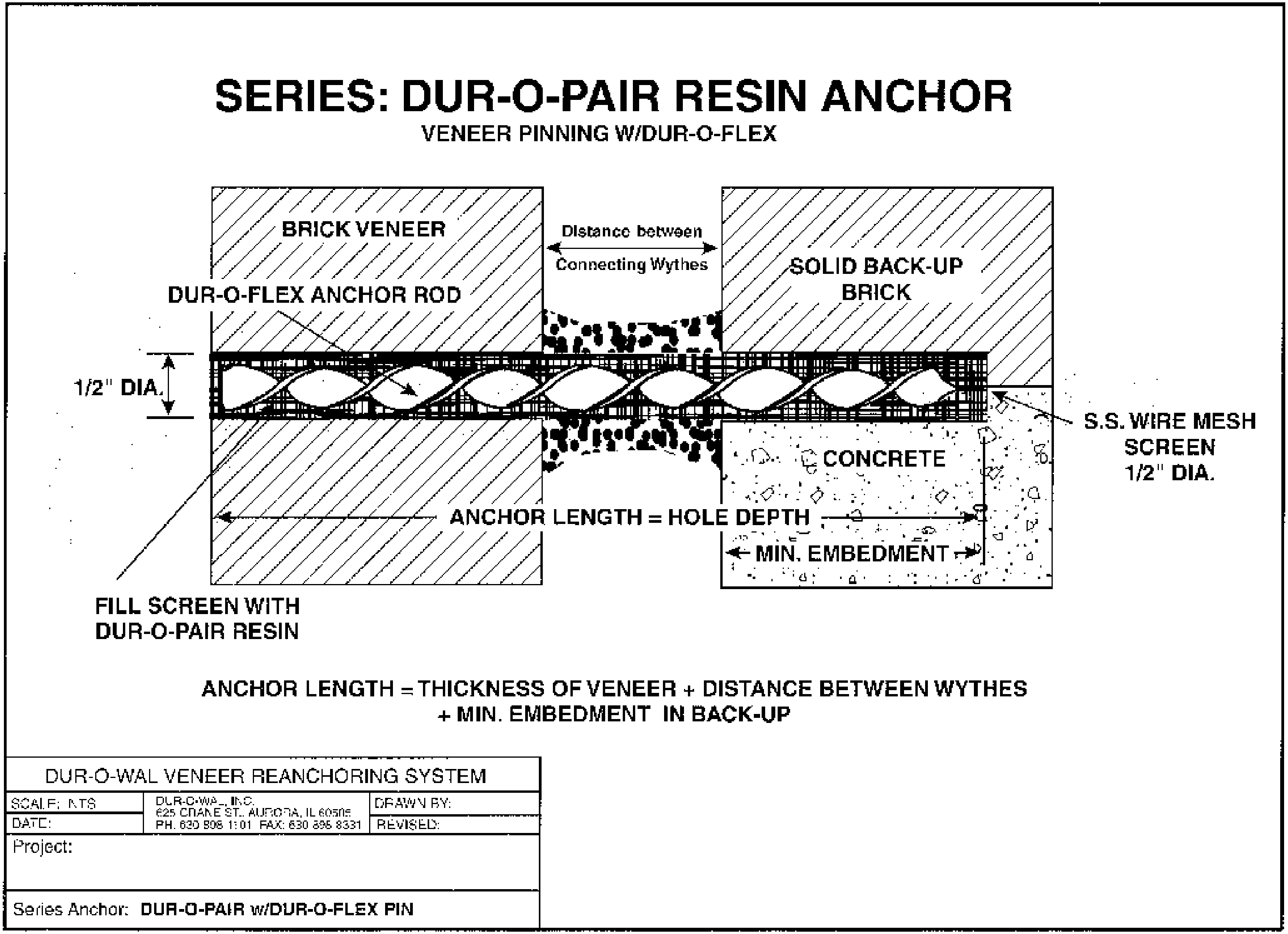
2.8.4 Reanchoring System for Brick-to-Structural Steel



DUR-O-WAL VENEER REANCHORING SYSTEM		
SCALE: NTS	DUR-O-WAL, INC. 525 CRANE ST. AURORA, IL 60505 PH: 630-898 1101, FAX 630 906 8331	DRAWN BY:
DATE:		REVISED:
Project:		
Series Anchor: **55205**		

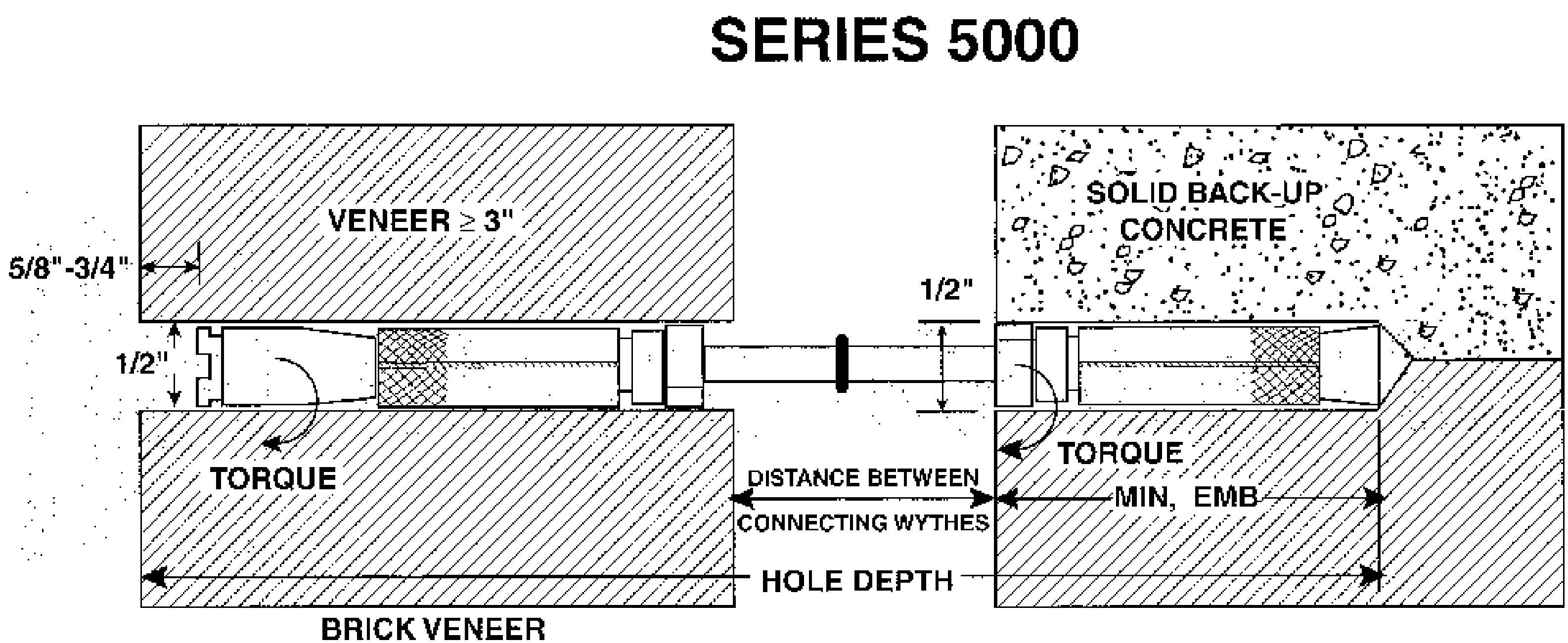
(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

2.8.5 Reanchoring System for Brick-to-Brick Back-up



(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

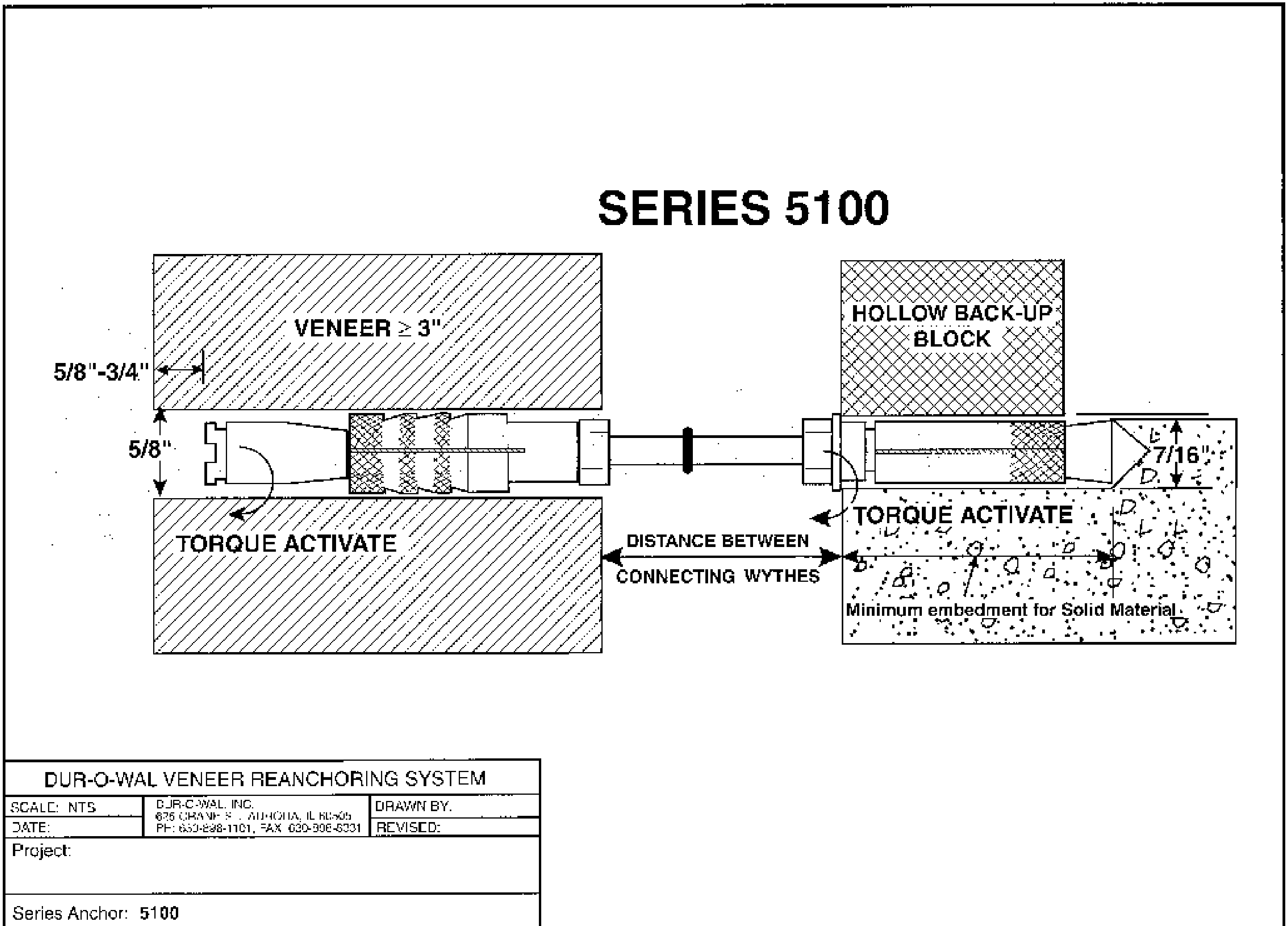
2.8.6 Reanchoring System for Brick-to-Concrete Back-up



DUR-O-WAL VENEER REANCHORING SYSTEM		
SCALE: NTS	DUR-O-WAL, INC. 625 CRANE ST., AURORA, IL 60505 PH 630 898 1101 FAX: 630 898 8281	DRAWN BY:
DATE:		REVISED:
Project:		
Series Anchor: **5000**		

(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

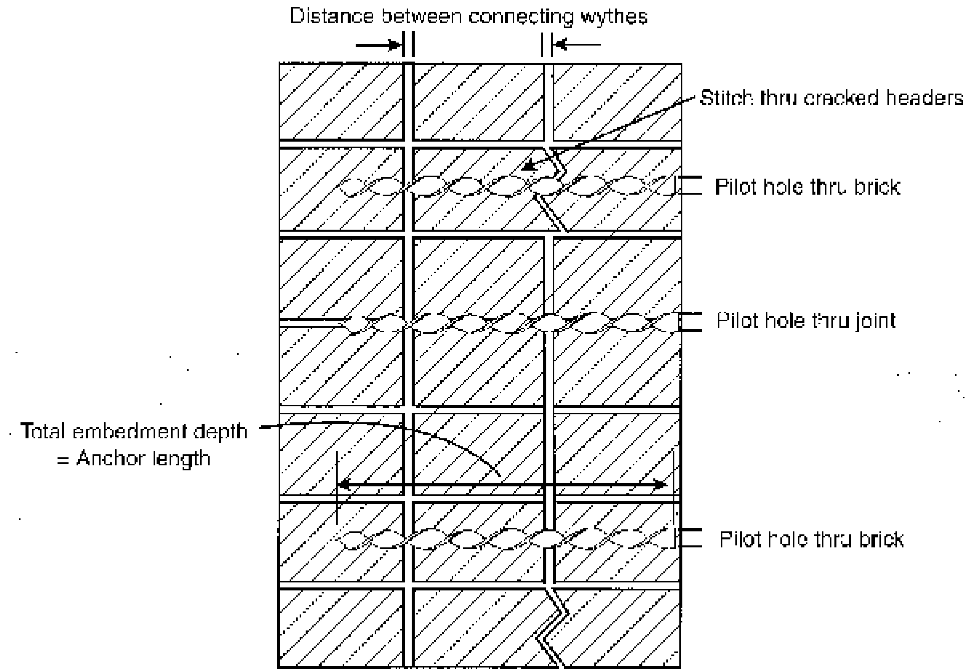
2.8.7 Reanchoring System for Brick-to-Hollow Block Back-up



(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

2.8.8 Reanchoring Multibrick Wythes

DUR-O-FLEX FRICTION PIN



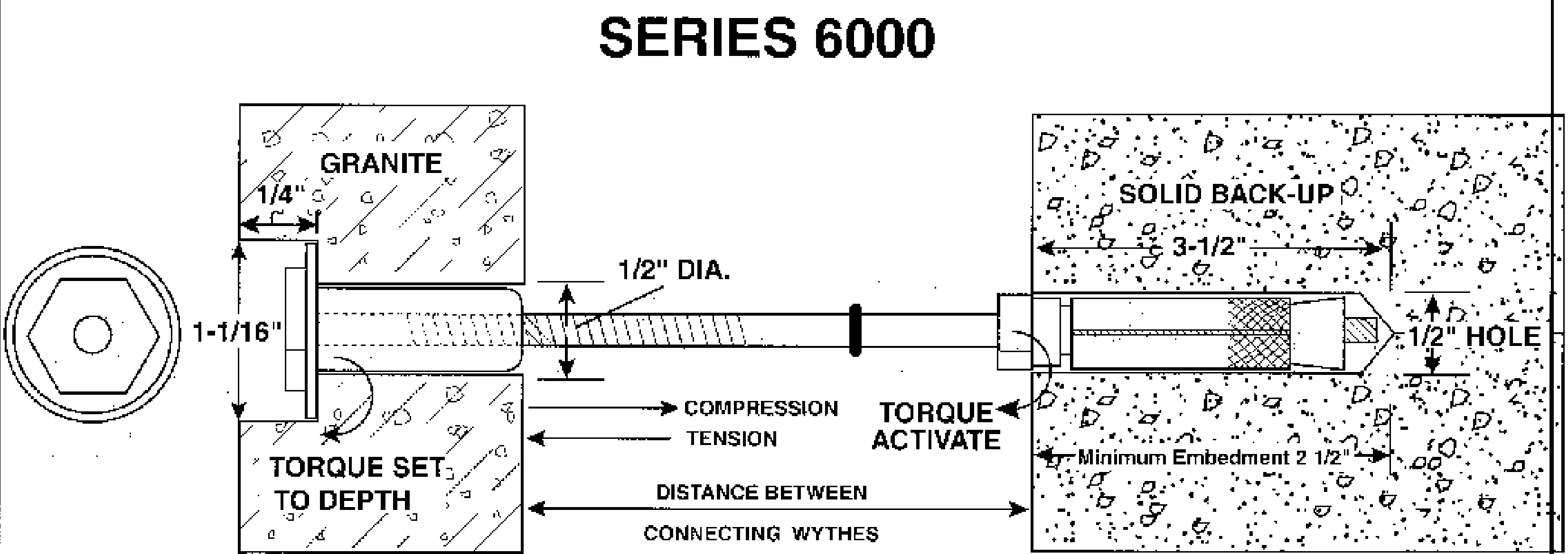
Multi brick wythes

NOTE: Pilot hole depth should be greater than anchor length by 1" min.

DUR-O-WAL VENEER REANCHORING SYSTEM		
SCALE: **NTS**	DUR-O-WAL, INC. 625 CRANE ST., AURORA, IL 60505 PH 630 808 1-01 FAX: 630 808 8331	DRAWN BY:
DATE:		REVISED:
Project:		
Series Anchor: **DUR-O-FLEX FRICTION PIN**		

(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

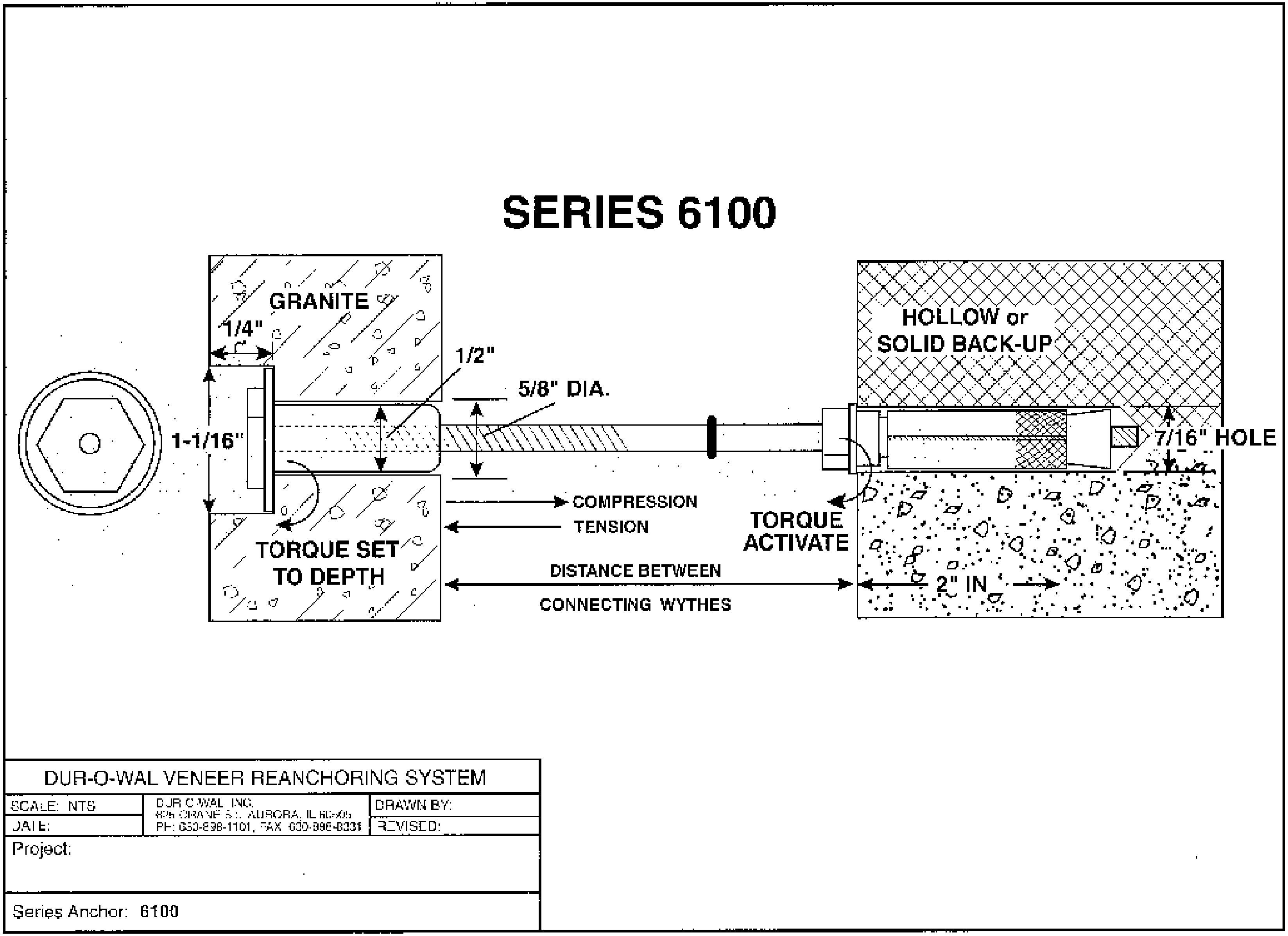
2.8.9 Reanchoring Stone Veneer-to-Solid Back-up



DUR-O-WAL VENEER REANCHORING SYSTEM		
SCALE: NTS	DUR-O-WAL, INC. 625 CRANE ST., AURORA, IL 60505 PH: 630-898-1101, FAX: 630-898-0301	DRAWN BY:
DATE:		REVISED:
Project:		
Series Anchor: **6000**		

(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

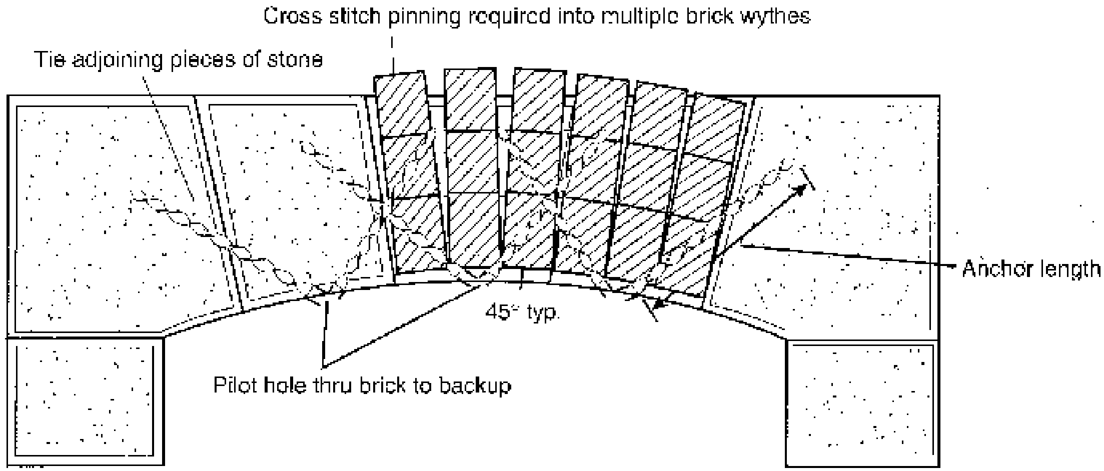
2.8.10 Reanchoring Stone Veneer-to-Hollow Block Back-up



(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

2.8.11 Repairing Limestone or Brick Arches

DUR-O-FLEX FRICTION PIN



Repairing limestone or brick arches

DUR-O-WAL VENEER REANCHORING SYSTEM		
SCALE: NTS	DUR-O-WAL, INC. 625 CRANE ST., AURORA, IL 60505 PH: 630-898-1101, FAX: 630-898-6331	DRAWN BY:
DATE:		REVISED:
Project:		
Series Anchor: **DUR-O-FLEX FRICTION PIN**		

(By permission from Dur-O-Wall, a Dayton Superior Company, Aurora, Illinois.)

2.9.0 Fire Resistance Ratings of Various Concrete Masonry Units and Assemblies

Listed is the minimum required equivalent thickness of concrete masonry assembly (inches and centimeters, metric in parentheses).

Aggregate type in the CMU	4 hour	3 hour	2 hour	1.5 hours	1 hour	0.75 hours	0.5 hours
Calcareous or siliceous gravel	6.2 (15.75)	5.3 (13.46)	4.2 (10.67)	3.6 (9.14)	2.8 (7.11)	2.4 (6.09)	2.0 (5.08)
Limestone, cinders slag	5.9 (14.99)	5.0 (12.7)	4.0 (10.16)	3.4 (8.73)	2.7 (6.86)	2.3 (5.84)	1.9 (4.82)
Expanded clay, shale or slate	5.1 (12.95)	4.4 (11.17)	3.6 (9.14)	3.3 (8.38)	2.6 (6.6)	2.2 (5.59)	1.8 (4.57)
Expanded slag pumice	4.7 (11.94)	4.0 (10.16)	3.2 (8.13)	2.7 (6.86)	2.1 (5.33)	1.9 (4.82)	1.5 (3.81)

Reinforced Concrete Masonry Columns

Minimum column dimensions inches/centimeters and fire-resistance rating

1 hour	2 hours	3 hours	4 hours
(8 inches)	10 inches	12 inches	14 inches
(20.32)	(25.4)	(30.48)	(35.56)

Reinforced Concrete Masonry Lintels

Minimum longitudinal reinforcing cover (inches/centimeters)

Nominal lintel	Fire-resistance rating			
Width (inches and centimeters)	1 hour	2 hours	3 hours	4 hours
6 inches (15.24)	1½	2	—	—
8 inches (20.32)	1½	1½	1¾	3
10 inches or more (25.4 cm or more)	1½	1½	1½	1¾

Equivalent Thickness of Concrete Masonry Units

Nominal width	Based on typical hollow units		Based on percent solid 75%	100%
4 (10.16)	2.68 (6.8)	[73.8]	2.72 (6.91)	3.62 (9.19)
6 (15.24)	3.09 (7.85)	[55.0]	4.22 (10.72)	5.62 (14.27)
8 (20.32)	4.04 (10.26)	[53.0]	5.72 (14.53)	7.62 (19.35)
10 (25.4)	4.98 (12.65)	[51.7]	7.22 (18.34)	9.62 (24.43)
12 (30.48)	5.66 (14.38)	[48.7]	8.72 (22.15)	11.62 (29.51)

Note: Values in brackets are percent solid values based on typical two-core concrete masonry units. Numbers in parentheses are metric equivalents, in centimeters, to inch dimensions.

2.10.0 Building Clean Brick Walls

If all bricklayers and construction personnel could learn to keep brickwork clean as walls are built, one of the masonry construction industry's most frustrating problems would be eliminated.

Many bricklayers do lay up clean brick walls, saving the prime contractor the cost of cleaning and, most important, saving for the owner and architect the unblemished appearance that was carefully planned for the structure. But most new brickwork does require some cleaning as a result of poor workmanship practices or as a result of poor job housekeeping.

The subject of cleaning masonry might best be preceded by a few tips on **building** clean brick walls.

1. Brick should be protected from mud when placed at a job site. Contractor should provide boards, plastic sheeting or other protective material when bricks are unloaded on ground.

   In certain cases, brick should be completely covered for protection from weather until used.

2. Protect wall as work progresses. This includes protecting the base of wall after the first course of brick is laid and protecting wall from the top at the end of the work day.

   Use sand, straw, sawdust or plastic sheeting along the ground to prevent mud splashes. Mud removal is much more expensive than ground cover materials. Base protection also minimizes mortar dropping damages.

   The wall must be covered at the end of each workday to prevent washout of fresh joints, and to keep excessive water out of the wall to avoid efflorescence. Covering is also essential for cold weather protection.

3. Scaffold should be set far enough away from the wall to allow mortar droppings to fall to the ground. If scaffolds are not set away, mortar may lodge on diagonal bracing and adhere to wall. However, when scaffold brackets are used for the bricklayers platform, bracing presents no problem.

   At the end of each workday the boards on the scaffold closest to wall should be removed or tilted up to dump excess mortar droppings and prevent possible rainfall from splashing mortar and dirt from the boards onto newly laid masonry.

4. If the bricklayer follows good practices he can lay up clean brick walls. Some good procedures are as follows:

   After spreading mortar (but before laying brick) use trowel edge to cut mortar even with wall face. This prevents mortar from running down face of wall.

   After laying brick, cut off excess mortar with a forward lifting and rolling motion of trowel that will collect mortar and prevent smearing of this mortar back onto brick face. Mortar should not be cut so that surplus drops to base of wall.

   Tool joints when mortar is "thumbprint" hard. After tooling, cut off mortar tailings with trowel and **brush** excess mortar burrs and dust from face of brick. **Bagging** or **sacking** very often rubs mortar particles into the brick face if done too soon, making it almost impossible to remove these embedded mortar particles with conventional cleaning methods. Brushing is safer and thus preferable to bagging or sacking. Use a bricklayer's brush made with medium soft hair.

5. Keep the wall clean. After the bricklayer and mason contractor leave the job, someone needs to "guard" the completed masonry. Watch the structural concrete crew, the terrazzo crew, welders, roofers, painters, landscape contractor. They don't seem to realize that almost **nothing** can be removed from masonry - easily. Keep the mud protection around base of walls until final landscaping work is being completed.

   If the preceding techniques are followed a final cleaning should be easy. Very often a water hose with high pressure nozzle will be adequate to remove the construction dust and the occasional mortar smear found on wall.

2.10.1 Brick Cleaning Systems

1. Bucket and Brush Cleaning

BUCKET AND BRUSH CLEANING is the most widely used method of cleaning newly constructed brick walls in both small and large jobs. A minimum amount of equipment is needed and workmen do not need to be highly skilled. Only the job foreman or supervisor need to be knowledgeable and experienced.

This method may be used for cleaning all colors and textures of brick. **However, care must be used in selecting the proper cleaning solution for the job.**

The safest way to determine the proper cleaning solution for a given type of brick is to ask the brick manufacturer for his recommendation.

Muriatic acid has been used for many years in cleaning red brick walls. This material is readily available and is economical. When used in a 10% solution (1 part muriatic acid and 9 parts water) and applied under proper conditions it will satisfactorily clean most red brick walls.

The problem with this cleaning material is that workmen too often use solutions stronger than the recommended 10% maximum to make their job easier, and often fail to apply the solution under proper conditions as will be explained below. Furthermore, workmen often use muriatic acid on some types of brick that can be damaged with this acid. For these reasons many cleaning contractors refuse to use muriatic acid, and many architects/engineers refuse to allow muriatic acid on the job.

The relationship between architect and cleaning subcontractor is a major factor in determining whether or not muriatic acid will be permitted on certain jobs. Also, permission to use muriatic acid should be obtained from the brick manufacturer.

There are many new commercial cleaning compounds on the market today that will clean new masonry as well as muriatic acid and can be used with more safety. Many of these cleaners contain small amounts of hydrochloric acid as well as "wetting" and "buffering" agents to improve the solution's action and to minimize deterioration of mortar joints and damage to surrounding materials.

Listed below are some of the recommended commercial cleaning compounds:

Sure Klean 101, 600 and Vanatrol

Superior 800 series

Goldblatt Brick Bath

Diedrich 202, 202V

Formulation of most commercial cleaners is so complicated that the users should not necessarily try to understand terminology such as wetting agents, buffering agents, oxidizing, chelating, inhibitors, etc., but should rely on chemical manufacturers' recommendations as found on containers, and on recommendations of brick manufacturers.

The following procedure is recommended for cleaning by the Bucket and Brush Method:

1. Wait for mortar to harden. While industry standards generally require masonry to be 7 days old before cleaning, it is possible to start cleaning operations 24 to 36 hours after completion of masonry work, depending on the type of brick and weather (drying) conditions.
2. Remove all large mortar particles with hand tools before applying water or cleaning solutions. Use wooden paddle, the rough edge of a brick, or metal scrape hoe. Chisels may be used, if necessary, to remove hardened mortar or concrete. This is a very important point in cleaning new masonry. Don't expect cleaning solutions alone to remove large particles of hardened mortar. **Cleaning solutions will only remove thin smears.**
3. Mask and otherwise protect adjacent metal, glass, wood, etc., surfaces as recommended by product manufacturers.
4. **Saturate** the wall with clean water. The area to be cleaned must be **saturated** as well as all masonry areas below.

   Hose should be trained upon wall until brick's thirst is completely satisfied. If wall appears to be drying on surface, reapply water until workman is ready to apply cleaning solution. Failure to completely saturate the wall is a major cause of cleaning stains. Cleaning solutions containing dissolved mortar particles can be drawn into a dry masonry wall, causing future staining. Such staining from portland cement dissolved in cleaning materials is extremely difficult, if not impossible, to remove since it is insoluble in most masonry cleaning solutions.

A saturated wall will not draw particles from its surface into brick pores. Water is cheap, and usually free to the cleaning contractor. Use it generously!

5. Use brush to apply cleaning solution to saturated wall. Start cleaning at the top of wall. Solution should be approved by architect/engineer and brick supplier. Concentration and method of application should be as recommended on container or by manufacturer.

   Cover small area, using long handled fiber brush. Scrub brick, not joints. Allow solution to remain on wall three to six minutes (or as recommended on label) as workmen scrape and scrub vigorously.

6. Rinse thoroughly as small areas are cleaned. To avoid rapid evaporation of water on areas being cleaned, keep crew just ahead of sunshine. This permits ideal conditions for cleaning walls, and also allows walls to dry soon after being washed, permitting crews to learn if all stains are being removed before going too far ahead.

A good phrase to remember in cleaning brickwork is "procedure is more important than the product used."

If the above procedures are followed, cleaning should be relatively easy and trouble free.

(Test clean a sample area to determine effectiveness of cleaning compound and the total cleaning system and to check wall for possible damages caused by the system. Approval of owner or owner's representative should be obtained before proceeding with operation.)

2.10.2 Brick Cleaning Systems—High Pressure Water Cleaning

HIGH PRESSURE WATER CLEANING is a relatively new method of cleaning newly constructed masonry although it has been used for many years in masonry restoration work.

The more sophisticated high pressure cleaning systems feature a high pressure gun and nozzle with remote control switch allowing an operator to automatically apply cleaning solution while operating the gun several hundred feet from base unit. Other systems provide two separate hoses, one with plain high pressure water and the other with solution of cleaning material, also under pressure. Care must be taken in selecting cleaning materials compatible with the pumping equipment as recommended by pump manufacturer.

All units must be portable in order to be taken within close range of job. Compact units are mounted on skids, wheels, trailer, etc. More elaborate systems are truck mounted, complete with pump, engine or motor, cleaning material containers, water storage tank, and water heater.

Nozzle pressures generally range between 400 psi and 800 psi. However, many available units are capable of producing pressures well over 1000 psi and should be used with caution. Flow is normally between 3 and 8 gallons per minute.

Many cleaning contractors are using high pressure systems in an effort to reduce high labor costs associated with traditional cleaning systems. Most contractors agree the high pressure system is more efficient. **However, hand labor is still needed to remove large mortar particles from the wall surface before applying water and cleaning solutions.** Also, extreme caution should be used in applying cleaning solutions under high pressure. This practice is economical but could be harmful to the operator, to adjoining property, and could drive the cleaning solution further into the wall than is necessary for surface cleaning, causing further staining.

Cleaning solutions may be applied more effectively and safely by brush or by low pressure (maximum 40 psi) orchard type sprayer.

In many cases, high pressure water without any special cleaning materials will successfully clean new masonry walls. When hot water is used, high pressure without chemicals is even more efficient. High pressure water cleaning may be used on most hard burned, textured clay brick. This includes reds, buffs, grays and other through-the-body colors. However, it is safest to keep pressure well below 1000 psi when cleaning buffs, grays, etc., since these colors are more susceptible to mineral oxidation which could be aggravated by excessively deep penetration of water. Also, high pressure water cleaning should be used only with approval of brick manufacturer.

This system is generally acceptable for cleaning lightly sanded or sandblast textures where a fine application of sand is well bonded to the brick body. Caution should be exercised in using high water pressure on slurry or "sandblast" textures where an excessive coating of sand adheres loosely to body. High nozzle pressures may cut streaks in the relatively soft sand facing.

High pressure water cleaning may be detrimental to handmade brick and any underburned product. Also, high pressure water can erode mortar joints.

The following procedure is recommended for High Pressure Water Cleaning:

1. Wait for mortar to harden, but cleaning with high pressure water should not start before mortar is 7 days old.
2. Remove all large mortar particles with hand tools before applying water or cleaning solutions. Use wooden paddle, the rough edge of a brick or metal scrape hoe. Chisels may be used, if necessary, to remove hardened mortar or concrete. This "pre-cleaning" is a very important part in cleaning new masonry. Don't expect cleaning materials and/or water alone to remove large particles of hardened mortar. These can only remove thin smears.
3. Mask and otherwise protect adjacent metal, glass, wood, etc., surfaces as recommended by product manufacturers.
4. **Saturate** wall with clean water. All immediate areas to be cleaned must be **saturated** as well as masonry areas below.
5. When thirst of wall is completely satisfied, apply cleaning solution, starting at the top of wall. Solution should be approved previously by architect/engineer and brick supplier. Concentration should be as recommended on container. Solution may be applied to wall with masonry cleaning brush or low pressure (maximum 40 psi) sprayer. Application of cleaning solution by high pressure should be previously approved by architect/engineer and brick supplier.

   Fifty degree nozzle is generally recommended for applying cleaning solutions.

   Let cleaning solution remain on wall for 3 to 6 minutes, or as directed on product label.
6. Rinse wall with high pressure water from top to bottom so all dissolved mortar particles will be completely flushed from wall surfaces. The most efficient sprayer is the fan type, stainless steel tip, dispersing a 25 degree to 50 degree fan spray. Never use less than a 15 degree fan spray tip.

(Test clean a sample area to determine effectiveness of cleaning compound and the total cleaning system and to check wall for possible damages caused by system. Approval of owner or owner's representative should be obtained before proceeding with operation.)

See Section IV when using high pressure water systems to remove type "S" mortar from buff, gray, white, etc., brick.

2.10.3 Brick Cleaning Systems—Sandblast Cleaning

Dry sandblast cleaning is a relatively new method of cleaning newly built masonry, although the system has been used for many years in masonry restoration work.

Many architect/engineers prefer sandblast cleaning over conventional wet (acid) cleaning because of possible adverse acid reactions with certain types of brick. Other designers are reluctant to permit sandblast cleaning from fear the blasting will erode the face of the brick and mortar joints.

Sandblast operators can be compared with other construction tradesmen; some are artisans and others are incompetent. However, with a qualified operator, proper specifications and good job inspection, sandblast cleaning is as good as any other system and is sometimes superior in many ways.

Basically, sandblast cleaning involves the following equipment: Portable air compressor, blasting tank, blasting nozzle, operators' protective clothing and hood.

Air pressure delivered by compressor to blasting tank may range from 40 lbs. to 100 lbs. per square inch. Blasting tank is charged with the specified abrasive material and pressurized to force the mixture of abrasive material and air into blasting hose and to nozzle.

Blasting pattern is determined by nozzle size, type and air pressure. Speed of cleaning is determined by type of abrasive used, nozzle size, type, air pressure, nozzle-to-wall distance and of course, condition of surface to be cleaned.

Abrasive material used in brick cleaning is usually sand, quartz, or granite and must be clean and finely graded.

Sandblast cleaning material should conform to one of two particle size gradations outlined in the specifications below.

Type "A" gradation is to be used when the masonry is very lightly soiled or when only a very light or fine texturing of the brickwork is permitted.

Type "B" gradation is used for cleaning heavy mortar stains from brickwork and where medium texturing of the masonry is permitted.

Sandblast cleaning may be used for cleaning all hard burned, nonglazed, smooth or textured brick. Included in this category are reds, buffs, whites, grays, chocolates, etc.

Lightly sanded, coated, slurry, or sandbox brick should not be cleaned by sandblasting, unless cleaning cannot be accomplished by any other method, as the brick face can be permanently damaged.

Handmade or reclaimed brick may also be permanently disfigured by sandblasting.

As a further precaution, **approval of the brick manufacturer must be obtained before permitting sandblast cleaning.**

The following procedure is recommended for Sandblast Cleaning:

1. Wait for mortar to harden. Brickwork should be completely dry and at least 7 days old, preferably 14 days.
2. Remove all large mortar particles with hand tools before blasting. Use wooden paddle, the rough edge of a brick, or metal scrape hoe. Chisels may be used if necessary to remove hardened mortar or concrete. This "precleaning" is a very important part of sandblast cleaning. Sandblast operator would irreparably damage wall if large droppings are left for him to remove by blasting.
3. Provide adequate protection for all nonmasonry surfaces adjacent to work areas. Use plastic sheeting and duct tape to protect windows, doors, etc.

   If possible, painting, caulking, etc., should be done after sandblast operation is completed.
4. When all surfaces are prepared and protected, the operator can begin a first test cleaning.

   Operator should clean a small area with the nozzle first close to wall, and then at varying distances from the wall, trying to select a working distance that will give the best cleaning job with least damage to brick and mortar work.

   Job superintendent and architectural inspector should be present at this time to confirm acceptable practice. Approved areas should be marked and identified as acceptable standard for the entire job.

2.10.3.1 Specifications—Sandblast Cleaning

I. SCOPE

This section includes cleaning of newly constructed clay masonry with dry abrasive material forced by compressed air from tank through hose and nozzle.

II. MATERIAL

Cleaning material must be dust-free and abrasive. Hardness should be approximately 6 on Mohs' Scale. Material size shall conform to one of the two categories listed below according to acceptable finish of masonry surface.

Type "A" (Fine Texturing)

Typical Screen Analysis

U.S. Sieve Size	Percent Passing
30 Mesh	98 – 100
40 Mesh	80 – 85
50 Mesh	50 – 60
100 Mesh	5 – 20
140 Mesh	0 – 10

The following material is acceptable for "fine texture" sandblasting:

Blast Sand Size No. 120 furnished by KMG Minerals, Inc., Kings Mountain, N. C.

Type "B" (Medium Texturing)

(For concrete work and extremely difficult masonry cleaning jobs.)

Typical Screen Analysis

U.S. Sieve Size	Percent Passing
16 Mesh	87 – 100
18 Mesh	75 – 95
30 Mesh	25 – 50
40 Mesh	0 – 15
50 Mesh	0 – 10

The following material is acceptable for "medium texturing" sandblasting:

Blast Sand No. 55 furnished by KMG Minerals, Inc., Kings Mountain, N. C.

Local materials may be used when dried and screened to meet required size and hardness and when determined to be free of grease or other impurities.

III. EQUIPMENT

Air Compressor must be capable of producing pressure between 60 pounds and 100 pounds per square inch at the machine and should have a minimum air flow capacity of 125 cu. ft. per minute.

Nozzle inside orifice or bore size may vary from $^{3}/_{16}$" diameter to $^{5}/_{16}$" diameter.

Sandblast machine (or tank) must be equipped with controls to regulate flow of abrasive materials to nozzle, and shall be capable of supplying sand at a minimum rate of 300 pounds per hour.

Operator must wear O.S.H.A.-approved hood and protective clothing.

IV. WORKMANSHIP

a. Brickwork must be dry and at least 7 days old, preferably 14 days.

b. Before blasting, all large mortar particles must be removed with hand tools. Use wooden paddles, metal scrape hoes or chisels if necessary to remove hardened mortar.

c. Provide adequate protection for all nonmasonry surfaces adjacent to work areas. Use plastic sheeting and duct tape to protect windows, doors, etc.

d. Sandblast operation may begin if representatives of architect and/or prime contractor are present to inspect trial cleaning areas.

Operators must test clean several areas, with nozzle trained at varying distances from wall, finally selecting working distance that affords best cleaning job with least damage to brick and joints.

Test areas approved by representative of architect and/or prime contractor must be marked and identified as acceptable standard for entire job.

e. All brick and mortar joint areas considered by the architect to be severely damaged by the cleaning operation must be replaced at the expense of the cleaning contractor.

f. If directed by the architect or engineer all brickwork cleaned by sandblasting shall be waterproofed with an approved clear coating as designated by architect or engineer.

Continued

2.10.4 Brick Cleaning Systems—Special Systems for Wet Cleaning Through-the-Body Light Brick, Where "S"-Type Mortar is Used

Type "S" (and type "M") mortar is very difficult to remove from the face of all brick, but is a special problem when through-the-body or light colored brick are used due to the sensitivity of these brick to strong cleaning materials.

The following cleaning procedures are recommended according to age of masonry work:

A. After work is 10 days old:

1. Remove all large mortar particles with hand tools before applying cleaning solutions.
2. Mask and otherwise protect adjacent non-masonry materials.
3. Saturate wall with clean water.
4. Use cleaning brush to apply solution of **Sure Klean Vanatrol, Diedrich 202V Vana-Stop** (or equal) mixed 4 to 6 parts of water to 1 part of solution.
5. Allow solution to remain on wall for 3 to 5 minutes while brushing and scraping, reapply solution.
6. Thoroughly rinse and brush clean.

B. After work is 30 days old:

1. Use procedure described above in Steps 1 through 5.
2. Use high water pressure equipment to rinse wall, using pressure not greater than 800 PSI with a 40 degree nozzle fan tip. Consult brick manufacturer before using high pressure water system.

C. After work is 45 days old:

Use same procedure as described in Procedure B, except use **Sure Klean Lime Putty Remover** (or equal) rather than **Sure Klean Vanatrol** or **Diedrich 202V Vana-Stop**.

Use a solution of 1 part **Sure Klean Lime Putty Remover** (or equal) to 6 parts water. Consult brick manufacturer and chemical manufacturer before using a stronger solution.

(Test clean a sample area to determine effectiveness of cleaning compound and the total cleaning system and to check wall for possible damages caused by system. Approval of owner or owner's representative should be obtained before proceeding with operation.)

2.10.5 Cleaning Guide

RED BRICK - TEXTURED

This category includes all textured red through-the-body brick.

Brick in this category may be cleaned by the bucket and brush method, high water pressure method, or by sandblasting.

RED BRICK - HEAVY SAND FINISH

This category includes all red through-the-body brick with various applied heavy sand finish faces.

Brick in this category may best be cleaned by the bucket and brush method, using plain water and scrub brush, or with **lightly applied** high pressure water system, with plain water being used. Sandblast cleaning is not recommended. If mortar stains are excessive, use of cleaning compounds may be required.

WHITE, BUFF, GRAY, CHOCOLATE BRICK

This category includes all textured and sand finish brick with through-the-body colors other than natural red.

Brick in this category may be cleaned by the bucket and brush method, or by **lightly applied** high pressure water system. Sandblast cleaning is also recommended except in the cases where heavy sand finish is involved. In the two wet cleaning systems, no muriatic acid or compounds containing muriatic acid may be used. Only plain water and detergent, or **Sure Klean Vanatrol, Diedrich 202V Vana-Stop** or equal may be used.

See Section IV for special cleaning systems where type "S" mortar is used.

2.10.6 Specialty Cleaning

WHITE EFFLORESCENCE – White efflorescence is a water soluble salt that is brought to the surface of masonry by evaporation of either construction water or by evaporation of rain water that has penetrated the wall.

Water used in mortar, grout, etc., will sometimes cause this "New Building Bloom." As the wall dries out, and as successive rains wash the walls, the "Bloom" should disappear.

If the masonry has received its regular cleaning and white efflorescence appears or reappears, no further action should be taken until this wall has had an opportunity to dry out completely. Application of additional cleaning solutions may only aggravate the problem at this point. Also, application of clear waterproofing materials may lock in moisture and crystalline growth, causing more scumming and possible spalling of brick.

If efflorescence stains persist, it is likely that rainwater is penetrating the wall. An inspection of the stained areas should be made to determine if sizeable cracks or openings exist, permitting water penetration. Faulty flashing or a lack of flashing will contribute to staining.

Any large openings should be repaired. Where only very fine hairline cracks are assumed to be allowing water penetration, application of a **penetrating water repellent** may be the only solution to the problem short of a complete tuckpointing job.

Before applying waterproofing materials, all possible repairs should be made and all efflorescence removed. This may be removed by applying plain water and brushing the affected area. If water fails to remove stain, use dilute solution of commercial cleaning compounds such as **Sure Klean 600, Diedrich 202 New Masonry Detergent** or equal for red brick and **Sure Klean Vanatrol, Diedrich 202V Vana-Stop** or equal for all others. Some heavy white stains, known as "lime runs" or "silicate deposits" may require special cleaning procedures for removal. Contact BANC for further details. Allow entire wall to dry out completely (over a period of little or no rainfall) before applying waterproofing solutions.

GREEN STAINS – Green staining is caused by presence of vanadium salts. Color and solubility of these salts are dependent upon acidity of the brick. Very often green stains are brought about by wrongful use of muriatic acid or compounds containing muriatic acid. When green stains appear, brick manufacturer should be consulted before attempting to remove the stain.

Green stains may be removed by using **Sure Klean 800 Stain Remover, Sure Klean Ferrous Stain Remover, Diedrich 940 Iron and Manganese Stain Remover, Diedrich 950 Acid Burn Remover** or equal.

BROWN STAINS – Brown staining can be caused by presence of soluble manganese or iron oxides. Very often brown or manganese stains are brought on by wrongful use of muriatic acid or compounds containing muriatic acid.

If these stains are light, **Brick Klenz** may take them off with little difficulty.

Also, oxalic acid (one pound mixed in a gallon of water) may do the job if stains are new and light in color.

Many brown stains can be removed with **Sure Klean 800 Stain Remover, Sure Klean Ferrous Stain Remover, Sure Klean Restoration Cleaner, Diedrich 950 Acid Burn Remover, Diedrich 940 Iron and Manganese Stain Remover, Diedrich 101G Brick Cleaner** or equal.

Each product should be tested for effectiveness and possible bleaching action on joints.

WHITE SCUM – INSOLUBLE – Insoluble white scum is generally caused by faulty cleaning - failure to adequately saturate wall before cleaning and failure to flush wall after applying cleaning compound. As opposed to white efflorescence, this stain cannot be removed with detergents or regular cleaning compounds.

Currently known method of removal is to use **Sure Klean White Scum Remover, Diedrich 930 White Scum Remover** or equal.

SMOKE STAINS – Smoke stains can generally be removed by using one of the following cleaners:

> **Brick Klenz**
>
> **Sure Klean Smoke Remover**

A follow-up cleaning with **Sure Klean Restoration Cleaner, Diedrich 101G Brick Cleaner** or equal may be required after using smoke removal products.

Follow the directions found on containers.

MUD STAINS – Mud stains are the most difficult of all to remove.

Currently known method of removal is as follows:

> Apply **Sure Klean Restoration Cleaner, Diedrich 101G Brick Cleaner** or equal (full strength) with stainless steel pressurized "orchard" sprayer.
>
> Allow to remain on wall 5 minutes. Flush off with high pressure water spray. Repeat if necessary.
>
> Sprayer nozzle should be held at 90 degree angle to wall, as should rinse water nozzle.
>
> **Sure Klean Light Duty Concrete Cleaner** might be less likely to bleach joints than **Sure Klean Restoration Cleaner** or **Diedrich 101G Brick Cleaner.**

PAINT STAINS – Paint stains are very difficult to remove from masonry. Probable sandblasting is the fastest way to remove paint, but this process is sometimes harmful to the masonry surface.

Commercial paint removers are effective in some cases.

Sure Klean Defacer Eraser and **Sure Klean Heavy Duty Paint Stripper, Diedrich 606 Multi-Layer Paint Remover** or equal are very good for paint removal. If these products do not completely remove all paint particles after following printed directions, apply **Sure Klean Restoration Cleaner, Diedrich 101G Brick Cleaner** or equal to the stained area. Allow to remain on wall several minutes, then "blast" the area with water hose. Follow directions found on containers.

CLEANING MASONRY LAID WITH COLORED MORTAR

Colored mortar is highly sensitive to masonry cleaning solutions. While mineral oxide pigments are inert and are not affected by most cleaning materials, the materials will dissolve surrounding cement paste, allowing pigment to be washed away, exposing sand grains and causing a change in mortar color and texture.

Most manufacturers of colored mortar recommend cleaning with detergent and water only. Where mortar stains are heavy, a 1 to 6 solution of **Sure Klean Vanatrol, Diedrich 202V Vana-Stop** or equal and water may be used; but a curing period of 3 to 5 weeks is recommended before cleaning with anything other than detergent and water.

Sandblast cleaning is usually acceptable, as is high pressure water cleaning with approved cleaning compounds. Protection of brick face must also be considered in selecting a cleaning system.

(As with all cleaning jobs, test clean a sample area to determine effectiveness of cleaning compound and the total cleaning system and to check wall for possible damages caused by system. Approval of owner or owner's representative should be obtained before proceeding with operation.)

2.10.7 General Cleaning Information

LIGHT AND DARK JOINTS – Color change in mortar joints may be attributed to change in quality of masonry cement, type of masonry cement, change in type or gradation of sand and change in methods of cleaning. Also, color of joints can be affected by variations in moisture content of joints at the time they are "tooled" or "struck." Moisture content of mortar is, in turn, affected by moisture content of individual brick surrounding the joint.

Joints struck while excessively wet can become light in color. Joints struck when "thumbprint" hard should dry to a uniform color if mortar and sand properties remain consistent.

Normal variations in joint color will be eliminated after completion of one of the wet cleaning processes. Where wide color variations are found, a mild bleaching of all joints with increased concentration of cleaning solutions usually brings improvement. Caution should be taken in using this process with acid-sensitive brick and colored mortars.

Light joints may be darkened by painting the joints with pigments specially selected to produce the required shade.

CLEAR WATERPROOFING APPLICATION

Care must be used in deciding where and when to use clear waterproofing materials on masonry walls.

Generally the industry considers applications of clear coatings to be a remedial process rather than a new construction process - to be used only if water penetration currently is a problem and if water penetration cannot be stopped by all other reasonable means. The use of penetrating water repellents which allow the wall to breathe are typically recommended.

Please refer to "White Efflorescence" under Specialty Cleaning on page 8 for basic information on this subject.

For these reasons architects may be inviting trouble when they indiscriminately specify clear waterproofing on all newly built, newly cleaned walls.

If clear materials are being used only to protect masonry walls from atmospheric stains, the same precautions outlined under "White Efflorescence" should also be observed.

2.11.0 Tolerances in Masonry Construction per ACI Specifications

In cross section or elevation	¼ inch (6.4mm), +/- ½ inch (13mm)
Mortar joint thickness	
Bed	+/- 1/8 inch (3.2 mm)
Head	- ¼ inch (6.4 mm) – 3/8 inch (9.5 mm)
Collar	-1/4 inch (6.4 mm) + 3/8 inch (9.5 mm)
Grout space or cavity width, except for masonry walls passing framed construction	- ¼ inch (6.4 mm) + 3/8 inch (9.5 mm)
Elements	
Variation from level	
Bed joints	+/- ¼ inch (6.4 mm) in 10 feet (3.1m) +/- ½ inch (13 mm) maximum
Top surface of bearing walls	+/1 ¼ inch (6.4 mm) in 10 feet (3.1m) +/- ½ inch (13 mm) maximum
Variations from plumb	+/- ¼ inch (6.4 mm) in 10 feet (3.1m) +/- 3/8 inch (9.5 mm) in 20 feet (6.1m) +/- ½ inch (13 mm) maximum
True to a line	+/- ¼ inch (6.4 mm) in 10 feet (3.1m) +/-3/8 inch (9.5 mm) in 20 feet (6.1m)
Alignment of columns and walls (bottom versus top)	+/- ½ inch (13 mm) for bearing walls +/- ¾ inch (19 mm) for nonbearing walls
Location of elements indicated on plan or in elevation	
Plan	+/- ½ inch (13 mm) in 20 feet (6.1m) +/- ¾ inch (19 mm) maximum
Elevation	+/- ¼ inch (6.4 mm) in story height +/- ¾ inch (19 mm) maximum

2.12.0 Masonry—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Unit Masonry

No.
04200

Date

1. Approved shop drawings are on site.
2. Approved samples are on site or evidenced.
3. Mortar mix and ingredients approved.
4. Sample panels provided and approved.
5. Materials stored off ground and covered.
6. Concrete Masonry units are not wet.
7. Reinforcement: type, size, splicing & spacing.
8. Do not allow excessive bending of rebar.
9. Pipes, sleeves, and boxes located.
10. No shovel measures for job mixed grout.
11. Climatic and temperature conditions are suitable.
12. Adequate lighting provided for good workmanship.
13. Joint size, type, tooling method as required.
14. Bonding is as required.
15. Observe full head and bed joints, etc.
16. Joints tooled to provide dense surface.
17. Wythes or spaces kept free of excess droppings.
18. Check anchors & ties for mat'l. size, & set.
19. Bucks & Anchors: secured, plumb, and level.
20. Provisions for flashings, cut-outs, & later items.
21. Provisions for parging if required.
22. Expansion and control joints are located.
23. Weeps are provided if required.
24. Structural members have suitable attachments.
25. Debris is removed periodically, not piled.
26. Protect work from freezing at least 48 hours.
27. Clean off splatters from freezing at least 48 hours.
28. Observe bond beam filling.
29. Hollow metal frames are filled solid.
30. Backfilling after proper curing & support.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

3

Structural Steel, Joists, and Metal Decking

Contents

3.0.0 History of Steel and Grades of Structural Steel

Iron was produced by primitive man by placing iron ore and charcoal in a clay pot and building a fire in the pot, using a crude bellows to provide the forced draft that deposited iron at the bottom. It was not until the mid-1800s that Henry Bessemer, an English metallurgist, developed a process whereby forced air was introduced into the iron-refining procedure raising the temperature of the crucible so that impurities in the molten pig iron were burned away. In the process, a more malleable metal, steel, was created.

Various minerals and metals are added to molten steel nowadays to enhance certain characteristics:

- *Nickel* Improves the hardenability of steel and increases impact strength at low temperatures.
- *Sulfur* Increases machinability.
- *Manganese* Increases strength and hardness.
- *Carbon* The principal hardening agent in steel.
- *Molydenum* Prevents brittleness.
- *Vanadium* Gives steel a fine grain structure and improves the fatigue values.
- *Silicon* Improves strength. It is a deoxidizer.
- *Phosphorous* Improves the machinability of high-sulfur steel sand imparts some resistance to corrosion.

ASTM Structural Steel Specifications

ASTM designation	Steel type
A36	Carbon
A529	Carbon
A441	High strength (low alloy)
A572 grade (includes 42, 50, 60, 65)	High strength (low alloy)
A242	Corrosion resistant, high strength Low alloy
A588	Corrosion resistant, high strength Low alloy
A852	Quenched and tempered (low alloy) (Plates only)
A514	Quenched and tempered alloy (Plates only)

3.0.1 ASTM A572-Grade 50 versus A992

During the last decade of the 20th century, ASTM A572-Grade 50 had become the industry standard. As the proliferation of specialty min-mills increased the price differential between A36 steel and A50 steel, A36 gradually disappeared and most structural engineers began routinely producing designs incorporating A50 steel.

Now A992, with a minimum strength of 50 ksi, has become the industry standard. This grade has an upper limit of 65 ksi, a minimum tensile strength of 65 ksi, and a specified maximum yield-to-tensile ratio of 0.85.

Although most producers of domestic steel have been rolling A992 steel for some time, this grade may not be available as warehouse steel in all locations.

The chemical composition and tensile requirements of both ASTM A527-Grade 50 and A992 are set forth below:

A572 Grade 50	A992
Covers structural steel shapes, plates, piling and bars	Covers “W” shapes (rolled wide flange shapes) intended for use in building framing.
Intended for riveted, bolted, or welded construction of bridges, buildings and other structures	

3.1.0 Surface Areas/Box Areas of "W" Shapes (W4 to W12)

Designation	Case A	Case B	Case C	Case D
W 12x 58	4.39	5.22	2.87	3.70
x 53	4.37	5.20	2.84	3.68
W 12x 50	3.90	4.58	2.71	3.38
x 45	3.88	4.55	2.68	3.35
x 40	3.86	4.52	2.66	3.32
W 12x 35	3.63	4.18	2.63	3.18
x 30	3.60	4.14	2.60	3.14
x 26	3.58	4.12	2.58	3.12
W 12x 22	2.97	3.31	2.39	2.72
x 19	2.95	3.28	2.36	2.69
x 16	2.92	3.25	2.33	2.66
x 14	2.90	3.23	2.32	2.65
W 10x112	4.30	5.17	2.76	3.63
x100	4.25	5.11	2.71	3.57
x 88	4.20	5.06	2.66	3.52
x 77	4.15	5.00	2.62	3.47
x 68	4.12	4.96	2.58	3.42
x 60	4.08	4.92	2.54	3.38
x 54	4.06	4.89	2.52	3.35
x 49	4.04	4.87	2.50	3.33
W 10x 45	3.56	4.23	2.35	3.02
x 39	3.53	4.19	2.32	2.98
x 33	3.49	4.16	2.29	2.95
W 10x 30	3.10	3.59	2.23	2.71
x 26	3.08	3.56	2.20	2.68
x 22	3.05	3.53	2.17	2.65
W 10x 19	2.63	2.96	2.04	2.38
x 17	2.60	2.94	2.02	2.35
x 15	2.58	2.92	2.00	2.33
x 12	2.56	2.89	1.98	2.31

Designation	Case A	Case B	Case C	Case D
W 8x67	3.42	4.11	2.19	2.88
x58	3.37	4.06	2.14	2.83
x48	3.32	4.00	2.09	2.77
x40	3.28	3.95	2.05	2.72
x35	3.25	3.92	2.02	2.69
x31	3.23	3.89	2.00	2.67
W 8x28	2.87	3.42	1.89	2.43
x24	2.85	3.39	1.86	2.40
W 8x21	2.61	3.05	1.82	2.26
x18	2.59	3.03	1.79	2.23
W 8x15	2.27	2.61	1.69	2.02
x13	2.25	2.58	1.67	2.00
x10	2.23	2.56	1.64	1.97
W 6x25	2.49	3.00	1.57	2.06
x20	2.46	2.96	1.54	2.04
x15	2.42	2.92	1.50	2.00
W 6x16	1.98	2.31	1.38	1.72
x12	1.93	2.26	1.34	1.67
x 9	1.90	2.23	1.31	1.64
W 5x19	2.04	2.45	1.28	1.70
x16	2.01	2.43	1.25	1.67
W 4x13	1.63	1.96	1.03	1.37

Case A Shape perimeter, minus one flange surface.
Case B. Shape perimeter.
Case C Box perimeter, equal to one flange surface plus twice the depth.
Case D. Box perimeter, equal to two flange surfaces plus twice the depth.

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3.1.1 Surface Areas/Box Areas of "W" Shapes (W12 to W18)

Designation	Case A	Case B	Case C	Case D
W 18x 46	4.41	4.91	3.52	4.02
x 40	4.38	4.88	3.48	3.99
x 35	4.34	4.84	3.45	3.95
W 16x100	5.28	6.15	3.70	4.57
x 89	5.24	6.10	3.66	4.52
x 77	5.19	6.05	3.61	4.47
x 67	5.16	6.01	3.57	4.43
W 16x 57	4.39	4.98	3.33	3.93
x 50	4.36	4.95	3.30	3.89
x 45	4.33	4.92	3.27	3.86
x 40	4.31	4.89	3.25	3.83
x 36	4.28	4.87	3.23	3.81
W 16x 31	3.92	4.39	3.11	3.57
x 26	3.89	4.35	3.07	3.53
W 14x730	7.61	9.10	5.23	6.72
x665	7.46	8.93	5.08	6.55
x605	7.32	8.77	4.94	6.39
x550	7.19	8.62	4.81	6.24
x500	7.07	8.49	4.68	6.10
x455	6.96	8.36	4.57	5.98
W 14x426	6.89	8.28	4.50	5.89
x398	6.81	8.20	4.43	5.81
x370	6.74	8.12	4.36	5.73
x342	6.67	8.03	4.29	5.65
x311	6.59	7.94	4.21	5.56
x283	6.52	7.86	4.13	5.48
x257	6.45	7.78	4.06	5.40
x233	6.38	7.71	4.00	5.32
x211	6.32	7.64	3.94	5.25
x193	6.27	7.58	3.89	5.20
x176	6.22	7.53	3.84	5.15
x159	6.18	7.47	3.79	5.09
x145	6.14	7.43	3.76	5.05

Designation	Case A	Case B	Case C	Case D
W 14x132	5.93	7.16	3.67	4.90
x120	5.90	7.12	3.64	4.86
x109	5.86	7.08	3.60	4.82
x 99	5.83	7.05	3.57	4.79
x 90	5.81	7.02	3.55	4.76
W 14x 82	4.75	5.59	3.23	4.07
x 74	4.72	5.56	3.20	4.04
x 68	4.69	5.53	3.18	4.01
x 61	4.67	5.50	3.15	3.98
W 14x 53	4.19	4.86	2.99	3.66
x 48	4.16	4.83	2.97	3.64
x 43	4.14	4.80	2.94	3.61
W 14x 38	3.93	4.50	2.91	3.48
x 34	3.91	4.47	2.89	3.45
x 30	3.89	4.45	2.87	3.43
W 14x 26	3.47	3.89	2.74	3.16
x 22	3.44	3.86	2.71	3.12
W 12x336	5.77	6.88	3.92	5.03
x305	5.67	6.77	3.82	4.93
x279	5.59	6.68	3.74	4.83
x252	5.50	6.58	3.65	4.74
x230	5.43	6.51	3.58	4.66
x210	5.37	6.43	3.52	4.58
W 12x190	5.30	6.36	3.45	4.51
x170	5.23	6.28	3.39	4.43
x152	5.17	6.21	3.33	4.37
x136	5.12	6.15	3.27	4.30
x120	5.06	6.09	3.21	4.24
x106	5.02	6.03	3.17	4.19
x 96	4.98	5.99	3.13	4.15
x 87	4.95	5.96	3.10	4.11
x 79	4.92	5.93	3.07	4.08
x 72	4.89	5.90	3.05	4.05
x 65	4.87	5.87	3.02	4.02

Case A Shape perimeter, minus one flange surface
Case B Shape perimeter
Case C Box perimeter, equal to one flange surface plus twice the depth
Case D Box perimeter, equal to two flange surfaces plus twice the depth.

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3.1.2 Surface Areas/Box Areas of "W" Shapes (W18 to W36)

Designation	Case A	Case B	Case C	Case D
W 36x300	9.99	11.40	7.51	8.90
x280	9.95	11.30	7.47	8.85
x260	9.90	11 30	7.42	8.80
x245	9.87	11.20	7.39	8.77
x230	9.84	11.20	7.36	8.73
W 36x210	8.91	9.93	7.13	8.15
x194	8.88	9.89	7.09	8.10
x182	8.85	9.85	7.06	8.07
x170	8.82	9.82	7.03	8.03
x160	8.79	9.79	7.00	8.00
x150	8.76	9.76	6.97	7.97
x135	8.71	9.70	6.92	7.92
W 33x241	9.42	10.70	7.02	8.34
x221	9.38	10.70	6.97	8.29
x201	9.33	10.60	6.93	8.24
W 33x152	8.27	9.23	6.55	7.51
x141	8.23	9.19	6.51	7.47
x130	8.20	9.15	6.47	7.43
x118	8.15	9.11	6.43	7.39
W 30x211	8.71	9.97	6.42	7.67
x191	8.66	9.92	6.37	7.62
x173	8.62	9.87	6.32	7.57
W 30x132	7.49	8.37	5.93	6.81
x124	7.47	8.34	5.90	6.78
x116	7.44	8.31	5.88	6.75
x108	7.41	8.28	5.84	6.72
x 99	7.37	8.25	5.81	6.68
W 27x178	7.95	9.12	5.81	6.98
x161	7.91	9.08	5.77	6.94
x146	7.87	9.03	5.73	6.89
W 27x114	6.88	7.72	5.39	6.23
x102	6.85	7.68	5.35	6.18
x 94	6.82	7.65	5.32	6.15
x 84	6.78	7.61	5.28	6.11
W 24x162	7.22	8.30	5.25	6.33
x146	7.17	8.24	5.20	6.27
x131	7.12	8.19	5.15	6.22
x117	7.08	8.15	5.11	6.18
x104	7.04	8.11	5.07	6.14
W 24x 94	6.16	6.92	4.81	5.56
x 84	6.12	6.87	4.77	5.52
x 76	6.09	6.84	4.74	5.49
x 68	6.06	6.80	4.70	5.45
W 24x 62	5.57	6.16	4.54	5.13
x 55	5.54	6.13	4.51	5.10
W 21x147	6.61	7.66	4.72	5.76
x132	6.57	7.61	4.69	5.71
x122	6.54	7.57	4.65	5.68
x111	6.51	7.54	4.61	5.64
x101	6.48	7.50	4.58	5.61
W 21x 93	5.54	6.24	4.31	5.01
x 83	5.50	6.20	4.27	4.96
x 73	5.47	6.16	4.23	4.92
x 68	5.45	6.14	4.21	4.90
x 62	5.42	6.11	4.19	4.87
W 21x 57	5.01	5.56	4.06	4.60
x 50	4.97	5.51	4.02	4.56
x 44	4.94	5.48	3.99	4.53
W 18x119	5.81	6.75	4.10	5.04
x106	5.77	6.70	4.06	4.99
x 97	5.74	6.67	4.03	4.96
x 86	5.70	6.62	3.99	4.91
x 76	5.67	6.59	3.95	4.87
W 18x 71	4.85	5.48	3.71	4.35
x 65	4.82	5.46	3.69	4.32
x 60	4.80	5.43	3.67	4.30
x 55	4.78	5.41	3.65	4.27
x 50	4.76	5.38	3.62	4.25

Case A: Shape perimeter, minus one flange surface.
Case B: Shape perimeter.
Case C: Box perimeter, equal to one flange surface plus twice the depth.
Case D: Box perimeter, equal to two flange surfaces plus twice the depth.

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3.2.0 Standard Mill Practices (Camber)

All beams are straightened after rolling to meet sweep and camber tolerances listed hereinafter for W shapes and S shapes. The following data refers to the subsequent cold cambering of beams to produce a predetermined dimension.

The maximum lengths that can be cambered depend on the length to which a given section can be rolled, with a maximum of 100 feet. The following table outlines the maximum and minimum induced camber of W shapes and S shapes.

MAXIMUM AND MINIMUM INDUCED CAMBER

Sections Nominal Depth in.	Specified Length of Beam, ft				
	Over 30 to 42, incl.	Over 42 to 52, incl.	Over 52 to 65, incl.	Over 65 to 85, incl.	Over 85 to 100, incl.
	Max. and Min. Camber Acceptable, in.				
W shapes, 24 and over	1 to 2, incl.	1 to 3, incl.	2 to 4, incl.	3 to 5, incl.	3 to 6, incl.
W shapes, 14 to 21, incl. and S shapes, 12 in. and over	¾ to 2½, incl.	1 to 3, incl.	2 to 4, incl.	2½ to 5, incl.	Inquire

Consult the producer for specific camber and/or lengths outside the above listed available lengths and sections.

Mill camber in beams of less depth than tabulated should not be specified.

A single minimum value for camber, within the ranges shown above for the length ordered, should be specified.

Camber is measured at the mill and will not necessarily be present in the same amount in the section of beam as received due to release of stress induced during the cambering operation. In general, 75% of the specified camber is likely to remain.

Camber will approximate a simple regular curve nearly the full length of the beam, or between any two points specified.

Camber is ordinarily specified by the ordinate at the mid-length of the portion of the beam to be curved. Ordinates at other points should not be specified.

Although mill cambering to achieve reverse or other compound curves is not considered practical, fabricating shop facilities for cambering by heat can accomplish such results as well as form regular curves in excess of the limits tabulated above.

CAMBER ORDINATE TOLERANCES

Lengths	Plus Tolerance	Minus Tolerance
50 ft and Less	½ inch	0
Over 50 ft	½ inch plus ⅛ inch for each 10 ft. or fraction thereof in excess of 50 ft.	0

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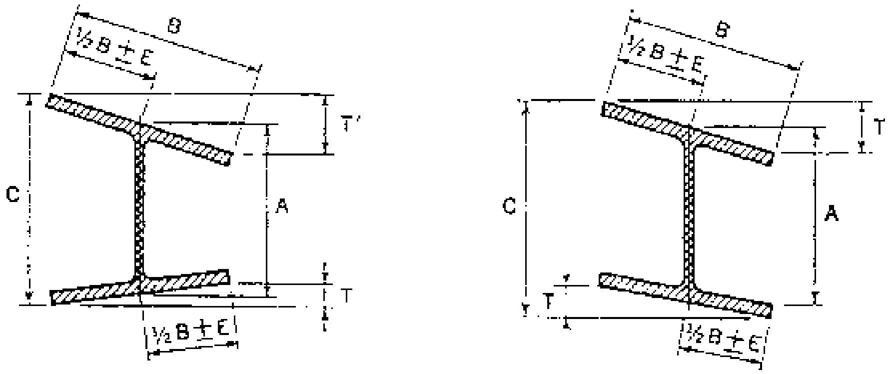

ROLLING TOLERANCES

Section Nominal Size, in.	A, Depth, in. Over Theoretical	A, Depth, in. Under Theoretical	B, Flg. Width, in. Over Theoretical	B, Flg. Width, in. Under Theoretical	T + T', Flanges, Out of Square, max., in.	[a]E, Web off Center, max., in.	C, Max. Depth at any Cross Section over Theoretical Depth, in.
To 12 incl.	1/8	1/8	1/4	3/16	1/4	3/16	1/4
Over 12	1/8	1/8	1/4	3/16	5/16	3/16	1/4

[a] Variation of 5/16 in. max. for sections over 426 lb/ft.

CUTTING TOLERANCES

W Shapes	Variations from Specified Length for Lengths Given, in. 30 ft and Under: Over	30 ft and Under: Under	Over 30 ft: Over	Over 30 ft: Under
Beams 24 in. and under in nominal depth	3/8	3/8	3/8 plus 1/16 for each additional 5 ft or fraction thereof	3/8
Beams over 24 in. nom. depth; all columns	1/2	1/2	1/2 plus 1/16 for each additional 5 ft or fraction thereof	1/2

OTHER TOLERANCES

Area and Weight Variation: ±2.5% theoretical or specified amount.

Ends Out-of-Square: 1/64 in. per in. of depth, or of flange width if it is greater than the depth.

Camber and Sweep:

Sizes	Length	Permissible Variation, in. Camber	Permissible Variation, in. Sweep
Sizes with flange width equal to or greater than 6 in.	All	$\frac{1}{8}$ in. × $\frac{\text{(total length, ft)}}{10}$	
Sizes with flange width less than 6 in.	All	$\frac{1}{8}$ in. × $\frac{\text{(total length, ft)}}{10}$	$\frac{1}{8}$ in. × $\frac{\text{(total length, ft)}}{5}$
[b] Certain sections with a flange width approx. equal to depth & specified on order as columns	45 ft and under	$\frac{1}{8}$ in. × $\frac{\text{(total length, ft)}}{10}$ with $\frac{3}{8}$ in. max.	
	Over 45 ft	$\frac{3}{8}$ in. + $\left[\frac{1}{8}\text{ in.} \times \frac{\text{(total length, ft} - 45)}{10}\right]$	

[b] Applies only to: W 8 x 31 and heavier, W 12 x 65 and heavier, W 10 x 49 and heavier, W 14 x 90 and heavier. If other sections are specified on the order as columns, the tolerance will be subject to negotiation with the manufacturer.

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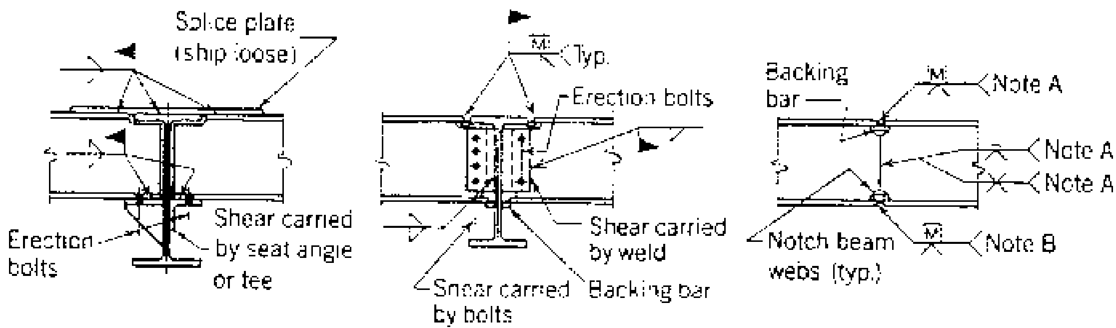
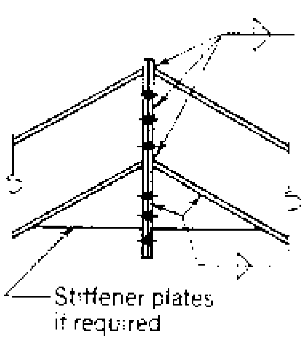
3.2.1 Standard Mill Practices ("W" Shape Tolerances)

WELDED MOMENT SPLICES

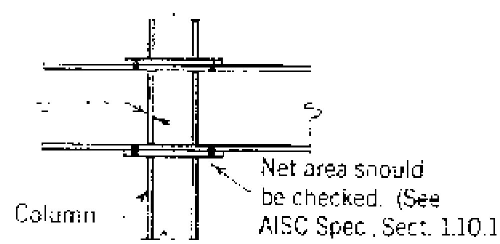


Note A: Joint preparation depends on thickness of material and welding process.
Note B: Invert this joint preparation if beam cannot be turned over.

MOMENT SPLICE AT RIDGE
(FIELD BOLTED)



*BEAM OVER COLUMN
(WITH CONTINUITY)



*For Plastic Design see Spec. Sect. 2.6.

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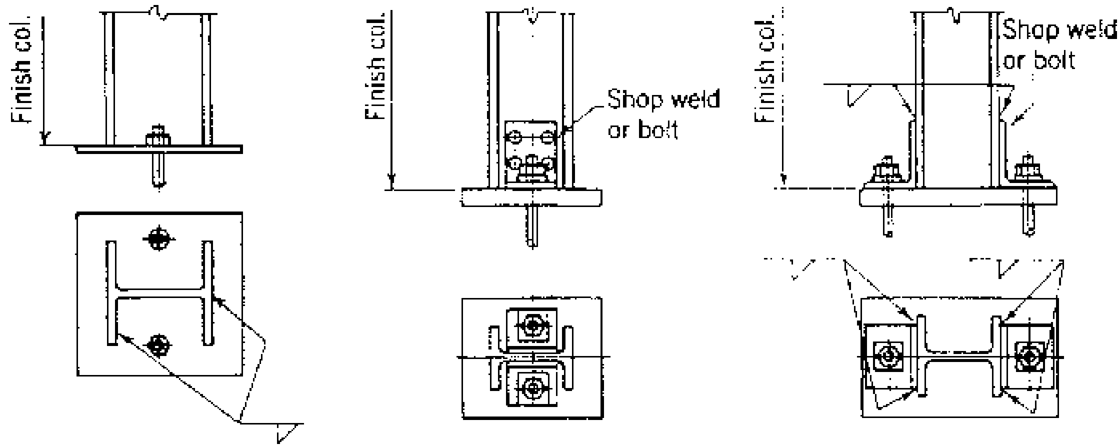
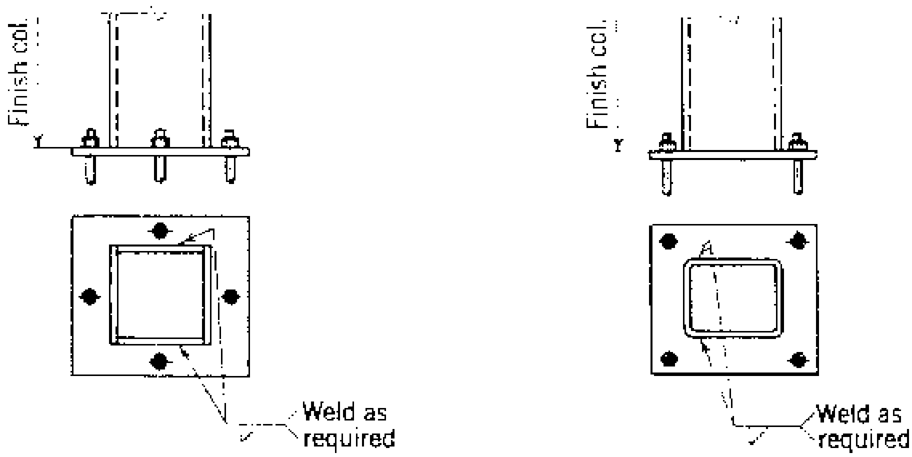
3.3.0 Suggested Beam Framing Details



Base plate detailed and shipped loose when required.



Notes:

1. Hole sizes for anchor bolts are normally made oversize to facilitate erection as follows:
   Bolts ¾ to 1″φ — $^{5}/_{16}$″ oversize
   Bolts 1 to 2″φ — ½″ oversize
   Bolts over 2″φ — 1″ oversize
2. The stability of a column with its loading should be considered at all stages of erection and its base designed accordingly for anchors and base plate.

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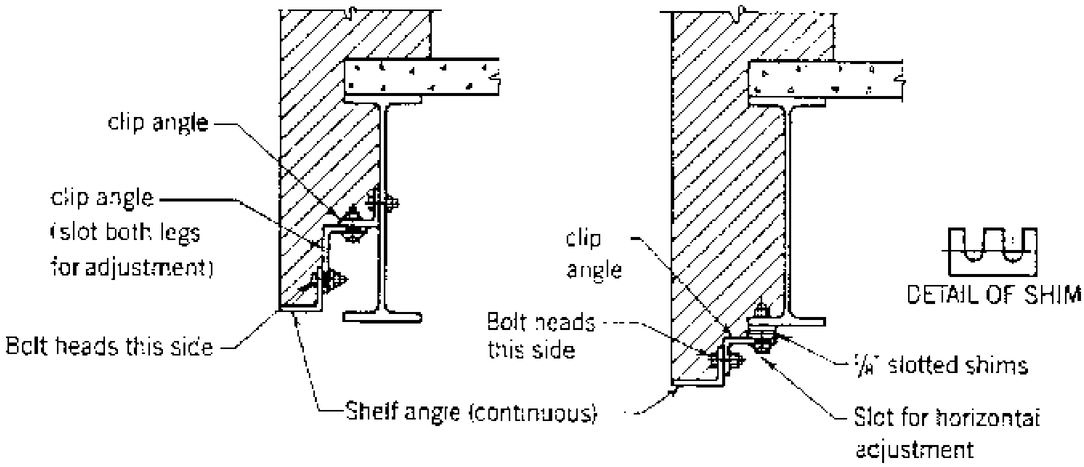
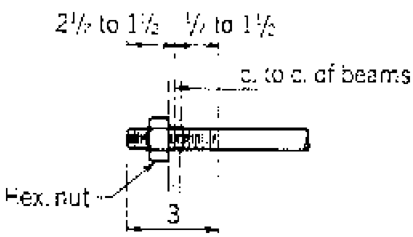
3.3.1 Suggested Column Base Plate Details

SHELF ANGLES WITH ADJUSTMENT



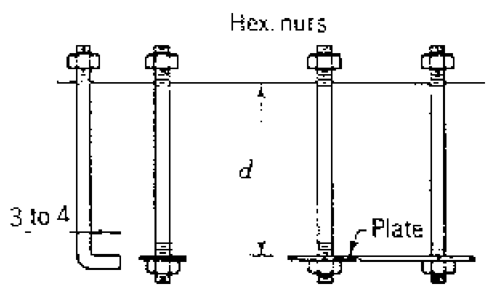
Notes: Horizontal adjustment is made by slotted holes; vertical adjustment may be made by slotted holes or by shims.
For tolerance allowance in alignment, see AISC Code of Standard Practice

TIE RODS AND ANCHORS



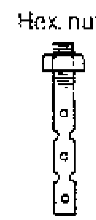
Note: Length of rod c. to c. should be specified in multiples of 3 in.

Tie Rods

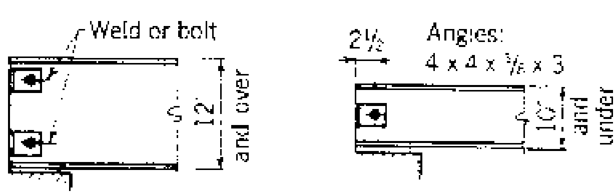


Note: Dimension d should be based on design req't for uplift

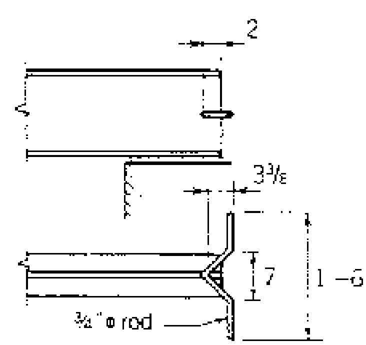
Anchor Bolts



Swedge Bolts



Angle Wall Anchors



Government Anchor

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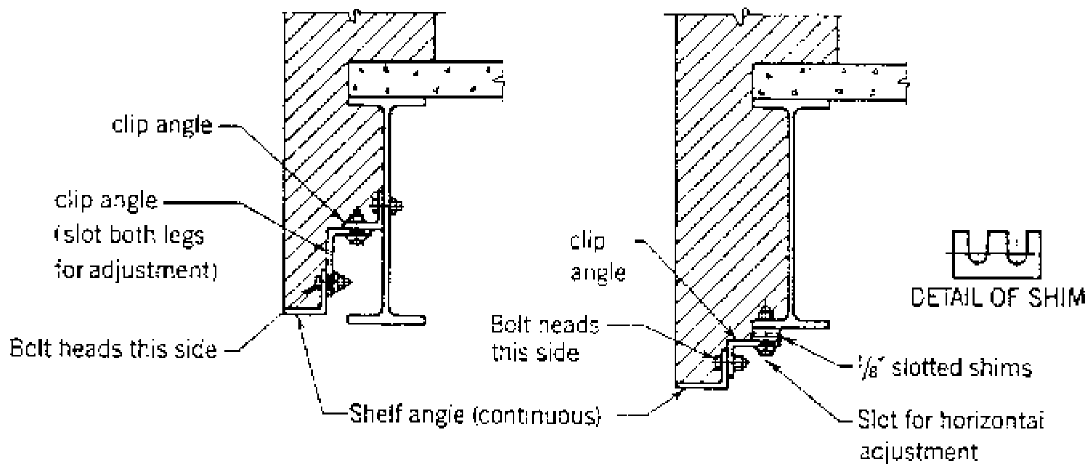
3.3.2 Suggested Structural Steel Erection Details—Miscellaneous

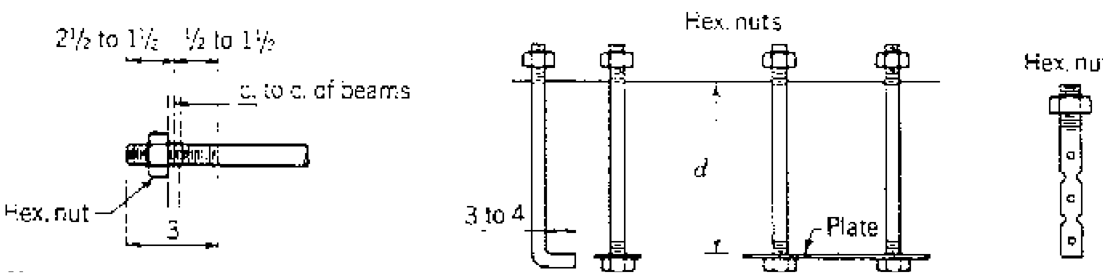
SHELF ANGLES WITH ADJUSTMENT



Notes: Horizontal adjustment is made by slotted holes; vertical adjustment may be made by slotted holes or by shims.

For tolerance allowance in alignment, see AISC Code of Standard Practice.

TIE RODS AND ANCHORS



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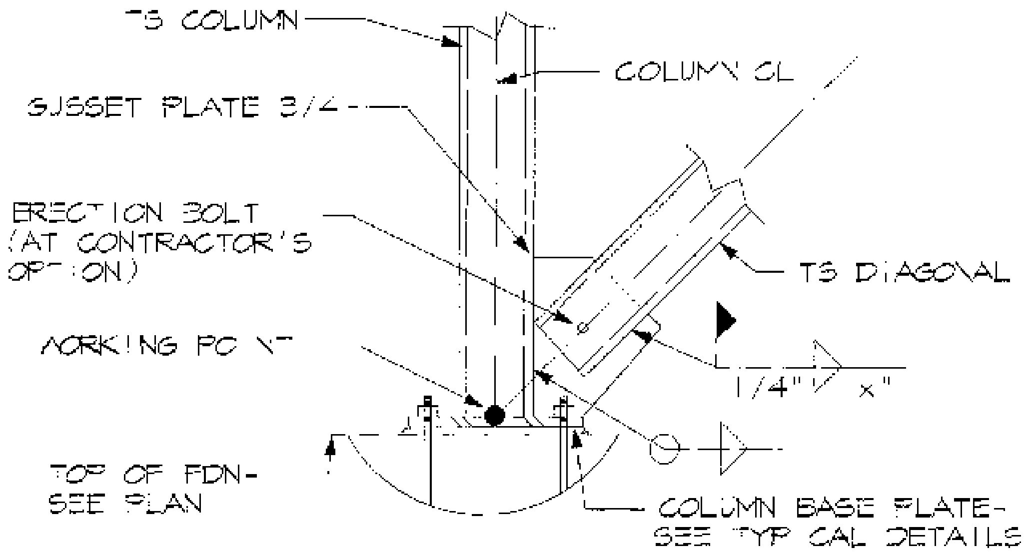
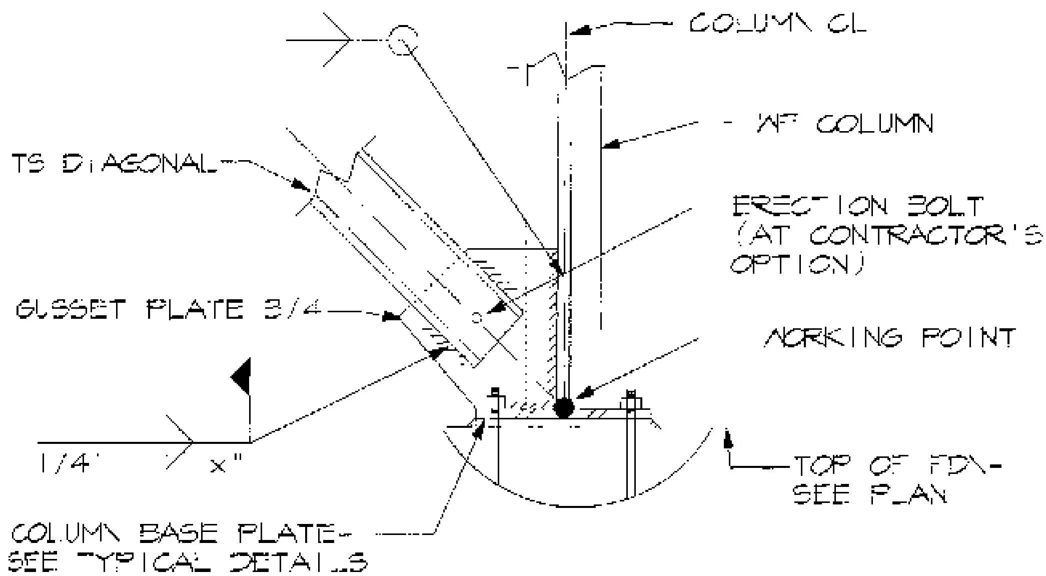
3.3.4 Typical Braced Bay—Detail Connections



DETAIL A, AT TS COLUMN



DETAIL A, AT WF COLUMN

BRACED BAY DETAIL A

NOT TO SCALE (DETAIL T5–BAYD1)

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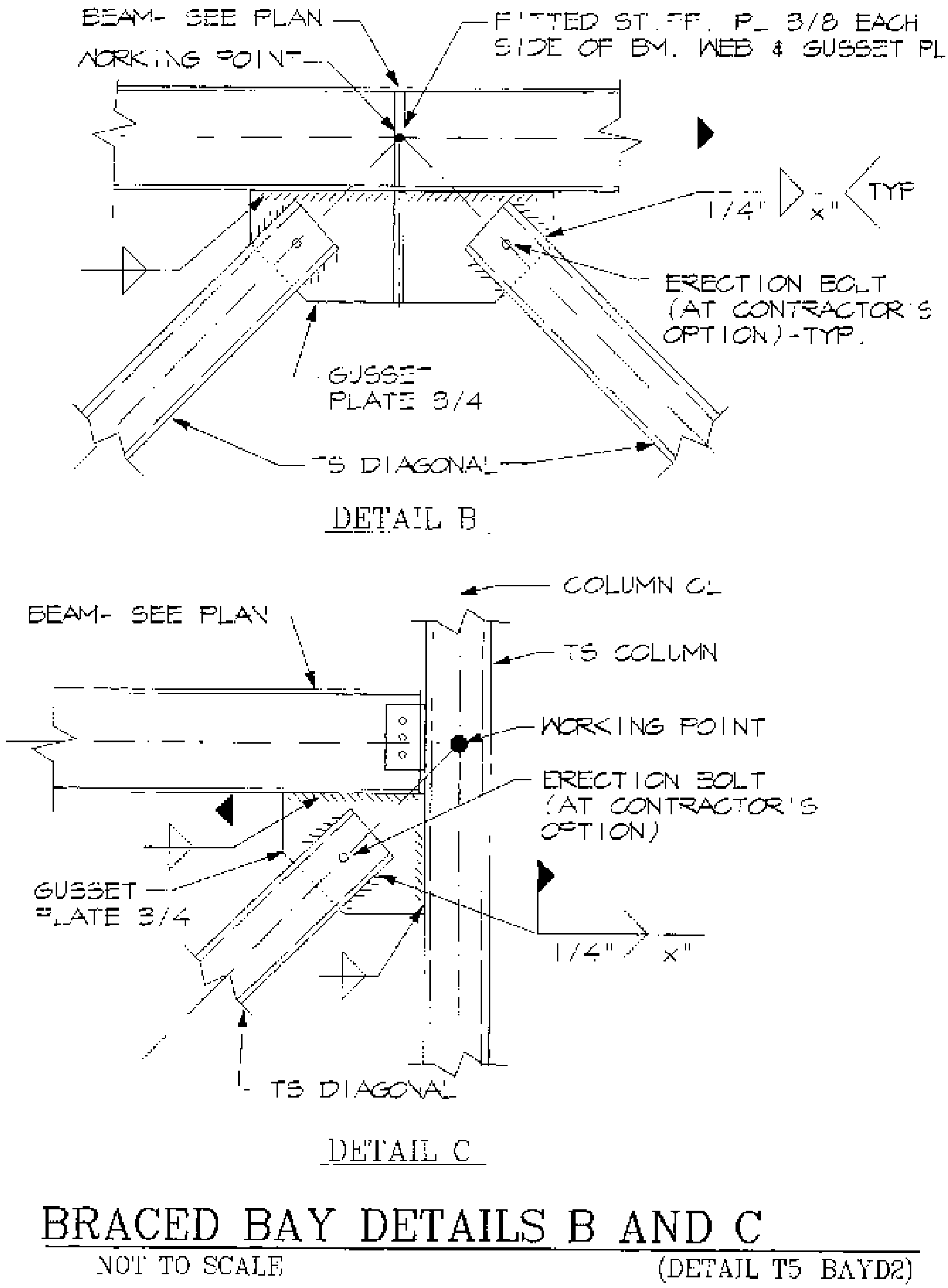
3.3.5 Typical Braced Bay—Other Detail Connections



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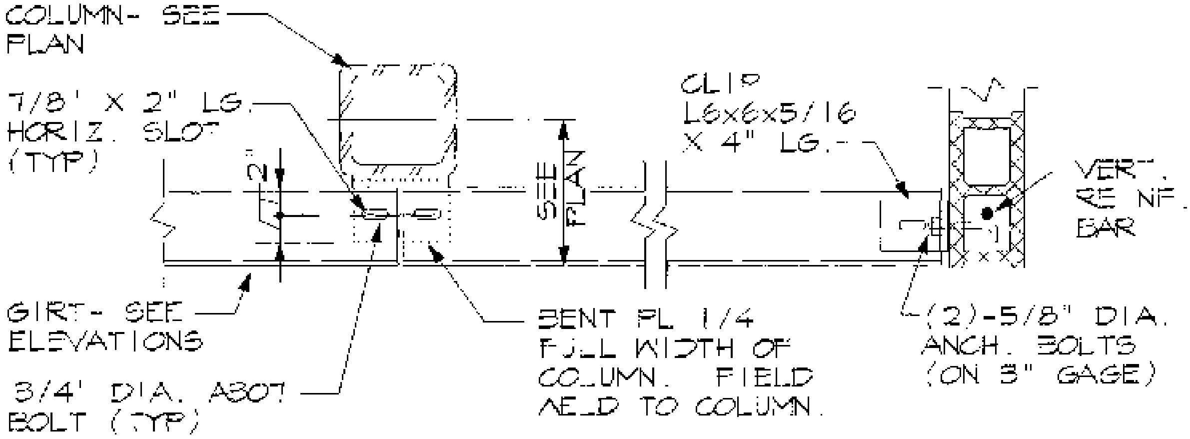
3.3.6 Typical Channel Girt Connection



AT COLUMNS AT MASONRY

TYPICAL CHANNEL GIRT CONNECTION DETAILS

NOT TO SCALE (DETAIL T5–GIRT3)

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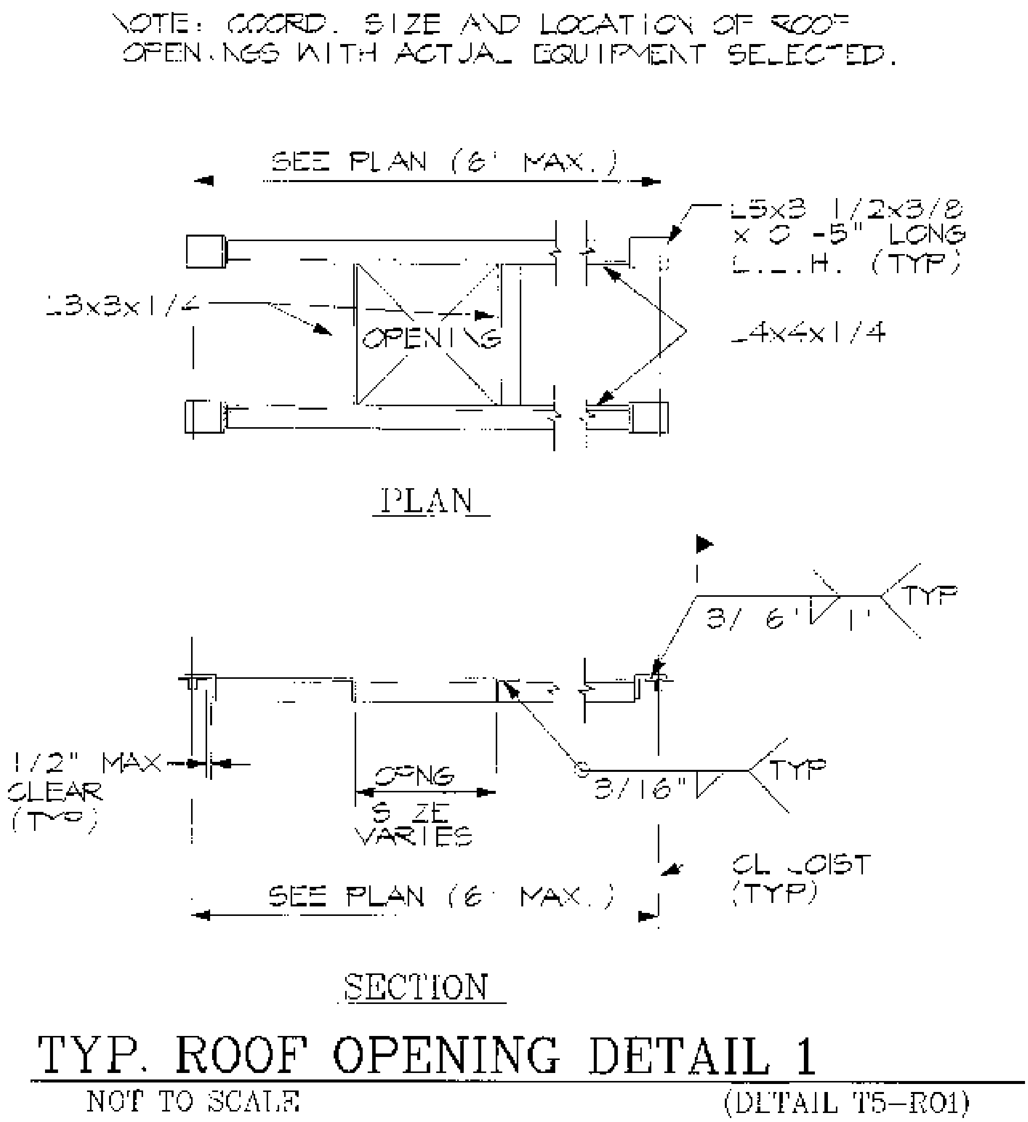
Figure 3.3.7 Typical Roof Opening Detail



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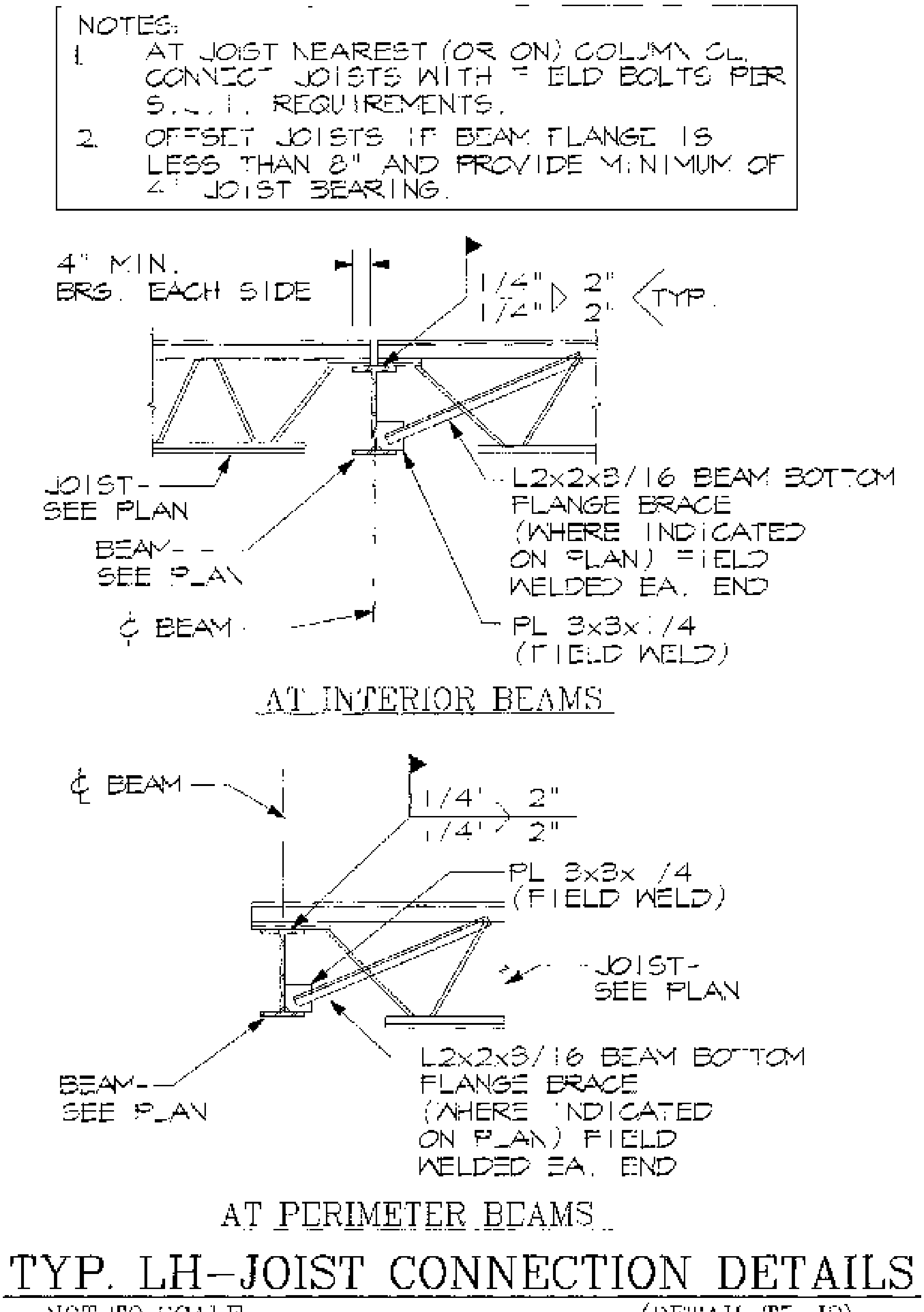
3.3.8 Typical LH–Joist Connection Details



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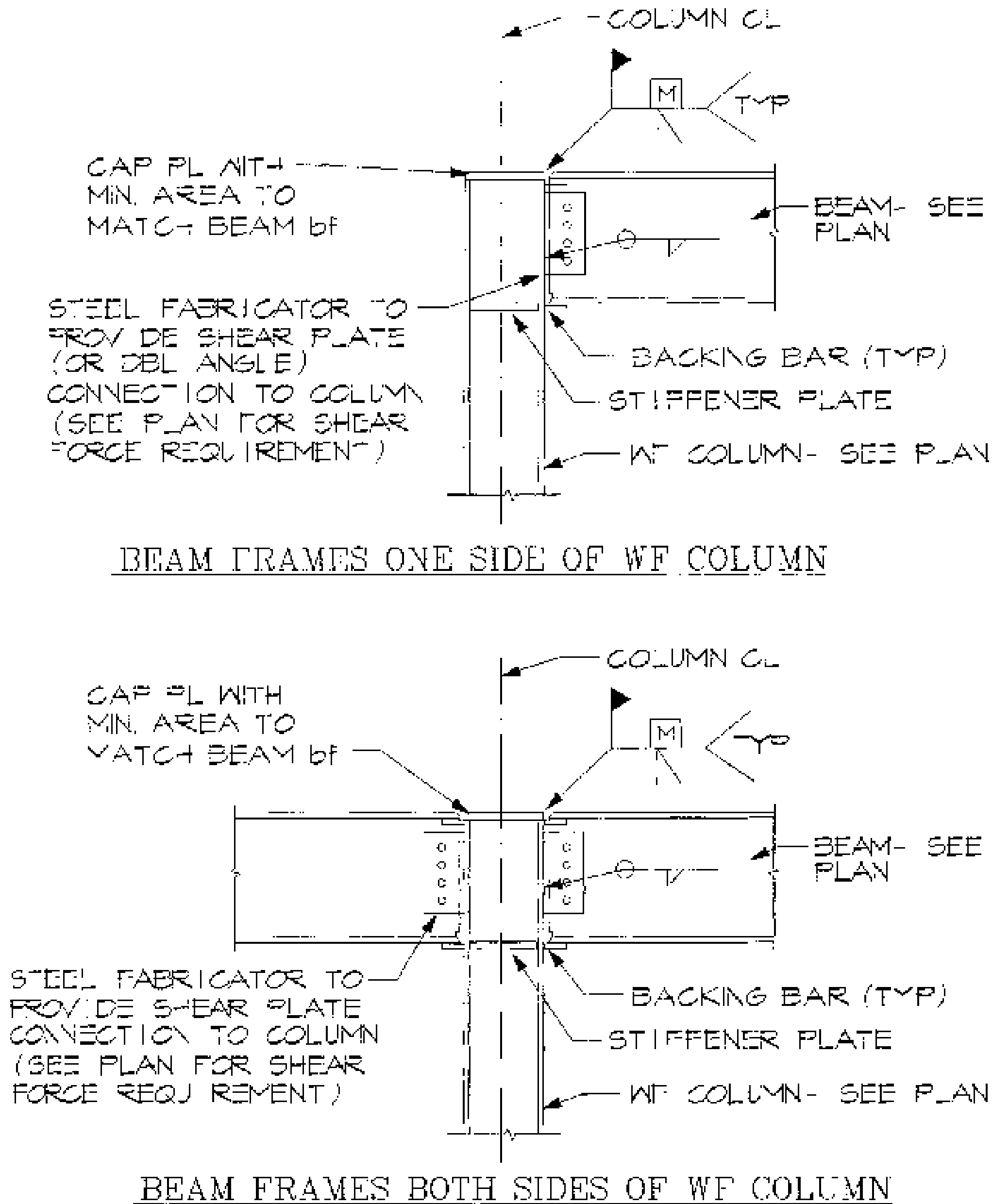
3.3.9 Beam Moment Connection Detail

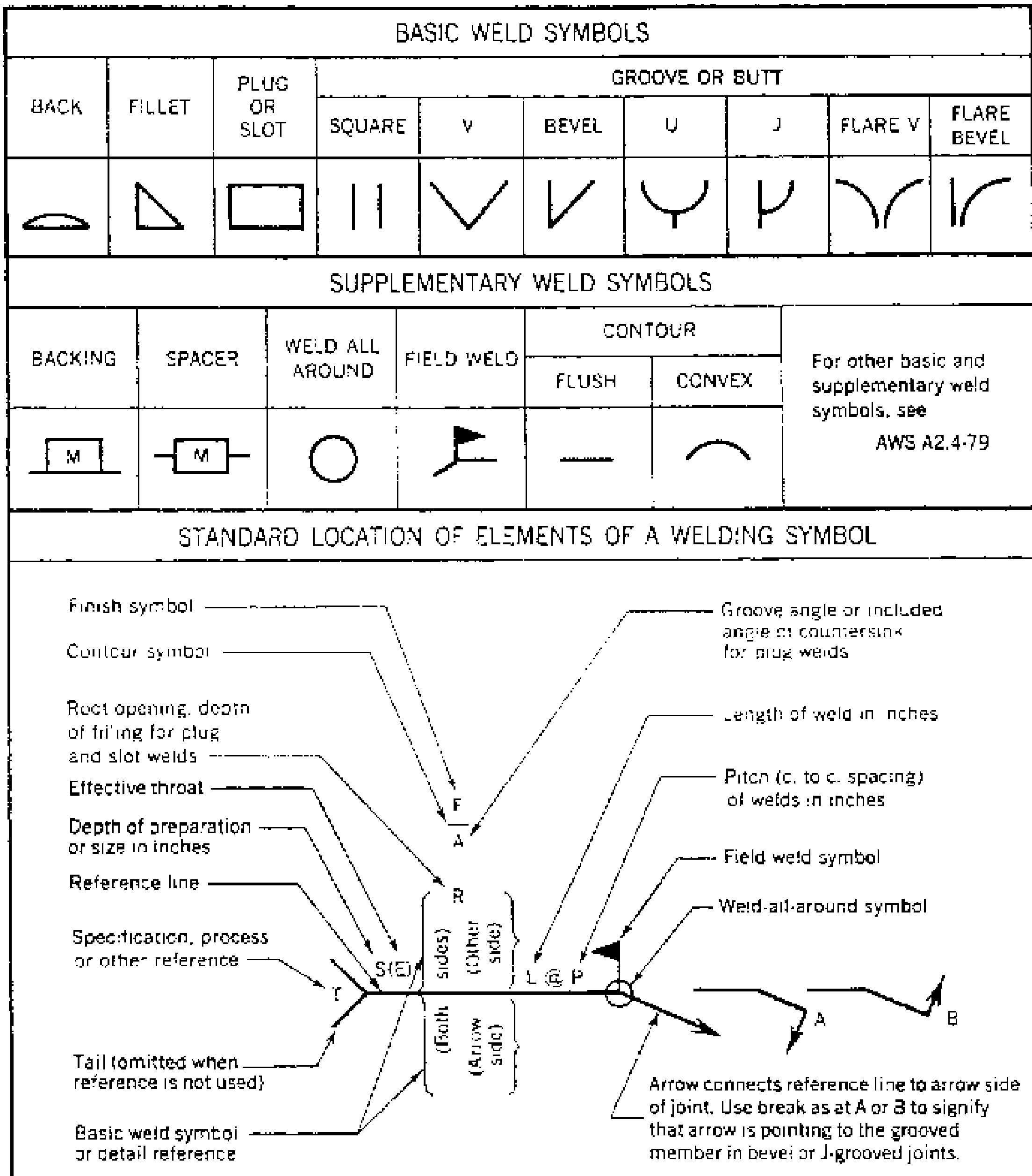


BEAM MOMENT CONNECTION DETAIL #2

NOT TO SCALE (DETAIL T5 CM02)

(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

3.4.0 Welded Joints—Standard Symbols



Note:

Size, weld symbol, length of weld and spacing must read in that order from left to right along the reference line. Neither orientation of reference line nor location of the arrow alter this rule.

The perpendicular leg of ◺, V, K, ⌐ weld symbols must be at left.

Arrow and Other Side welds are of the same size unless otherwise shown. Dimensions of fillet welds must be shown on both the Arrow Side and the Other Side Symbol.

The point of the field weld symbol must point toward the tail.

Symbols apply between abrupt changes in direction of welding unless governed by the "all around" symbol or otherwise dimensioned.

These symbols do not explicitly provide for the case that frequently occurs in structural work, where duplicate material (such as stiffeners) occurs on the far side of a web or gusset plate. The fabricating industry has adopted this convention: that when the billing of the detail material discloses the existence of a member on the far side as well as on the near side, the welding shown for the near side shall be duplicated on the far side.

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3.4.1 Tensile Strength of Puddle Welds

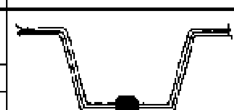
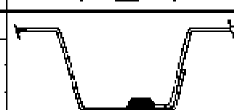
Tensile Strength of Arc Puddle Welds

The weld tensile strengths, pounds, shown in the table are based on the lowest weld strengths obtained using the range of steel properties of roof deck (and floor deck). The AISI 1996 Specifications are the basis of the table. The strengths are the nominal (ultimate) values. For LRFD apply a ϕ factor of 0.60; and, for ASD, use a safety factor of 2.5. For ASD it may be appropriate to take advantage of the 1/3 increase allowed for temporary wind loading.

Case 1: Single deck thickness.

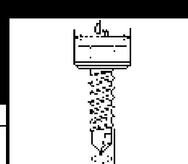
Case 2: Two layers of deck such as at an end lap.

Case 3: At a side lap (on structural steel or bar joist).

Case #	Gage	Visible Weld Diameter				Profile
		.5	.625	.75	1.0	
1	22	550	690	840	1130	
	20	660	830	1010	1360	
	18	850	1080	1310	1750	
	16	1040	1330	1630	2220	
2	22	870	1150	1440	2000	
	20	980	1330	1670	2360	
	18	1130	1590	2050	2960	
	16	1200	1780	2350	3500	
3	22	380	490	590	790	
	20	460	580	710	950	
	18	590	760	920	1250	
	16	730	930	1140	1550	

Wind Uplift Values on Screws

The failure mode to be investigated for wind uplift on screws is "pull over". The formula for the (ultimate) nominal pull over strength is P_{nov}, kips = $1.5 t d_w F_u$; $d_w \le 0.50"$ where d_w is the washer or head diameter (inches); t is the deck metal thickness (inches); and F_u is the tensile strength of the deck metal (ksi).

SCREW DATA				
Screw Size	d dia.	d_w nom. head dia	Avg. tested tensile strength, kips	
10	0.190	0.415 or 0.400	2.56	
12	0.210	0.430 or 0.400	3.62	
¼	0.250	0.480 or 0.520	4.81	

Pull Over Values, kips

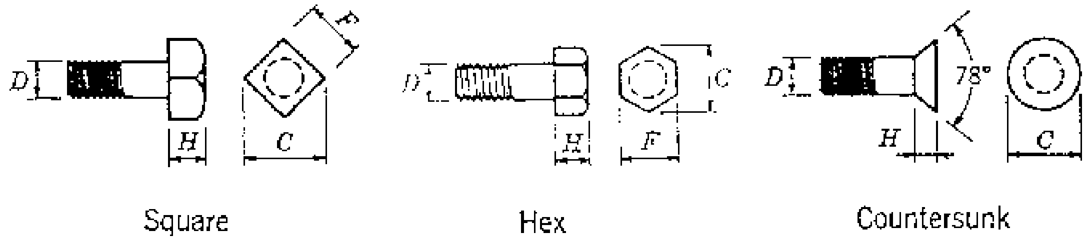
d_w	Gage						
	16	18	20	22	24	26	28
0.400	1.61	1.28	0.97	0.80	0.86	0.64	0.54
0.415	1.68	1.33	1.00	0.83	0.89	0.67	0.56
0.430	1.74	1.38	1.04	0.86	0.92	0.69	0.58
0.480	1.94	1.54	1.16	0.96	1.03	0.77	0.64
0.500	2.02	1.60	1.21	1.00	1.08	0.81	0.67

The table pull over strengths, kips, are based on F_u = 45 ksi for 16 thru 22 gage; and 60 ksi for 24 thru 28 gage.

The safety factor for pull over (ASD) is 3. But for wind loading the 1/3 load increase may be proper. The ϕ factor (LRFD) is 0.5.

(By permission from Steel Deck Institute, Fox River Grove, Illinois.)

3.5.0 Threaded Fasteners—Bolt Head Shapes



Bolt head dimensions, rounded to nearest $\frac{1}{16}$ inch, are in accordance with ANSI B18.2.1—1972 (Square and Hex) and ANSI 18.5—1971 (Countersunk)

Standard Dimensions for Bolt Heads

Diam. of Bolt D	Square			Hex			Heavy Hex			Countersunk	
	Width F	Width C	Height H	Width F	Width C	Height H	Width F	Width C	Height H	Diam. C	Height H
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{3}{16}$	...	...	...	$\frac{1}{2}$	$\frac{1}{8}$
$\frac{3}{8}$	$\frac{9}{16}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{1}{4}$	...	...	...	$\frac{11}{16}$	$\frac{3}{16}$
$\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{16}$	$\frac{5}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{7}{8}$	1	$\frac{3}{8}$	$\frac{7}{8}$	$\frac{1}{4}$
$\frac{5}{8}$	$\frac{15}{16}$	$1\frac{5}{16}$	$\frac{7}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$\frac{7}{16}$	$1\frac{1}{16}$	$1\frac{1}{4}$	$\frac{7}{16}$	$1\frac{1}{8}$	$\frac{5}{16}$
$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{9}{16}$	$\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{5}{16}$	$\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{7}{16}$	$\frac{1}{2}$	$1\frac{3}{8}$	$\frac{3}{8}$
$\frac{7}{8}$	$1\frac{5}{16}$	$1\frac{7}{8}$	$\frac{5}{8}$	$1\frac{5}{16}$	$1\frac{1}{2}$	$\frac{9}{16}$	$1\frac{7}{16}$	$1\frac{11}{16}$	$\frac{9}{16}$	$1\frac{9}{16}$	$\frac{7}{16}$
1	$1\frac{1}{2}$	$2\frac{1}{8}$	$\frac{11}{16}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$\frac{11}{16}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$\frac{11}{16}$	$1\frac{13}{16}$	$\frac{1}{2}$
$1\frac{1}{8}$	$1\frac{11}{16}$	$2\frac{3}{8}$	$\frac{3}{4}$	$1\frac{11}{16}$	$1\frac{15}{16}$	$\frac{3}{4}$	$1\frac{13}{16}$	$2\frac{1}{16}$	$\frac{3}{4}$	$2\frac{1}{16}$	$\frac{9}{16}$
$1\frac{1}{4}$	$1\frac{7}{8}$	$2\frac{5}{8}$	$\frac{7}{8}$	$1\frac{7}{8}$	$2\frac{3}{16}$	$\frac{7}{8}$	2	$2\frac{5}{16}$	$\frac{7}{8}$	$2\frac{1}{4}$	$\frac{5}{8}$
$1\frac{3}{8}$	$2\frac{1}{16}$	$2\frac{15}{16}$	$\frac{15}{16}$	$2\frac{1}{16}$	$2\frac{3}{8}$	$\frac{15}{16}$	$2\frac{3}{16}$	$2\frac{1}{2}$	$\frac{15}{16}$	$2\frac{1}{2}$	$\frac{11}{16}$
$1\frac{1}{2}$	$2\frac{1}{4}$	$3\frac{3}{16}$	1	$2\frac{1}{4}$	$2\frac{5}{8}$	1	$2\frac{3}{8}$	$2\frac{3}{4}$	1	$2\frac{11}{16}$	$\frac{3}{4}$
$1\frac{3}{4}$	...	...	...	$2\frac{5}{8}$	3	$1\frac{3}{16}$	$2\frac{3}{4}$	$3\frac{3}{16}$	$1\frac{3}{16}$	...	...
2	...	...	...	3	$3\frac{7}{16}$	$1\frac{3}{8}$	$3\frac{1}{8}$	$3\frac{5}{8}$	$1\frac{3}{8}$	...	...
$2\frac{1}{4}$	...	...	...	$3\frac{3}{8}$	$3\frac{7}{8}$	$1\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{16}$	$1\frac{1}{2}$	...	...
$2\frac{1}{2}$	...	...	...	$3\frac{3}{4}$	$4\frac{5}{16}$	$1\frac{11}{16}$	$3\frac{7}{8}$	$4\frac{1}{2}$	$1\frac{11}{16}$	...	...
$2\frac{3}{4}$	...	...	...	$4\frac{1}{8}$	$4\frac{3}{4}$	$1\frac{13}{16}$	$4\frac{1}{4}$	$4\frac{15}{16}$	$1\frac{13}{16}$	...	...
3	...	...	...	$4\frac{1}{2}$	$5\frac{3}{16}$	2	$4\frac{5}{8}$	$5\frac{5}{16}$	2	...	...
$3\frac{1}{4}$	...	...	...	$4\frac{7}{8}$	$5\frac{5}{8}$	$2\frac{3}{16}$	...	...	...	...	...
$3\frac{1}{2}$	...	...	...	$5\frac{1}{4}$	$6\frac{1}{16}$	$2\frac{5}{16}$	...	...	...	...	...
$3\frac{3}{4}$	...	...	..	$5\frac{5}{8}$	$6\frac{1}{2}$	$2\frac{1}{2}$	...	...	...	...	...
4	...	...	...	6	$6\frac{15}{16}$	$2\frac{11}{16}$	...	...	...	...	...

For dimensions for high strength bolts, refer to "Specifications for Structural Joints Using ASTM A325 or A490 Bolts".

Countersunk head bolts may be ordered with slotted or socket head.

(By permission of the American Institute of Steel Construction, Chicago, Illinois.)

3.5.1 Threaded Fasteners—Weight of Bolts

Length Under Head Inches	Diameter of Bolts in Inches								
	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
1	2.38	6.11	13.0	24.1	38.9	...	...	...	...
1 1/4	2.71	6.71	14.0	25.8	41.5	...	...	...	...
1 1/2	3.05	7.47	15.1	27.6	44.0	67.3	95.1	...	...
1 3/4	3.39	8.23	16.5	29.3	46.5	70.8	99.7	...	...
2	3.73	8.99	17.8	31.4	49.1	74.4	104	143	...
2 1/4	4.06	9.75	19.1	33.5	52.1	77.9	109	149	...
2 1/2	4.40	10.5	20.5	35.6	55.1	82.0	114	155	206
2 3/4	4.74	11.3	21.8	37.7	58.2	86.1	119	161	213
3	5.07	12.0	23.2	39.8	61.2	90.2	124	168	221
3 1/4	5.41	12.8	24.5	41.9	64.2	94.4	129	174	229
3 1/2	5.75	13.5	25.9	44.0	67.2	98.5	135	181	237
3 3/4	6.09	14.3	27.2	46.1	70.2	103	140	188	246
4	6.42	15.1	28.6	48.2	73.3	107	145	195	254
4 1/4	6.76	15.8	29.9	50.3	76.3	111	151	202	262
4 1/2	7.10	16.6	31.2	52.3	79.3	115	156	208	271
4 3/4	7.43	17.3	32.6	54.4	82.3	119	162	215	279
5	7.77	18.1	33.9	56.5	85.3	123	167	222	288
5 1/4	8.11	18.9	35.3	58.6	88.4	127	172	229	296
5 1/2	8.44	19.6	36.6	60.7	91.4	131	178	236	304
5 3/4	8.78	20.4	38.0	62.8	94.4	136	183	242	313
6	9.12	21.1	39.3	64.9	97.4	140	188	249	321
6 1/4	9.37	21.7	40.4	66.7	100	143	193	255	329
6 1/2	9.71	22.5	41.8	68.7	103	147	198	262	337
6 3/4	10.1	23.3	43.1	70.8	106	151	204	269	345
7	10.4	24.0	44.4	72.9	109	156	209	275	354
7 1/4	10.7	24.8	45.8	75.0	112	160	214	282	362
7 1/2	11.0	25.5	47.1	77.1	115	164	220	289	371
7 3/4	11.4	26.3	48.5	79.2	118	168	225	296	379
8	11.7	27.0	49.8	81.3	121	172	231	303	387
8 1/2	...	28.6	52.5	85.5	127	180	241	316	404
9	...	30.1	55.2	89.7	133	189	252	330	421
9 1/2	...	31.6	57.9	93.9	139	197	263	343	438
10	...	33.1	60.6	98.1	145	205	274	357	454
10 1/2	...	34.6	63.3	102	151	213	284	371	471
11	...	36.2	66.0	106	157	221	295	384	488
11 1/2	...	37.7	68.7	110	163	230	306	398	505
12	...	39.2	71.3	115	170	238	316	411	522
12 1/2	...	...	74.0	119	176	246	327	425	538
13	...	...	76.7	123	182	254	338	439	556
13 1/2	...	...	79.4	127	188	263	349	452	572
14	...	...	82.1	131	194	271	359	466	589
14 1/2	...	...	84.8	135	200	279	370	479	605
15	...	...	87.5	140	206	287	381	493	622
15 1/2	...	...	90.2	144	212	296	392	507	639
16	..	...	92.9	148	218	304	402	520	656
Per Inch Additional	1.3	3.0	5.4	8.4	12.1	16.5	21.4	27.2	33.6

Bolt is Square Bolt. ANSI B18.2.1—72 and nut is Hex Nut. ANSI B18.2.2—72. This table conforms to weight standards adopted by the Industrial Fasteners Institute.

(By permission of the American Institute of Steel Construction, Chicago, Illinois.)

3.5.2 Threaded Fasteners—Weight of ASTM A325 or A490 Bolts

Length Under Head Inches	Diameter of Bolt in Inches								
	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$
1	16.5	29.4	47.0	...	...	...	...	...	...
$1\frac{1}{4}$	17.8	31.1	49.6	74.4	104	...	...	...	...
$1\frac{1}{2}$	19.2	33.1	52.2	78.0	109	148	197	...	...
$1\frac{3}{4}$	20.5	35.3	55.3	81.9	114	154	205	261	333
2	21.9	37.4	58.4	86.1	119	160	212	270	344
$2\frac{1}{4}$	23.3	39.8	61.6	90.3	124	167	220	279	355
$2\frac{1}{2}$	24.7	41.7	64.7	94.6	130	174	229	290	366
$2\frac{3}{4}$	26.1	43.9	67.8	98.8	135	181	237	300	379
3	27.4	46.1	70.9	103	141	188	246	310	391
$3\frac{1}{4}$	28.8	48.2	74.0	107	146	195	255	321	403
$3\frac{1}{2}$	30.2	50.4	77.1	111	151	202	263	332	416
$3\frac{3}{4}$	31.6	52.5	80.2	116	157	209	272	342	428
4	33.0	54.7	83.3	120	162	216	280	353	441
$4\frac{1}{4}$	34.3	56.9	86.4	124	168	223	289	363	453
$4\frac{1}{2}$	35.7	59.0	89.5	128	173	230	298	374	465
$4\frac{3}{4}$	37.1	61.2	92.7	133	179	237	306	384	478
5	38.5	63.3	95.8	137	184	244	315	395	490
$5\frac{1}{4}$	39.9	65.5	98.9	141	190	251	324	405	503
$5\frac{1}{2}$	41.2	67.7	102	146	196	258	332	416	515
$5\frac{3}{4}$	42.6	69.8	105	150	201	265	341	426	527
6	44.0	71.9	108	154	207	272	349	437	540
$6\frac{1}{4}$	...	74.1	111	158	212	279	358	447	552
$6\frac{1}{2}$	...	76.3	114	163	218	286	367	458	565
$6\frac{3}{4}$	...	78.5	118	167	223	293	375	468	577
7	...	80.6	121	171	229	300	384	479	589
$7\frac{1}{4}$	...	82.8	124	175	234	307	392	489	602
$7\frac{1}{2}$	...	84.9	127	179	240	314	401	500	614
$7\frac{3}{4}$	...	87.1	130	183	246	321	410	510	626
8	...	89.2	133	187	251	328	418	521	639
$8\frac{1}{4}$	...	...	...	192	257	335	427	531	651
$8\frac{1}{2}$	...	...	...	196	262	342	435	542	664
$8\frac{3}{4}$	...	...	...	...	...	...	444	552	676
9	...	...	...	...	...	...	453	563	689
Per inch additional add	5.5	8.6	12.4	16.9	22.1	28.0	34.4	42.5	49.7
For each 100 plain round washers add	2.1	3.6	4.8	7.0	9.4	11.3	13.8	16.8	20.0
For each 100 beveled square washers add	23.1	22.4	21.0	20.2	19.2	34.0	31.6	...	...

This table conforms to weight standards adopted by the Industrial Fasteners Institute, 1965, updated for washer weights.

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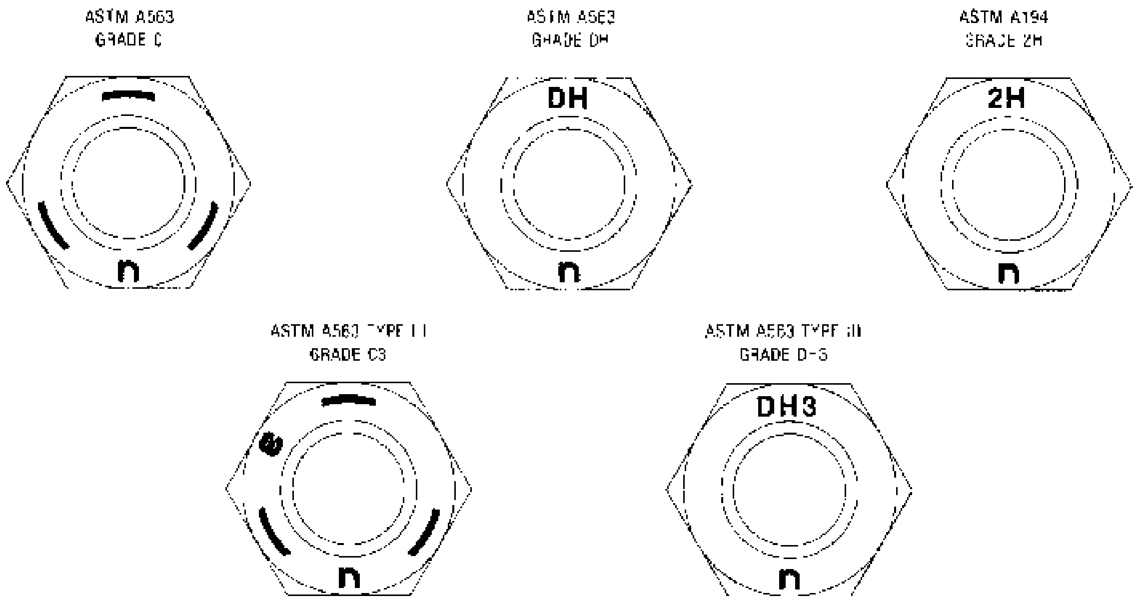
Heavy Hex Structural Bolts with Heavy Hex Nuts in Pounds per 100

Grade	Proof Load Stress	Rockwell Hardness
A563 Grade C & C3	144,000 PSI	B78-C38
A563 Grade DH & DH3	175,000 PSI	C24-C38
A19 Grade 2H	175,000 PSI	C24-C38



(By permission of Nucor Fastener division of Nucor Corp., St. Joe, Indiana.)

3.5.3 Properties of Heavy Hex Nuts and Identifying Marks

AISC/LRFD (ASTM A325-A490)				ISO/TC 167 (ASTM A325M - A490M)	
Bolt Diameter		Hole		Bolt Diameter	Hole
in.	mm	in.	mm	mm	mm
1/2	12.7	9/16	14.3	-	-
5/8	15.9	11/16	17.5	M16	18
3/4	19.0	13/16	20.6	-	-
-	-	-	-	M20	22
7/8	22.2	15/16	23.8	M22	24
-	-	-	-	M24	26
1	25.4	1 1/16	27.0	-	-
1 1/6	28.6	1 3/16	30.2	M27	30
1 1/4	31.8	1 5/16	33.3	M30	33
1 3/8	34.9	1 7/16	36.5	-	-
-	-	-	-	M36	39
1 1/2	36.1	1 9/16	39.7	-	-

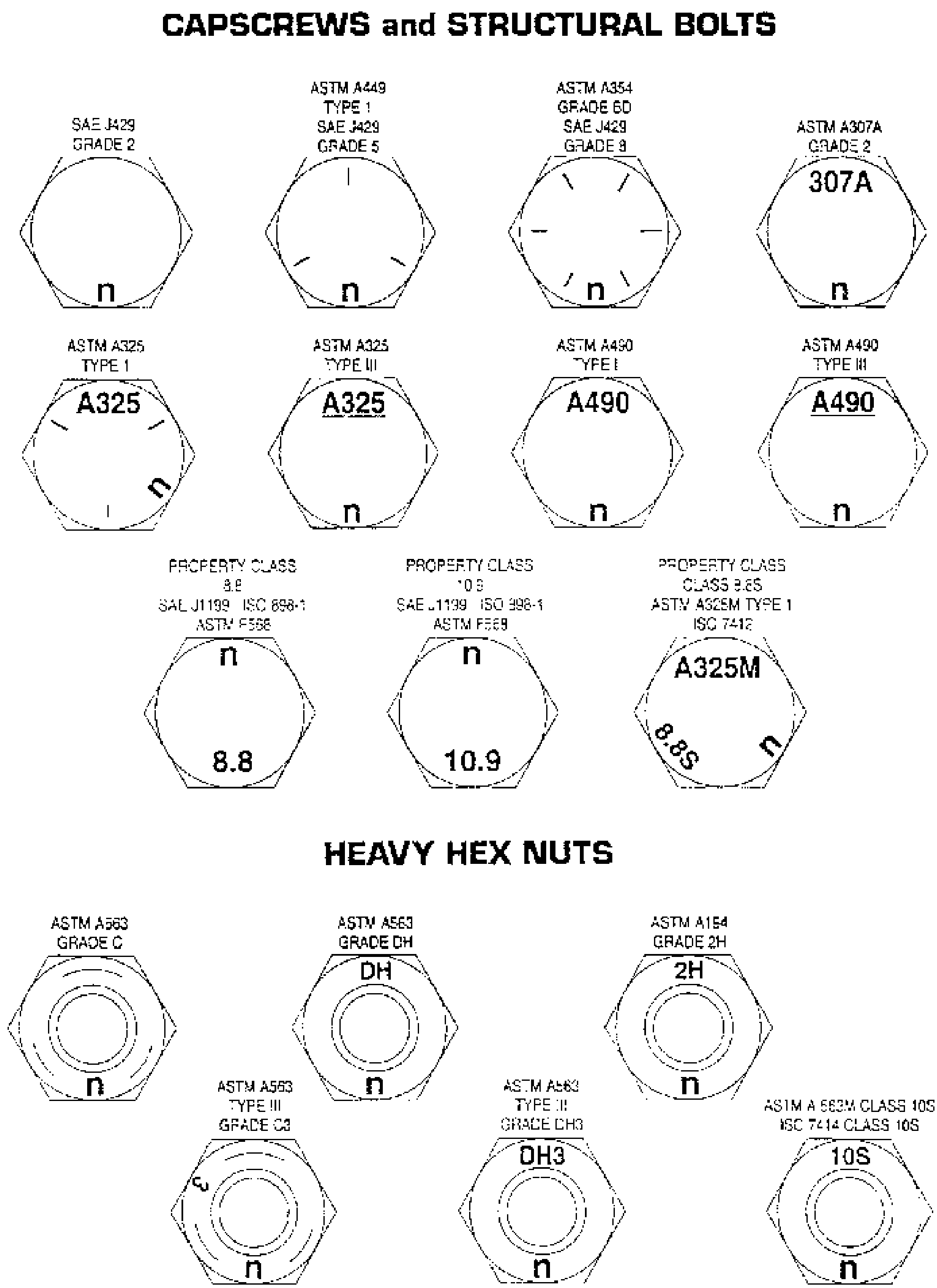
Standard Hole Diameters

Metric Bolt mm	U.S. Substitution inch
M16	5/8
M22	7/8
M27	1 1/8
M30	1 1/4

Suggested Permissible Bolt Substitutions

(By permission of Nucor Fastener division of Nucor Corp., St. Joe, Indiana.)

3.5.4 Bolt Diameters and Standard Hole Dimensions



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3.5.5 Capscrews/Bolts/Heavy Hex Nut Identifying Marks

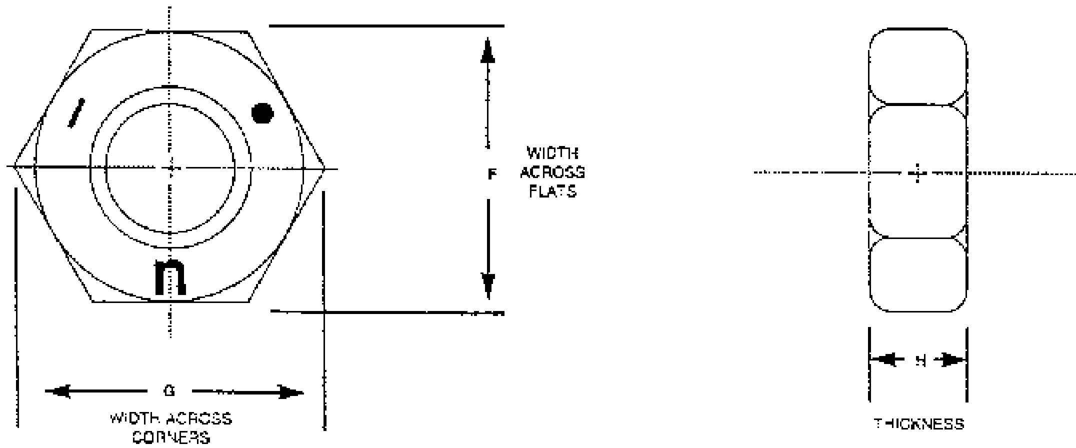


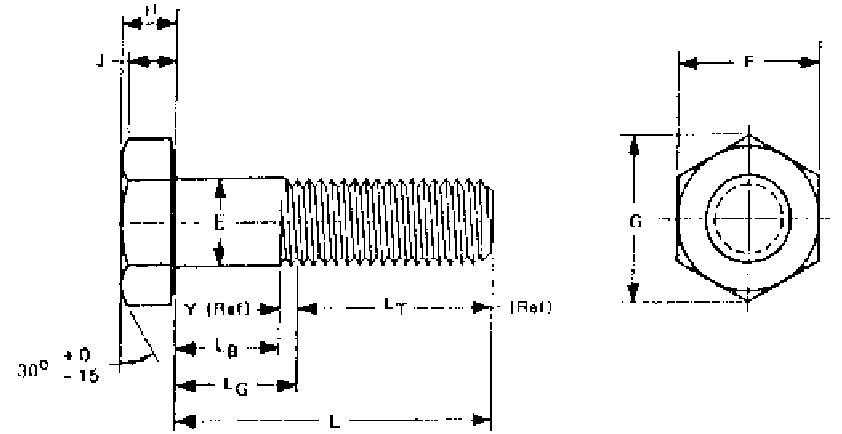
Table 2
DIMENSIONS OF FINISHED HEX NUTS

Nominal Size or Basic Major Diam. of Thread		Width across Flats			Width across Corners		Thickness Hex Nuts		
		Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.
1/4	0.2500	7/16	0.438	0.428	0.505	0.488	7/32	0.226	0.212
5/16	0.3125	1/2	0.500	0.489	0.577	0.557	17/64	0.273	0.258
3/8	0.3750	9/16	0.562	0.551	0.650	0.628	21/64	0.337	0.320
7/16	0.4375	11/16	0.688	0.675	0.794	0.768	3/8	0.385	0.365
1/2	0.5000	3/4	0.750	0.736	0.866	0.840	7/16	0.448	0.427
9/16	0.5625	7/8	0.875	0.861	1.010	0.982	31/64	0.496	0.427
5/8	0.6250	15/16	0.938	0.922	1.083	1.051	35/64	0.559	0.535
3/4	0.7500	1-1/8	1.125	1.088	1.299	1.240	41/64	0.665	0.617
7/8	0.8750	1-5/16	1.312	1.269	1.516	1.447	3/4	0.776	0.724
1	1.0000	1-1/2	1.500	1.450	1.732	1.653	55/64	0.887	0.831
1-1/8	1.1250	1-11/16	1.688	1.631	1.949	1.859	31/32	0.999	0.939
1-1/4	1.2500	1-7/8	1.875	1.812	2.165	2.066	1-1/16	1.094	1.030
1-3/8	1.3750	2-1/16	2.062	1.994	2.382	2.273	1-11/64	1.206	1.136
1-1/2	1.5000	2-1/4	2.250	2.175	2.598	2.480	1-9/32	1.317	1.245

(ANSI B18.2.2-1987)

(By permission of Nucor Fastener division of Nucor Corp., St. Joe, Indiana.)

3.5.6 Dimensions of Finished Hex Nuts



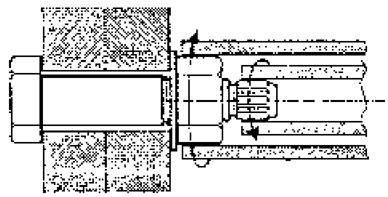
Nominal Size or Basic Product Diameter	E Body Diameter Max	E Body Diameter Min	F Width across Flats Basic	F Width across Flats Max	F Width across Flats Min	G Width across Corners Max	G Width across Corners Min	H Height Basic	H Height Max	H Height Min	J Wrenching Height Min	L_T Thread Length for Screw Lengths 6 in. and Shorter Basic	L_T Thread Length for Screw Lengths Over 6 in. Basic	Y Transition Thread Length Max	Runout of Bearing Surface FIM Max
1/4 0.2500	0.2500	0.2450	7/16	0.438	0.428	0.505	0.488	5/32	0.163	0.150	0.106	0.750	1.000	0.250	0.010
5/16 0.3125	0.3125	0.3065	1/2	0.500	0.489	0.577	0.557	13/64	0.213	0.195	0.140	0.875	1.125	0.278	0.011
3/8 0.3750	0.3750	0.3690	9/16	0.562	0.551	0.650	0.628	15/64	0.243	0.226	0.160	1.000	1.250	0.312	0.012
7/16 0.4375	0.4375	0.4305	5/8	0.625	0.612	0.722	0.698	9/32	0.291	0.272	0.195	1.125	1.375	0.357	0.013
1/2 0.5000	0.5000	0.4930	3/4	0.750	0.736	0.866	0.840	5/16	0.323	0.302	0.215	1.250	1.500	0.385	0.014
9/16 0.5625	0.5625	0.5545	13/16	0.812	0.798	0.938	0.910	23/64	0.371	0.348	0.250	1.375	1.625	0.417	0.015
5/8 0.6250	0.6250	0.6170	15/16	0.938	0.922	1.083	1.051	25/64	0.403	0.378	0.269	1.500	1.750	0.455	0.017
3/4 0.7500	0.7500	0.7410	1 1/8	1.125	1.100	1.299	1.254	15/32	0.483	0.455	0.324	1.750	2.000	0.500	0.020
7/8 0.8750	0.8750	0.8660	1 5/16	1.312	1.285	1.516	1.465	35/64	0.563	0.531	0.378	2.000	2.250	0.556	0.023
1 1.0000	1.0000	0.9900	1 1/2	1.500	1.469	1.732	1.675	39/64	0.627	0.591	0.416	2.250	2.500	0.625	0.026
1 1/8 1.1250	1.1250	1.1140	1 11/16	1.688	1.631	1.949	1.859	11/16	0.718	0.658	0.461	2.500	2.750	0.714	0.029
1 1/4 1.2500	1.2500	1.2390	1 7/8	1.875	1.812	2.165	2.066	25/32	0.813	0.749	0.530	2.750	3.000	0.714	0.033
1 3/8 1.3750	1.3750	1.3630	2 1/16	2.062	1.994	2.382	2.273	27/32	0.876	0.810	0.569	3.000	3.250	0.833	0.036
1 1/2 1.5000	1.5000	1.4880	2 1/4	2.230	2.175	2.598	2.480	1 5/16	0.974	0.902	0.640	3.250	3.500	0.833	0.039

(By permission of Nucor Fastener division of Nucor Corp., St. Joe, Indiana.)

3.5.7 Dimensions of Finished Hex Bolts

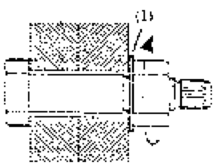
3.5.8 Tension Control (TC) Bolt Installation Procedures

Tru-Tension Fasteners are designed to be installed with various types of lightweight portable electric wrenches specifically intended for use with this style of structural fastener. They can be utilized for any applications where A325 and A490 bolts are specified. The installation tool has an inner socket, which engages the spline tip of the bolt spline, and when the tension is sufficient in the fastener, the spline tip simply twists off, leaving the tightened bolt correctly installed in the connection.



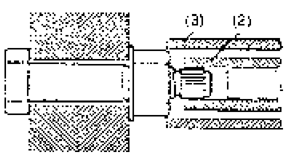
INSTALLATION PROCEDURES

1



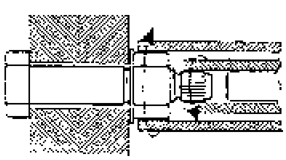
Place the bolt into the connection with the washer (1) under the nut. Finger tighten the nut.

2



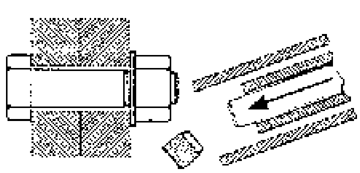
Fit inner socket (2) over the grooved spline and push the wrench slightly then engage the outer socket (3) over the nut.

3



Start the wrench. The outer socket rotates the nut relative to the bolt during tightening, and the bolt will be tightened until the required bolt tension is reached. At this point the splined tip shears off.

4



When the installation is complete remove the socket from the nut and depress the ejection lever to discharge the sheared spline from the inner socket of the wrench.

Note: Particularly when installing multiple rows of bolts or where uneven steel contact is encountered, the fasteners should be preloaded to snug tight conditions prior to final tightening. This method will prevent interactions between bolts as additional bolts are tightened. As always, fasteners should be tightened in sequence from the most rigid section out. As with all high-strength structural fasteners, Tru-Tension fasteners should be stored in their sealed metal kegs until ready for use. Opened cans should be stored indoors protected from the elements to prevent environmental contamination (rain, dirt, etc.).

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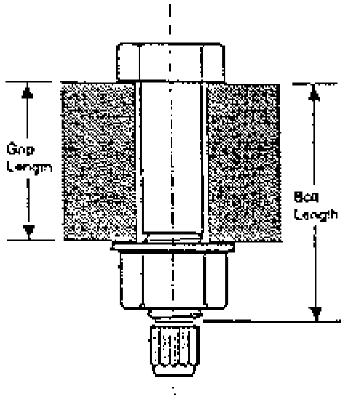
3.5.9 Tru-Tension (TC) Bolt Assembly Specifications

DETERMINATION OF TRU-TENSION LENGTH



Bolt Size in.	To Determine Required Bolt Length Add to Grip, In.
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2

STRUCTURAL FASTENER TENSION

Fastener Test Tension Required for Slip-Critical Connections and Connections Subject to Direct Tension

Nominal Bolt Size, Inches	Minimum Tension[2] in 1000's of Pounds (kips)	
	A325 Bolts	A490 Bolts
5/8	20.0	25.2
3/4	29.4	36.8
7/8	41.0	51.5
1	53.6	67.2
1 1/8	58.8	84.0

[2] Equal to 70 percent of specified minimum tensile strengths of bolts (as specified in ASTM Specifications for test of full size A325 and A490 bolts with UNC threads loaded in axial tension) rounded to nearest 100 lbs. (Includes 5% per AISC spec.)

TRU-TENSION ASSEMBLY WEIGHTS

A325 and A490 ASSEMBLIES (Assembly: Bolt 1, Nut 1, and Washer 1)

Nominal bolt size	5/8"			3/4"			7/8"			1"		
Length (Inches)	Net Weight per 100 Pieces (lb)	Container Quantity (pcs.)	Net Container Weight (lb)	Net Weight per 100 Pieces (lb)	Container Quantity (pcs.)	Net Container Weight (lb)	Net Weight per 100 Pieces (lb)	Container Quantity (pcs.)	Net Container Weight (lb)	Net Weight per 100 Pieces (lb)	Container Quantity (pcs.)	Net Container Weight (lb)
1 1/2	39.3	500	197	61.7	320	197						
1 3/4	41.1	450	185	64.8	300	194	93.8	210	197			
2	43.2	420	182	67.9	280	190	98.0	200	196	133.0	140	186
2 1/4	45.3	400	182	71.1	273	192	102.3	190	194	138.5	140	194
2 1/2	47.4	380	180	74.2	250	186	106.6	180	192	166.4	110	183
2 3/4	49.5	360	178	77.3	250	193	110.8	180	199	148.7	130	195
3	51.6	320	165	80.5	240	193	115.1	170	196	158.3	120	186
3 1/4	53.6	300	161	83.6	230	192	119.3	160	203	160.8	120	193
3 1/2	55.7	300	167	86.7	220	191	123.6	150	185	166.4	110	183
3 3/4	57.8	290	168	89.9	200	180	127.9	140	179	172.0	110	189
4	59.9	280	168	93.0	190	177	132.1	140	185	177.6	100	178
4 1/4				96.1	180	173	136.3	130	177	183.2	100	183
4 1/2	64.1	270	173	99.3	180	179	140.7	125	169	188.7	100	189
4 3/4				102.4	170	174	144.9	120	174	194.3	90	175
5	68.3	250	171	105.5	160	169	148.2	110	165	199.9	90	180
5 1/4				108.7	140	153	153.4	110	169	205.4	90	185
5 1/2				111.8	130	145	157.7	100	158	211.0	80	169
5 3/4				114.9	130	150	162.0	100	162	216.6	80	173
6				118.1	120	142	166.2	90	150	222.1	80	178

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3.6.0 Major Characteristics of Joist Series

MAJOR CHARACTERISTICS OF JOIST SERIES **

K Series
Min. Fy=50000 psi
Depths 8" thru 30"
Spans to 60'-0

CS Series
Min. Fy=50000 psi
Depths 10" thru 30"
Spans 20'-0 thru 60'-0

LH Series
Min. Fy=50000 psi
Depths 18" thru 48"
Spans to 96'-0

DLH Series
Min. Fy=50000 psi
Depths 52" thru 72"
Spans to 144'-0

SLH Series
Min. Fy=50000 psi
Depths from 80"
Spans - Contact Vulcraft

JOIST GIRDER Series
Min. Fy=50000 psi
Depths as required
Spans as required

** Some design and/or delivery requirements may dictate yield strength other than that shown.

(By permission of Nucor Research and Development, Norfolk, Nebraska.)

3.6.1 General Information on K Series Joists

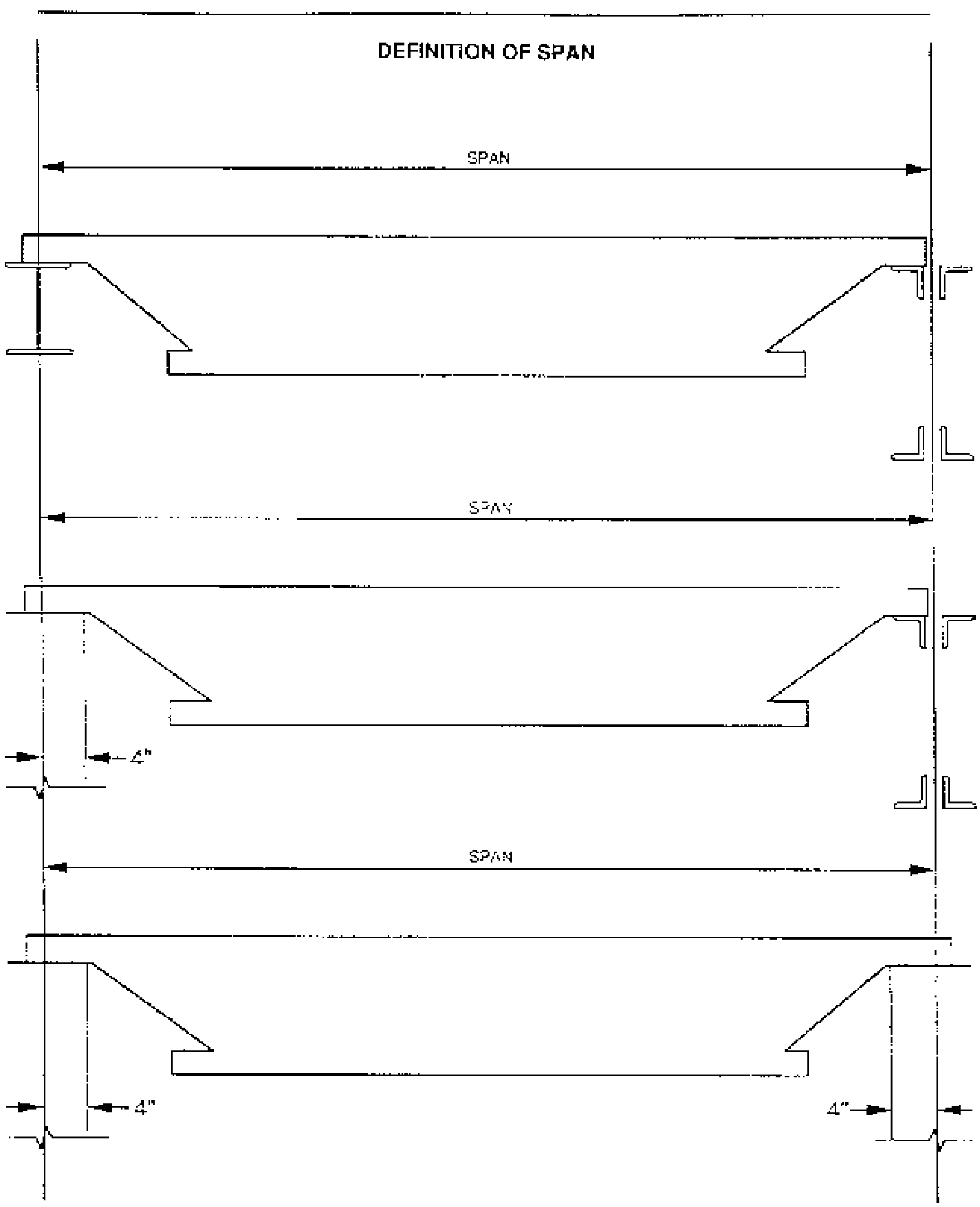
- Economical
- High strength
- *Design* Vulcraft K Series open web steel joists are designed in accordance with specifications of the Steel Joist Institute.
- SJI spans to 60'0"
- *Paint* Vulcraft joists receive a shop-coat of rust-inhibitive primer, whose performance characteristics conform to those of the Steel Joist Institute specifications 3.3.

Standing Beam Bridging

The bridging table was developed to support the top chords against lateral movement during the construction period. It is then intended that the floor or roof deck will laterally support the top chords under a full loading condition by meeting the provisions of Section 5.8 of the specifications.

Most standing-seam roof systems will not adequately brace the top chords laterally with the number of rows as required by the bridging table. We, therefore, recommend that when standing-seam roof systems are specified, the specifying engineer employ a note to have the joist manufacturer check the system and to provide bridging as required to adequately brace the top chords against lateral movement under a full-loading condition.

3.6.2 Standard Specifications for Open Web Joists (K Series)



[DESIGN LENGTH = SPAN – 0.33 FT.]

(By permission of the Steel Joist Institute, Myrtle Beach, South Carolina.)

3.6.3 K Series Open Web Steel Joists

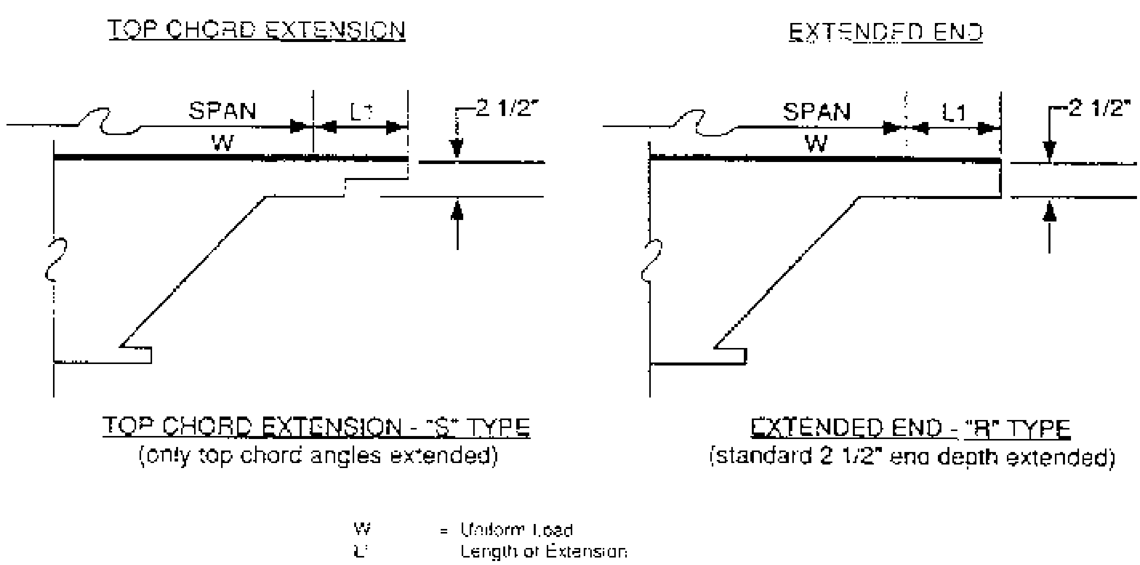
Top Chord Extensions and Extended Ends

Joist extensions are commonly furnished to support a variety of overhang conditions. The two types are pictured. The first is the top chord extension or "S" type, which has only the top chord angles extended. The second is the extended end or "R" type in which the standard 2½" end-bearing depth is maintained over the entire length of the extension. The "S" type extension is so designated because of its simple nature whereas the "R" type involves reinforcing the top chord angles. The specifying authority should be aware that an "S" type is more economical and should be specified whenever possible.

The following load tables for K-series top chord extensions and extended ends have been developed as an aid to the specifying authority. The black number in the tables is the maximum allowable uniform load in pounds per linear foot. The blue number is the uniform load, which will produce an approximate deflection of $L_1/240$, where L_1 is the length of the extension. The load tables are applicable for uniform loads only. If there are concentrated loads and/or nonuniform loads, a loading diagram must be provided by the specifying authority on the contract drawings. In cases where it is not possible to meet specific job requirements with a 2½" deep "R" type extension (refer to "S" and "I" values in the Extended End Load Table), the depth of the extension must be increased to provide greater load-carrying capacity. If the loading diagram for any condition is not shown, the joist manufacturer will design the extension to support the uniform load indicated in the K-Series Joist Load Table for the span of the joist.

When top chord extensions or extended ends are specified, the allowable deflection and the bracing requirements must be considered by the specifying authority.

Note that an "R" type extension must be specified when building details dictate a 2½" depth at the end of the extension. In the absence of specific instructions, the joist manufacturer could provide either type.



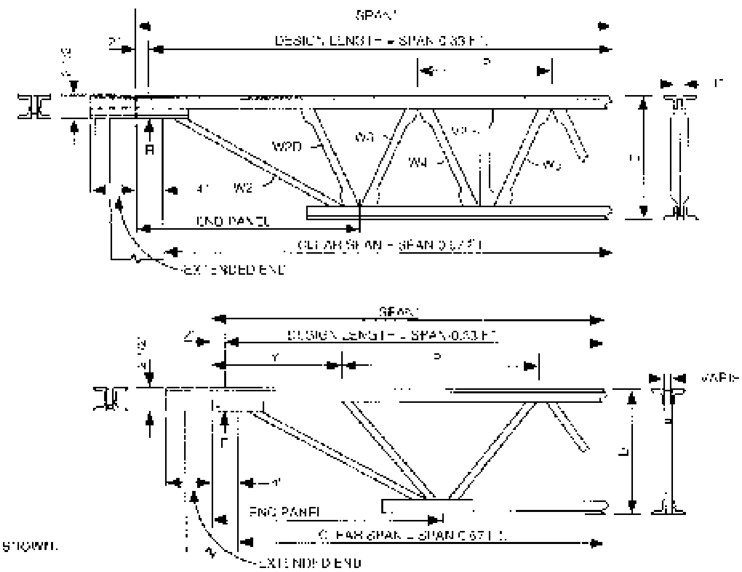
(By permission of the Steel Joist Institute, Myrtle Beach, South Carolina.)

Uplift Bridging

Where uplift forces caused by wind are a design requirement, these forces must be indicated on the structural drawings in terms of net uplift in pounds per square foot or pounds per lineal foot. When these loads are specified, they must be considered in the design of joists and bridging. A single line of bottom chord bridging must be provided near the first bottom cord panel points whenever uplift from wind load is a design consideration.

CRIMPED ANGLE WEB

ROD WEB



NOTE: Actual layout may vary from that shown.

Number of Rows of Bridging***
Distances are Span Lengths

Section Number*	1 Row	2 Rows	3 Rows	4 Rows**	5 Rows**
#1	Up thru 16'	Over 16' thru 24'	Over 24' thru 28'		
#2	Up thru 17'	Over 17' thru 25'	Over 25' thru 32'		
#3	Up thru 18'	Over 18' thru 28'	Over 28' thru 38'	Over 38' thru 40'	
#4	Up thru 19'	Over 19' thru 28'	Over 28' thru 38'	Over 38' thru 48'	
#5	Up thru 19'	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 50'	Over 50' thru 52'
#6	Up thru 19'	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 51'	Over 51' thru 56'
#7	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#8	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#9	Up thru 20'	Over 20' thru 33'	Over 33' thru 46'	Over 46' thru 59'	Over 59' thru 60'
#10	Up thru 20'	Over 20' thru 37'	Over 37' thru 51'	Over 51' thru 60'	
#11	Up thru 20'	Over 20' thru 38'	Over 38' thru 53'	Over 53' thru 60'	
#12	Up thru 20'	Over 20' thru 39'	Over 39' thru 53'	Over 53' thru 60'	

*Last digit(s) of joist designation shown in load tables.
**Where 4 or 5 rows of bridging are required, a row nearest the midspan of the joist shall be diagonal bridging with bolted connections at chords and intersection.
***See Section 5.11 for additional information.

Sizes of Horizontal Bridging

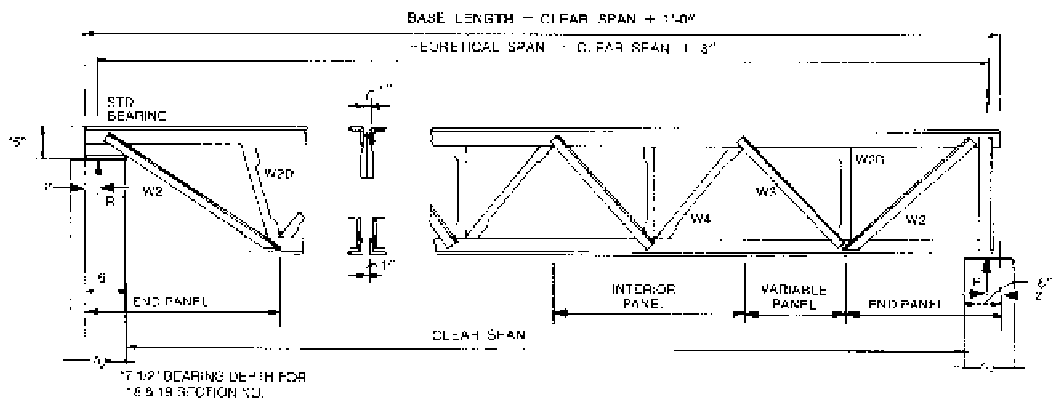
Size					Maximum Joist Spacing
L 1	x	1	x	7/64	5'-0"
L 1 1/4	x	1 1/4	x	7/64	6'-3"
L 1 1/2	x	1 1/2	x	7/64	7'-6"
L 1 3/4	x	1 3/4	x	1/8	8'-9"
L 2	x	2	x	1/8	10'-0"

(By permission of Nucor Research and Development, Norfolk, Nebraska.)

3.6.4 General Information on LH and DLH Series Joists

- High strength
- Economical
- *Design* Vulcraft LH and DLH series long-span steel joists are designed in accordance with the specifications of the Steel Joist Institute.
- Roof spans to 144'
- Floor spans to 120'
- *Paint* Vulcraft joists receive a shop-coat of rust inhibitive primer whose performance characteristics conform to those of the Steel Joist Institute specification 102.4.

LH & DLH SERIES DETAILS



LH & DLH TABLE MINIMUM BEARING LENGTHS			
Joist Type	On Masonry	On Concrete	On Steel
LH 02 thru 17 DLH 10 thru 19	6"*	6"*	4"
MINIMUM BEARING PLATE WIDTHS			
LH 02 thru LH 12 DLH 10 thru DLH 12	9"*	9"*	
LH 13 thru LH 17 DLH 13 thru DLH 19	12"*	12"*	

*See Sect. 104.4 on page 43.

BRIDGING SPACING		
Section No.*	Min. Bolt Diameter**	Maximum Spacing of Lines of Bridging
LH 02 to 09, incl.	3/8"	11'-0"
DLH 10	3/8"	14'-0"
LH 10 to 14, incl.	3/8"	16'-0"
DLH 11 to 14, incl.	3/8"	16'-0"
LH 15 to 17, incl.	1/2"	21'-0"
DLH 15 to 17, incl.	1/2"	21'-0"
DLH 18 to 19, incl.	5/8"	26'-0"

*Last two digits of joist designation shown in spec table.
**Size required for the requirements as indicated for bolted x bridging connections in Section 104.5(e). Minimum A307 bolt required for connection.

JOIST SPACING FOR BRIDGING ANGLE SIZE

DIAGONAL BRIDGING CHART Bridging Angle Size					
DEPTH	L1x1x7/64	L1¼x1¼x7/64	L1½x1½x7/64	L1¾x1¾x1/8	L2x2x1/8
18	6'- 5"	8'- 2"	9'-10"	11'- 6"	
20	6'- 5"	8'- 1"	9'-10"	11'- 6"	
24	6'- 4"	8'- 1"	9'- 9"	11'- 5"	
28	6'- 2"	8'- 0"	9'- 8"	11'- 5"	
32	6'- 1"	7'-10"	9'- 7"	11'- 4"	13'- 0"
36		7'- 9"	9'- 6"	11'- 3"	12'-11"
40		7'- 7"	9'- 5"	11'- 2"	12'-10"
44		7'- 5"	9'- 3"	11'- 0"	12'- 9"
48		7'- 3"	9'- 1"	10'-11"	12'- 8"
52			9'- 0"	10'- 9"	12'- 7"
56			8'-10"	10'- 8"	12'- 5"
60			8'- 7"	10'- 6"	12'- 4"
64			8'- 5"	10'- 4"	12'- 2"
68			8'- 2"	10'- 2"	12'- 0"
72			8'- 0"	10'- 0"	11'-10"

†HORIZONTAL BRIDGING CHART Bridging Angle Size					
DEPTH	L1x1x7/64	L1¼x1¼x7/64	L1½x1½x7/64	L1¾x1¾x1/8	L2x2x1/8
ALL DEPTHS	5'- 0"	6'- 3"	7'- 6"	8'- 9"	10'- 0"

† See specification section 104.5 for the proper use of horizontal bridging

NOTES:
1. Special designed LH and DLH can be supplied in longer lengths. See SLH Series Page 47.
2. Additional bridging may be required when joists support standing seam roof decks. The specifying engineer should require that the joist manufacturer check the system and provide bridging as required to adequately brace the joists against lateral movement. For bridging requirements due to uplift pressures refer to sect. 104.12.

(By permission of Nucor Research and Development, Norfolk, Nebraska.)

3.6.5 LH and DLH Series Longspan Steel Joists

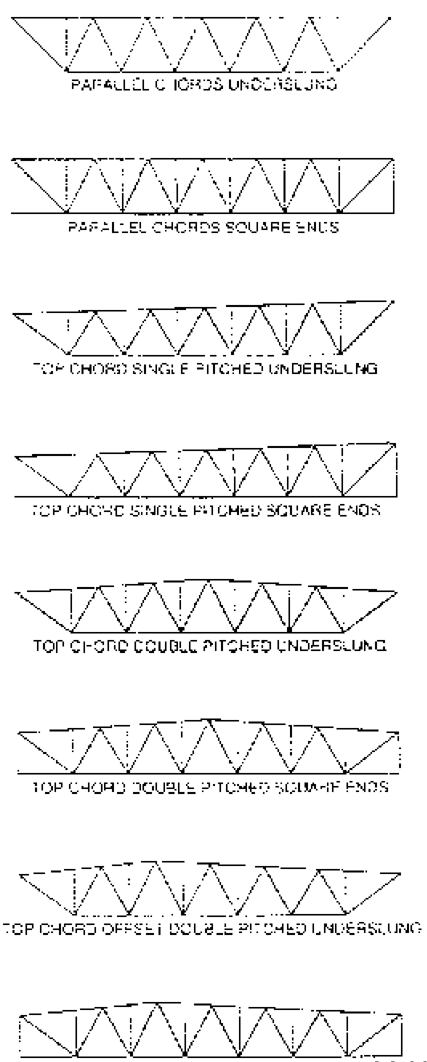
Standard Types

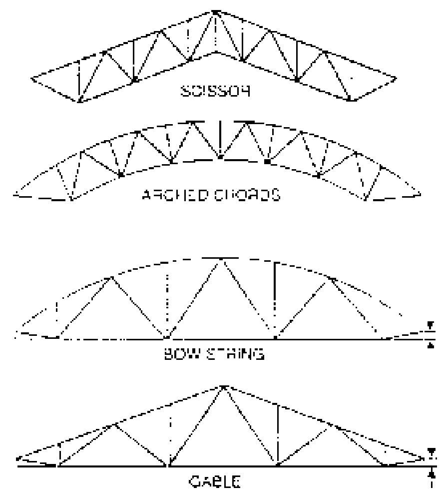
Longspan steel joists can be furnished with either underslung or square ends, with parallel chords, or with single- or double-pitched top chords to provide sufficient slope for roof drainage.

The Longspan joist designation is determined by its nominal depth at the center of the span, except for offset double-pitched joists, where the depth should be given at the ridge. A part of the designation should be either the section number or the total design load over the design live load (TL/LL given in plf). All pitched joists will be cambered in addition to the pitch.

Nonstandard Types

The following joists can also be supplied by Vulcraft; however, the district sales office or manufacturing facility nearest you should be contacted for any limitations in depth or length that they might have.





*Contact Vulcraft for minimum depth at ends.

CAMBER FOR STANDARD TYPES

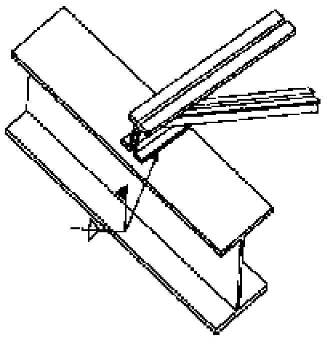
LH & DLH series joists shall have camber in accordance with the following table:**

Top Chord Length	Approx. Camber
20'	1/4"
30'	3/8"
40'	5/8"
50'	1"
60'	1 1/2"
70'	2"
80'	2 3/4"
90'	3 1/2"
100	4 1/4"
110'	5"
120'	6"
130'	7"
140'	8"
144'	8 1/2"

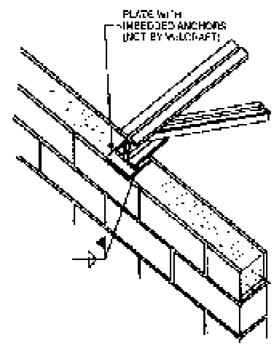
** NOTE: If full camber is not desired near walls or other structural members please note on the structural drawings.

(By permission of Nucor Research and Development, Norfolk, Nebraska.)

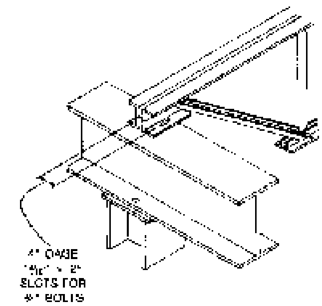
3.6.5 LH and DLH Series Longspan Steel Joists—Continued



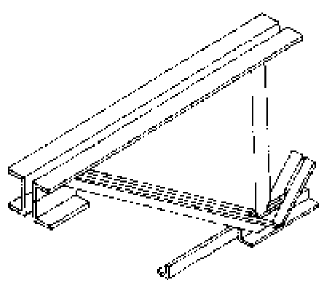
ANCHORAGE TO STEEL
SEE SJI SPECIFICATION
104.4 (b) AND 104.7 (a).



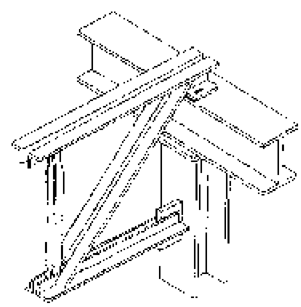
ANCHORAGE TO MASONRY
SEE SJI SPECIFICATION
104.4 (a) AND 104.7 (a).



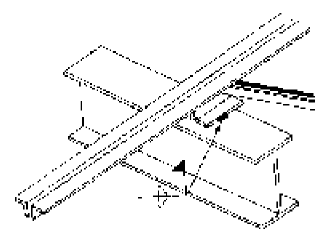
BOLTED CONNECTION (c)
Typically required at columns



CEILING EXTENSION



BOTTOM CHORD STRUT



TOP CHORD EXTENSION (a)

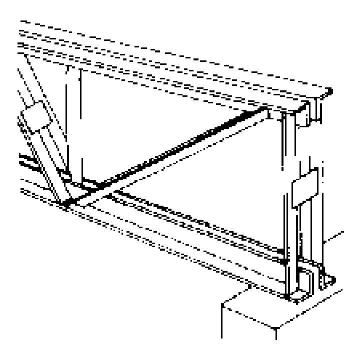
(a) Extended top chords or full depth cantilever ends require the special attention of the specifying engineer.

The magnitude and location of the design loads to be supported, the deflection requirements, and the proper bracing shall be clearly indicated on the structural drawings.

(b) See SJI Specification - Section 105 for Handling and Erection of LH and DLH Joists.

(c) The Occupational Safety and Health Administration Standards (OSHA), Paragraph 1910.12 refers to Paragraph 1518.751 of "Construction Standards" which states:

"In steel framing, where bar joists are utilized, and columns are not framed in at least two directions with structural steel members, a bar joist shall be field-bolted at columns to provide lateral stability during construction."



SQUARE END
See SJI Specification 104.5 (f)

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3.7.0 Joist Girders—What Are They?

Joist girders are primarily framing members. The design is simple span supporting equally spaced concentrated loads from open-web steel joists. These concentrated loads are considered to act at the panel points of the joist girder. Joist girders are designed to allow for the efficient use of steel in longer spans for primary framing members.

The following weight tables list joist girders from 20" to 96" deep and spans up to 100 feet. (For depths and lengths not listed, contact Vulcraft.) The depth designation is determined by the nominal depth at the center of the span, except for offset double-pitched girders, where the depth is determined at the ridge.

The standard configuration of a joist girder is a parallel chord with underslung ends and bottom chord extensions. (Joist girders can be furnished in other configurations.) The standard depth of bearing for joist girders is 6 inches* at the end of the bearing seat.

The standard method of connecting girders to columns is two ¾" diameter A325 bolts. A loose connection of the lower chord to the column or other support is required during erection in order to stabilize the lower chord laterally and to help brace the joist girder against overturning. Caution: If a rigid connection of the bottom chord is to be made to column or other support, it is to be made only after the application of the dead loads. The joist girder is then no longer simply supported and the system must be investigated for continuous frame action by the specifying engineer.

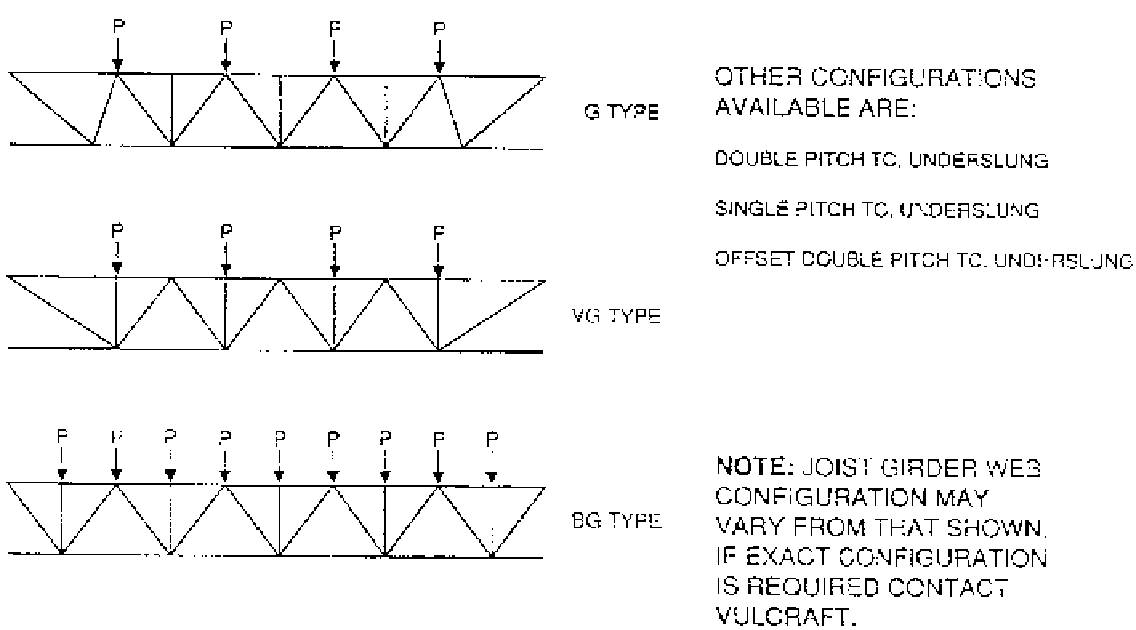
Joist girders along the perimeter, with joists coming in from one side only, and those with unbalanced loads must be designed so that the reactions pass through the center of the joist girder.

The weight tables list the approximate weight per linear foot for a joist girder supporting the panel point loads given by the specifying engineer. Note: The weight of the joist girder must be included in the panel point load.

For calculating the approximate deflection or checking ponding the following formula can be used in determining the approximate moment of inertia of the joist girder.

$$I_{JG} = 0.027\,NPLd$$

Where N = number of joist spaces, P = panel point load in kips, L = joist girder length in feet, and d = effective depth of the joist girder in inches. Contact Vulcraft if a more exact joist girder moment of inertia must be known.



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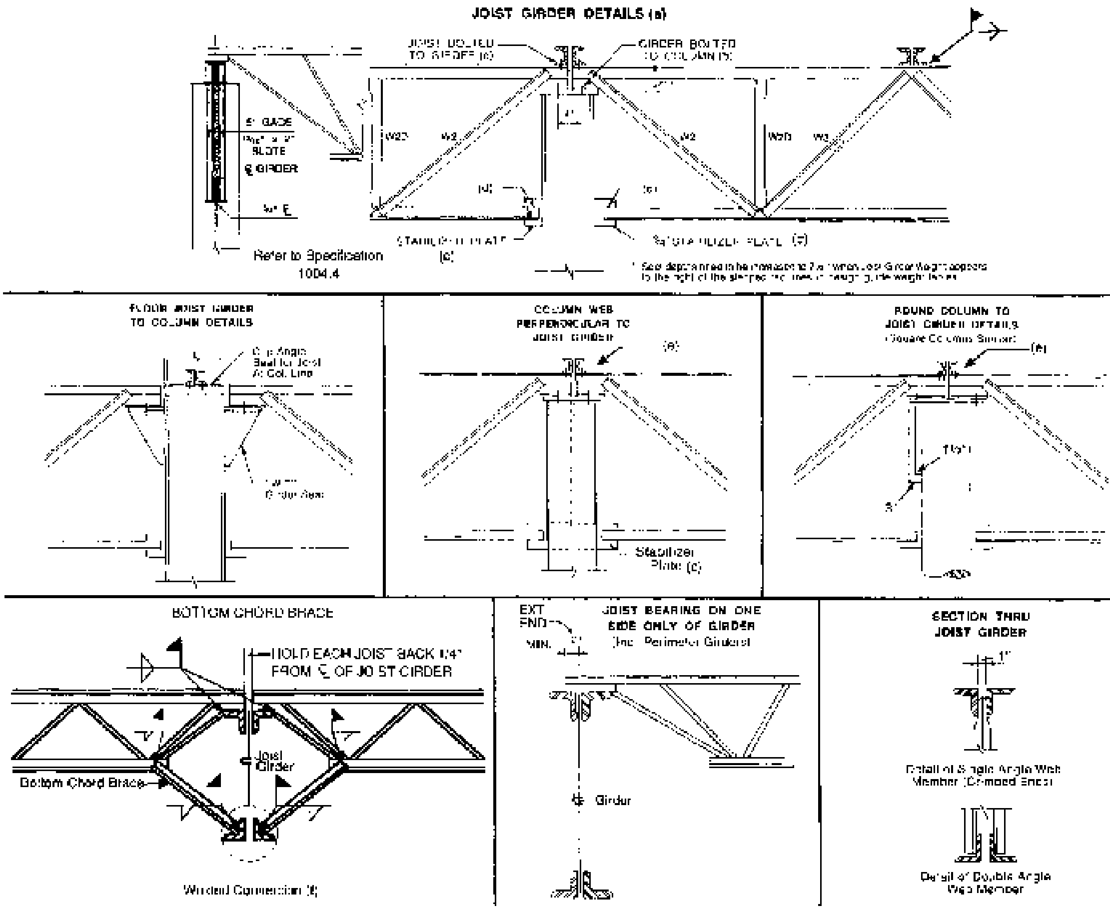
*Increase seat depth to 7½ inches if weight of joist girder appears to the right of the stepped blue lines in the weight tables.

3.7.1 Joist Girder Notes and Connection Details



(a) All Joist Girder dimensions shown are subject to change when required by the physical size of large Joist Girders. If changes are necessary Vulcraft will so note on the placing plans.

(b) The standard connection for Joist Girders to columns is ¹³⁄₁₆ inch slots for ¾ inch bolts in girder bearings. The girder erection bolts are by others. If the specifying engineer wishes to use the Joist Girder bearing to transmit horizontal loads, he should specify the required amount of weld to connect the Joist Girder seat to the column. For additional information see the section of this catalog "JOIST GIRDERS IN MOMENT RESISTIVE FRAMES."

(c) Stabilizer plates between bottom chord angles stabilize the bottom chord laterally and brace the Joist Girder against overturning during erection. (Refer to 1004.4)

(d) Joist Girder bottom chord struts do not require welding to the stabilizer plate unless required by design to transmit horizontal forces. When welding is required, the amount of weld should be specified by the specifying engineer. UNLESS OTHERWISE SPECIFIED, BOTTOM CHORD STRUTS SHOULD NOT BE WELDED.

(e) Joists are connected to the girder by welding except that the joists at (or nearest) the column shall be bolted (O.S.H.A. Sec. 1910.12 Construction Standards Sec 1518.751).

(f) The l/r_y of the bottom chord of the Joist Girder cannot exceed 240. For STANDARD Joist Girders, the specifying engineer can use the "Joist Girder Bottom Chord Brace Chart" in conjunction with the "Design Guide Weight Table/Joist Girders, G Series" to select the correct number of bottom chord braces. Joist Girders which must resist uplift, end moments, or axial bottom chord forces may require additional braces.

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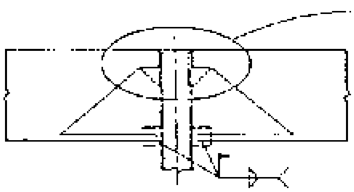
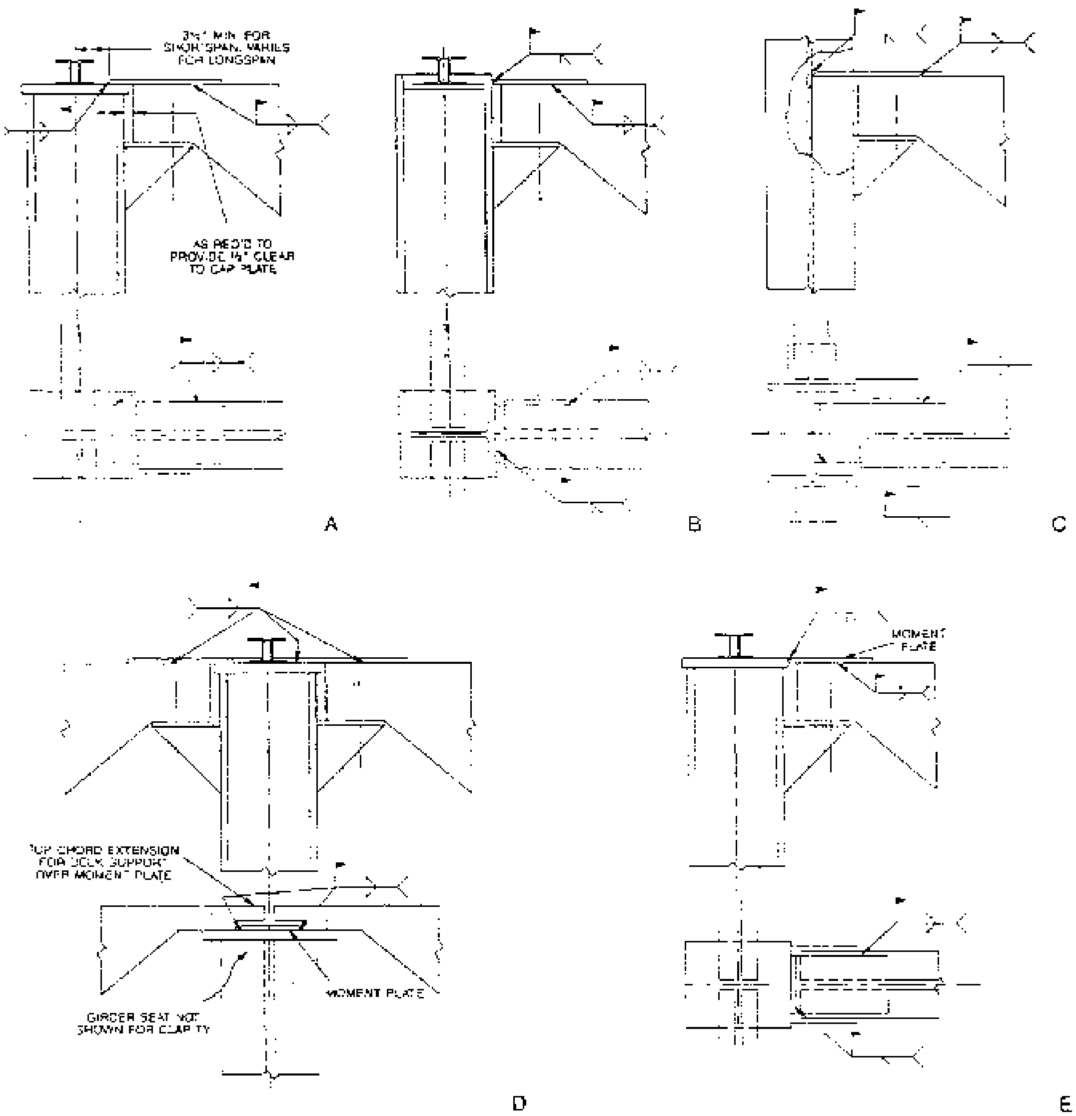
3.7.2 Joist Girder Moment Connection Details



Presented below are five suggested details for a moment resistive connection involving roof Joist Girders. Similar details could also be utilized for longspan or even shortspan joists with end moments. In all cases, the bottom chord is to be connected to the column with a vertical stabilizer plate which is to be sized to carry the required load and obtain required weld (use 6 × 6 × ¾ plate minimum for Joist Girders).



NOTES:
(1) Connections type B & C would also be recommended for floor girder details.
(2) Where a backer bar is required for groove welds, additional clearance must be provided when determining girder hold back dimension.
(3) Similar details would apply at other types of columns.
(4) Additional stiffener plates as required not shown for clarity.
(5) In all details, moment plate design and material is not by Vulcraft.

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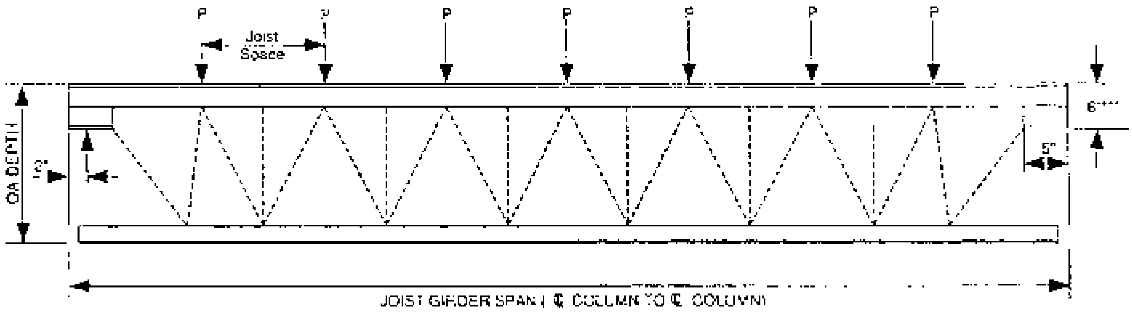
3.7.3 Specifying Joist Girders

For a given joist girder span, the designer first determines the number of joist spaces. Then the panel point loads are calculated and depth is selected. The following tables gives the Joist Girder weight per linear foot for various depths and loads.



STANDARD DESIGNATION

48**G	8N	8.8K*
Depth in Inches	Number of Joist Spaces	Kip Load on Each Panel Point (One Kip = 1000 lbs.)

Example: Given 50'-0 x 40'-0 bay   Joists spaced on 6'-3 centers

Live Load = 20 psf
Dead Load = 15 psf *
Total Load = 35 psf

Note: Web configuration may vary from that shown. Contact Vulcraft if exact layout must be known.

* Includes the approximate Joist Girder weight in panel point loads.
**See page 59 for other Girder types.
*** Increase to 7 1/2" if weight of Joist Girder is to right of stepped lines in the weight tables.

1. Determine number of actual joist spaces (N).
   In this example, N = 8
2. Joist Selection
   a) Span = 40'-0
   b) T.L. = 6.25 x 35 = 219 plf
   c) from K-Series load tables select a 22K7
   (T.L. = 231 > 219; L.L. = 185 > 125)
   123 x 1.5 = 185 (l/240 limit applies since ceiling is not plastered)
3. Joist Girder Selection
   a) compute the concentrated load at top chord panel points P = 219 x 40 = 8,760 lbs. = 8.8 kips (use 9K for depth selection) Live load deflection rarely governs in Joist Girder selection because of their depth.
   b) Select girder depth
   The 50'-0 span 8 panel Joist Girder table on page 72 indicates that the rule of about one inch of depth for each foot of span is a good compromise of limited depth and economy. Therefore select depth of 48 inches.
   c) the Joist Girder will then be designated 48G8N8.8K
   d) the Joist Girder table shows the weight for a 48G8N9K is 43 pounds per lineal foot
   e) total weight of this Joist Girder system per square foot is:

   Joists 9.7 plf/6.25 = 1.55
   Girder 43 plf/40 = 1.07
   2.62 psf
4. For rectangular bays check economy with joists and girders spanning the opposite way

   Joists (26K10) 13.8 plf/6.67 = 2.07
   Girder (40G6N12K) 41 plf/50 = .82
   2.89 psf

NOTES:

1. When it is required to have joists bear only at vertical web members to gain space for duct work, the Joist Girder should be labeled as a "VG" in lieu of a "G".
2. The following tables serve as a design guide only. Odd size joist girder lengths, depths, kip loadings, and panel lengths are available.
3. Based on tests by Underwriters Laboratories Inc., Vulcraft Joist Girders have been approved for use in designs P231, G256, G514, N732, N754 and N736 as primary framing members. For additional fire resistance information, see FIRE RATING SECTION on page 83 and the Underwriters Laboratories Fire Resistance Directory.

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3.8.0 Recommended Maximum Spans for Steel Decking

Recommended Maximum Spans for Construction and Maintenance Loads Standard 1½-Inch and 3-Inch Roof Deck

	Type	Span Condition	Span ft-In.	Maximum Recommended Spans Roof Deck Cantilever
Narrow Rib Deck	NR22	1	3'-10"	1'-0"
	NR22	2 or more	4'-9"	
	NR20	1	4'-10"	1'-2"
	NR20	2 or more	5'-11"	
	NR18	1	5'-11"	1'-7"
	NR18	2 or more	6'-11"	
Intermediate Rib Deck	IR22	1	4'-6"	1'-2"
	IR22	2 or more	5'-6"	
	IR20	1	5'-3"	1'-5"
	IR20	2 or more	6'-3"	
	IR18	1	6'-2"	1'-10"
	IR18	2 or more	7'-4"	
Wide Rib Deck	WR22	1	5'-6"	1'-11"
	WR22	2 or more	6'-6"	
	WR20	1	6'-3"	2'-4"
	WR20	2 or more	7'-5"	
	WR18	1	7'-6"	2'-10"
	WR18	2 or more	8'-10"	
Deep Rib Deck	3DR22	1	11'-0"	3'-6"
	3DR22	2 or more	13'-0"	
	3DR20	1	12'-6"	4'-0"
	3DR20	2 or more	14'-8"	
	3DR18	1	15'-0"	4'-10"
	3DR18	2 or more	17'-8"	

Type (gage)	Design Thickness		Minimum Thickness	
	in.	mm	in.	mm
28	0.0149	0.38	0.014	0.35
26	0.0179	0.45	0.017	0.43
24	0.0239	0.60	0.023	0.57
22	0.0295	0.75	0.028	0.71
20	0.0358	0.91	0.034	0.86
18	0.0474	1.20	0.045	1.14
16	0.0598	1.52	0.057	1.44

Finishes available are:

1. Galvanized (Conforming to ASTM A924-94 and or ASTM A653-94);
2. Uncoated (Black);
3. Painted with a shop coat of primer paint (one or both sides).

The uncoated finish is, by custom, referred to as "black" by some users and manufacturers; the use of the word "black" does not refer to paint color on the product.

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3.8.1 Checklist for Ordering Metal Deck

DECK ORDERING
CHECK LIST

Steel Deck Institute

I. Deck Profile
- Wide Rib (WR)—B
- Intermediate Rib (IR)—F
- Narrow Rib (NR)—A
- 3″ Deep Rib (3DR)—N
- Other

II. Deck Type (thickness) see SDI manual for decimal thickness
- 22
- 20
- 18
- 16
- Cellular Bottom Plate
- 20
- 18
- 16
- Other—Specify decimal thickness

III. Deck Finish
- Prime Painted—Manufacturers Standard
- G60 Galvanized
- G90 Galvanized
- Prime Paint (manufacturers standard) over G60
- Galvanizing Uncoated
- Other—Specify in Separate Document

IV. Is Fire Rating Required?
- Yes—Give Appropriate U.L. Design Number and Hours Required or F.M. Number

V. Sheet Length Limits
- None or Specify

VI. Bundle Weight Restrictions
- Not to exceed lbs.
- No Restrictions

VII. Required Space between Bundles for Hoisting Devices
- Standard 1½″
- Other—Specify

VIII. Special Tagging on Bundles
- U.L. Labels
- F.M. Labels
- Other—Specify

Any special sequencing, timing or other restrictions must be provided to the deck supplier. The deck receiver must also supply a complete and accurate address for shipping.

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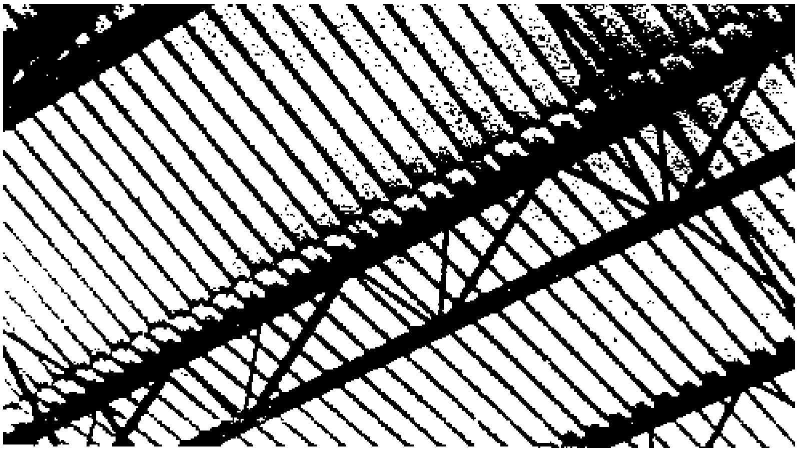
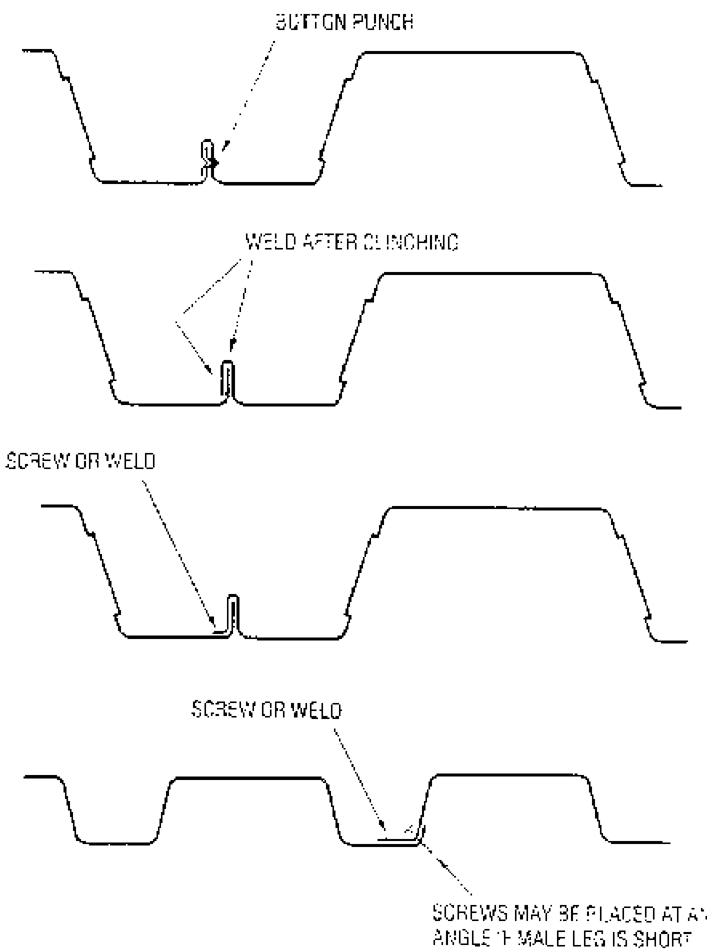
3.8.2 Methods of Lapping Steel Deck





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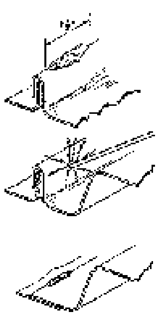
3.8.3 Side Lap Connections

Sheet to sheet connections may be required at the side laps of deck. These are frequently referred to as stitch connections. Self drilling screws, welds or button punches are the usual stitch connections. Stitch screws are usually self drilling type; #8's through ¼ inch diameter can be used but screws smaller than #10 diameter are not recommended. The installer must be sure that the underlying sheet is drawn tightly against the top sheet. Again, as when screws are used as the frame attachment, the special screw driving guns are used to prevent over torquing.

Manual button punching of side laps requires a special crimping tool. Button punching requires the worker to adjust his weight so the top of the deck stays level across the joint. Since the quality of the button punch attachment depends on the strength and care of the tool operator, it is important that a consistent method be developed. Automatic power driven crimping devices are rarely seen on deck jobs but should not be ruled out as a fastening method.

Good metal to metal contact is necessary for a good side lap welds. Burn holes are the rule rather than the exception and an inspector should not be surprised to see them in the deck. The weld develops its strength by holding around the perimeter. A good weld will have 75% or more of its perimeter working. On occasion, side lap welds will be specified for deck that has the button punchable side lap arrangement (see Figure 8 for comments on this subject; see Figures 8 and 9 for welding these deck units to the frame). Welding side laps is not recommended for decks type 22 (0.028 inch minimum) or lighter. Weld washers should never be used at side laps between supports. Just as when welding to the frame, adequate ventilation must be available and welding near combustibles prohibited.

SIDE LAP WELDS BETWEEN SUPPORTS
Figure 8A

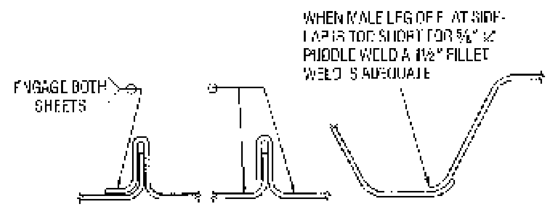


This may be a difficult weld to make. The upstanding leg must be caught by the weld.

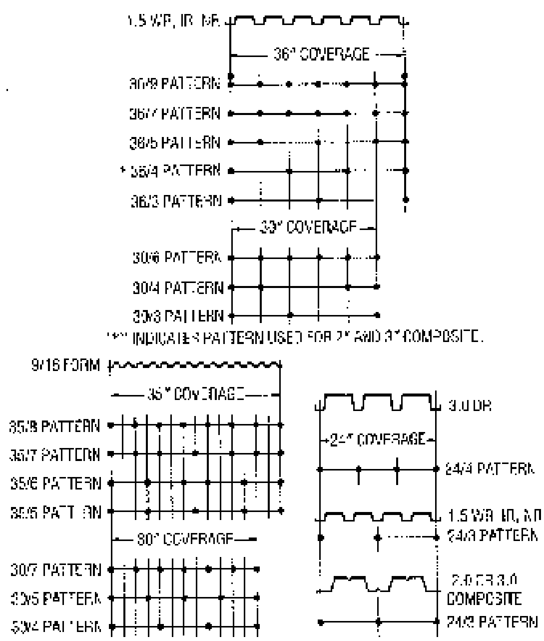
Welding from the side (after clinching metal) can be accomplished if rib does not interfere with rod.

Building a fillet on deck lighter than 20 gage is difficult. Two spot welds would be easier and would probably be just as effective.

SIDE LAP WELDS AT SUPPORTS
Figure 8B



FRAME CONNECTION LAYOUTS
Connections may be arc puddle welds, screws powder-actuated, or pneumatically driven fasteners.
Figure 9



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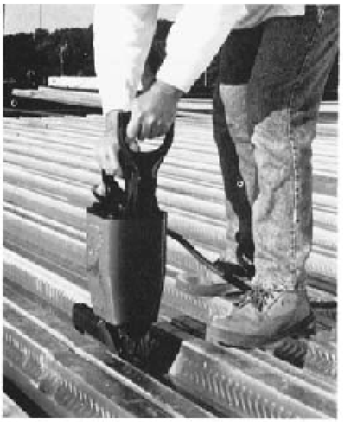
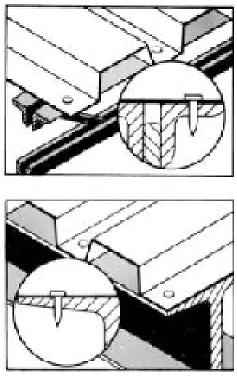
3.8.4 Welding Procedures for Metal Deck





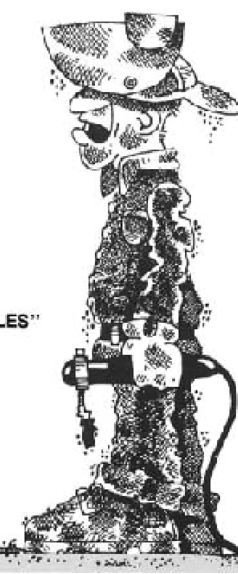
Air Driven/Pneumatic

Welding

Welding must be done by a qualified welder during proper weather conditions. Quality welding of light gage deck requires experience and the selection of proper amperage and electrodes. All welding should be done in accordance with the Structural Welding Code, AWS D1.1 or D1.3. Weld washers are not recommended for deck thicknesses of 0.028 inches thick (minimum 22 gage) and greater. Weld washers are recommended for metal thicknesses less than 0.028 inches. Proper welding requires good metal to metal contact; therefore, lapping composite deck units with shear lugs is not recommended. For the same reason, built in hanger tabs (in floor deck) that bear on structural steel should be flattened or removed.

Welding should not be done near any type of combustible material. Cutting and welding sparks can cause construction fires. Conditions at a construction site are subject to rapid change. Welding may be safe in a given area and then, because combustibles are introduced, the area is suddenly not safe. The General Contractor (job supervisor) should prevent other trades from storing combustibles near or under areas where welding is to be done. Constant alertness in the general area and below is mandatory.

"DO NOT WELD NEAR COMBUSTIBLES"



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3.8.5 Placing Concrete on Metal Deck

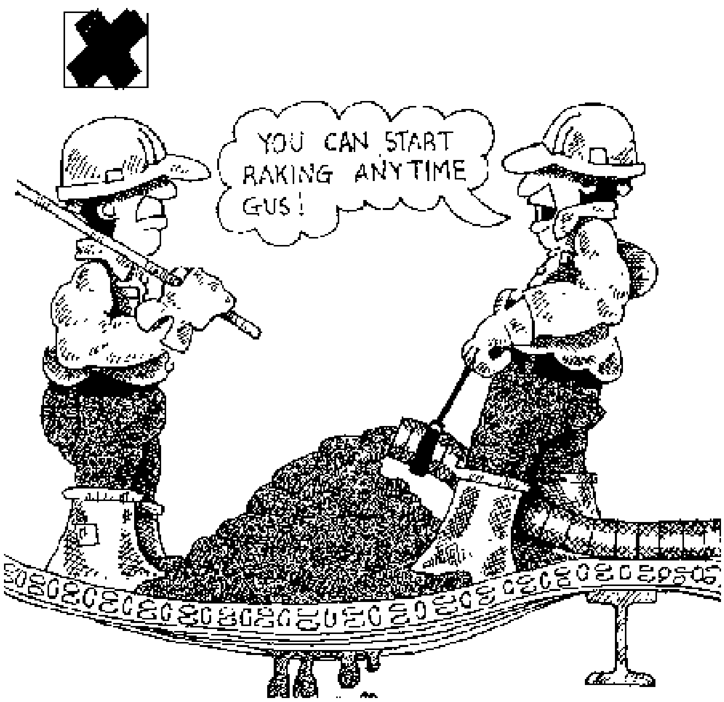
After the floor deck (or form deck) has been properly installed, it acts as a working platform for many trades. The deck should have been selected to provide at least fifty pounds per square foot capacity as a working platform. If the contractor anticipates loads on the platform that will exceed 50 psf, he should take appropriate steps to ensure the deck will carry the load.

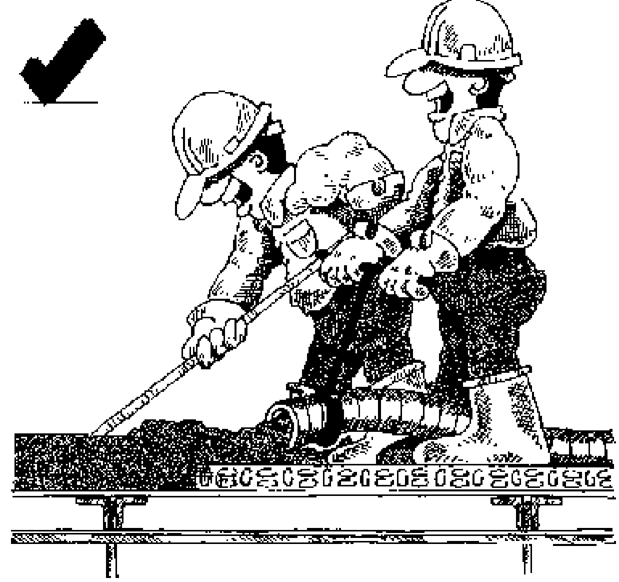
Before concrete is poured, the contractor should make sure that the deck is properly and completely fastened in accordance with approved deck erection drawings and the deck has adequate bearing on all supports. Damaged areas must be repaired or accepted. All ferrules should have been broken off the studs. All dirt and debris must be removed. All reinforcement, wires or rods, should be securely in place. The concrete contractor should review the deck shoring requirements and make sure that shores are securely in place.

Concrete should be poured from a low level to avoid impacting the deck. It should be placed uniformly over the supporting structure and spread towards the center of the deck span. Concrete should be placed in a direction so that the weight is first applied to the top sheet at the side lap, reducing the possibility of the side opening during the pour. Workers should not congregate around the concrete placement zone. If buggies are used to place the concrete, runways should be planked and the buggies should only operate on the planking. The planks should be stiff enough to transfer the buggy loads without damaging the deck. Deck damage caused by roll bars or careless placement must be avoided.

For calculating deck stresses and deflections during concreting the SDI loading schedule as shown in figure 16 is recommended. This method of analysis has been in use for many years and has provided good results. Because pouring room can be restricted, special consideration is required for single span conditions. For example, a single span condition commonly occurs between elevator shafts, and it is likely that concrete placement will be less controlled. A 50% factor is then added to the concrete weight and a deck gage selected is based on this loading. As an alternative, shoring may be specified. Although deck connections are important for all span conditions, they are extremely important for single spans. Connections should be thoroughly checked.

As concrete is placed, the entire frame as well as the deck will deflect. Concrete quantities should be calculated with all deflections taken into account.





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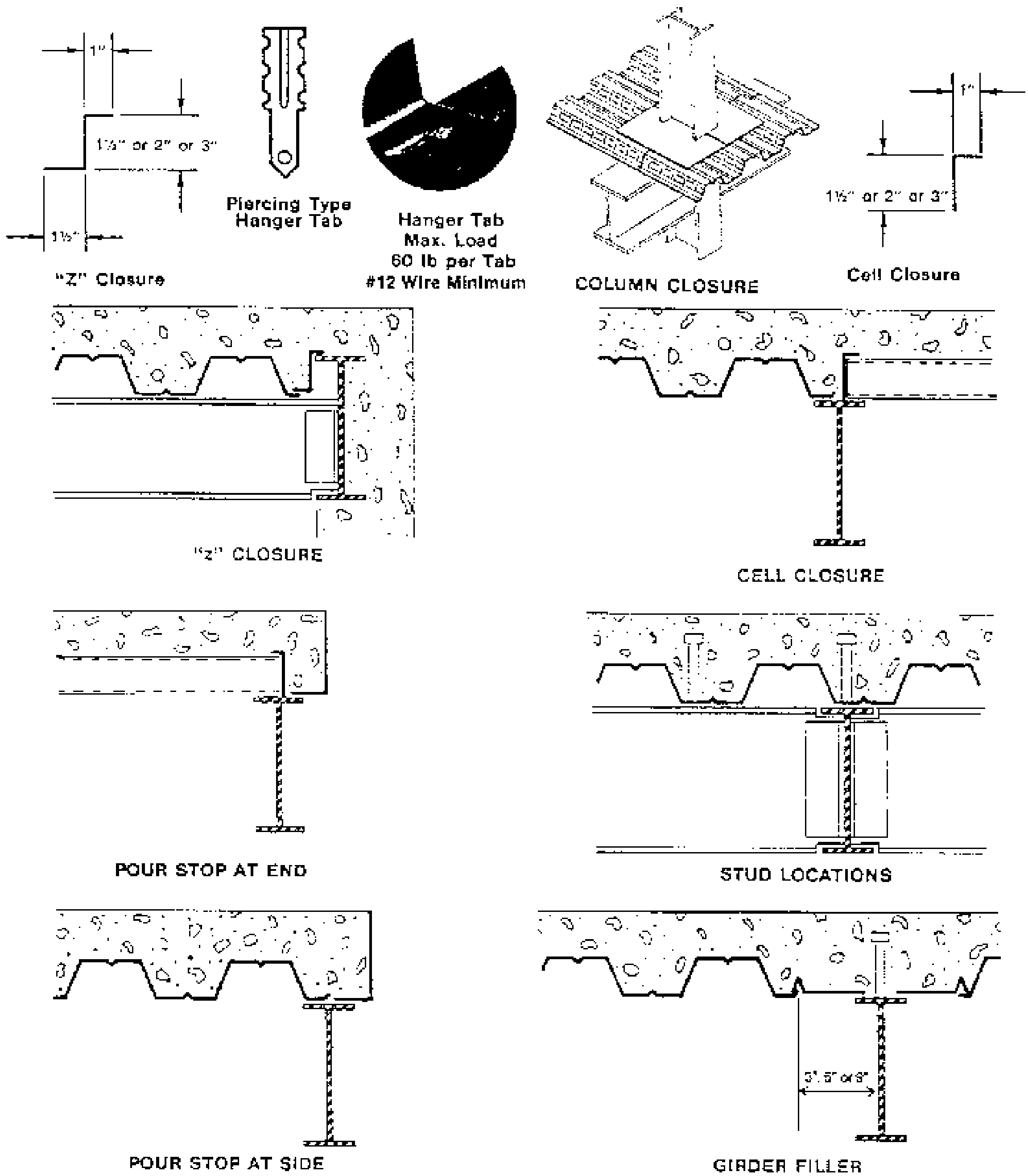
3.8.6 Noncomposite and Composite Deck Details



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3.8.7 Shear Studs and Composite Decks

Shear stud facts:

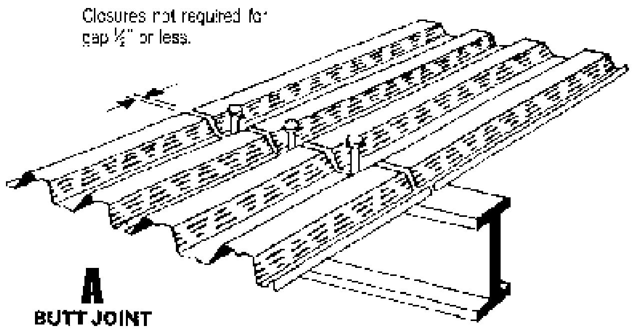
1. Shear studs are used to make steel beams composite. They are not necessary to make the deck composite but they enhance the load capacity of the composite slab. At times shear studs are not used to make beams composite but are present to transfer diaphragm shear loads into the frame. In this case the American Institute of Steel Construction (AISC) spacing rules for composite construction do not apply.
2. Most UL floor assembly fire ratings accept shear studs as an option.
3. The maximum shear stud diameter allowable by AISC is ¾ inch (19 mm) diameter. Each stud must be at least 1½ inches (38.1 mm) longer than the depth of the deck rib.
4. The location of the stud within the deck rib is important. Optimum construction of composite beams places the stud in the portion of deck rib closest to the beam end.
5. Shear studs can replace the welds used to attach the deck to the beam; however, if the studs are spaced greater than 12" on center (25.4 mm), welds of ⅝ inch (15.9 mm) should be used where the studs are missing.
6. Shear studs can be welded through galvanizing, but the G90 coating is the maximum recommended for this purpose. Shear studs can also be welded through cellular deck. The above information was provided by United Steel Deck, Inc., and is meant to be used as a guideline only since structural requirements may vary from project to project.

3.8.7 Shear Studs and Composite Decks—Continued

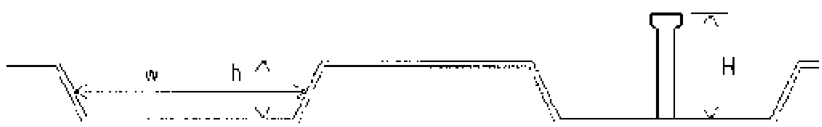
Special deck arrangements when shear studs are present.

All LOK-FLOOR is furnished in 24 inch or 36 inch widths. Any cutting that is required shall be done in the field by the deck erector.

Lateral and longitudinal spacing is controlled by sec. I5 A.I.S.C Manual of Steel Construction. For location of stud to edge of flange see Structural Welding Code AWS 7.4.5.



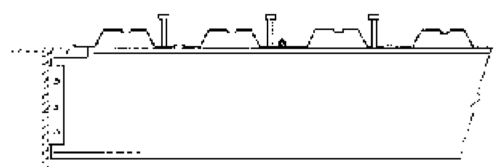
When studs are used deck must not be lapped in order to permit welding of studs.



$$\text{Rib Coefficient} = \frac{0.85}{\sqrt{N}}\left(\frac{w}{h}\right)\left(\frac{H}{h} - 1.0\right) \le 1.0$$

N = Number of studs per rib.
H = Length of stud.
h = Height of rib.
w = Average width of rib

For best construction of composite beams place studs in the portion of the deck rib closest to the beam end.

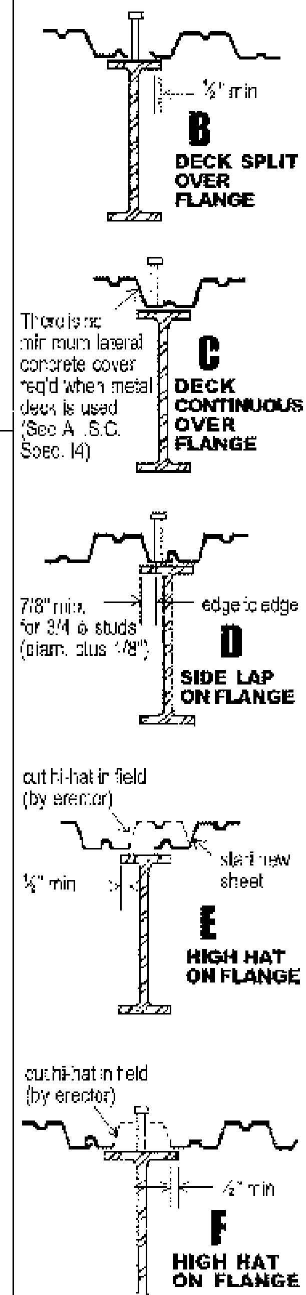


STUDS ARE ¾" DIAMETER			
CONCRETE*		STUD STRENGTH	
f'_c, ksi	weight, pcf	LRFD Q_n kips	ASD Q_u kips
3.0	115	17.7	9.9
3.0	145	21.0	11.5
3.5	115	19.8	10.8
3.5	145	23.8	12.5
4.0	115	21.9	11.4
4.0	145	26.1	13.3

*145 pcf concrete made with ASTM C33 aggregates. 115 pcf concrete made with ASTM C330 aggregates

DECK RIB RATIOS	
DECK TYPE	w/h
1.5" B Lok	1.5
1.5" Inverted B Lok	2.5
1.5" Lok Floor	3.85
2" Lok Floor	3.0
3" Lok Floor	2.0

Girder Details



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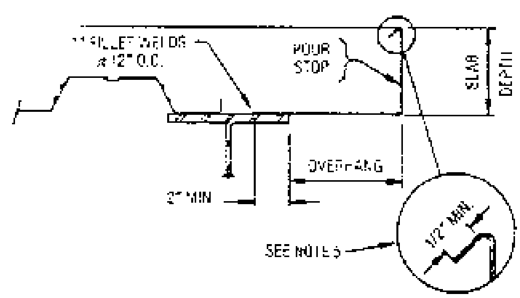
3.8.8 Pour Stop Selection Table

Allowable cantilever of metal deck where pour stops are required.

SELECTION TABLE

SLAB DEPTH (Inches)	OVERHANG (INCHES) 0	1	2	3	4	5	6	7	8	9	10	11	12
	POUR STOP TYPES												
4.00	20	20	20	20	18	18	16	14	12	12	12	10	10
4.25	20	20	20	18	18	16	16	14	12	12	12	10	10
4.50	20	20	20	18	18	16	16	14	12	12	12	10	10
4.75	20	20	18	18	16	16	14	14	12	12	10	10	10
5.00	20	20	18	18	16	16	14	14	12	12	10	10	
5.25	20	18	18	16	16	14	14	12	12	12	10	10	
5.50	20	18	18	16	16	14	14	12	12	12	10	10	
5.75	20	18	16	16	14	14	12	12	12	12	10	10	
6.00	18	18	16	16	14	14	12	12	12	10	10	10	
6.25	18	18	16	14	14	12	12	12	12	10	10		
6.50	18	16	16	14	14	12	12	12	12	10	10		
6.75	18	16	14	14	14	12	12	12	10	10	10		
7.00	16	16	14	14	12	12	12	12	10	10	10		
7.25	16	16	14	14	12	12	12	10	10	10			
7.50	16	14	14	12	12	12	12	10	10	10			
7.75	16	14	14	12	12	12	10	10	10	10			
8.00	14	14	12	12	12	12	10	10	10				
8.25	14	14	12	12	12	10	10	10	10				
8.50	14	12	12	12	12	10	10	10					
8.75	14	12	12	12	12	10	10	10					
9.00	14	12	12	12	10	10	10						
9.25	12	12	12	12	10	10	10						
9.50	12	12	12	10	10	10							
9.75	12	12	12	10	10	10							
10.00	12	12	10	10	10	10							
10.25	12	12	10	10	10								
10.50	12	12	10	10	10								
10.75	12	10	10	10									
11.00	12	10	10	10									
11.25	12	10	10										
11.50	10	10	10										
11.75	10	10											
12.00	10	10											

TYPES	DESIGN THICKNESS
20	0.0358
18	0.0474
16	0.0598
14	0.0747
12	0.1046
10	0.1345



NOTES: The above Selection Table is based on following criteria:

1. Normal weight concrete (150PCF)
2. Horizontal and vertical deflection is limited to 1/4" maximum for concrete dead load.
3. Design stress is limited to 20 KSI for concrete dead load temporarily increased by one-third for the construction live load of 20 PSF
4. Pour Stop Selection Table does not consider the effect of the performance, deflection, or rotation of the pour stop support which may include both the supporting composite deck and/or the frame
5. Vertical leg return lip is recommended for type 16 and lighter
6. This selection is not meant to replace the judgement of experienced Structural Engineers and shall be considered as a reference only

SDI reserves the right to change any information in this selection without notice.

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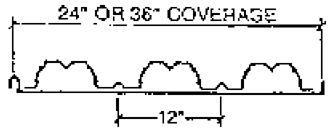
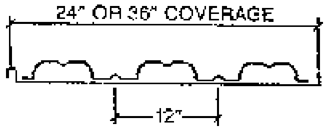
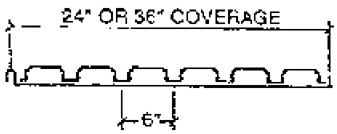
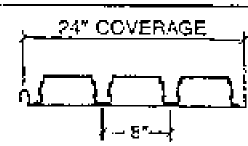
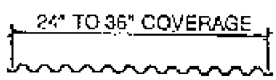
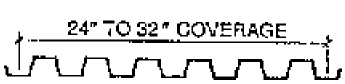
3.8.9 Cellular Floor Deck and Form Deck Profiles

Cellular Floor Deck Profiles	Name	Nominal Thickness Range	Weight Range	Comments
	3" x 12" Composite Cellular	.03" to .06"	4 psf to 7 psf	Bottom plate may be perforated for acoustical.
	2" x 12" Composite Cellular	.03" to .06"	4 psf to 7 psf	Bottom plate may be perforated for acoustical.
	1½" x 6" Composite Cellular	.03" to .06"	4 psf to 7 psf	May also be used as roof deck. Bottom plate may be perforated for acoustical.
	3" x 8" Composite Cellular	.03" to .06"	4 psf to 7 psf	May also be used as roof deck. Bottom plate may be perforated for acoustical.

Form Deck Profiles	Name	Nominal Thickness Range	Weight Range	Comments
	9/16" x Varies Form Deck	.014" to .030"	0.8 psf to 1.5 psf	Standard form deck. Used as centering.
	15/16" x Varies Form Deck	.017" to .040"	1.0 psf to 2.0 psf	Heavy duty form deck. Used as centering.
	1 5/16" x Varies Form Deck	.017" to .047"	1.0 psf to 2.6 psf	Extra heavy duty form deck. Used as centering.
	1½" or 2" x Varies Form Deck	.023" to .047"	1.4 psf to 2.8 psf	Super duty form deck. Used as centering.

Note: All profiles may be used as roof deck ***(for a patented assembly)***

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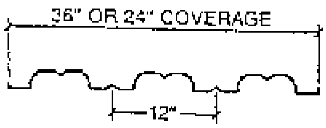
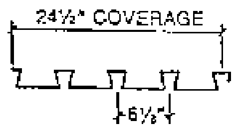
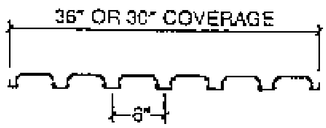
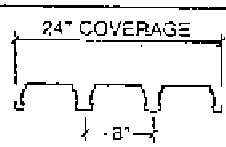
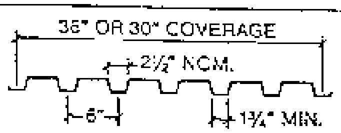
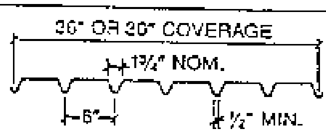
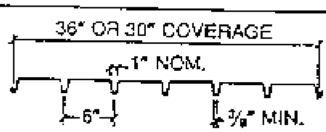
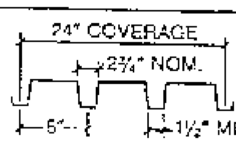
3.8.10 Composite Floor Deck and Roof Deck Profiles

Composite Floor Deck Profiles	Name	Nominal Thickness Range	Weight Range	Comments
	1½" x 12" 2 x 12" 3" x 12" Composite	.03" to .06"	2 psf to 4 psf	Embossment patterns will vary from manufacturer to manufacturer. Side laps are flat adjustable or button punchable.
	2" x 12" Composite	.03" to .06"	2 psf to 4 psf	
	1½" x 6" Composite	.03" to .06"	2 psf to 4 psf	Embossment patterns will vary from manufacturer to manufacturer. Side laps are flat adjustable or button punchable.
	3" x 8" Composite	.03" to .06"	2 psf to 4 psf	Embossment patterns will vary from manufacturer to manufacturer. Side laps are flat adjustable or button punchable. This profile is not generally suitable for use with shear studs.

Roof Deck Profiles	Name	Nominal Thickness Range	Weight Range	Comments
	1½" x 6" Wide Rib (WR)	.03" to .06"	2 psf to 4 psf	May be referred to as "B" deck. Sidelaps may be flat adjustable or button punchable. Accoustical deck will have perforated webs.
	1½" x 6" Intermediate Rib (IR)	.03" to .06"	2 psf to 4 psf	May be referred to as "F" deck.
	1½" x 6" Narrow Rib (NR)	.03" to .06"	2 psf to 4 psf	May be referred to as "A" deck.
	3" x 8" Deep Rib (DR)	.03" to .06"	2 psf to 4 psf	May be referred to as "N" deck. Sidelaps may be flat adjustable or button punchable. Acoustical deck will have perforated webs.

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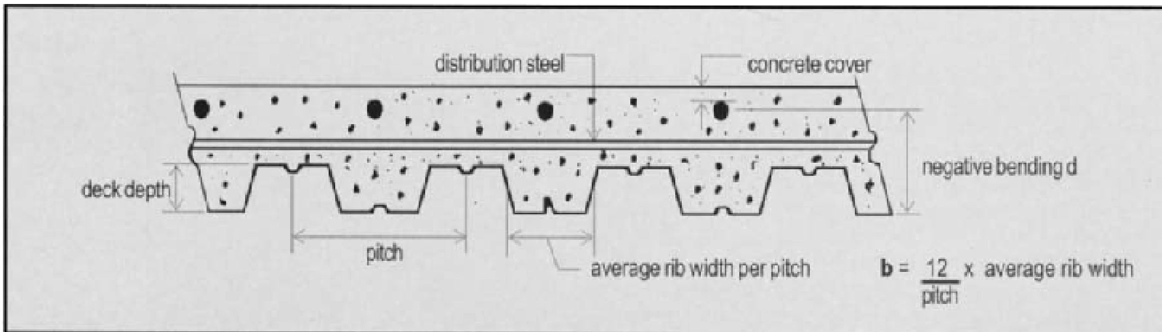
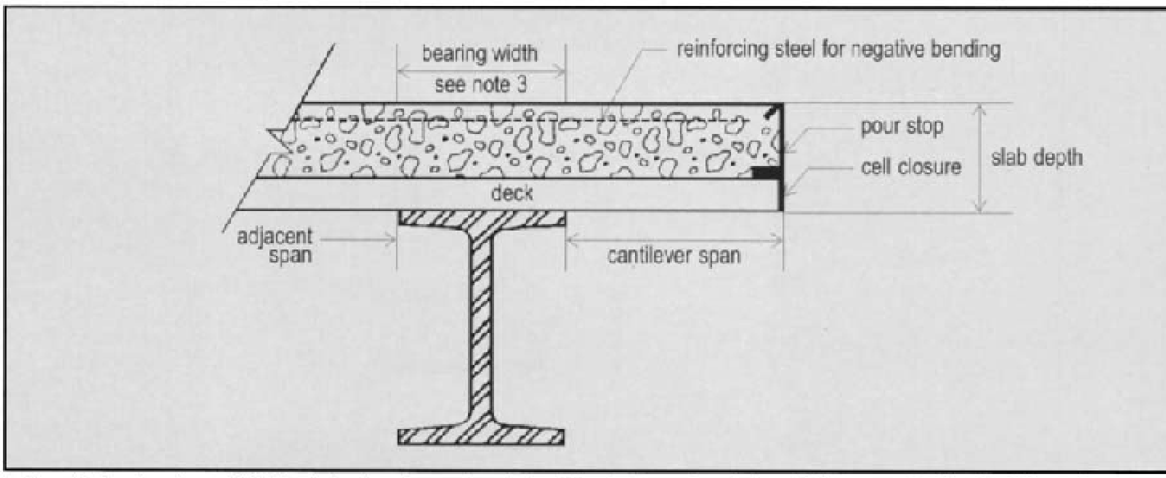
3.8.11 Floor Deck Cantilevers



DECK SECTION	PITCH	AVERAGE RIB WIDTH	b WIDTH FOR NEGATIVE BENDING
B-LOK	6"	2.25"	4.5"
INV B-LOK	6"	3.75"	7.5"
LOK FLOOR	12"	6"	6"

Use Standard concrete design procedures as per ACI.



1. Allowable bending stress of 20 ksi with loading of concrete + deck + 20 psf or concrete + deck + 150 lb. concentrated load, whichever is worse.
2. Allowable deflection of free edge (based on fixed end cantilever) of 1/120 of cantilever span under loading of concrete + deck.
3. Bearing width of 3½" assumed for web crippling check: concrete + deck + 20 psf over cantilever and adjacent span: if width is less than 3½" check with the Summit, New Jersey office.

NORMAL WEIGHT CONCRETE (150 PCF)																
	United Steel Deck, Inc. DECK PROFILE															
	B-LOK				1.5 LOK-FLOOR				2.0 LOK-FLOOR				3.0 LOK-FLOOR			
SLAB DEPTH	22 GAGE	20 GAGE	18 GAGE	16 GAGE	22 GAGE	20 GAGE	18 GAGE	16 GAGE	22 GAGE	20 GAGE	18 GAGE	16 GAGE	22 GAGE	20 GAGE	18 GAGE	16 GAGE
4.00"	1'11"	2'3"	2'10"	3'4"	1'11"	2'4"	3'0"	3'6"								
4.50"	1'10"	2'2"	2'9"	3'3"	1'10"	2'3"	2'10"	3'4"	2'6"	2'11"	3'8"	4'3"				
5.00"	1'10"	2'2"	2'8"	3'2"	1'10"	2'3"	2'9"	3'3"	2'5"	2'10"	3'6"	4'1"	3'8"	4'3"	5'3"	6'0"
5.50"	1'9"	2'1"	2'7"	3'0"	1'9"	2'2"	2'9"	3'2"	2'4"	2'9"	3'5"	4'0"	3'7"	4'1"	5'0"	5'9"
6.00"	1'9"	2'0"	2'6"	2'11"	1'9"	2'1"	2'8"	3'1"	2'3"	2'8"	3'4"	3'10"	3'5"	3'11"	4'10"	5'7"
6.50"	1'8"	2'0"	2'6"	2'11"	1'9"	2'1"	2'7"	3'0"	2'3"	2'8"	3'3"	3'9"	3'4"	3'10"	4'8"	5'5"
7.00"	1'8"	1'11"	2'5"	2'10"	1'8"	2'0"	2'6"	2'10"	2'2"	2'7"	3'2"	3'8"	3'3"	3'9"	4'6"	5'3"
7.50"	1'8"	1'11"	2'4"	2'9"	1'8"	2'0"	2'6"	2'10"	2'2"	2'6"	3'1"	3'7"	3'2"	3'8"	4'5"	5'1"
8.00"	1'7"	1'11"	2'4"	2'8"	1'7"	1'11"	2'5"	2'10"	2'1"	2'5"	3'0"	3'6"	3'1"	3'6"	4'3"	4'11"

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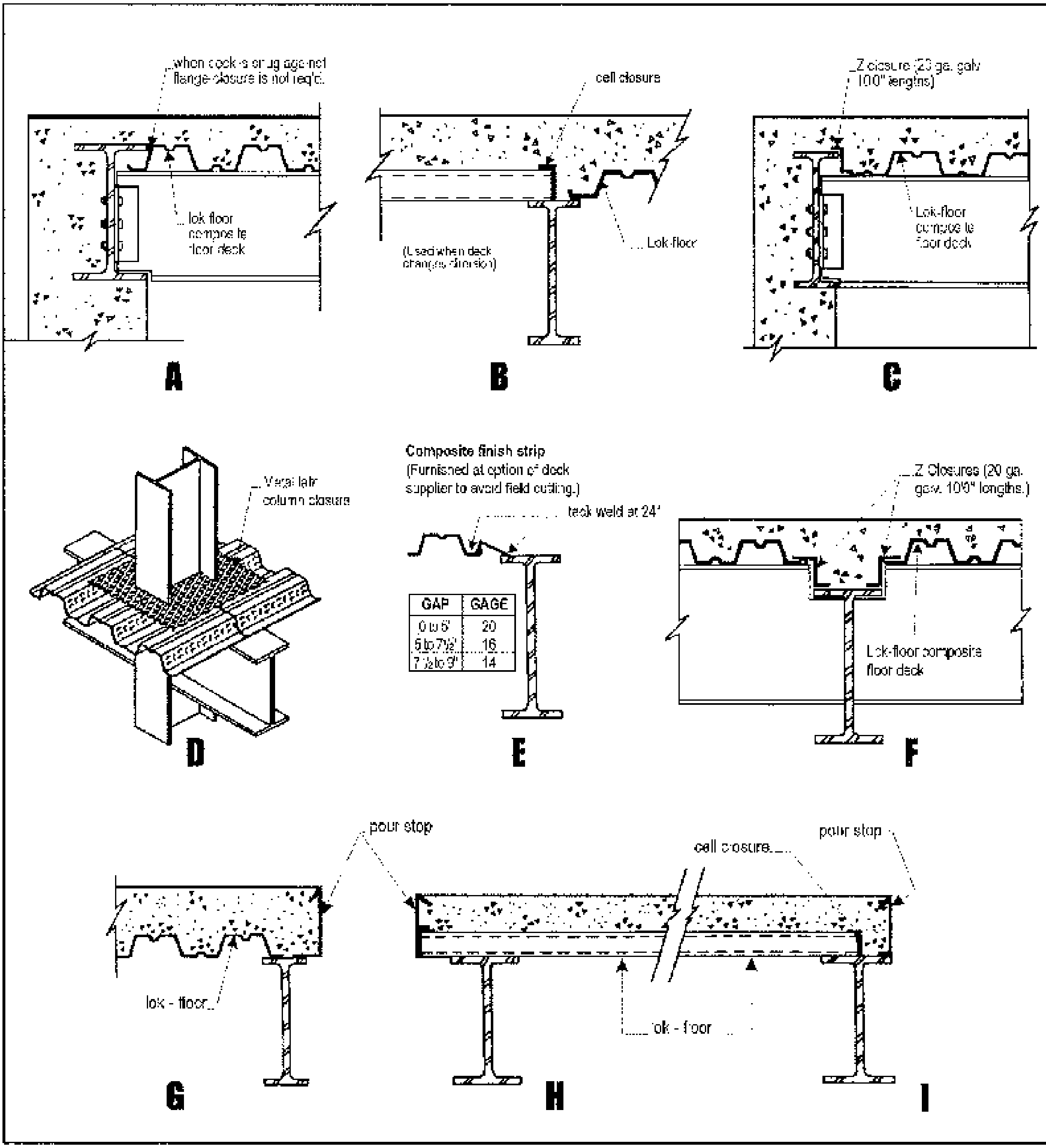
3.8.12 Deck Closure Details

The following details are used to obtain full coverage and to provide a seal against concrete leakage. B-lok details are similar.
DETAILS A THRU I ARE APPLICABLE WITH OR WITHOUT SHEAR STUDS.



GAP	GAGE
0 to 5'	20
5 to 7½'	16
7½ to 9'	14

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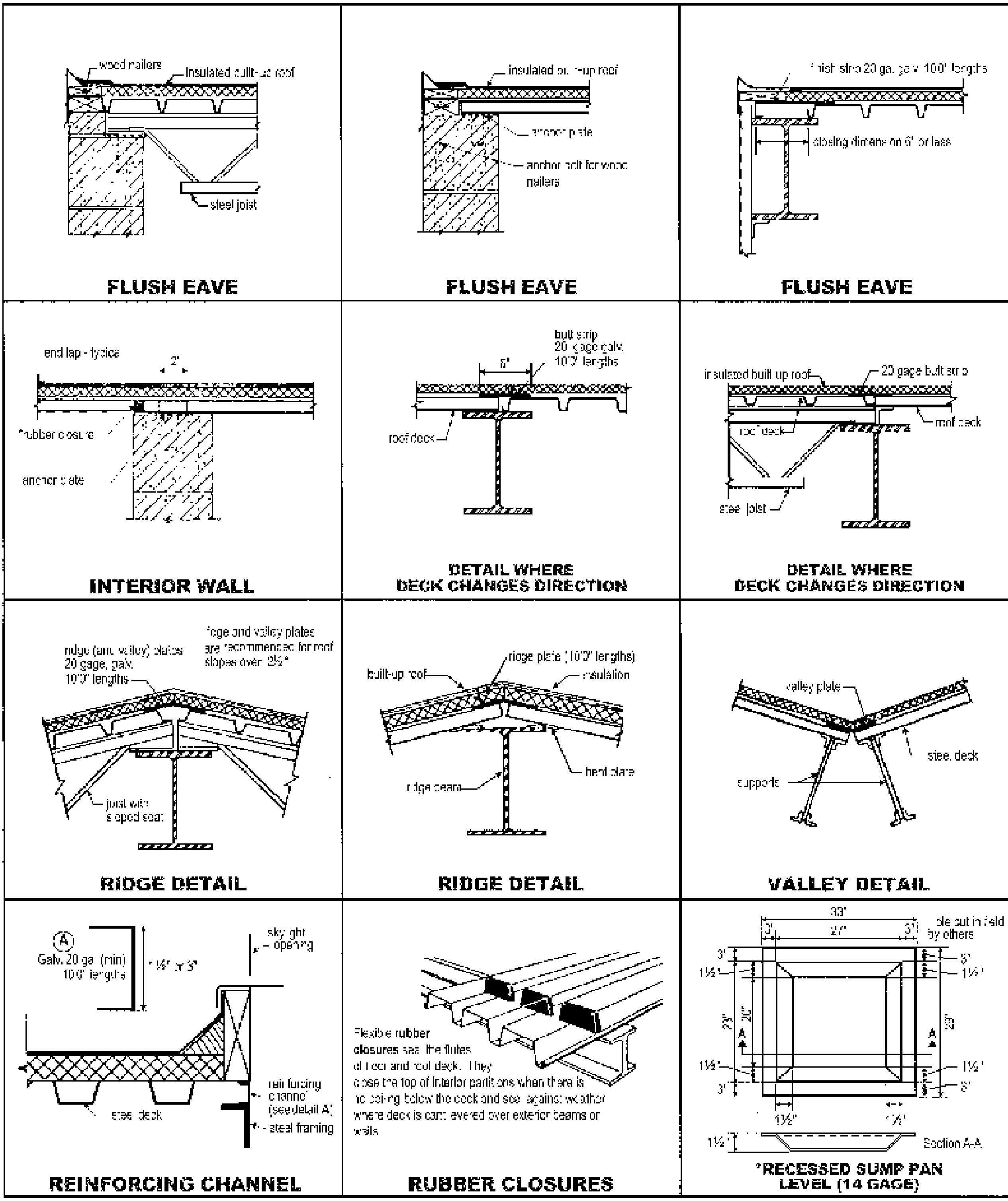
3.8.13 Roof Deck Closure Details



*Ridge and valley plates, reinforcing channels, rubber closures and sump pans are furnished only when ordered by the purchaser. The level sump pan is the standard

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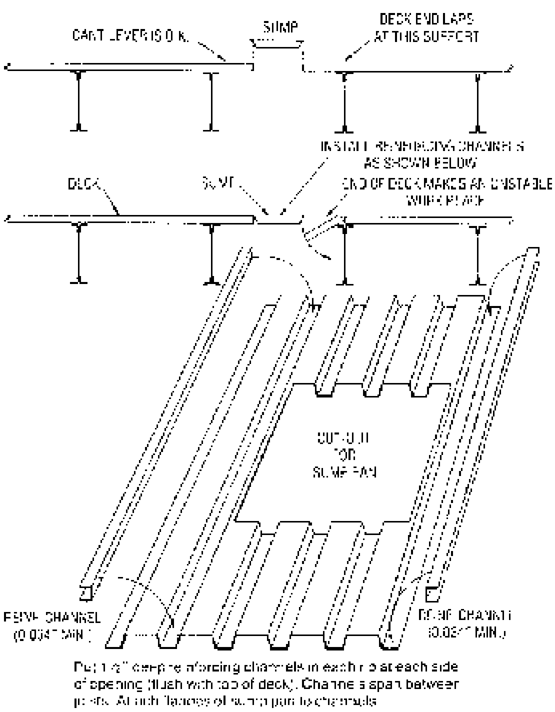
3.8.14 Reinforcing Openings in Steel Decks

Methods of cutting and reinforcing penetrations through decking.

SUMP REINFORCING AT END OF DECK



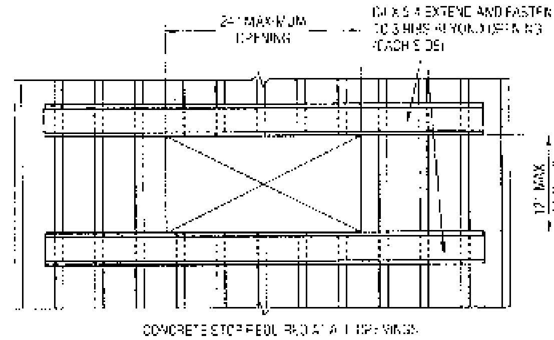
Burn holes in deck side laps, caused by welded side lap attachments, are spaced far enough apart not to cause problems. Burn holes near intermediate supports are unlikely to cause much loss of strength unless a total area greater than a 6" diameter hole is removed. These burn holes are usually caused by the welder searching for the unseen structural member; therefore, the use of chalk lines is recommended.

Distributed small dents, such as those caused by foot traffic, will not cause a structural problem; but if the denting covers a large percentage of the job, the insulation board will be better attached with mechanical fasteners rather than by adhesives. The designer must approve any change in fastening.

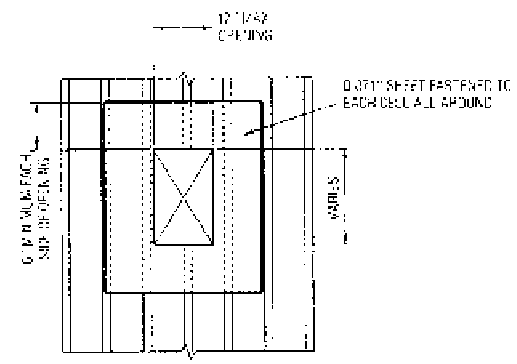
Vigilance should be maintained to detect and correct any "soft" spots in roofs that could cause insulation boards to crack under foot loading.

EXAMPLES OF DETAILS FOR OPENINGS

DETAILS FOR OPENINGS TO 2'-0" PERPENDICULAR TO DECK



DETAILS FOR OPENINGS TO 12" PERPENDICULAR TO DECK



NOTE:
For holes 6" ∅ or less no reinforcing or minimum 0.045" plate required, depending on location.

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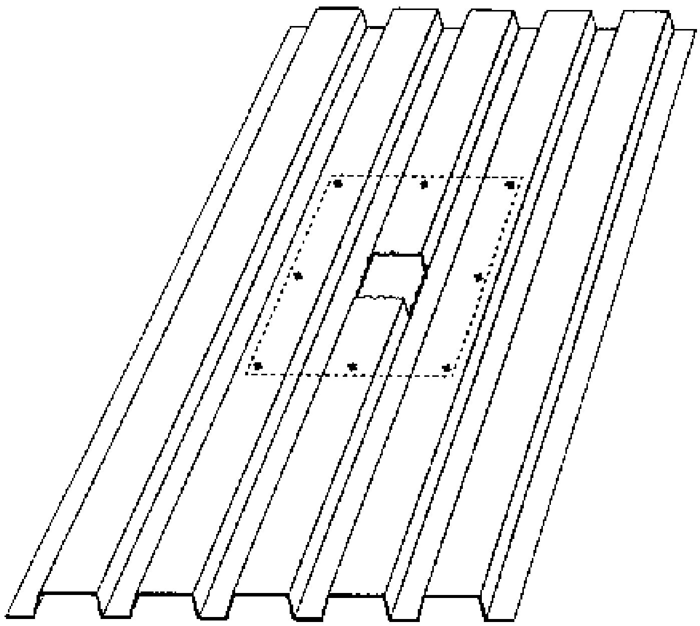
3.8.15 Example of 6-inch Penetration in Steel Deck



SUGGESTED SCHEDULE:

One Rib Removed (6″ Diameter)	No Reinforcing Or 0.045″ Plate (Min.)
8″ Diameter	0.045″ Plate (Min.)
8″ to 13″ Diameter	0.057″ Plate (Min.)
Over 13″	Frame Opening* (Design By Project Engineer)

*Check cantilever ability of deck

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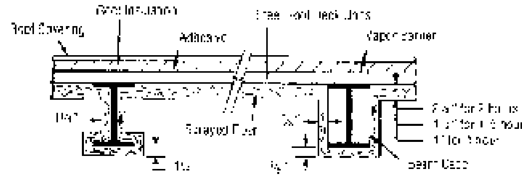
3.9.0 Fire Resistance Ratings for Roof Decks

FIRE RESISTANCE RATINGS

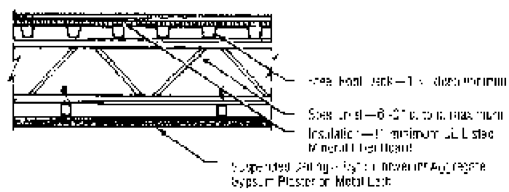
2-Hour Rating with Directly-Applied Protection

Illustration refers to UL Design P801 using a sprayed mineral fiber insulation. See also UL Designs P701, 711, and P805



2-Hour Rating with Metal Lath and Plaster Ceiling

Illustration refers to UL Design P404 See also UL Design P409.



Other 2-Hour Ratings

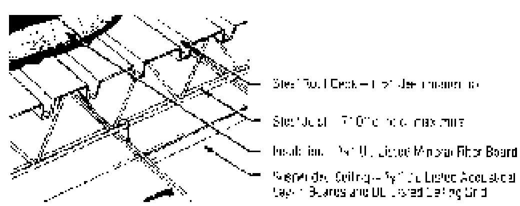
Although standard roof deck sections were not used for the following tests, it is the opinion of persons knowledgeable in fire test procedures that galvanized steel roof deck with a minimum depth of 1½ inches and a 0.0295-inch design thickness can be used without decreasing the fire resistance of the assembly. In each case the assembly was tested using either a steel form unit with a minimum depth of 9/16 inch or a steel floor deck essentially identical to products marketed as roof deck. The authorities having jurisdiction should be consulted before substituting steel roof deck in the following assemblies:

UL Designs P215 and P219: acoustical ceiling systems. 2 inches vermiculite concrete on special roof topping mixture on steel deck

UL Design P902: no ceiling required. 2¾ inches cellular concrete on steel deck.

1-Hour Ratings with Suspended Acoustical Ceiling

Illustration refers to UL Design P201. See also UL Designs P204, P210, P211, P224, P232, P235, P238, and P243, and Factory Mutual Roof-Ceiling Construction 3-1 hour.



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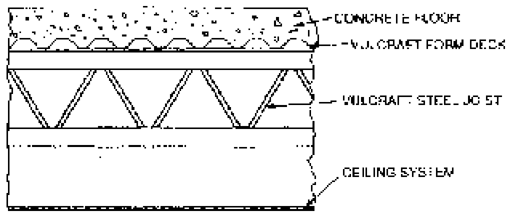
3.9.1 Floor Ceiling Fire-Resistance Ratings with Steel Joists

FLOOR-CEILING ASSEMBLIES WITH MEMBRANE PROTECTION



RESTRAINED ASSEMBLY RATING	TYPE OF PROTECTION SYSTEM	CONCRETE TYPE & THICKNESS ABOVE DECK	MINIMUM JOIST SIZE	MAX. JOIST SPACING SEE NOTE 2	U.L. DESIGN NUMBER	UNRESTRAINED BEAM RATING
1 HR	EXPOSED GRID	2 1/2" NW	8K1	4'-0	G253	1 HR
		2 1/2" NW	8K1	6'-0	G256	1, 2, 3 HR
1 1/2 HRS	EXPOSED GRID	3" NW	10K1	4'-0	G203	1 1/2, 2 HR
		2 1/2" NW	10K1	4'-0	G228	1 1/2, 2 HR
		2" NW	10K1	4'-0	G229	1 1/2, 2, 3 HR
		2 1/2" NW	10K1	4'-0	G243	1 1/2, 2 HR
2 HRS	CONCEALED GRID	2 1/2" NW	10K1	4'-0	G008	2 HR
		2 1/2" NW	10K1	4'-0	G018	---
		2 1/4" NW	8K1	4'-0	G023	2 HR
		2 1/2" NW	10K1	4'-0	G028	---
		2 1/2" NW	8K1	4'-0	G031	3 HR
		2 1/2" NW	10K1	4'-0	G036	3 HR
		2 1/4" NW	10K1	4'-0	G037	2 HR
	EXPOSED GRID	3" NW	8K1	4'-0	G203	1 1/2, 2 HR
		2 1/2" NW	10K1	4'-0	G204	2 HR
		2 1/2" NW	10K1	4'-0	G208	2 HR
		3" NW	10K1	4'-0	G209	---
		2 1/2" NW	10K1	4'-0	G211	---
		3" NW	8K1	4'-0	G212	2 HR
		2 1/2" NW	10K1	4'-0	G213	2, 3 HR
		2 1/2" NW	10K1	4'-0	G227	3 HR
		2 1/2" NW	10K1	4'-0	G228	1 1/2, 2 HR
		2" NW	10K1	4'-0	G229	1 1/2, 2, 3 HR
		2 1/2" NW	10K1	4'-0	G243	1 1/2, 2 HR
		3" NW	8K1	4'-0	G244	2 HR
		2 1/2" NW	10K1	4'-0	G250	2 HR
		2 1/2" NW	10K1	4'-0	G255	1, 2, 3 HR
		2 1/2" NW	8K1	6'-0	G256	1, 2, 3 HR
		2 1/2" NW	8K1	4'-0	G258	2, 3 HR
	GYPSUM BOARD	2 1/2" NW	8K1	4'-0	G523	2, 3 HR
		2 1/2" NW, LW	10K1	4'-0	G529	3 HR
3 HRS	CONCEALED GRID	3 1/2" NW	8K1	4'-0	G033	3 HR
		3 1/4" NW	10K1	4'-0	G036	3 HR
	EXPOSED GRID	3" NW	10K1	4'-0	G213	2, 3 HR
		3 1/4" NW	10K1	4'-0	G229	1 1/2, 2, 3 HR
		3 1/2" NW	8K1	4'-0	G256	1, 2, 3 HR
	GYPSUM BOARD	2 3/4" NW	10K1	4'-0	G529	3 HR
4 HRS	METAL LATH	2 1/2" NW	12K5	4'-0	G401	---

(By permission of Nucor Research and Development, Norfolk, Nebraska.)

3.9.2 UL Design Numbers for Floors with Concrete Decks

RESTRAINED ASSEMBLY RATINGS (HOURLY)	U.L. DESIGN NO.	CONCRETE COVER AND TYPE	USD FORM PRODUCT
1	G039	2"NW	UFS (26 ga. min.)
	G206	2½"NW	UFS
	G211	2½"NW	UFS (24 ga. min.)
	G255	2½"NW	UFS
	G256	2½"NW	UFS (24 ga. min)
	G262	2½"NW	UFS
	G501	2"NW	UFS
	G531	2½"LW	UF1X
	G534	1½"LW (MIN.)	UFS
	G701	2½"NW, LW	UFS
	G703	3⅛"NW, 2⅝"LW	UFS
	G705	2½"NW, LW	UFS
	G706	3¼", 4½"NW; 3", 4½"LW	UFS, B
	G707	3⅛"NW, 2⅝"LW	UFX
	G708	2½"NW, LW	UFS
	G801	2¼"NW, LW	UFS
	G802	3¼", 4½"NW; 3", 4½"LW	UFS, B
	G803	3¼", 4½"NW; 3", 4½"LW	UFS, B
	G804	2½"NW, LW	UFS
	G805	3⅛"NW, 2⅝"LW	UFX
1½	G204	2½"NW	UFS
	G211	2½"NW	UFS
	G213	2½"NW	UFS, B
	G228	2½"NW	UFS
	G229	3¼"NW	UFS
	G231	2½"NW	UFS
	G236	2½"NW	UFS
	G243	2½"NW	UFS
	G244	3"NW	UFS
	G256	2½"NW	UFS
	G262	2½"NW	UFS (24 ga. min.)
	G264	2½"NW	UFS (24 ga. min.)
	G502	2"NW	UFS
	G506	2"NW	UFS
	G509	2"NW	UFS
	G530	2"NW	UF1X (24 ga. min.)
	G531	2½"NW	UFS, UFX
	G701	2½"NW, LW	UFS
	G703	3⅞"NW, 2⅞"LW	UFX, B
	G705	2½"NW, LW	UFS
	G706	4½"NW, 3½"LW	UFS, B
	G707	3¾"NW, LW	UFX
	G708	2½"NW, LW	UFS
	G801	2½"NW, LW	UFS
	G802	4½"NW, LW	UFS, B
	G803	4½"NW, LW	UFS, B
	G804	2½"NW, LW	UFS
	G805	3½"NW, LW	UFX
2	G023	2¼"NW	UFS
	G028	2½"NW	UFS
	G031	2½"NW	UFS, UF1X, UFX
	G036	2½"NW	UFS
	G037	2¼"NW	UFS
	G038	3"NW	UFS
	G204	2½"NW	UFS
	G208	2½"NW	UFS
	G209	3"NW	UFS
	G211	2½"NW	UFS
	G212	3"NW	UFS
	G213	2½"NW	UFS, B
	G227	2½"NW	UFS
	G228	2½"NW	UFS
	G229	2½"NW	UFS
	G231	2½"NW	UFS
	G236	2½"NW	UFS
	G243	2½"NW	UFS
	G244	3"NW	UFS
	G250	2½"NW	UFS
	G255	2½"NW	UFS
	G256	2½"NW	UFS
	G258	2½"NW	UFS
2 cont'd	G503	2½"NW	UFS
	G504	2½"NW	UFS
	G505	2"NW	UFS
	G510	2½"NW	UFS
	G514	2½"NW	UFS
	G515	2¾"NW	UFS
	G521	2½"NW	UFS
	G523	2½"NW	UFS
	G529	2½"NW, LW	UFS
	G530	2½"NW, LW	UF1X, (24 ga. min.)
	G531	3¼"NW, 2¾"LW	UFS, UFX
	G533	3" LW	UFS
	G538	2½"NW	UFS
	G701	2½"NW, LW	UFS
	G703	4⅝"NW, 3⅞"LW	UFX, B
	G705	2½"NW, LW	UFS
	G706	5¼"NW, 4½"LW	UFS, B
	G707	4⅝"NW, 3⅞"LW	UFX
	G708	2½"NW, LW	UFS
	G801	2¾"NW, LW	UFS
	G802	5¼"NW, 4½"LW	UFS, B
	G803	5¼"NW, 4½"LW	UFS, B
	G804	2½"NW, LW	UFS
	G805	4⅝"NW, 3⅞"LW	UFS
3	G033	3½"NW	UFS
	G036	3¼"NW	UFS
	G211	3"NW	UFS
	G213	3½"NW	UFS, B
	G229	3¼"NW	UFS
	G256	3½"NW	UFS
	G512	2½"NW	UFS
	G523	3"NW	UFS
	G529	2¾"NW, LW	UFS
	G701	2¾"NW, LW	UFS
	G703	2¾", 3⅝"NW, LW	UFX, B
	G705	2¾"NW, LW	UFS
	G707	2¾", 3⅝"NW, LW	B
	G708	2¾"NW, LW	UFS
	G801	2¾"NW, LW	UFS
	G805	2⅝", 3⅝"NW,LW	B
4	G401	2½"NW	UFS

The table shows constructions that are normally used for floors. For roofs see U.L. Numbers Pxxx and page 14 of this manual. In general, heavier and deeper form members may be used without compromising the fire rating; however, concrete cover must remain and any beam and joist spacing restrictions still apply. In all cases the U.L. Fire Resistance Directory should be consulted for concrete densities, fastening requirements, and all details of construction. Some ratings have the concrete cover vary with the span—particulary the 700 numbers. This table was prepared using the 1996 U.L. Fire Resistance Directory.

FIRE PROTECTION CODE	
U.L. #	
000-099	Concealed Grid
200-299	Exposed Grid
400-499	Suspended Plaster
500-599	Suspended Gypsum Board
700-799	Cementitious Sprayed
800-899	Sprayed Fibrous

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.9.3 Fire Rating of Composite Deck—1" and 1½"

RESTRAINED ASSEMBLY RATINGS (HOURLY)	U.L. DES. NO.	F.P.	CONCRETE COVER	USD PRODUCTS
1	D216	S	2 ½ NW,LW	BL,BLC,LF2,LFC2,LF3,LFC3,NL,NLC
	D703	C	2 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D712	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D722	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D739	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC,AWC2,AWC3*
	D743	C	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D759	C	2 ½ NW,LW	BL,LF15,LF2,LF3,NL*
	D767	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,AWC2,AWC3
	D779	C	2 ½ NW,LW	BL,LF15,LF2,LF3
	D832	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D847	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,NLC*
	D858	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,AWC2,AWC3*
	D859	F	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D902	N	3 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	2 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	2 ⅝ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D914	N	2 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	3 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	2 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	2 ⅝ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	3 ½ NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	2 ½ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	3 ½ NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	2 ½ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	3 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	2 ⅝ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	3 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	2 ⅝ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	3 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	2 ⅝ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D927	N	3 ½ NW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D927	N	2 ⅝ LW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D929	N	3 ½ NW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D929	N	2 ⅝ LW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
1 ½	D502	S	2 ½ NW	BL,BLC,NL,NLC,LF2,LFC2,LF3,LFC3
	D703	C	2 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D712	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D722	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D739	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,AWC2,AWC3*
	D743	C	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D750	C	2 ½ NW,LW	BL,INV BL,LF2,LF3,NL*
	D759	C	2 ½ NW,LW	BL,LF15,LF2,LF3,NL*
	D767	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,AWC2,AWC3
	D779	C	2 ½ NW,LW	BL,LF15,LF2,LF3
	D832	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D847	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,NLC*
	D858	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,AWC2,AWC3*
	D859	F	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D902	N	4 NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	3 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	4 NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	3 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	4 NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	4 NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	3 LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	4 NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	3 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	4 NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	3 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	4 NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	3 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D927	N	4 NW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D927	N	3 LW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D929	N	3 ½ NW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D929	N	3 LW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC

1. **United Steel Deck, Inc.**, is not responsible for the adhesive ability of any spray applied fire protection material, or for any treatment, cleaning, or preparation of the deck surface required for adhesion of fire protection material.

2. The live loads shown in the composite tables may require a reduction if a U.L. fire rating is required. The worst load reduction for any design is 40%. Designs D733, D742, D825, D840, D860, D902, D907, D914, and D916 do not require a reduction if the sidelaps are attached at 24" o.c. as was used in the fire test.

3. Be sure to check the U.L. **Fire Resistance Directory** for all details of construction.

4. Listings marked with * allow the use of phosphatized/painted noncellular deck except LF15. All D9xx listings allow the use of phosphatized/painted noncellular deck.

5. **IN THE F.P. COLUMN:**
S = suspended ceiling
F = fibrous fireproofing
C = cementitious
N = no fireproofing on the deck.

6. The concrete cover is measured from the top of the deck - add the deck depth to get the total slab thickness.

7. The BSA approvals for use in New York City are 620-76-SM (2 hours) and 621-76-SM (3 hours).

8. **PRODUCT CODES:**
BL = B-LOK
BLC = B-LOK cellular
INV. BL = inverted B-LOK
LF15 = 1½" LOK floor
LFC1 = 1½" LOK floor cellular
LF2 = 2" LOK floor
LFC2 = 2" LOK floor cellular
LF3 = 3" LOK floor
LFC3 = 3" LOK floor cellular
NL = N-LOK
NLC = N-LOK cellular
INV. NL = inverted N-LOK
AWC2, **AWC3** = three service compact cell sections

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.9.4 Fire Rating of Composite Deck—2"

RESTRAINED ASSEMBLY RATINGS (HOURLY)	U.L. DES. NO.	F.P.	CONCRETE COVER	USD PRODUCTS
2	D216	S	2 ½ NW,LW	BL,BLC,LF2,LFC2,LF3,LFC3,NL,NLC
	D502	S	2 ½ NW	BL,BLC,LF2,LFC2,LF3,LFC3,NL,NLC
	D703	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D704	C	2 ½ NW	BL,BLC,LF15,LFC1
	D706	C	2 ½ NW	LF3,LFC3
	D712	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D716	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3*
	D722	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D726	C	2 ½ NW,LW	LF15,LF2,LF3,NL *
	D727	C	2 ½ NW	INV.BL,INV. NL *
	D730	C	2 ½ NW	LF2,LFC2,LF3,LFC3,NL,NLC*
	D733	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D739	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC,AWC2,AWC3*
	D742	C	2 ½ NW	LF15,LF2,LF3,NL*
	D743	C	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D745	C	2 ½ NW,LW	LF2,LF3 *
	D746	C	2 ½ LW	BL *
	D747	C	2 ½ LW	LF2 *
	D750	C	2 ½ NW,LW	BL,INV.BL,LF2,LF3,NL *
	D752	C	2 ½ LW	BL,BLC,LF2,LFC2,LF3,LFC3*
	D755	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D759	C	2 ½ NW,LW	BL,LF15,LF2,LF3,NL*
	D760	C	2 ½ NW,LW	LF2,LF3
	D767	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,AWC2,AWC3
	D777	C	2 ½ NW	LF15,LF2,LF3,NL*
	D772	C	2 ½ NW,LW	LF2,LF3*
	D773	C	2 ½ LW	BL*
	D774	C	2 ½ LW	LF2*
	D775	C	2 ½ NW,LW	BL,INV. BL,LF2,LF3*
	D779	C	2 ½ NW,LW	BL,LF15,LF2,LF3
	D822	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,NL,NLC*
	D824	F	2 ½ NW,LW	BL,BLC,LF15,LFC1
	D825	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D826	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D831	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D832	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D833	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3*
	D837	F	2 ½ NW	BL,BLC,LF15,LFC1*
	D840	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D847	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,NLC*
	D852	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3*
	D858	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3,AWC2,AWC3*
	D859	F	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D860	F	3 ¼ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D861	F	2 ½ NW,LW	LF2,LF3*
	D862	F	2 ½ LW	LF2,LF3*
	D870	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3*
	D902	N	4 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	3 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D906	N	3 ¼ LW	NLC
	D907	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3
	D908	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D913	N	3 ¼ LW	BL,LF15,LF2,LFC2,LF3,LFC3
	D916	N	4 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	3 ¼ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	3 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	4 ½ NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	3 ¼ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	3 ½ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	3 ¼ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	3 ½ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D920	N	3 ¼ LW	LF2,LFC2,LF3,LFC3
	D922	N	4 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	3 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	4 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	3 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	4 ½ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	3 ½ LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D927	N	4 ½ NW	B,BLC,LF2,LF2C,LF3,LF3C,NL,NLC
	D927	N	3 ¼ LW	B,BLC,LF2,LF2C,LF3,LF3C,NL,NLC
	D929	N	4 ½ NW	B,BLC,LF2,LF2C,LF3,LF3C,NL,NLC
	D929	N	3 ¼ LW	B,BLC,LF2,LF2C,LF3,LF3C,NL,NLC

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.9.5 Fire Rating of Composite Deck—3" and 4"

RESTRAINED ASSEMBLY RATINGS (HOURLY)	U.L. DES. NO.	F.P.	CONCRETE COVER	USD PRODUCTS
3	D216	S	3 ¼ NW,LW	BL,BLC,LF2,LFC2,LF3,LFC3,NL,NLC
	D701	C	2 ½ NW	BL,BLC,LF15,LFC1,LF3,LFC3
	D703	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC *
	D708	C	2 ½ NW,LW	BL,BLC,LF15,LFC1, LF2,LFC2,LF3,LFC3*
	D709	C	2 ½ NW,LW	LF3,LFC3
	D715	C	2 ½ NW,LW	LF2,LF3,NL *
	D739	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D742	C	3 ½ NW	LF15,LF2,LF3*
	D743	C	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D746	C	2 ½ LW	BL *
	D754	C	3 ¼ LW	LF15,LF2,LF3,NL*
	D755	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D760	C	2 ½ NW,LW	LF2,LF3
	D767	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3L
	D768	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3
	D771	C	3 ½ NW	LF15,LF2,LF3,NL*
	D773	C	2 ½ LW	BL*
	D777	C	3 ¼ LW	LF15,LF2,LF3,NL*
	D779	C	2 ½ NW,LW	BL,LF15,LF2,LF3
	D814	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF3,LFC3*
	D816	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC *
	D831	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D832	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D833	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3*
	D838	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3
	D849	F	2 ½ NW	LF3,LFC3,NL,NLC
	D858	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3*
	D859	F	2 NW,LW	LF2,LFC2,LF3,LFC3*
	D860	F	3 ¼ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D867	F	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3
	D869	F	2 ½ NW	LF3,LFC3,NL,NLC*
	D902	N	4 3/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	4 7/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D902	N	5 ¼ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	4 3/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	4 7/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D916	N	5 ¼ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	5 ¼ NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	4 3/16 LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D918	N	4 7/16 LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	5 ¼ NW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	4 3/16 LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D919	N	4 7/16 LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	5 ¼ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D922	N	4 7/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	5 ¼ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D923	N	4 7/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	5 ¼ NW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D925	N	4 7/16 LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC
	D927	N	5 ¼ NW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
	D927	N	4 3/16 LW	B,BLC,LF2,LF2C,LF3,LF3C,NC,NLC
4	D739	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC*
	D754	C	3 ¼ LW	LF15,LF2,LF3,NL*
	D760	C	2 ½ NW,LW	LF2,LF3
	D767	C	2 ½ NW,LW	BL,BLC,LF15,LFC1,LF2,LFC2,LF3,LFC3,AWC2,AWC3
	D777	C	3 ¼ LW	LF15,LF2,LF3,NL*
	D779	C	2 ½ NW,LW	BL,LF15,LF2,LF3
	D858	F	2 ½ NW,LW	LF2,LFC2,LF3,LFC3*
	D860	F	3 ¼ LW	LF15,LFC1,LF2,LFC2,LF3,LFC3,NL,NLC

The following information is taken from the Steel Deck Institute publication "Composite Deck Design Handbook," 1997 edition:

"In the Underwriter *Fire Resistance Directory* the composite deck constructions show hourly ratings for restrained and unrestrained assemblies. ASTM E119 provides information in appendix X3 called "Guide for Determining Conditions of Restraint for Floor and Roof Assemblies and for Individual Beams". After a careful review of this guide the Steel Deck Institute determined that all interior and exterior spans of multispan deck properly attached to steel framing are restrained. Additionally, all multiple span composite deck slabs attached to bearing walls are restrained. In fact, there is almost no realistic condition in which a composite deck-slab could not be considered to be restrained - perhaps a single span deck system which is unattached to framing or a wall in order to provide a removable slab."

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.9.6 UL Designs for Roof/Ceiling Fire-rated Assemblies

Roof - ceiling fire rated assemblies listed in the Underwriters Laboratory Inc. Fire Resistance Directory, follow this numbering code: P2xx have suspended acoustical ceilings with an exposed grid system; P4xx have suspended gypsum board; P7xx have sprayed on cementitious fire protection material (fpm) applied to the steel deck; P8xx have sprayed on fibrous fpm; and P9xx assemblies have no fpm applied to the deck although it is still required on the beams or the joists. The P9xx ratings (with steel deck) in the directory are all with insulating concrete. Individual designs in each of the categories can have a variety of insulation systems: insulating boards of various materials, vermiculite or perlite or cellular concrete, foamed plastic, and combinations of these.

All of the designs describe the steel deck in generic terms. Some show, in addition to the general description, a list of classified products. United Steel Deck, Inc., is specifically listed in some assemblies but, even if not specifically named, United Steel Deck can meet the general requirements with one or more of our deck products and therefore can supply the required deck component for the assembly.

It is also important to note that U.L. will allow the substitution of heavier (thicker), deeper and stronger members than shown in the assembly requirements. However the designer should review the details of the assembly to check span limits, spacing considerations, and connection requirements. When U.L. calls for the use of welding washers, the washers can be eliminated for deck that is 22 gage or thicker.

Galvanized deck should be used for constructions that require the use of sprayed-on fire protection material. **United Steel Deck, Inc., is not responsible for the adhesive ability of any spray applied fpm, or for any treatment, cleaning, or preparation of the deck surface required for the adhesion of fpm.** Consult the fpm manufacturer for application directions and limitations.

This listing is based on the Underwriters Laboratories *Fire Resistance Directory*, 1996 Edition.

U.L. DESIGN	HOURS	U.L. DESIGN	HOURS
P201	1	P722	1,1½,2,3
P202	1	P723	1,1½,2
P203	¾	P724	1,1½,2,3
P204	1	P725	1,1½,2
P206	1	P726	1,1½,2
P210	1	P727	1,1½,2,3
P211	1	P728	1½,2
P214	1	P729	2
P224	1	P730	1,1½,2,3
P225	1,1½	P731	1,1½,2
P227	1,1½	P732	1,1½,2,3
P230	1	P733	1,1½,2,3
P231	1,1½	P734	1,1½,2
P232	1	P735	1
P235	1	P736	1,1½,2
P237	2	P738	1,1½,2
P238	1	P739	1,1½,2
P241	2	P740	1,1½,2
P246	1	P801	1,1½,2
P250	1,1½	P802	1,1½,2
P251	1,1½,2	P803	1,1½
P254	1	P804	1,1½
P255	1	P805	1,1½,2
P257	1	P811	1,1½,2,3
P259	1,1½	P813	1,1½
P261	1	P814	1,1½,2
P264	1	P815	1,1½,2
P266	2	P816	1,1½,2
P267	1	P817	1,1½,2
P404	1½,2	P818	1,1½,2
P405	3	P819	1,1½,2
P407	2	P820	1
P409	2	P821	1,1½,2
P410	2	P823	1,1½
P411	2	P824	1
P508	1	P825	1,1½,2
P509	1	P826	1,1½,2,3
P510	1,1½	P827	1,1½,2
P511	1	P828	1,1½,2
P512	1	P901	1,1½,2
P513	1½	P902	1,1½,2
P514	2	P903	1
P701	1,1½,2	P907	1,1½,2
P709	1,1½,2	P908	1,1½,2
P710	1	P910	1,1½
P711	1,1½,2	P920	1,1½,2
P712	1,1½,2,3	P921	1,1½,2
P713	1,1½,2,3	P922	1,1½,2
P714	1,1½,2,3	P923	1,1½,2
P717	1,1½,2	P924	1,1½,2
P718	2	P925	1,1½,2
P719	1,1½,2,3	P927	1,1½,2
P720	2	P926	1,1½,2
P721	1	P929	1,1½,2

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.10.0 Hot Dip Galvanizing—Corrosion and Protection of Steel

Introduction

Corrosion and repair of corrosion damage are multibillion dollar problems. Hot dip galvanizing after fabrication is a versatile corrosion control process which solves many corrosion problems in most major industrial applications. Chemical process industries, transportation and public utilities each have extensively used hot dip galvanized steel to combat corrosion.

The value of galvanized steel stems from the relative corrosion resistance of zinc, which under most service conditions is considerably better than iron and steel. In addition to forming a physical barrier against corrosion, zinc applied as a hot dip galvanized coating cathodically protects exposed steel. Furthermore, galvanizing for protection of iron and steel is favored because of its low cost, the ease of application and the extended, maintenance-free service it provides.

Corrosion and Protection of Steel

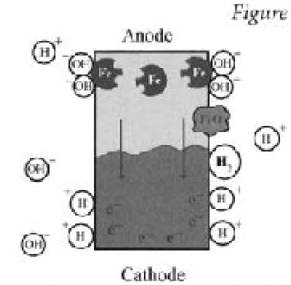
Corrosion of Steel

Rust, the corrosion product of iron, is the result of an electrochemical process. Rust occurs because of differences in electrical potential between small areas on the steel surface involving anodes, cathodes and an electrolyte. These differences in potential on the steel surface are caused by:

- variations in composition/structure
- presence of impurities
- uneven internal stress
- presence of a non-uniform environment

These differences in the presence of an electrolyte, a medium for conducting ions, create corrosion cells. These corrosion cells consist of microscopic anodes and cathodes. Because of differences in potential within the cell, negatively charged electrons flow from anode to cathode and iron atoms in the anode area are converted to positively charged iron ions. The positively charged iron ions (Fe^{++}) of the anode attract and react with the negatively charged hydroxyl ions (OH^-) in the electrolyte to form iron oxide, or rust. Negatively charged electrons (e^-) react at the cathode surface with positively charged hydrogen ions (H^+) in the electrolyte to form hydrogen gas. A simplified picture of what occurs in this corrosion cell is shown in Figure 1.

Figure 1.

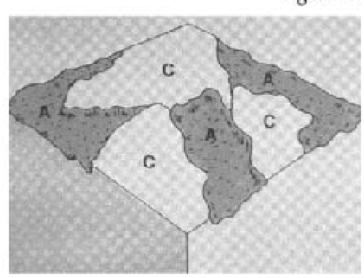


$$Fe^{++} + 2OH^- \longrightarrow FeO + H_2O$$
$$2H^+ + 2e^- \longrightarrow H_2 \text{ gas}$$

Impurities present in the electrolyte create an even better medium for the corrosion process. For example, these impurities can be the constituents of the liquid in which the steel is immersed, or present in atmospheric contaminants, including sulfur oxides, chlorides, or other pollutants present in a damp atmosphere or dissolved in surface moisture.

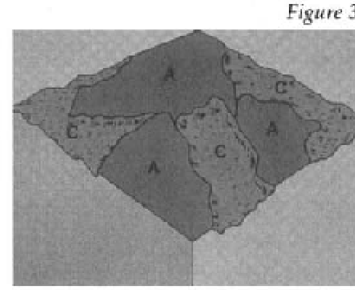
As mentioned before, the anode and cathode areas on a piece of steel are microscopic. Greatly magnified, the surface might appear as the mosaic of anodes and cathodes pictured in Figure 2-- all electrically connected by the underlying steel.

Figure 2.



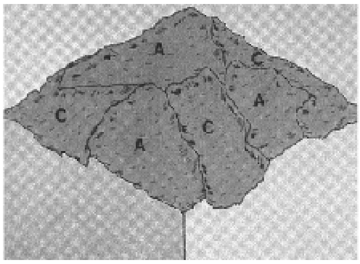
Moisture in the air provides the electrolyte and completes the electrical path between the anodes and cathodes on the metal surface. Due to potential differences, a small electric current begins to flow as the metal is consumed in the anodic area. The iron ions produced at the anode combine with the environment to form the loose, flaky iron oxide known as rust.

Figure 3.



As anode areas corrode, new material of different composition and structure is exposed. This results in a change of electrical potentials and also changes the location of anodic and cathodic sites. The shifting of anodic and cathodic sites does not occur all at once. In

(By permission from the American Galvanizers Association, Aurora, Colorado.)



time, previously uncorroded areas are attacked and a uniform surface corrosion is produced. This processes continues until the steel is entirely consumed.

How Zinc Protects Steel From Corrosion

The reason for the extensive use of hot dip galvanizing is the two-fold nature of the coating. As a barrier coating, it provides a tough, metallurgically bonded zinc coating which completely covers the steel surface and seals the steel from the corrosive action of the environment. Additionally, the sacrificial action of zinc protects the steel even where damage or minor discontinuity occurs in the coating.

Barrier Protection

Because zinc is a reactive metal, it oxidizes in air to form a corrosion resistant film of zinc oxide. This thin, hard, tenacious layer of zinc oxide is the first step in the development of the protective layer normally associated with the galvanized coating. When the zinc oxide layer is exposed to freely moving air in normal atmospheric exposure, the surface reacts with rainfall or dew to form zinc hydroxide. During drying, the zinc hydroxide reacts with carbon dioxide in the atmosphere and is converted into a thin, compact, tightly adherent layer of basic zinc carbonate.

The zinc carbonate layer provides the excellent barrier protection afforded by the galvanized coating. Because it is relatively insoluble, the basic zinc carbonate layer is weather resistant and, once formed, minimizes further corrosion. After a period of time, this whitish-gray film tends to obscure the underlying zinc crystals on the surface of the galvanized coating.

The degree of protection obtained varies with the nature of the environment. The presence of chlorides and sulfur gases in the air modifies the composition of the carbonate layer by increasing its solubility, so it weathers more rapidly. However, the corrosion rate is relatively low and the galvanized coating continues to provide considerable service life.

Cathodic Protection

Table 1 shows the galvanic series of metals and alloys arranged in decreasing order of electrical activity. Metals toward the top of the table, often referred to as more active metals, have a greater tendency to lose electrons than the more noble metals. Thus metals higher in the series provide cathodic or sacrificial protection to those metals below them.

Because zinc is anodic to steel, the galvanized coating will provide cathodic protection to exposed steel. When zinc and steel are connected in the presence of the electrolyte, the zinc is slowly consumed, while the steel is protected. The zinc's sacrificial action offers protection where small areas of steel are exposed, in areas such as cut edges, drill holes, scratches, or as the result of severe surface abrasion. Cathodic protection of the steel from corrosion continues until all the zinc is consumed.

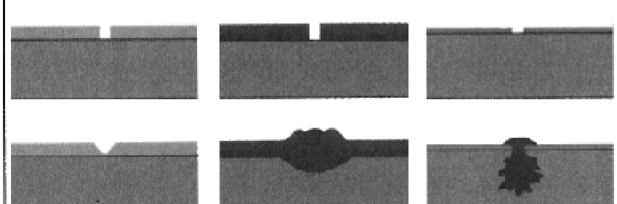
Table 1.

Corroded End Anodic or less noble (ELECTRONEGATIVE)	***Arrangement of Metals in Galvanic Series:***
Magnesium	*Any one of these metals and alloys will theoretically corrode while offering protection to any other which is lower in the series, so long as both are electrically connected.*
Zinc	
Aluminum	*In actual practice, however, zinc is by far the most effective in this respect.*
Cadmium	
Iron or Steel	
Stainless Steels (active)	
Soft Solders	
Lead	
Tin	
Nickel	
Brass	
Bronzes	
Copper	
Nickel-Copper Alloys	
Stainless Steels (passive)	
Silver Solder	
Silver	
Gold	
Platinum	
Protective End Cathodic or most noble (ELECTROPOSITIVE)	

This is what happens at a scratch on galvanized steel. The zinc coating sacrifices itself slowly by galvanic action to protect the base steel. The sacrificial action continues as long as any zinc remains in the immediate area.

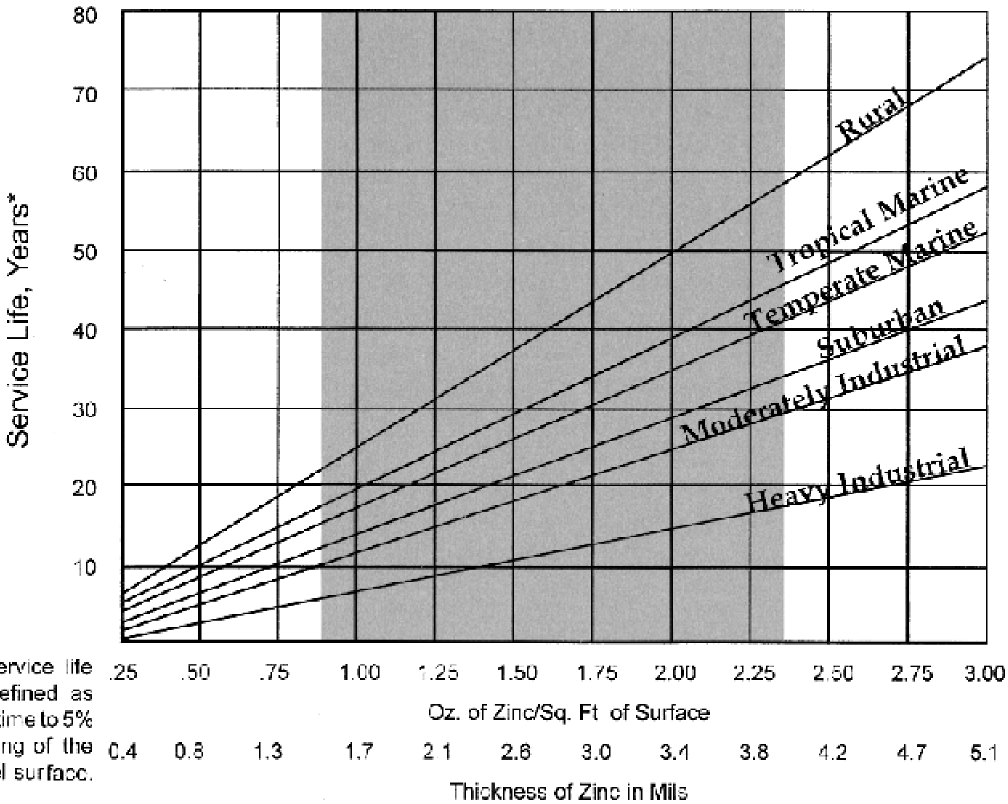
This is what happens at a scratch on painted steel. The exposed steel corrodes and forms a pocket of rust, which lifts the paint film from the metal surface to form a blister. Both the corrosion pit and the blister continue to grow.

This is what happens at a scratch on steel coated with a less active metal, such as copper. The exposed steel corrodes faster than it normally would to protect the more noble metal.



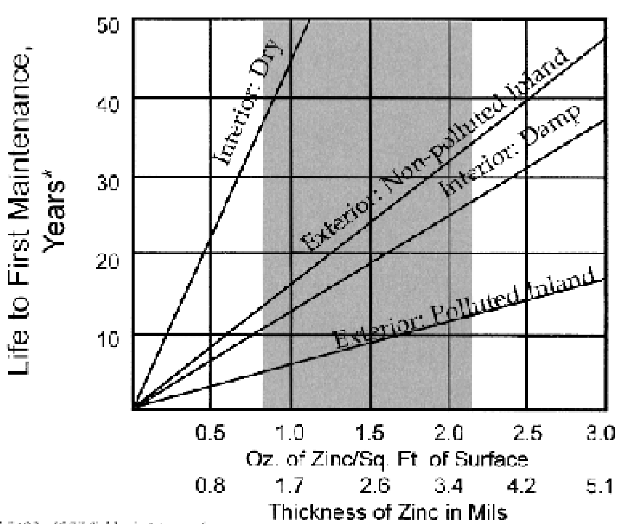
Continued

3.10.1 Hot Dip Galvanizing—Life of Protection vs Thickness of Zinc



* Service life is defined as the time to 5% rusting of the steel surface.

The shaded areas represent the thickness range, which is based on minimum thicknesses for all grades, classes, etc., encompassed by ASTM specifications A123 and A153.



*Life to first maintenance is calculated to allow substantial retention of the galvanized coating for subsequent painting.

Source: British Standard 5493: 1977 Table 3, Figure 1

(By permission from the American Galvanizers Association, Aurora, Colorado.)

3.10.2 Hot Dip Galvanizing—Atmospheric Corrosiveness, Various Cities

Comparative Rankings of 38 Locations Based on Steel and Zinc Losses

			2-Year Exposure Grams Lost *		
Zinc	Steel	Location	Zinc	Steel	Steel:Zinc Loss Ratio
1	1	Norman Wells, N.W.T., Canada	0.07	0.73	10.3
2	2	Phoenix, Ariz.	0.13	2.23	17.0
3	3	Saskatoon, Sask., Canada	0.13	2.77	21.0
4	4	Esquimalt, Vancouver Island, Canada	0.21	6.50	31.0
5	6	Fort Amidor Pier, Panama, C.Z.	0.28	7.10	25.2
6	8	Ottawa, Ontario, Canada	0.49	9.60	19.5
7	22	Miraflores, Panama, C.Z.	0.50	20.9	41.8
8	28	Cape Kennedy, 1/2 mile from Ocean	0.50	42.0	84.0
9	11	State College, Pa.	0.51	11.17	22.0
10	7	Morenci, Mich.	0.53	7.03	18.0
11	15	Middletown, Ohio	0.54	14.00	26.0
12	9	Potter County, Pa.	0.55	10.00	18.3
13	20	Bethlehem, Pa.	0.57	18.3	32.4
14	5	Detroit, Mich.	0.58	7.03	12.2
15	36	Point Reyes, Calif.	0.67	244.0	364.0
16	19	Trail, B.C., Canada	0.70	16.90	24.2
17	14	Durham, N.H.	0.70	13.30	19.0
18	13	Halifax (York Redoubt), N.S.	0.70	12.97	18.5
19	18	South Bend, Pa.	0.78	16.20	20.8
20	27	East Chicago, Ind.	0.79	41.1	52.1
21	29	Brazos River, Texas	0.81	45.4	56.0
22	23	Monroeville, Pa.	0.84	23.8	28.4
23	34	Dayton Beach, Fl.	0.88	144.0	164.0
24	32	Kure Beach, N.C. 800-foot Lot	0.89	71.0	80.0
25	17	Columbus, Ohio	0.95	16.00	16.8
26	12	Montreal, Quebec, Canada	1.05	11.44	10.9
27	16	Pittsburgh, Pa.	1.14	14.90	13.1
28	10	Waterbury, Conn.	1.12	11.00	9.8
29	25	Limon Bay, Panama, C.Z.	1.17	30.3	25.9
30	21	Cleveland, Ohio	1.21	19.0	15.7
31	24	Newark, N.J.	1.63	24.7	15.1
32	33	Cape Kennedy, 60 yds from Ocean, 30-ft Elev.	1.77	80.2	45.5
33	35	Cape Kennedy, 60 yds from Ocean, Ground Level	1.83	215.0	117.0
34	31	Cape Kennedy, 60 yds from Ocean, 60-ft Elev.	1.94	64.0	33.0
35	26	Bayonne, N.J.	2.11	37.7	17.9
36	37	Kure Beach, N.C. 80-ft Lot	2.80	260.0	93.0
37	30	Halifax (Federal Building) N.S.	3.27	55.3	17.0
38	38	Galeta Point Beach, Panama, C.Z.	6.80	336.0	49.4

*Weight loss for 4" x 6" (10cm x 15cm approx.) test specimens.

Source: "Corrosiveness of Various Atmospheric Test Sites as Measured by Specimens of Steel and Zinc, Metal Corrosion in the Atmosphere, ASTM STP 435.

(By permission from the American Galvanizers Association, Aurora, Colorado.)

3.10.3 Hot Dip Galvanizing—Additional Corrosion of Zinc and Galvanized Steel Resulting from Contact with Other Metals

	Environment				
	Atmospheric			Immersed	
Metal in contact	Rural	Industrial/Urban	Marine	Fresh water	Sea water
Aluminum and aluminum alloys	0	0 - 1	0 - 1	1	1 - 2
Aluminum bronzes and silicon bronzes	0 - 1	1	1 - 2	1 - 2	2 - 3
Brasses including high tensile (HT) brass (manganese bronze)	0 - 1	1	0 - 2	1 - 2	2 - 3
Cadmium	0	0	0	0	0
Cast irons	0 - 1	1	1 - 2	1 - 2	2 - 3
Cast iron (austenitic)	0 - 1	1	1 - 2	1 - 2	1 - 3
Chromium	0 - 1	1 - 2	1 - 2	1 - 2	2 - 3
Copper	0 - 1	1 - 2	1 - 2	1 - 2	2 - 3
Cupro-nickels	0 - 1	0 - 1	1 - 2	1 - 2	2 - 3
Gold	(0 - 1)	(1 - 2)	(1 - 2)	(1 - 2)	(2 - 3)
Gunmetals, phosphor and tin bronzes	0 - 1	1	1 - 2	1 - 2	2 - 3
Lead	0	0 - 1	0 - 1	0 - 2	(0 - 2)
Magnesium and magnesium alloys	0	0	0	0	0
Nickel	0 - 1	1	1 - 2	1 - 2	2 - 3
Nickel copper alloys	0 - 1	1	1 - 2	1 - 2	2 - 3
Nickel-chromium-iron alloys	(0 - 1)	(1)	(1 - 2)	(1 - 2)	(1 - 3)
Nickel-chromium-molybdenum alloys	(0 - 1)	(1)	(1 - 2)	(1 - 2)	(1 - 3)
Nickel silvers	0 - 1	1	1 - 2	1 - 2	1 - 3
Platinum	(0 - 1)	(1 - 2)	(1 - 2)	(1 - 2)	(2 - 3)
Rhodium	(0 - 1)	(1 - 2)	(1 - 2)	(1 - 2)	(2 - 3)
Silver	(0 - 1)	(1 - 2)	(1 - 2)	(1 - 2)	(2 - 3)
Solders hard	0 - 1	1	1 - 2	1 - 2	2 - 3
Solders soft	0	0	0	0	0
Stainless steel (austenitic and other grades containing approximately 18% chromium)	0 - 1	0 - 1	0 - 1	0 - 2	1 - 2
Stainless steel (martensitic grades containing approximately13% chromium)	0 - 1	0 - 1	0 - 1	0 - 2	1 - 2
Steels (carbon and low alloy)	0 - 1	1	1 - 2	1 - 2	1 - 2
Tin	0	0 - 1	1	1	1 - 2
Titanium and titanium alloys	(0 - 1)	(1)	(1 - 2)	(0 - 2)	(1 - 3)

Key: 0 Zinc and galvanized steel will suffer either no additional corrosion, or at the most only very slight additional corrosion, usually tolerable in service.

1 Zinc and galvanized steel will suffer slight or moderate additional corrosion which may be tolerable in some circumstances.

2 Zinc and galvanized steel may suffer fairly severe additional corrosion and protective measures will usually be necessary.

3 Zinc and galvanized steel may suffer severe additional corrosion and the contact should be avoided.

General notes: Ratings in parenthesis are based on very limited evidence and are less certain than other values shown. The table is in terms of additional corrosion and the symbol 0 should not be taken to imply that the metals in contact need no protection under all conditions of exposure.
Source: British Standards Institution pp. 6484:1979 Table 23.

(By permission from the American Galvanizers Association, Aurora, Colorado.)

3.11.0 Principal Producers of Structural Shapes

A. Ameristeel	J. J&L Structural Inc.	R. Roanoke Steel	U. Nucor Steel**
C. Chaparral Steel	M. SMI Steel Inc.	S. North Star Steel	W. Northwestern Steel & Wire
G. British Steel	N. Nucor-Yamato Steel	T. TradeARBED	Y. Bayou Steel Corp.

Section Weight Per Ft	Nominal b.	Producer Code
W14 x 82, 74, 61, 68	10	C,N
W14 x 43, 48, 53	8	C,N
W14 x 38	6.75	C,G,N,T,W
30, 34	6.75	C,G,N,T,W
W14 x 22, 26	5	C,G,N,T,W,U
W12 x 252, 279, 305, 336 210, 230, 170, 190	12	G,N
65, 72, 79, 87, 96, 106, 120, 136, 152	12	G,N,T
W12 x 53, 58	10	C,N
W12 x 50, 40, 45	8	C,N,W
W12 x 26, 30, 35	6.5	C,G,N,T,W,U
W12 x 16, 19, 22	4	C,G,N,T,U,W
14	4	C,T,W,U
W10 x 100, 112	10	G,N,T
49, 54	10	C,N,T,W
60, 68	10	G,N,T
77, 88	10	C,G,N,T
W10 x 33, 39, 45	8	C,N,W
W10 x 22, 26, 30	5.75	C,G,N,T,U,W
W10 x 15, 17, 19	4	C,G,U,T,W
12	4	C,T,U,W
W8 x 31, 35, 40, 48, 58, 67	8	C,G,N,T,W
W8 x 24, 28	6.5	C,N,T,W,U
W8 x 18, 21	5.25	C, G, N, U, T, W, Y
W8 x 15	4	C,U,T,W
10, 13	4	C,M,U, T,W
W6 x 15, 20, 25	6	C,G,N,T,U,W
W6 x 16	4	C,R,T,U,W,Y
12	4	C,M,R,T,U,W,Y
9	4	C, J, M, R,T,U, W, Y
8.5*	4	C,J,M,U,Y
W5 x 16, 19	5	T,U
W4 x 13	4	C,M,R,U,Y,J

Section Weight Per Ft	Producer Code
M12.5 x 11.6, 12.4	C
M12 x 10.8, 11.8	C,J
M12 x 10.0*	J
M10 x 8, 9	C,J,U
M10 x 7.5*	J
M8 x 6.5	C,J,U
M8 x 6.2*	J
M6 x 3.7*, 4.4*	J
M5 x 18.9	B
M4 x 6*	C,U
S18 x 54.7, 70	W
S15 x 42.9, 50	W
S12 x 40.8, 50	W
S12 x 35	W
S12 x 31.8	C,W
S10 x 35	C,S
S10 x 25.4	C,S
S8 x 18.4, 23	C,S
S6 x 17.25	C,R,S
S6 x 12.5	C,R,S,Y
S5 x 10	C,R,Y
S4 x 9.5	C,J,M
S4 x 7.7	C,J,M,R,Y
S3 x 7.5, 5.7	C,J,M,R,Y
HP14 x 73, 89, 102, 117	G,N
HP12 x 53, 63, 74, 84	G,N
HP10 x 42, 57	C,G,N,W
HP8 x 36	C,G,N,W
C15 x 33.9, 40, 50	N,T,W
C12 x 30	N,S,T,W
C12 x 20.7, 25	C,N,S,T,W
C10 x 25, 30	S,T,U,W
C10 x 15.3, 20	C,S,T,U,W
C9 x 20	B
C9 x 13.4, 15	S
C8 x 18.75	M,S,T,U,W,Y
C8 x 11.5	C,J,M,S,T,U,W,Y
C8 x 13.75	C,M,S,T,U,W,Y
C7 x 14.75	S
C7 x 12.25	M,S,U,W
C7 x 9.8	M,S,U,W
C6 x 13	M,R,S,U,W,Y
C6 x 10.5	A,C,M,R,S,U,W,Y
C6 x 8.2	A,C,J,M,R,S,U,W,Y
C5 x 9	A,C,M,U,W,Y
C5 x 6.7	C,A,M,U,W,Y
C4 x 5.4	C,A,M,R,U,W,Y

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.

* Shapes not currently listed in *Manual of Steel Construction*

** Includes Nucor-Berkeley

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A. Ameristeel	J. J&L Structural Inc.	R. Roanoke Steel	U. Nucor Steel**
C. Chaparral Steel	M. SMI Steel Inc.	S. North Star Steel	W. Northwestern Steel & Wire
G. British Steel	N. Nucor-Yamato Steel	T. TradeARBED	Y. Bayou Steel Corp.

Section Weight Per Ft	Nominal b_f	Producer Code
W44 x 230, 262, 290, 335	16	T
W40 x 593, 503, 431	16	T
397*	16	N,T
372*	16	N
362*	16	N,T
324*, 297, 277, 249, 215, 199	16	N,T
W40 x 392	12	T
294*, 327*	12	N
278, 331	12	T,G
264, 235, 211, 183 149, 167	12	G,N,T
W36 x 439, 527, 650, 798	16.5	T
393	16.5	N,T
230, 245, 260, 280, 300, 328, 359	16.5	G,N,T
W36 x 232, 256	12	G,N
135, 150, 160, 170, 182, 194, 210	12	G,N,T
W33 x 387*	15.75	N
201, 221, 241, 263, 291, 318, 354	15.75	N
W33 x 118, 130, 141, 152, 169	11.5	G,N,T
W30 x 357*, 391	15	N
173, 191, 211, 235	15	G,N
261, 292, 326	15	G,N
W30 x 99, 108, 116, 124, 132, 148	10.5	G,N,T
90	10.5	N
W27 x 539	14	G
368	14	C,N
336*	14	N
307	14	G,N
281*	14	N
258, 235, 146, 161, 178, 194, 217	14	G,N
W27 x 132*	10	G
84, 94, 102, 114, 129	10	G,N,T

Section Weight Per Ft	Nominal b_f	Producer Code
W24 x 335, 370*	12.75	T
306*	12.75	N,T
279	12.75	G,N,T
250	12.75	G,N
229	12.75	G,N,T
207	12.75	N
176, 192	12.75	G,N,T
104, 117, 131, 146, 162	12.75	G,N,T
W24 x 103	9	N
84, 94	9	C,G,N,T
68, 76	9	C,G,N,T
W24 x 55, 62	7	C,G,N,T
W21 x 182, 201	12.25	G
101, 111, 122, 132, 147, 166	12.25	G,N
W21 x 83, 93, 62, 68, 73	8.25	C,G,N,T
48*, 55*	8.25	N
W21 x 44, 50, 57	6.5	C,G,N
W18 x 130, 143, 158, 175, 192, 211 234, 258, 283, 311	11	N
W18 x 76, 86, 97, 106, 119	11	N, T
W18 x 65, 71.50, 55, 60	7.5	C,G,N,T,W
W18 x 35, 40, 46	6	C,G,N,T,W
W16 x 67, 77, 89, 100	10.25	N,G
W16 x 36, 40, 45, 50, 57	7	C,G,N,T,W
W16 x 26, 31	5.5	C,G,N,T,W
W14 x 455, 500, 550, 605, 665, 730	16	G,T
W14 x 426, 398, 370, 311, 342 145, 159, 176, 193, 211 ,233, 257, 283	16	G,N,T
W14 x 90, 99, 109, 120, 132	14.5	G,N,T

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.

* Shapes not currently listed in *Manual of Steel Construction*

** Includes Nucor Berkeley

Continued

3.11.1 Principal Producers of "C" Channels

A. Ameristeel	J. J&L Structural Inc.	R. Roanoke Steel	U. Nucor Steel
C. Chaparral Steel	M. SMI Steel Inc.	S. North Star Steel	W. Northwestern Steel & Wire
G. British Steel	N. Nucor-Yamato Steel	T. TradeARBED	Y. Bayou Steel Corp.

Section Weight Per Ft	Producer Code
C12 x 20.7, 25	C, N, S, T, W
C10 x 25, 30	S, U, W
C10 x 15.3, 20	C, S, U, W
C9 x 20	B
C9 x 13.4, 15	S
C8 x 18.75	M, S, U, W, Y
C8 x 11.5, 13.75	C, M, S, U, W, Y
C7 x 14.75	S
C7 x 12.25	M, S, U, W
C7 x 9.8	M, S, U, W
C6 x 13	M, S, U, W, Y
C6 x 10.5	C, M, S, U, W, Y
C6 x 8.2	C, A, M, S, U, W, Y,
C5 x 9	C, M, U, W, Y
C5 x 6.7	C, A, M, U, W, Y
C4 x 5.4	C, A, M, R, U, W, Y
C4 x 7.25	C, M, U, W, Y
C4 x 4.5*	A, M, U, Y
C3 x 6	M, U, W, Y
C3 x 4.1, 5	C, A, M, R, U, W, Y
C3 x 3.5*	A, M, R, U, Y
MC18 x 42.7, 45.8, 51.9, 58	N
MC13 x 31.8, 35, 40, 50	N
MC12 x 31, 35, 40, 45, 50	N
MC12 x 10.6	J, S
MC10 x 28.5, 33.6, 41.1	N
MC10 x 22, 25	N
MC10 x 8.4	J, S
MC10 x 6.5*	J
MC9 x 23.9, 25.4	S
MC8 x 21.4, 22.8	S
MC8 x 18.7, 20	S
MC8 x 8.5	J, M
MC8 x 6.6*	J
MC7 x 19.1, 22.7	N, S
MC6 x 18	B
MC6 x 16.3	B,S
MC6 x 15.3*	S
MC6 x 15.1	S
MC6 x 12	S
MC6 x 6.5*, 7.0*	J
MC4 x 13.8*	S

Section by Leg Lengths & Thickness		Producer Code
MC 3 x 7.1*		S
L8 x 8 x	1 1/8	N, S, T
	1	N, S, T
	7/8	N, T
	3/4	N, S, T
	5/8	N, S
	9/16	N
	1/2	N, S
L6 x 6 x	1	S, U, Y
	7/8	U, Y
	3/4	M, U, Y
	5/8	M, U, Y
	9/16	M, U, Y
	1/2	M, S, U, Y
	7/16	M, U, Y
	3/8	M, S, U, Y
	5/16	M, U, Y
	1/4*	U, Y
L5 x 5 x	7/8	U, Y
	3/4	M, U, Y
	5/8	M, U, Y
	1/2	M, U, W, Y
	7/16	M, U, Y
	3/8	M, U, W, Y
	5/16	M, U, W, Y
	1/4*	U, Y
L4 x 4 x	3/4	M, U, Y
	5/8	M, U, Y
	1/2	A, M, R, U, W, Y
	7/16	A, M, R, U, Y
	3/8	A, M, R, U, W, Y
	5/16	A, M, R, U, W, Y
	1/4	A, M, R, U, W, Y
L3 1/2 x 3 1/2 x	1/2	A, M, U, W, Y
	7/16	U, Y
	3/8	A, M, R, U, W, Y
	5/16	A, M, R, U, W, Y
	1/4	A, M, R, U, W, Y
L3 x 3 x	1/2	A, M, U, W, Y
	7/16	U, Y
	3/8	A, M, R, S, U, W, Y
	5/16	A, M, R, S, U, W, Y

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.
* Shapes not currently listed in *Manual of Steel Construction*

Left column: Principal producers of "C" channels. Right column: Principal producers of structural angles. *(By permission from the American Institute of Steel Construction, Inc., Reprinted with permission. All rights reserved.)*

3.11.2 Principal Producers of Structural Angles

A. Ameristeel	J. J&L Structural Inc.	R. Roanoke Steel	U. Nucor Steel
C. Chaparral Steel**	M. SMI Steel Inc.	S. North Star Steel	W. Northwestern Steel & Wire
G. British Steel	N. Nucor-Yamato Steel	T. TradeARBED	Y. Bayou Steel Corp.

Section by Leg Lengths & Thickness		Producer Code
	1/4	A, M, R, S, U, W, Y
	3/16	A, M, R, S, U, W, Y
L2 1/2 x 2 1/2 x	1/2	A, R, U, Y
	3/8	A, R, S, U, Y
	5/16	A, R, S, U, Y
	1/4	A, R, S, U, Y
	3/16	A, R, S, U, Y
L2 x 2 x	3/8	A, R, S, U, Y
	5/16	A, R, S, U, Y
	1/4	A, R, S, U, Y
	3/16	A, R, S, U, Y
	1/8	A, R, S, U, Y
L8 x 6 x	1	S
	3/4	S
	1/2	S
	7/16	B
L8 x 4 x	1	S
	3/4	S
	1/2	S
L7 x 4 x	3/4	S, U, Y
	5/8	U, Y
	1/2	S, U, Y
	7/16	U, Y
	3/8	S, U, Y
L6 x 4 x	7/8	U, Y
	3/4	M, S, U, W, Y
	5/8	M, U, W, Y
	9/16	M, U, W, Y
	1/2	M, S, U, W, Y
	7/16	U, W, Y
	3/8	M, S, U, W, Y
	5/16	M, S, U, W, Y
L6 x 3 1/2 x	1/2	M, U, W, Y
	3/8	M, U, W, Y
	5/16	M, U, W, Y
L5 x 3 1/2 x	3/4	M, U, Y
	5/8	M, U, Y
	1/2	A, M, U, W, Y
	3/8	A, M, U, W, Y
	5/16	A, M, U, W, Y
	1/4	A, M, U, W, Y
L5 x 3 x	1/2	A, M, U, W, Y
	7/16	U, W, Y
	3/8	A, M, U, W, Y
	5/16	A, M, U, W, Y
	1/4	A, M, U, W, Y
L4 x 3 1/2 x	1/2	A, M, U, W, Y
	3/8	A, M, U, W, Y
	5/16	A, M, R, U, W, Y
	1/4	A, M, R, U, W, Y
L4 x 3 x	5/8	U, Y
	1/2	A, M, U, W, Y
	7/16	U, W, Y
	3/8	A, M, R, U, W, Y
	5/16	A, M, R, U, W, Y
	1/4	A, M, R, U, W, Y
L3 1/2 x 3 x	1/2	U, W
	3/8	M, U, W
	5/16	M, U, W
	1/4	M, U, W
L3 1/2 x 2 1/2 x	1/2	U
	3/8	M, U, W
	5/16*	M, U, W
	1/4	M, U, W
L3 x 2 1/2 x	1/2	U
	3/8	M, U, W
	5/16	M, U, W, Y
	1/4	M, R, U, W
	3/16	U
L3 x 2 x	1/2	A, U
	3/8	A, U
	5/16	A, U
	1/4	A, R, U
	3/16	A, R, U
L2 1/2 x 2 x	3/8	R, S, U
	5/16	S, U
	1/4	R, S, U
	3/16	R, S, U

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.
* Shapes not currently listed in *Manual of Steel Construction*
**Will begin rolling in September 1999

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3.11.3 Principal Producers of Structural Tubing

A. Acme Roll Forming Co.	H. Hanna Steel Corp.	N. Hannibal Industries, Inc.	U. Leavitt Tube Company, Inc.
B. Bull Moose Tube Co.	I. Independence Tube Corp.	O. Northwest Pipe Co.	V. Valmont Industries
C. Copperweld Corp.	J. Vest Inc.	P. IPSCO Inc.	W. Welded Tube Co. of America
D. Dallas Tube & Rollform	K. Maverick Tube	R. Copperweld Canada	X. EXLTUBE
E. Eugene Welding Co.	L. Laclede Steel Co.	T. Atlas Tube, Inc.	Y. James Steel & Tube Co.
G. British Steel**	M. Maruichi American Corp.		Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
7x5x3/8, 5/16, 1/4, 3/16	B,C,D,H,I,J,K,P,R,S,T,U,W,X,Z
7x5x1/2	B,C,I,P,R,S,T,Z
7x4x1/2	B,P,R,U,Z
7x4x3/8, 5/16, 1/4, 3/16	B,C,D,H,I,K,P,R,S,U,W,Z
7x4x1/8	B,C,I,P,R,S,Z
7x3x1/2	I
7x3x3/8, 5/16	B,C,D,H,I,P,R,S,W,Z
7x3x1/4, 3/16	B,C,D,H,I,P,R,S,W,X,Z
7x3x1/8	B,C,D,H,I,P,R,S,Z
7x2x1/4, 1/8	B,P
7x2x3/16	P
6x5x3/8, 5/16, 1/4, 3/16, 1/8	B,I
6x5x1/8, 3/16, 1/4, 5/16, 1/2	P,W
6x4x1/2	B,C,I,J,K,M,P,S,T,U,W,X,Z
6x4x3/8, 5/16	B,C,D,H,I,J,K,M,P,R,
	S,T,U,W,X,Z
6x4x1/4, 3/16	B,C,D,H,I,J,K,M,P,R,S,T,
	U,W,X,Y,Z
6x4x1/8	B,C,D,I,J,P,R,S,T,V,X,Y,Z
6x3x1/2	C,P,R,S,U
6x3x3/8, 5/16	B,C,D,H,I,J,K,M,P,R,S,T,U,W,Z
6x3x1/4, 3/16	B,C,D,H,I,J,K,M,P,R,S,T,U,
	W,X,Y,Z
6x3x1/8	B,C,D,H,I,J,K,M,P,R,S,T,X,Y,Z
6x2x3/8	H,I,K,P,R,S,T,W,X,Z
6x2x5/16	B,H,I,J,K,P,R,S,T,W,X,Z
6x2x1/4, 3/16	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,
	W,X,Y,Z
6x2x1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,
	U,W,X,Y,Z
5x4x1/2	B,P,R,T
5x4x3/8, 5/16	B,C,I,J,M,P,R,T,W,Z
5x4x1/4, 3/16	B,C,D,I,J,K,M,P,R,T,W,Y,Z
5x4x1/8	B,D,I,J,M
5x3x1/2	C,I,M,P,R,S,U,X
5x3x5/16	B,C,D,H,I,J,K,M,P,R,S,T,U,W,X,Z,
5x3x3/8	C,D,H,I,J,K,M,P,R,S,T,U,W,X,Z
5x3x1/4, 3/16	B,C,D,E,H,I,J,K,M,N,P,R,S,T,
	U,W,X,Z
5x3x1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,
	W,X,Y,Z
5x2 1/2x1/4, 3/16	B,D,E,K,R,S,Y,Z
5x2x3/8	C,I,P,R,T
5x2x5/16	C,I,J,P,R,S,T,W,Z
5x2x1/4, 3/16, 1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,
	W,X,Z

Nominal Size and Thickness	Producer Code
4x3x3/8	B,D,I,J,P,R,S,T
4x3x5/16	B,D,I,J,P,R,S,T,U,W,Z
4x3x1/4, 3/16	B,C,D,E,H,I,J,K,M,N,P,R
	S,T,U,W,X,Y,Z
4x3x1/8	B,C,D,E,H,I,J,K,M,N,P,S,R
	T,U,W,X,Y,Z
4x2 1/2x5/16	Y,Z
4x2 1/2x1/4	B,D,E,R,S,Y,Z
4x2 1/2x3/16	D,E,R,S,Y,Z
4x2x3/8	C,H,I,P,R,S,T,Y
4x2x5/16	C,H,I,J,P,R,S,T,U,W,Z
4x2x1/4	B,C,D,E,H,I,J,K,M,N,P,R,S,
	T,U,W,X,Y,Z
4x2x3/16	A,B,C,D,E,I,J,K,M,N,P,S,R
	S,T,U,W,X,Y,Z
4x2x1/8	A,B,C,D,E,H,I,J,K,M,N,P,R,S,T,
	U,W,X,Y,Z
3 1/2x2 1/2x3/8	B,I,R,S,T,U,Z
3 1/2x2 1/2x5/16	I,R,Z
3 1/2x2 1/2x1/4	B,D,I,N,R,S,T,U,Y,Z
3 1/2x2x3/8, 3/16, 1/4	B,D,P
3 1/2x2x5/32, 1/8	D,P
3x2 1/2x1/4	B,R,S,U,Y,Z
3x2x5/16	I,R,S,
3x2x1/4	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,
	W,X,Y,Z,
3x2x3/16	A,B,C,D,E,I,J,K,M,N,P,R,S,
	T,U,W,X,Y,Z
3x2x1/8	A,B,C,D,E,H,I,J,K,M,N,P,R,S,
	T,U,W,X,Y,Z
3x1 1/2x3/16, 1/8	C,E,I,N,U,R,W,Y,Z
3x1 1/2x1/4	B,I,R,T,U,Y
2 1/2x1 1/2x1/4	B,C,I,R,S,T,U,Y
2 1/2x1 1/2x3/16	A,B,C,E,H,I,R,S,T,U,Y,Z
2x1 1/2x3/16	B,E,R,Y,Z
2 1/2x1 1/2x1/8	B,E,I,R,U
2 1/4x2x3/16, 1/8	D,E,I,Z
2x2 1/2x1/8	D,E
2x1x3/16	R,T,Y,Z

Notes: *Size is manufactured by Submerged Arc Welding (SAW) process and are not stocked by steel service centers (contact producer for specific requirements). All other sizes are manufactured by Electric Resistance Welding and most are available from steel service centers.
**British Steel also produces a full range of metric

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A. Acme Roll Forming Co.	H. Hanna Steel Corp.	N. Hannibal Industries, Inc.	U. Leavitt Tube Company, Inc.
B. Bull Moose Tube Co.	I. Independence Tube Corp.	O. Northwest Pipe Co.	V. Valmont Industries
C. Copperweld Corp.	J. Vest Inc.	P. IPSCO Inc.	W. Welded Tube Co. of America
D. Dallas Tube & Rollform	K. Maverick Tube	R. Copperweld Canada	X. EXLTUBE
E. Eugene Welding Co.	M. Maruichi American Corp.	S. Atlas Tube Inc.	Y. James Steel & Tube Co.
G. British Steel**			Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
30x24x5/8, 1/2, 3/8	V*
28x24x5/8, 1/2, 3/8	V*
26x24x5/8, 1/2, 3/8	V*
24x22x5/8, 1/2, 3/8	V*
22x20x5/8, 1/2, 3/8	V*
20x18x5/8, 1/2, 3/8	V*
20x12x1/2, 3/8	G,V*,W
20x12x5/16	G,W
20x12x5/8	G,W
20x8x1/2, 3/8, 5/16	W
20x8x5/8	G
20x4x1/2, 3/8, 5/16	Z
18x12x1/2, 3/8	V*
18x6x5/8	B, G
18x6x1/2, 3/8, 5/16	B,G,W
18x6x1/4	B,G
16x12x1/2, 3/8, 5/16	G,V*,W
16x12x5/8	G,V*,W
16x8x1/2, 3/8, 5/16	B,G,W
16x8x5/8	B, G
16x4x1/2, 3/8, 5/16	B,G,W
16x4x5/8	G
14x12x1/2, 3/8	V*
14x10x1/2, 3/8	B,G,R,S,T,W
14x10x5/8	B,G,R
14x10x5/16	B,R,T,W
14x6x5/8	B,G,R
14x6x1/2, 3/8, 5/16, 1/4	B,G,J,R,W
14x4x5/8	B,S
14x4x1/2, 3/8, 5/16, 1/4	B,S,W
14x4x3/16	B,S
12x10x1/2, 3/8, 1/4	B,S
12x8x5/8	B,C,G,I,R,S,W
12x8x1/2, 3/8, 5/16, 1/4	B,C,G,H,I,J,R,S,T,U,W
12x8x3/16	B,C,G,H,I,R,S
12x6x5/8	B,I,S,W
12x6x1/2, 3/8, 5/16, 1/4	B,C,H,I,J,R,S,U,W,X
12x6x3/16	B,C,H,I,J,R,S,W
12x4x5/8	C,G,S
12x4x1/2, 3/8, 5/16, 1/4, 3/16	B,C,G,H,I,J,K,S,U,W,X,Z
12x3-1/2x3/8, 5/16	B,Z
12x3x5/16, 1/4, 3/16	B,C,K,Z
12x2x1/4, 3/16	B,I,K,S,U,Z
10x8x1/2, 3/8, 5/16, 1/4, 3/16	B,C,H,I,R,S,U,X,W

Nominal Size and Thickness	Producer Code
10x8x5/8	I
10x6x5/8	B,G,I
10x6x1/2	B,C,G,H,I,J,K,M,P,R,S,T,U,W,X,Z
10x6x3/8, 5/16, 1/4	B,C,D,G,H,I,J,K,M,P,R,S, T,U,W,X,Z
10x6x3/16	B,C,D,H,I,J,K,M,P,R,S,U,W,Z
10x5x3/8, 5/16, 1/4, 3/16	B,C,D,S
10x4x5/8	G
10x4x1/2	B,C,G,I,J,K,M,P,S,T,U,W,X,Z
10x4x3/8, 5/16, 1/4, 3/16	B,C,D,G,I,J,K,M,P,S,T,U,W,X,Z
10x3-1/2x3/16	B,M,T,Z
10x3-1/2x5/16, 1/4, 3/16	B,T
10x3-1/2x3/8, 1/2	T
10x3x3/8, 5/16, 1/4	B,D,K,T
10x3x3/16	B,D,K,T,Z
10x3x1/2	B,T
10x2x3/8	T,W,Z
10x2x5/16	D,I,P,S,T,U,W,Z
10x2x1/4, 3/16	B,D,I,J,K,P,S,T,U,W,X,Z
10x2x1/2	B,T
9x7x1/2, 3/8, 5/16, 1/4, 3/16	B,C,I,J,P,R,W,Z
9x7x5/8	I,R
9x5x1/2, 3/8, 5/16, 1/4, 3/16	B,C,I,P,R,W,Z
9x5x5/8	I
9x3x1/2	C,I,P
9x3x3/8, 5/16	B,C,I,Z
9x3x1/4, 3/16	B,C,I,P,Z
8x6x5/8	B,G,I,R
8x6x1/2	B,C,G,H,I,J,K,P,R,S,T,U,W,X,Z
8x6x3/8, 5/16, 1/4, 3/16	B,C,D,G,H,I,J,K,M,P,R,S,T,U,W, X,Z
8x4x5/8	B,G,I,S
8x4x1/2	B,C,G,H,I,J,K,M,P,R,S,T,U,W,X,Z
8x4x3/8, 5/16	B,C,D,G,H,I,J,K,M,P,R,S,T,U,W, X,Z
8x4x1/4, 3/16	B,C,D,G,H,I,J,K,M,P,R,S,T,U,W, X,Z
8x4x1/8	B,C,D,G,I,J,P,R,S,T,Z
8x3x1/2	C,P,U
8x3x3/8, 5/16	C,D,H,I,J,P,R,T,U,W,Z
8x3x1/4, 3/16	B,C,D,H,I,J,P,R,S,T,U,W,Z
8x3x1/8	B,C,D,I,J,P,R,S,T,Z
8x2x3/8	H,I,K,R,S,T,U,W,Z
8x2x5/16	B,H,I,J,K,P,R,S,T,U,W,Z
8x2x1/4, 3/16	B,C,D,H,I,J,K,P,R,S,T,U,W,Z
8x2x1/8	B,C,D,I,J,P,R,S,T,Z
7x5x1/2	B,C,I,J,P,R,S,T,U,W,X,Z

Notes: *Size is manufactured by Submerged Arc Welding (SAW) process and are not stocked by steel service centers (contact producer for specific requirements). All other sizes are manufactured by Electric Resistance Welding and most are available from steel service centers.
**British Steel also produces a full range of metric
Some manufactures produce a .120 size instead of a 1/8 please check with individual manufacturers

Continued

3.11.4 Principal Producers of Steel Pipe (this page) and Round HSS (following page)

A. Acme Roll Forming Co.	H. Hanna Steel Corp.	N. Hannibal Industries, Inc.	U. Leavitt Tube Company, Inc.
B. Bull Moose Tube Co.	I. Independence Tube Corp.	O. Northwest Pipe Co.	V. Valmont Industries
C. Copperweld Corp.	J. Vest Inc.	P. IPSCO Inc.	W. Welded Tube Co. of America
D. Dallas Tube & Rollform	K. Maverick Tube	R. Copperweld Canada	X. EXLTUBE
E. Eugene Welding Co.	L. Laclede Steel Co.	T. Atlas Tube, Inc.	Y. Jones Steel & Tube Co.
G. British Steel**	M. Maruichi American Corp.		Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
20x.500, .375	G,W
20x.250	G
18x.500, .375	G,W
18x.250	G
16x.500	G,W,X
16x.375	G,W,X
16x.250	G,O,P,X
16x.188	O,P,X
14x.500	G,P,W,X
14x.438	G,P,X
14x.375	G,P,W,X
14x.250, .188	G,O,P,X
12.75x.500	G,P,W,X
12.75x.406	P,X,G
12.75x.375	P,W,X,G
12.75x.250	G,O,P,W,X
12.75x.188, .125	O,P,X
12.25x.625, .500, .375, .312, .250, .188	C
11.25x.625, .500, .375, .312, .250, .188	C
10.75x.500, .365	G,P,W,Z
10.75x.250	G,O,P,W,Z
10x.625	C
10x.500, .375, .312	C,Z
10x.250, .188	C,O,Z
10x.125	O,V
9.625x.500, .375, .312, .250, .188	P,U,W,Z
8.75x.500, .375, .312, .250, .188	C,Z
8.625x.500	C,P,T,U,Z
8.625x.375	C,K,P,T,U,Z
8.625x.322	C,K,P,T,U,W,Z
8.625x.250, .188	C,K,O,P,T,U,W,Z
8.625x.125	O,P,T
7.5x.500, .375, .312, .250, .188	C,S,Z
7x.500	C,P,U,Z
7x.375, .312, .250	C,H,K,P,S,U,Z
7x.188	C,H,O,P,S,U,Z
7x.125	C,O,P,Z
6.875x.500, .375, .312, .250, .188	C
6.625x.500, .432	K,P,T,U,Z
6.625x.375, .312	H,K,P,S,T,U,Z
6.625x.280	H,K,P,S,T,U,W,X,Z
6.625x.250, .188	H,K,M,O,P,S,T,U,W,
	X,Z
6.625x.125	O,P,T,Z
6.125x.500, .375, .312, .250, .188	C
6x.500	Z
6x.375, .312	H,S,Z
6x.280	H,S,Z
6x.250	H,S,Z
6x.188	H,O,S,Z
6x.125	B,O,Z
5.563x.500	T
5.563x.375	P,T,X
5.563x.258	K,M,P,T,W,X,Z
5.563x.188	K,M,P,S,T,X,Z

Nominal Size and Thickness	Producer Code
5.563x.134	P,S,T,X,Z
5.5x.500	U,Z
5.5x.375, .258	K,P,U,Z
5x.500, .375, .312	C,P,S,T,X,Z
5x.258	C,P,S,T,U,X,Z
5x.250, .188	C,H,M,N,O,P,S,T,U,Y,
	X,Z
5x.125	C,H,O,P,S,T,N,U,Y,
	X,Z
4.5x.337	K,L,P,T,Z
4.5x.237	C,H,K,L,M,P,S,T,U,
	W,X,Z
4.5x.188	C,H,K,M,O,P,S,T,
	U,X,Z
4.5x.125	B,C,H,L,O,P,S,T,U,Z
4x.337	H,S
4x.318	L,S
4x.313	S,Z
4x.250, .188	C,H,O,N,S,U,Y,X,Z
4x.237	C,H,S,U,X,Y,Z
4x.226	L,U,X,S,Z,M,W,Z
4x.125	B,C,H,O,S,U,X,Y,Z,N
4x.120	B,M
3.5x.313	Z
3.5x.250, .203, .188	H,K,P,S,U,Y,X,Z
3.5x.125	B,H,K,P,S,U,Y,X,Z
3.5x.216	H,K,L,P,S,
	M,U,W,X,Y,Z
3.5x.300	H,K,L,P,U,X,Z
3.5x120	M
3x.250, .203, .188	H,N,S,X,Z
3x.152	B,H,N,S,X,Z
3x.300	X,Z
3x.216	B,S,U,X,Y,Z
3x.120, .134	B,S,N,U,X,Y,Z
2.875x.276	L,P,T
2.875x.250	P,T,U,X,Z
2.875x.203	H,K,L,P,T,M,U,W,X,Z
2.875x.188	P,T,U,X,Y,Z
2.875x.125	B,P,T,U,X,Y,Z
2.875x.120	B,M,P
2.5x.120	P
2.5x.250	P,S,T,Z
2.5x.188	B,N,P,S,T,Z
2.5x.125	B,N,P,S,T,Z,N
2.375x.250	H,L,P,X,Y,Z,N
2.375x.218	H,K,P,X,Y,Z,N
2.375x.188	B,H,P,X,Y,Z,N
2.375x.154	B,H,K,L,P,N
	U,W,X,Y,Z,M
2.375x.125	B,H,P,S,U,X,Y,Z,N
2.375x.109	M
1.900x.145	H,L,S,T,U,W,X,Z,M,N
1.660x.140	B,H,L,S,U,W,X,Z,M
1.660x.109	M

Notes: *Size is manufactured by Submerged Arc Welding (SAW) process and are not stocked by steel service centers (contact producer for specific requirements). All other sizes are manufactured by Electric Resistance Welding and most are available from steel service centers.
**British Steel also produces a full range of metric.

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A. Acme Roll Forming Co.
B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
G. British Steel
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
K. Maverick Tube
L. [illegible] Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
O. Northwest Pipe Co.
P. IPSCO Inc.
R. Copperweld Canada
T. Atlas Tube, Inc.
U. Leavitt Tube Company, Inc.
V. Valmont Industries
W. Welded Tube Co. of America
X. EXLTUBE
Y. James Steel & Tube Co.
Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
2½x1½x⅛	E, I, R, U
2x2½x⅛	E
2x1x⅛	R, T, Y, Z
20x.500, .375	G, P*, W
20x.250	G, P*
18x.500, .375	G, P*, W
18x.250	G, P*
16x.500	G, P*, W, X
16x.375	G, P*, W, X
16x.250	C, O, P, X
16x.188	O, P, X
14x.500	G, P, W, X
14x.438	G, P, X
14x.375	G, P, W, X
14x.250, .188	G, O, P, X
12.75x.500	G, P, W, X
12.75x.406	G, P, X
12.75x.375	G, P, W, X
12.75x.250	G, W, O, X
12.75x.188, .125	O, P, X
12.25x.625, .500, .375, .312, .250, .188	C
11.25x.625, .500, .375, .312, .250, .188	C
10.75x.500, .365	G, P, W, Z
10.75x.250	G,O,P,W, Z
10x.625	C
10x.500, .375, .312	C, Z
10x.250, .188	C, O, Z
10x.125	O, V
9.625x.500, .375, .312, .250, .188	P, U, Z
8.75x.500, .375, .312, .250, .188	C, Z
8.625x.500	C, P, T, U, Z
8.625x.375	C, K, P, T, U, Z
8.625x.322	C, K, P, T, U, W, Z
8.625x.250, .188	C, K, O, P, T, U, W, Z
8.625x.125	O, P, T
7.625x.125	Z
7.5x.500, .375, .312, .250, .188	C, S, Z
7x.500	C, P, U, Z
7x.375, .312, .250	C, H, K, P, S, U, Z
7x.188	C,H,O,P,S,U,Z
7x.125	C, O, P, Z
6.875x.500, .375, .312, .250, .188	C
6.625x.500, .432	K, P, T, U, Z
6.625x.375, .312	H, K, P, S, T, U, Z
6.625x.280	H,K,P,S,T,U,W,X,Z
6.625x.250, .188	H,K,O,P,S,U,
	M,T,W,X,Z
6.625x.125	O,P, T,Z
6.125x.500, .375, .312, .250, .188	C
6x.500	Z
6x.375, .312	H, S, Z
6x.280	H, S, Z
6x.250	H, S, Z
6x.188	H, O, S, Z
6x.125	H, O, Z
5.563x.500	T
5.563x.375	P, T, X
5.563x.258	K,M, P, T, W, X, Z
5.563x.188	K, M,P, S, T, X, Z
5.563x.134	P, S, T, X, Z
5.5x.500	U, Z
5.5x.375, .255	K, P, U, Z
5x.500, .375, .312	C, P, S, T, X, Z
5x.258	C, P, S, T, U, X, Z
5x.250, .188	C,H,O,P,S,T,U,Y,X,Z
5x.125	C,H,O,P,S,T
	U,Y,X,Z
4.5x.337	K, L***, P, T, Z
4.5x.237	C, H, K, L***,M,P
	S, T, U, W, X, Z
4.5x.188	C, H, K, O, P, S, T
	M, U, X, Z
4.5x.125	C,H, L,O,P,S,T,U,Z
4x.337	H, S
4x.318	L***, S
4x.313	S, Z
4x.250, .188	C,H,O,S,U,Y,X,Z
4x.237	C,H,S,U,X,Y,Z
4x.226	L***,U, X,S,Z,M,W
4x.125	C,H,O,S,U,X,Y,Z
4x.120	M
3.5x.313	Z
3.5x.300	H,K,L***,P,U,X, Z
3.5x.250, .203, .188, .125	H,K,P,S,U,Y,X,Z
3.5x.216	E, K, L***, P, S
	M, U, W, X, Y, Z
3.5x.300	H,K,L***,P,U,X, Z
3x.250, .203, .188, .152	H, S, U, X, Z
3x.300	X, Z
3x.216	S, U, X, Y, Z
3x.120, .134	S, U, X, Y, Z
2.875x.276	L***, T
2.875x.250	P, T, U, X, Z
2.875x.203	H,K,L***,P,T,
	U,W,X,Z,M
2.875x.188, .125	P, T, U, X, Y, Z
2.875x.120	M
2.5x.250	S, T, Z
2.5x.188	B, N, S, T, Z
2.5x.125	B, N, S, T, Z
2.375x.250	H, L***, P, X, Y, Z
2.375x.218	H, K, P, X, Y, Z
2.375x.188	B, H, P, X, Y, Z
2.375x.154	B, H, X, L***, P,
	U, W, X, Y, Z
2.375x.125	B,H,P,S,U,X,Y,Z

Notes. *Size is manufactured by Submerged Arc Welding (SAW) process and are not stocked by steel service centers (contact producer for specific requirements). All other sizes are manufactured by Electric Resistance Welding and most are available from steel service centers.
***Size produced by Continuous Butt Welding

Continued

3.12.0 Uniform Building Code—Uniform and Concentrated Loads

USE OR OCCUPANCY		UNIFORM LOAD[1] (psf)	CONCENTRATED LOAD (pounds)
Category	Description	× 0.0479 for kN/m²	× 0.004 48 for kN
1. Access floor systems	Office use	50	2,000[2]
	Computer use	100	2,000[2]
2. Armories		150	0
3. Assembly areas[3] and auditoriums and balconies therewith	Fixed seating areas	50	0
	Movable seating and other areas	100	0
	Stage areas and enclosed platforms	125	0
4. Cornices and marquees		60[4]	0
5. Exit facilities[5]		100	0[6]
6. Garages	General storage and/or repair	100	[7]
	Private or pleasure-type motor vehicle storage	50	[7]
7. Hospitals	Wards and rooms	40	1,000[2]
8. Libraries	Reading rooms	60	1,000[2]
	Stack rooms	125	1,500[2]
9. Manufacturing	Light	75	2,000[2]
	Heavy	125	3,000[2]
10. Offices		50	2,000[2]
11. Printing plants	Press rooms	150	2,500[2]
	Composing and linotype rooms	100	2,000[2]
12. Residential[8]	Basic floor area	40	0[6]
	Exterior balconies	60[4]	0
	Decks	40[4]	0
	Storage	40	0
13. Restrooms[9]			
14. Reviewing stands, grandstands, bleachers, and folding and telescoping seating		100	0
15. Roof decks	Same as area served or for the type of occupancy accommodated		
16. Schools	Classrooms	40	1,000[2]
17. Sidewalks and driveways	Public access	250	[7]
18. Storage	Light	125	
	Heavy	250	
19. Stores		100	3,000[2]
20. Pedestrian bridges and walkways		100	

[1]See Section 1607 for live load reductions.
[2]See Section 1607.3.3, first paragraph, for area of load application.
[3]Assembly areas include such occupancies as dance halls, drill rooms, gymnasiums, playgrounds, plazas, terraces and similar occupancies that are generally accessible to the public.
[4]When snow loads occur that are in excess of the design conditions, the structure shall be designed to support the loads due to the increased loads caused by drift buildup or a greater snow design as determined by the building official. See Section 1614. For special-purpose roofs, see Section 1607.4.4.
[5]Exit facilities shall include such uses as corridors serving an occupant load of 10 or more persons, exterior exit balconies, stairways, fire escapes and similar uses.
[6]Individual stair treads shall be designed to support a 300-pound (1.33 kN) concentrated load placed in a position that would cause maximum stress. Stair stringers may be designed for the uniform load set forth in the table.
[7]See Section 1607.3.3, second paragraph, for concentrated loads. See Table 16-B for vehicle barriers.
[8]Residential occupancies include private dwellings, apartments and hotel guest rooms.
[9]Rest-room loads shall not be less than the load for the occupancy with which they are associated, but need not exceed 50 pounds per square foot (2.4 kN/m²).

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3.12.1 Uniform Building Code—Special Loads

USE		VERTICAL LOAD	LATERAL LOAD
Category	Description	(pounds per square foot unless otherwise noted)	
		× 0.0479 for kN/m²	
1. Construction, public access at site (live load)	Walkway, see Section 3303.6	150	
	Canopy, see Section 3303.7	150	
2. Grandstands, reviewing stands, bleachers, and folding and telescoping seating (live load)	Seats and footboards	120[2]	See Footnote 3
3. Stage accessories (live load)	Catwalks	40	
	Followspot, projection and control rooms	50	
4. Ceiling framing (live load)	Over stages	20	
	All uses except over stages	10[4]	
5. Partitions and interior walls, see Sec. 1611.5 (live load)			5
6. Elevators and dumbwaiters (dead and live loads)		2 × total loads[5]	
7. Mechanical and electrical equipment (dead load)		Total loads	
8. Cranes (dead and live loads)	Total load including impact increase	1.25 × total load[6]	0.10 × total load[7]
9. Balcony railings and guardrails	Exit facilities serving an occupant load greater than 50		50[8]
	Other than exit facilities		20[8]
	Components		25[9]
10. Vehicle barriers	See Section 311.2.3.5		6,000[10]
11. Handrails		See Footnote 11	See Footnote 11
12. Storage racks	Over 8 feet (2438 mm) high	Total loads[12]	See Table 16-O
13. Fire sprinkler structural support		250 pounds (1112 N) plus weight of water-filled pipe[13]	See Table 16-O
14. Explosion exposure	Hazardous occupancies, see Section 307.10		

[1]The tabulated loads are minimum loads. Where other vertical loads required by this code or required by the design would cause greater stresses, they shall be used.
[2]Pounds per lineal foot (× 14.6 for N/m).
[3]Lateral sway bracing loads of 24 pounds per foot (350 N/m) parallel and 10 pounds per foot (145.9 N/m) perpendicular to seat and footboards.
[4]Does not apply to ceilings that have sufficient total access from below, such that access is not required within the space above the ceiling. Does not apply to ceilings if the attic areas above the ceiling are not provided with access. This live load need not be considered as acting simultaneously with other live loads imposed upon the ceiling framing or its supporting structure.
[5]Where Appendix Chapter 30 has been adopted, see reference standard cited therein for additional design requirements.
[6]The impact factors included are for cranes with steel wheels riding on steel rails. They may be modified if substantiating technical data acceptable to the building official is submitted. Live loads on crane support girders and their connections shall be taken as the maximum crane wheel loads. For pendant-operated traveling crane support girders and their connections, the impact factors shall be 1.10.
[7]This applies in the direction parallel to the runway rails (longitudinal). The factor for forces perpendicular to the rail is 0.20 × the transverse traveling loads (trolley, cab, hooks and lifted loads). Forces shall be applied at top of rail and may be distributed among rails of multiple rail cranes and shall be distributed with due regard for lateral stiffness of the structures supporting these rails.
[8]A load per lineal foot (× 14.6 for N/m) to be applied horizontally at right angles to the top rail.
[9]Intermediate rails, panel fillers and their connections shall be capable of withstanding a load of 25 pounds per square foot (1.2 kN/m²) applied horizontally at right angles over the entire tributary area, including openings and spaces between rails. Reactions due to this loading need not be combined with those of Footnote 8.
[10]A horizontal load in pounds (N) applied at right angles to the vehicle barrier at a height of 18 inches (457 mm) above the parking surface. The force may be distributed over a 1-foot-square (304.8-millimeter-square) area.
[11]The mounting of handrails shall be such that the completed handrail and supporting structure are capable of withstanding a load of at least 200 pounds (890 N) applied in any direction at any point on the rail. These loads shall not be assumed to act cumulatively with Item 9.
[12]Vertical members of storage racks shall be protected from impact forces of operating equipment, or racks shall be designed so that failure of one vertical member will not cause collapse of more than the bay or bays directly supported by that member.
[13]The 250 pound (1.11 kN) load is to be applied to any single fire sprinkler support point but not simultaneously to all support joints.

(Reproduced from the 1997 Edition of the Uniform Building Code, Volumes 1, 2, 3, copyright 1997, with the permission of the publisher, the International Conference of Building Officials (ICBO), ICBO assumes no responsibility for the accuracy or the completion of summaries provided therein.)

3.13.0 International Units Conversion Tables—Galvanizing, Steel and Deck Properties

Galvanizing Designations

Customary Units (total of both sides)	SI Units (total of both sides)	Approximate Total Thickness (both sides)	
		inches	mm
G30 0.30 oz./ft^2 min.	Z090 90 g/m^2 min.	0.0005	0.013
G60 0.60 oz./ft^2 min.	Z180 180g/m^2 min.	0.0010	0.026
G90 0.90 oz./ft^2 min.	Z275 275g/m^2 min.	0.0015	0.039

The weights shown are the total for both sides of the sheet and are minimum values.

Steel Properties

ASTM Number	Customary Units, ksi			SI Units, MPa		
	Fy	Fu	F*	Fy	Fu	F*
A611 grade C	33	48	20	230	330	140
A611 grade D	40	52	24	275	360	165
A611 grade E	80	82	36	550	565	250
A653 grade 33	33	45	20	230	310	140
A653 grade 40	40	55	24	275	380	165
A653 grade 50	50	65	30	345	450	205
A653 grade 80	80	82	36	550	570	250

* Design stress in bending

Conversion Factors for Deck Products

m = Meters; **mm** = Millimeters; kg = Kilograms; **N** – Newtons; **Pa** – Pascals; kPa = Kilopascals; MPa = Megapascals

To Convert	To	Multiply by	Notes
m	ft	3.28	
m	in.	39.4	
mm	in.	0.0394	
m^2	sq ft	10.8	
m^2	sq	0.108	1 sq. = 100 ft^2
mm^2	sq in.	0.00155	
mm^2/m	sq in./ft	0.000473	reinforcing steel area; concrete area available for shear
mm^4	in.^{4}	2.40 x 10^{-6}	moment of inertia
mm^4/m	in.^{4}/ft	0.732 x 10^{-6}	deck moment of inertia per unit width
mm^4/mm	in.^{4}/ft	0.732 x 10^{-3}	
mm^3	in.^{3}	61.0 x 10^{-6}	section modulus
mm^3/m	in.^{3}/ft	18.6 x 10^{-6}	deck section modulus per unit of width
mm^3/m	in.^{3}/ft	18.6 x 10^{-3}	
mm	mils	39.4	1 mil = 0.001 inches, paint thickness
m^3	ft^3	35.29	concrete volume
m^3	yd^3	1.307	concrete volume
m^3/m^2	ft^3/ft^2	3.28	concrete vol. per unit area - slab vol.
kg	lb	2.20	mass unit - **NOT to be used for stress or deflection calculations**
kg/m^2	lb/ft^2	0.205	mass units
g/m^2	oz/ft^2	3.28 x 10^{-3}	galvanizing
kg/m^3	lb/ft^3	0.0624	concrete density
kg/m^2	Pa	9.81	**use pascals (N/m^2) for stress and deflection calculations**
N	lb (force)	0.225	concentrated loads, stress and deflection calcs
Nm	lb ft	0.738	bending moment
Nm	in.	8.85	bending moment
N/m	lb/ft	0.0685	line loads; diaph. strength or stiffness
kPa	lb/ft^2	20.9	1 pascal = 1 N/m^2; live loads; pressure
MPa*	lb/in.^{2}	145	stress; Modulus of Elasticity (E)

*For steel deck, the modulus of elasticity (E) is 210 000 MPa.

(By permission from the Steel Deck Institute, Fox River Grove, Illinois.)

3.14.0 Structural Steel—Quality Control Checklist

Quality Control Checklist

Project no.

Section: Structural Steel

No. 05120

Date

1. Setting of foundation anchor bolts, size, and location are as required.
2. Testing and inspection laboratory has observed shop fabrication as required or specified.
3. Size and type of bolts and washers are as required
4. Shop painting is provided as required and items to be embedded are not shop coated unless required.
5. Shop painting is provided as required and items to be embedded are not shop coated unless required.
6. Delivered steel is new, undamaged, and free of distortions.
7. Steel is suitably stored. Blocked off ground, and covered where prolonged storage occurs.
8. Column ends are milled and protected if required.
9. Observe setting of base and bearing plates. See that full engagement of nut occurs and that bending of anchor bolts or undue chipping of concrete does not occur. Verify clearances required for finish coverings or materials are provided.
10. Temporary connections to hold steel in place are provided before final bolts or weld connections are made.
11. See that concrete is cleaned and free of dirt and laitance, and grouting is properly performed. Space between concrete and bottom of bearing plate usually must not exceed 1/24 bearing plate width. See that dry pack mortar is properly rammed and cured.
12. See that temporary connections, guys, and braces are provided to hold work in place before permanent connections are completed. Work is installed plumb and to tolerance required (ASTM 1:500).
13. Beam members are set with natural camber up. Camber is furnished where required.
14. Steel members are not cut for passage of conduit, pipes, etc., unless so indicated on shop drawings.
15. Type, size and length of bolt, size and type of washer, and size of hole are as required.
16. All bolt heads and nuts are inspected after installation.
17. Burning of holes to correct misalignment is not permitted.
18. Identification of a bolt is made, and washer and nut are of proper type. (Testing may be required.)
19. Verify whether paint is allowed on contact surface. Generally, all deleterious materials such as dirt, oil, or loose scale, or defects such as burrs or pits should not be present.
20. Verify that contractor has performed adequate calibration checks and calibrations for the impact variations.
21. Slope of flanges (1:20); beveled washers as required.
22. Hardened washers are provided as required

WELDING

23. Welders are qualified.
24. Visual inspection and non-destructiving tests of shop welding are performed if required.
25. Field inspection of welding by testing laboratory has been scheduled if required.
26. Generally observe that finished welds are of size, length, and locations required.
27. Generally observe that contour and appearance of welds are of good workmanship. Surface defects, craters, undercutting, over-lapping, cracks, and other unacceptable defects should be removed and corrected.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

3.14.1 Steel Joist—Quality Control Checklist

Quality Control Checklist

Project no.

Section

Steel Joists

No.

05200

Date

1. Joists are coated with type of paint and number of coats required.
2. Verify that welds have been inspected for length and size.
3. Nailer on top and/or bottom chord is provided if required.
4. Joists are accurately spaced and have proper bearing and anchorage.
5. Installation and connections are as required.
6. Ceiling extensions are provided where required.
7. Bridging and anchoring are installed as soon as joists are placed and before application of loads.
8. Ends of bridging lines terminating at walls or beams are anchored at plane of top and chords as required.
9. No cutting or drilling of web or chord members.
10. Do not allow excessive concentrated loads of heavy building materials or moving of heavy equipment over joists.
11. All rust, scale, slag, and splatter are removed and joist is clean before it is painted.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

3.14.2 Metal Deck—Quality Control Checklist

Quality Control Checklist

Project no.

Section: **Metal Deck**

No. **05300**

Date

1. Approved shop drawings are on site.
2. Material approved type, shapes, gauge, and size.
3. Approved samples are on job if required.
4. Verify that contractor has reviewed approved decking layout submissions.
5. Material is properly stored on site and protected.
6. All accessory items are furnished and approved type.
7. Welding inspection by test lab is required.
8. Welders are certified if required.
9. Sequence of fastening is performed.
10. Closures at edges are provided as required.
11. Decking in contact with beams; proper tack welds.
12. Observe tabs and hangers for equipment and ceilings.
13. Observe coordination with: sheet metal, roofing, insulation, elect.
14. Decking is continuous over supports if required.
15. Welded connections and spacings are as required.
16. Observe panel to panel seams for tack weld.
17. Check seam welding for burn-outs.
18. Reinforcement at columns and penetrations as required.
19. Reinforcement at major concentrated loads as required.
20. Type, spacing, alignment of seam connections as required.
21. No rough edges to damage wire pulled through cells.
22. Butt ends taped to keep concrete fill out.
23. No concentrated loads on decks during construction.
24. Verify if shoring is required for conc. topping.
25. Deck is free of loose dirt, debris before topping.
26. On roof decking, de-slag welds and paint with zinc.
27. Verify if U.L. labels are required.
28. Roof ventilation provisions are met.
29. Touch-up exposed and outgalvanized metal.
30. Record all damaged panels.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

3.14.3 Metal Stairs—Quality Control Checklist

Quality Control Checklist

Project no

Section: Metal Stairs

No.: 05500

Date

1. Approved submittals; shop drawings, samples, product data, certificates as required, are on site.
2. Stamped calculations in reference to structural properties of all members, assemblies, connections are on site.
3. Materials are properly stored on site and protected.
4. All materials furnished are approved types; shapes, gauges, sizes, metal treatments and finishes.
5. All accessory items furnished are approved types.
6. Observe coordination and scheduling with the work of related trades including miscellaneous metal, structural steel framing, concrete, gypsum drywall.
7. Welding inspection by test lab if required.
8. Welders are certified.
9. Welds continuous along entire line of contact.
10. Exposed welds flush and ground smooth.
11. Exposed joints not conspicuous, close fitting.
12. Exposed bolts and screws cut off flush with nuts or other adjacent metal.
13. Threaded connections tight—all threads concealed.
14. Exposed bolts and screw heads flat and countersunk.
15. Shop painted coats touched-up as required.
16. Surfaces clean; stains, grease marks removed as required.
17. Metal stairs free from scratches, waves, dents, buckles, tool marks, rattles.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

3.14.4 Miscellaneous—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Miscellaneous Metal

No.
05501

Date

1. Materials are fabricated from approved shop drawings.
2. Templates are furnished for placement and anchorage.
3. Provisions made for bracing, blocking and anchorage.
4. Verify that contractor located and coordinated placement of sleeves, bolts, cut-outs and connectors.
5. Protect from damage before and after installation.
6. Bucks, angle and thresholds adequately braced, aligned.
7. Bucks and thresholds bear labels.
8. On railings: vertical spacing, returns meet code.
9. Nosings of metal pan threads are protected.
10. Check bearing supports for metal stairs.
11. Verify that contractor coordinated metal stairs with adjacent finishes.
12. Workmanship: ground welds, caulking, shop coats.
13. Turn over shop drawings and as-builts to Owner.
14. Back-painting.
15. Grouting.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

4

Wood and Lumber Products

Contents

The numerous species of wood can be divided into two basic classifications: softwood and hardwood. These classifications do not necessarily refer to the hardness or softness of the species, but rather to the type of tree from which the wood is taken.

4.0.0 Introduction to Softwoods, Hardwoods, and Lumber Terminology

Hardwood comes from trees that shed their leaves at the end of a growing season (such as oak, hickory, chestnut, elm, maple, and birch). Softwoods, on the other hand, are trees, such as evergreens, that do not shed their leaves (cedar, pine, hemlock, larch, and spruce, for example). Hardwoods are generally used for flooring, furniture, cabinetry, and millwork. Softwoods find wide application as framing members, although some species of pine are used as shelving or are incorporated into various types of millwork.

The characteristics of wood vary from tree to tree as well as from section to section within a tree. Therefore, some method is required to select and grade pieces of lumber cut from a tree to form some degree of uniformity. Then organizations were established to set the standards for various grades of lumber. They have the authority to inspect member mills to ensure that the buyer receives the quality they bargain for.

4.1.0 Introduction to Western Wood Products Association (WWPA) and Southern Pine Inspection Bureau (SPIB)

The Western Wood Products Association (WWPA) was formed around 1900. By 1924, various other grading associations in the United States developed product standards with the assistance of the U.S. Department of Commerce. The WWPA, headquartered in Portland, Oregon, establishes standards of size and levels of quality for a variety of western softwoods. Its inspectors regularly visit member mills to ensure that the quality and production of these mills meet pre-established standards. Only then is the mill allowed to stamp their product with the approved WWPA certification. Softwood lumber is further classified according to extent of manufacture:

- *Rough lumber* Lumber that has not been dressed, but only sawn edged and trimmed to the extent of showing saw marks on all four sides.
- *Dressed or surfaced lumber* Lumber that has been run through a surfacing machine to achieve a smooth and uniform surface on one side (S1S), two sides (S2S), one edge (S1E), two edges (S2E), all four sides (S4S), or any combination thereof.
- *Worked lumber* Lumber that, in addition to being dressed or surfaced, has been matched, shiplapped or tongue and grooved.
- *Resawn lumber* Lumber that is dressed before resawing and not afterward. Uniformity of thickness does not characterize resawn lumber.

The Southern Pine Inspection Bureau (SPIB) in Pensacola, Florida, establishes the grading rules for four principle species of Southern pine: longleaf (*pinus palustris*), slash (*pinus elliottii*), shortleaf (*pinus echinata*), and loblolly (*pinus eaeda*). A few other species of negligible or less importance to the construction industry are also included.

4.2.0 American Lumber Standards Committee (ALSC) and Wood Preservatives

The American Lumber Standard Committee (ALSC) also stamps lumber and is administered by the U.S. Department of Commerce. The ALSC provides supervisory inspections for pressure-treated wood products and has established a series of abbreviations for the various types of wood preservatives in use today.

CCA	chromated copper arsenate
ACA	ammoniacal copper arsenate
ACZA	ammoniacal copper zinc arsenate
ACC	acid copper chromate

ACQ	ammoniacal copper quat. type-B
COPPER NAP	copper naphthenate
PENTA	pentaclorophenol
CREOSOTE	creosote and/or solutions
BORATE	borates

4.2.1 ALSC Pressure-Treated Wood-Stamp Markings

ACCREDITED AGENCIES FOR SUPERVISORY AND LOT INSPECTION OF PRESSURE TREATED WOOD PRODUCTS
March 1996

Agencies accredited by the Board of Review of the American Lumber Standard Committee, Incorporated, and typical quality marks.

Interpreting a Quality Mark

ABC 1	19__-19__ 3
	GROUND CONTACT 6
	.40 5
	AWPA ____ STDS 2
XXX 7	PRESERVATIVE 4
	KDAT 8
	X-XX 9

1 - The identifying symbol, logo or name of the accredited agency.
2 - The applicable American Wood Preservers' Association (AWPA) commodity standard.
3 - The year of treatment if required by AWPA standard.
4 - The preservative used, which may be abbreviated.
5 - The preservative retention.
6 - The exposure category (e.g., Above Ground, Ground Contact, etc.).
7 - The company name and location of home office; or company name and number; or company number.
8 - If applicable, moisture content after treatment.
9 - If applicable, length and/or class.

As specified below for particular agencies, some or all of the following American Wood Preservers' Association commodity standards are used by American Lumber Standard Committee, Incorporated, accredited agencies which supervise facilities which pressure-treat wood products:

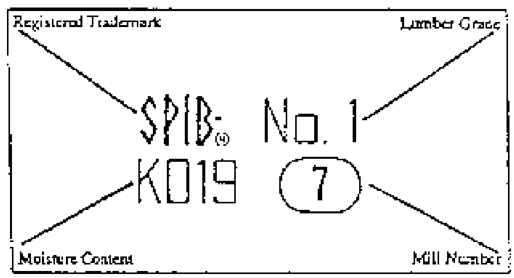
C1	All Timber Products--Preservative Treatment by Pressure Processes
C2	Lumber, Timbers, Bridge Ties and Mine Ties–Preservative Treatment by Pressure Processes
C3	Piles--Preservative Treatment by Pressure Processes
C4	Poles--Preservative Treatment by Pressure Processes
C5	Fence Posts--Preservative Treatment by Pressure Processes
C6	Crossties and Switch Ties-Preservative Treatment by Pressure Process
C9	Plywood–Preservative Treatment by Pressure Processes
C15	Wood for Commercial-Residential Construction–Preservative Treatment by Pressure Processes
C17	Playground Equipment Treated with Inorganic Preservatives--Preservative Treatment by Pressure Processes
C18	Standard for Pressure Treated Material in Marine Construction
C22	Lumber and Plywood for Permanent Wood Foundations--Preservative Treatment by Pressure Processes
C23	Round Poles and Posts used in Building Construction--Preservative Treatment by Pressure Processes
C24	Sawn Timber Piles Used for Residential and Commercial Building
C25	Sawn Crossarms-Preservative Treatment by Pressure Process
C28	Standard for Preservative Treatment of Structural Glued Laminated Members and Laminations Before Gluing of Southern Pine, Pacific Coast Douglas Fir, Hemfir and Western Hemlock by Pressure Processes
C31	Lumber Used Out of Contact With the Ground and Continuously Protected from Liquid Water–Treatment by Pressure Processes
C33	Standard for Preservative Treatment of Structural Composite Lumber by Pressure Processes
C34	Shakes and Shingles-Preservative Treatment by Pressure Processes

(By permission of American Lumber Standard Committee, Inc.)

4.2.2 ALSC Registered Trademarks

There are twenty-five agencies certified by the American Lumber Standard Committee (ALSC). The ALSC program is based on Voluntary Product Standard PS 20-94 and is administered by the Department of Commerce. Each agency has a registered trademark which is an integral part of the grade-mark applied to lumber graded under each agency's supervision. Copies of a brochure printed by the ALSC entitled "ALSC Certified Agencies and Typical Grade-Marks" can be obtained at no charge through the ALSC, P.O. Box 210, Germantown, MD 20974. Your personnel should be familiar with the species of lumber used and the agencies providing service for that species. A copy of the ALSC brochure should be available to your personnel at all times.

An example of an ALSC certified agency grade-mark and the information that a certified grade-mark must contain:



1. Agency logo or species of lumber bearing the stamp. In the case of the Southern Pine Inspection Bureau, the agency logo identifies the species Southern Pine.

2. Grade of Lumber.

3. Moisture content of lumber at the time of dressing if dressed lumber is involved. The moisture content designation is required on lumber in thickness less than 5 inches.

KD-15	--	Kiln dried to 15% max. moisture content
KD-19	--	Kiln dried to 19% max. moisture content
S-DRY	--	Kiln or Air dried to 19% max. moisture content
S-GRN	--	Indicates moisture content in excess of 19% and should be applied to all green lumber from 2-1/2" to 4-1/2" nominal thickness

4. Mill Identification Number.

SPIB will provide accurate information concerning ALSC approved grade-marks upon request.

Jim Loy, (904) 434-2611

John McDaniel, (301) 972-1700

Updated: 9/95

(By permission of American Lumber Standard Committee, Inc.)

4.3.0 Moisture Content in Lumber

Both the WWPA and the SPIB have similar standards to designate moisture content in the lumber bearing their grading stamps. The moisture content of lumber is the weight of water contained in the lumber, expressed as a percentage of weight of the wood from which some water has been removed. Dry lumber is defined as having a moisture content of 19% or less; lumber with a moisture content in excess of 19% is classified as unseasoned lumber.

When standard-sized dry lumber is grade-stamped, the grade stamp will indicate the condition of "seasoning" as either MC15, KD15, S-DRY, or KD.

- *MC-15* Lumber surfaced with a moisture content of 15% or less.
- *KD-15* Kiln-dried lumber, surfaced, with a moisture content of 15% or less (kiln-dried lumber is lumber that has been heat-seasoned in a chamber to produce a predetermined moisture content).
- *S-DRY* Lumber surfaced with a moisture content of 19% or less.
- *KD* Kiln-dried lumber with a moisture content of 19% or less.
- *S-GRN* Unseasoned lumber with a moisture content in excess of 19%.

It is important to note that restrictions on moisture content apply at the time of shipment, as well as the time when it was surfaced. When lumber is shipped on open conveyances where it is susceptible to picking up moisture, the seller is relieved of any moisture content restrictions as long as the buyer is notified of the method of shipment (e.g., open-to-the-weather trucks, rail cars, or even ships) and agrees to this method of shipment.

4.4.0 WWPA Guide to Understanding Grade Stamps

Integrity of Grade Stamp

Western Wood Products Association is the largest association of lumber manufacturers in the United States. WWPA members and grading service subscribers are located in the 12 western states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington and Wyoming. The Association's Quality Standards Department supervises lumber grading by maintaining a highly competent staff of lumber inspectors who regularly check the quality of mill production, including visual grade requirements of glued products and machine stress-rated lumber.

The Association's *Grading Rules for Western Lumber* establishes standards of size and levels of quality in conformance with the American Softwood Lumber Standard PS 20-94. The Association is certified as a rules writing and inspection agency by the Board of Review, American Lumber Standard Committee. The Association is approved to provide mill supervisory services under its rules and the rules of the West Coast Lumber Inspection Bureau, the Redwood Inspection Service, the National Lumber Grades Authority for Canadian Lumber and the NGR portion of the Southern Pine Inspection Bureau Rules. In addition, WWPA is approved to supervise finger-jointed and machine stress-rated lumber.

Interpreting Grade Marks

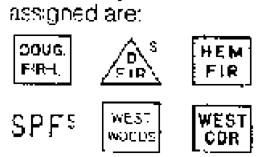
Most grade stamps, except those for rough lumber or heavy timbers, contain 5 basic elements

a. **WWPA certification mark.** Certifies Association quality supervision. WWP® is a registered trademark.

b. **Mill identification.** Firm name, brand or assigned mill number. WWPA can be contacted to identify an individual mill whenever necessary.

c. **Grade designation.** Grade name, number or abbreviation.

d. **Species identification.** Indicates species by individual species or species combination. Species identification marks for groups to which design values are assigned are:



e. **Condition of seasoning.** Indicates condition of seasoning at time of surfacing:

MC-15 — KD-15	15% maximum moisture content
S-DRY KD	19% maximum moisture content
S-GRN —	over 19% moisture content (unseasoned)

Inspection Certificate

When an inspection certificate issued by the Western Wood Products Association is required on a shipment of lumber and specific grade marks are not used, the stock is identified by an imprint of the Association mark and the number of the shipping mill or inspector.

Grade Stamp Facsimiles

WWPA uses a set of marks similar to the randomly selected examples shown on the reverse side, to identify lumber graded under its supervision.

Species Combinations

The species groupings for dimension lumber products are shown left and explained in the second box on the reverse side. When alternative species combinations, as shown in the third box on the reverse side, are used for structural applications, design values are controlled by the species with the lowest strength value within the combination.

(By permission of Western Wood Products Association.)

4.4.1 Species of Wood Included in WWPA Jurisdiction

Species or Species Combination	Mark
Douglas Fir and Larch Douglas Fir Western Larch	DOUG. FIR-L
Douglas Fir-South Lumber manufactured from Douglas Fir grown in Arizona, Colorado, Nevada, New Mexico and Utah.	D FIR S
Hem-Fir California Red Fir, Grand Fir, Noble Fir, Pacific Silver Fir, White Fir and Western Hemlock	HEM FIR
Spruce-Pine-Fir (South) Engelmann Spruce, Sitka Spruce, Lodgepole Pine, Balsam Fir, Jack Pine, Red Pine, and Eastern Spruces The SPF^{S} grouping is used by all U.S. rule writing agencies that write grading rules for certain Spruces, Pines and Firs. In the United States the SPF^{S} mark can be used on any one of these species or combinations thereof.	SPF^{S}
Western Cedars Incense, Western Red, Alaska and Port Orford Cedar	WEST CDR
Western Woods Any combination of western softwood species except Redwood and Western Cedars.	WEST WOODS

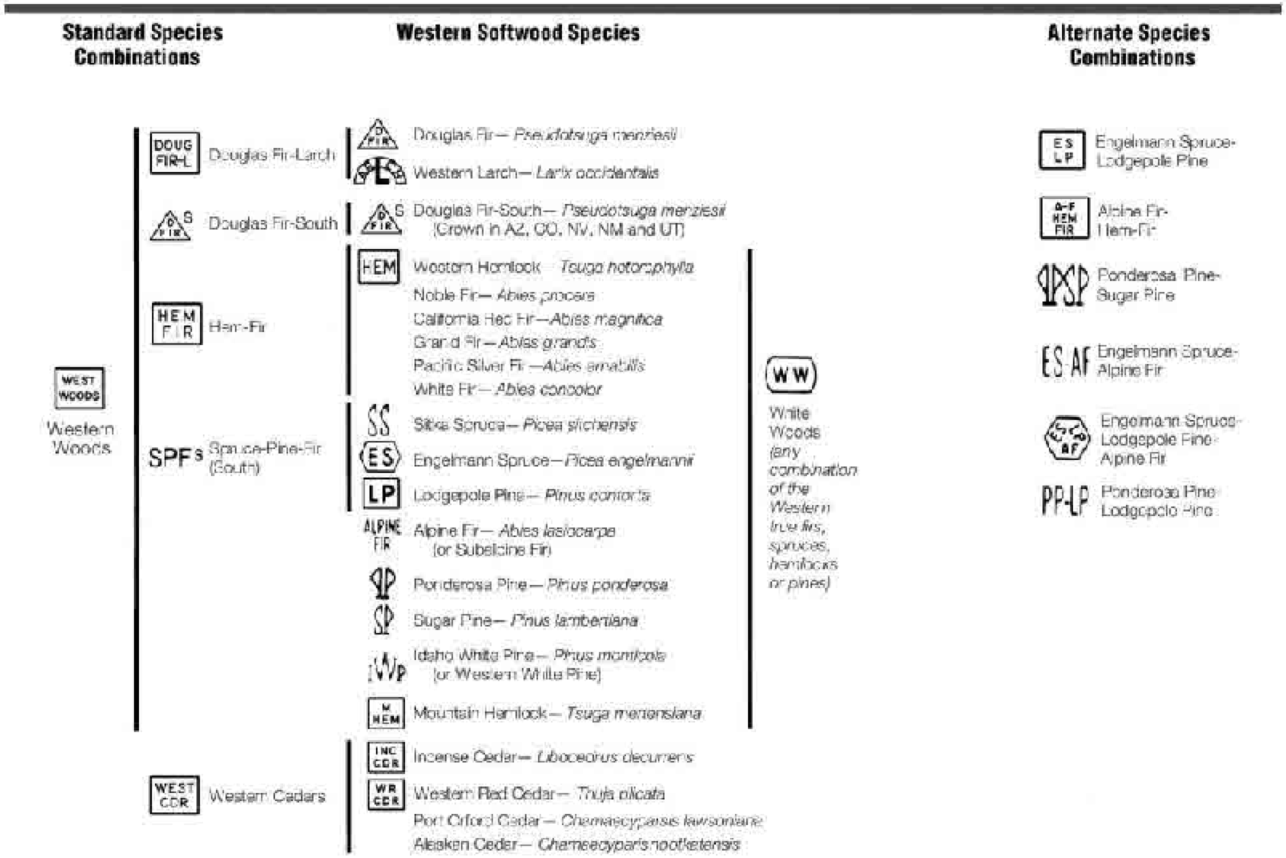
Assigned design values for the following species combination are the same as those shown for Western Woods.

White Woods Any true firs, spruces, hemlocks or pines.	WW

(By permission of Western Wood Products Association.)

4.4.2 Western Lumber Species and Grades

WESTERN LUMBER SPECIES MARKETING CATEGORIES



GRADE CATEGORIES

Western solid-sawn lumber is grouped into three broad categories: framing (or structural) lumber, which is graded for strength; appearance lumber, which is not graded for strength; and industrial (or factory) lumber, which is generally graded for specific end uses or for remanufacturing and recovery purposes.

Framing lumber includes the grades intended for structural applications in both conventional and pre-engineered framing systems. Western species structural lumber is manufactured primarily from second- and third-growth softwoods and graded, either visually or mechanically, on the basis of its strength; each species and grade has an assigned design value. General classifications include:

- Dimension lumber grades
- Special Dimension lumber grades
- Timber grades

Design values for Dimension lumber are published as BASE VALUES which must be adjusted for size as well as conditions of use. Refer to pages 6 to 17.

Appearance lumber includes a variety of non-structural grades intended for applications where strength is not the primary consideration. Appearance grade Western lumber is manufactured primarily from older (not "old growth") and second-growth softwood trees. Many of the products in this category are often run-to-pattern for paneling and siding applications. General classifications include:

- High-quality Appearance grades
  (Selects, Finish and Special Western Red Cedar Grades)
- General purpose board grades
  (Commons under WWPA Rules and Alternate Board grades under WCLIB Rules)
- Radius-edged Patio Decking grades
  (Patio 1 and Patio 2)

Refer to pages 18 to 20.

Industrial lumber includes both structural and non-structural grades intended for specific applications. General classifications include:

- Structural grades
  (Mining Timbers, Scaffold Plank, Foundation lumber & Stress-rated boards)
- Factory & Shop grades
  (non-structural grades intended for cut up and remanufacturin
- Non-structural grades
  (Gutter, Picket, Lath, Batten, Stepping)

Refer to pages 21 & 22.

(By permission from the Western Wood Products Association, Portland, Oregon.)

4.4.2.1 WWPA Species Groupings

WESTERN WOODS REGION

The Western Woods region holds two thirds of the nation's forest inventory on 136 million acres of forestland. More than 60% of these forestlands is publicly owned and managed by county, state or federal agencies. Some 25% is privately owned by non-industrial individuals and companies. The remaining 13% is owned and managed by forest product companies.

Recognizing the need to work together and go beyond ownership boundaries, timber companies and public agencies developed the first of the western forestland management laws in the early 1940s – the Oregon Forest Conservation Act of 1941. Over time it evolved into the Oregon Forest Practices Act of 1971 which, in turn, influenced the formation of similar forest practice laws in Washington, California and Idaho.

Since then, management practices on western timberlands have continued to improve and the early acts have evolved into the toughest forestland management laws in the US, ranking among the most progressive in the world. Private and publicly funded research is on-going to further improve stream and watershed protection, fish and wildlife habitat, and determine how best to manage for the health of the whole forest ecosystem rather than for specific values.

Today, nearly 50 million acres in the Western region are set aside in national parks, wilderness areas, wildlife preserves and research areas (more than doubling since 1967). Harvesting is prohibited or highly restricted on more than 80% of the region's 59.8 million acres of national forests. And on forest lands where harvesting is permitted, growth exceeds harvest by some 34% overall and by more than 50% in some areas.

WESTERN LUMBER

Approximately 90% of the lumber produced from the Western Woods region comes from its "timber basket" in Oregon, Washington, northern California, Idaho and western Montana where *State Forest Practices Acts* and *Best Management Practices* are the most rigorous in the region. To foster the sustainability of western forests in perpetuity, where timber for products is but one of the many values assigned to and respected in these working timberlands, the following and more are fully regulated:

- protection for threatened and endangered species;
- wildlife habitat and stream protection;
- watershed, wetlands and riparian areas protection;
- soil conservation and site productivity;
- logging practices, with a State Forester overseeing every logging operation on both private and publicly owned timberlands;
- time-specified, site-specific, multi-species reforestation;
- limitations on the application of fertilizer and herbicides; and
- scenic corridors protection (in Oregon).

These are not voluntary standards nor guidelines for certification. These are forestland management and harvesting laws. Because of its forestland management practices, the western U.S. is also the highest-cost region in the country for wood product manufacturers.

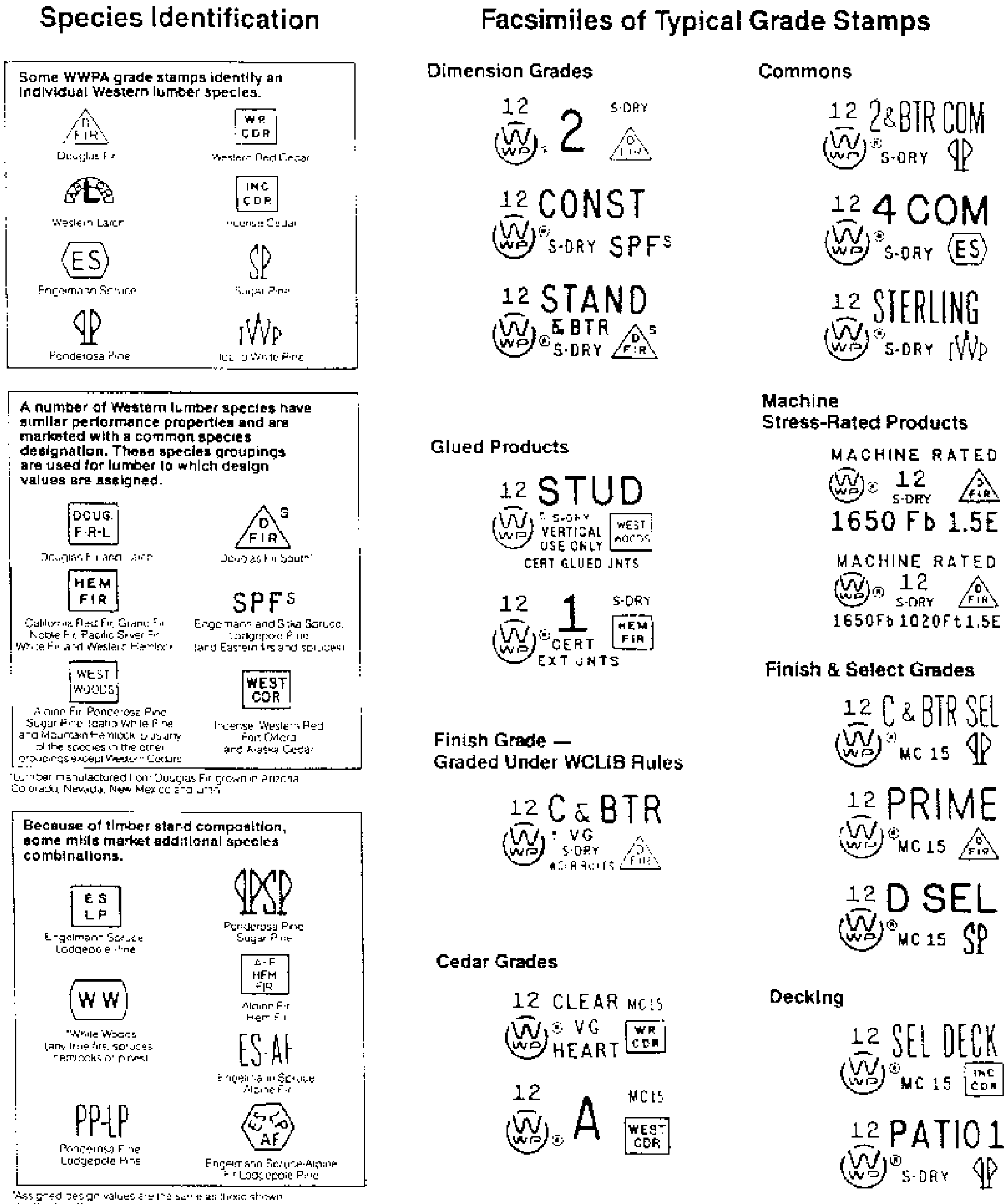
SPECIES GROUPINGS

There are more than 15 commercially important Western softwood species. The lumber from several of the Western softwood species shares performance properties and is similar enough in appearance that many species are grouped together into "Marketing Categories." The species within these categories are often harvested, manufactured and sold interchangeably in the marketplace.

Western lumber may be bought, sold and specified as separate species or according to the species groups, or "Marketing Categories," shown on the map below and outlined on the following page.

(By permission from the Western Wood Products Association, Portland, Oregon.)

4.4.3 Species Identification and Facsimile Grade Stamps



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4.4.4 Design Values for Various Species of Western Wood Products

Species or Group	Grade	Extreme Fiber Stress in Bending "Fb" Single	Tension Parallel to Grain "Ft"	Horizontal Shear "Fv"	Compression Perpendicular "Fc ⊥"	Compression Parallel to Grain "Fc ∥"	Modulus of Elasticity "E"
Douglas Fir-Larch	Select Structural	1450	1000	95	625	1700	1,900,000
	No. 1 & Btr.	1150	775	95	625	1500	1,800,000
Douglas Fir	No. 1	1000	675	95	625	1450	1,700,000
Western Larch	No. 2	875	575	95	625	1300	1,600,000
	No. 3	500	325	95	625	750	1,400,000
	Construction	1000	650	95	625	1600	1,500,000
	Standard	550	375	95	625	1350	1,400,000
	Utility	275	175	95	625	875	1,300,000
	Stud	675	450	95	625	825	1,400,000
Douglas Fir-South	Select Structural	1300	875	90	520	1550	1,400,000
	No. 1	900	600	90	520	1400	1,300,000
Douglas Fir South	No. 2	825	525	90	520	1300	1,200,000
	No. 3	475	300	90	520	750	1,100,000
	Construction	925	600	90	520	1550	1,200,000
	Standard	525	350	90	520	1300	1,100,000
	Utility	250	150	90	520	875	1,000,000
	Stud	650	425	90	520	825	1,100,000
Hem-Fir	Select Structural	1400	900	75	405	1500	1,600,000
Western Hemlock	No. 1 & Btr.	1050	700	75	405	1350	1,500,000
Noble Fir	No. 1	950	600	75	405	1300	1,500,000
California Red Fir	No. 2	850	500	75	405	1250	1,300,000
Grand Fir	No. 3	500	300	75	405	725	1,200,000
Pacific Silver Fir							
White Fir	Construction	975	575	75	405	1500	1,300,000
	Standard	550	325	75	405	1300	1,200,000
	Utility	250	150	75	405	850	1,100,000
	Stud	675	400	75	405	600	1,200,000
Spruce-Pine-Fir (South)	Select Structural	1300	575	70	335	1200	1,300,000
	No. 1	850	400	70	335	1050	1,200,000
Western Species:	No. 2	750	325	70	335	975	1,100,000
Engelmann Spruce	No. 3	425	200	70	335	550	1,000,000
Sitka Spruce							
Lodgepole Pine	Construction	850	375	70	335	1200	1,000,000
	Standard	475	225	70	335	1000	900,000
	Utility	225	100	70	335	650	900,000
	Stud	575	250	70	335	600	1,000,000
Western Cedars	Select Structural	1000	600	75	425	1000	1,100,000
Western Red Cedar	No. 1	725	425	75	425	825	1,000,000
Incense Cedar	No. 2	700	425	75	425	650	1,000,000
Port Orford Cedar	No. 3	400	250	75	425	375	900,000
Alaska Cedar							
	Construction	800	475	75	425	850	900,000
	Standard	450	275	75	425	650	800,000
	Utility	225	125	75	425	425	800,000
	Stud	550	325	75	425	400	900,000
Western Woods	Select Structural	875	400	70	335	1050	1,200,000
Any of the species in the first four species groups above plus any or all of the following:	No. 1	650	300	70	335	925	1,100,000
	No. 2	650	275	70	335	875	1,000,000
	No. 3	375	175	70	335	500	900,000
Idaho White Pine	Construction	725	325	70	335	1050	1,000,000
Ponderosa Pine	Standard	400	175	70	335	900	900,000
Sugar Pine	Utility	200	75	70	335	600	800,000
Alpine Fir							
Mountain Hemlock	Stud	500	225	70	335	550	900,000

*Design values in pounds per square inch.

(By permission of Western Wood Products Association.)

4.4.5 Scaffold Plank Sizes and Design Values—Western Wood Products

SCAFFOLD PLANK
Douglas Fir and Larch
1¼" and Thicker
8" and Wider

There are two grades of Scaffold Plank: SCAFFOLD NO. 1 and SCAFFOLD NO. 2. Design Values for Douglas Fir and Larch are as follows:

Design Values—For Flatwise Use*

Thickness	Grade	Extreme Fiber Stress in Bending (Fb) in psi	Modulus of Elasticity (E) in psi
2" & less	No. 1	2350	1,800,000
	No. 2	2200	1,800,000
These values apply to dry use conditions. For wet use conditions, these values shall be multiplied by 0.86 for Fb and 0.97 for E.			
3"	No. 1	1800	1,600,000
	No. 2	1650	1,600,000
These values apply to both dry and wet use conditions.			

*See Sections 100.000 through 170.00 for information about these values.

Other species may be graded under these rules and design values for them may be obtained from the Association. All pieces are FOHC and the face showing the more serious characteristics are used to determine the grade. Knot size is determined by the average diameter of the largest knot showing on either wide face. Knots showing on narrow faces are permitted if they displace no more of the cross section than knots on wide faces, except spike knots across the full width are not permitted.

Scaffold plank is usually ordered unseasoned and grades are based on rough lumber. Scaffold plank is full sawn, except an occasional piece may be ⅛" scant in thickness or ¼" scant in width.

(By permission of Western Wood Products Association.)

4.4.6 Relative Properties—Western Wood Products

WESTERN SPECIES DIMENSIONAL STABILITY

Wood shrinks as it seasons (dries) from the fiber saturation point (of 28% to 30% MC) to the moisture level of surrounding atmospheric conditions. Within most structures, this moisture content level is between 8% and 12%.

In one- and two-story structures, the cumulative effect of shrinkage can be accommodated on the job site, even when unseasoned lumber is specified. However, for three story and higher buildings, designs should allow for shrinkage in the horizontal members, e.g., wall plates and joists.

The shrinkage of western species (except Western cedars) is approximately 6% as it dries from 30% to 0% MC (4.5% for Western cedars), i.e., 0.2% shrinkage for every 1% change in moisture content for Western species and 0.15% for Western cedars. The shrinkage factor assumes a growth-ring angle of 45° and is an average for multiple species.

Example: To calculate the amount of shrinkage in a 2x10 lumber floor joist, manufactured at 19% (S-DRY) with an equilibrium moisture content of 8%:

9.25 Inches	x	0.002	x	11	= 0.20 Inches
width (actual width of dry 2x10)		shrinkage factor (.2% = .002)		% change in moisture content (19 − 8 = 11)	

Vertical members exhibit less dimensional change because wood's longitudinal shrinkage is quite small (approximately .003 to .0067 percent for every 1% change in MC).

Shrinkage factors for individual species and specific grain orientations can be found in WWPA's *Dimensional Stability-Technical Guide* (TG-3).

WEIGHT PER LINEAR FOOT

To calculate the weight per linear foot for a particular size and species, multiply the cross-sectional area of the member by the species weight and increase factors shown in Table 22. The weight factors apply to lumber at 15% MC.

WEIGHT FACTOR (15% moisture content) Table **22**

Species or Species Group	Weight Factor	Species or Species Group	Weight Factor
Douglas Fir-Larch	233	Western Woods *(continued)*	
Douglas Fir-South	216	Alpine Fir	.170
Hem-Fir	203	Mountain Hemlock	.220
Spruce-Pine-Fir (South)	203	Western Cedars	
Western Woods		Western Red Cedar	.162
Ponderosa Pine	203	Alaskan Yellow Cedar	.220
Idaho White Pine	94	Port Orford Cedar	.205
Sugar Pine	184	Incense Cedar	.163

WEIGHT INCREASE FACTORS

Moisture Content	Increase Factor	Moisture Content	Increase Factor
20%	1.044	50%	1.314
30%	1.140	60%	1.392
40%	1.218	70%	1.483

Example: Weight for three feet of 2 × 8 DF-L @ 30% MC.

3	×	1.5 × 7.5	×	.233	×	1.140	=	8.97 pounds
		actual size of unseasoned 2 × 8		weight factor for DF-L		increase factor for 30% MC		

FLAME SPREAD RATINGS AND SMOKE-DEVELOPED INDICES

Species of wood differ in their burning rates. By measuring these rates, a standard can be established to compare different species of wood with regard to fire safety.

Flame spread classifications have been developed by Underwriters' Laboratories, Inc. The UL Standard Test Method has established a numerical scale based on a noncombustible, asbestos-cement board as 0 (zero) and a combustible red oak as 91. (Prior to 1979, red oak was assigned a value of 100.) The Steiner Tunnel test (ASTM E-84), conducted in a 25-foot-long tunnel furnace, is used to develop the actual burning and flame-spread data. Table 23 provides flame-spread ratings and smoke-developed indices for western softwood species, along with references to the facilities that conducted the tests.

FLAME-SPREAD RATINGS AND SMOKE-DEVELOPED INDICES: CONFORMANCE WITH MODEL BUILDING CODES Table **23**

Western Softwoods	Flame-Spread Rating	Smoke-Developed Index	Source
Western Red Cedar	69	137	W*
Douglas Fir	90	70	W
Pacific Silver Fir	69	53	CWC
West Coast Hemlock	73	80	W
Idaho White Pine	82	83	W
Lodgepole Pine	88	90	W
Ponderosa Pine	115	136	HPVA
Engelmann Spruce	55	35	HPVA
Sitka Spruce	74	71	CWC

W* Weyerhaeuser Fire Technology Unit, 1987, sponsored by Council of Forest Industries.

W Weyerhaeuser Fire Technology Unit, Jan. and Feb. 1988, as determined by ASTM Test Method E-84-87a. Values are averages of two or more test panels.

HPVA Hardwood Plywood & Veneer Association, March/April 1995, as determined by ASTM Test Method E-84-94. Values are averages of three test panels

CWC "Wood and Fire Safety" by the Canadian Wood Council, 199

Model Code Requirements

The most widely accepted flame-spread classification system appears in the National Fire Protection Association Life Safety Code, NFPA No. 101, and the model building codes as follows:

			Example Building Locations:
0–25	flame-spread	Class 1 or A	Enclosed vertical exits
26–75	flame-spread	Class 2 or B	Exit access corridors
76–200	flame-spread—	Class 3 or C	Other rooms and areas

The model building codes require a Smoke Developed Index of 450 or less for most construction applications.

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.7 Specific Gravity and Thermal Conductivity—Western Wood Products

SPECIFIC GRAVITY

Variations in the size of the cell cavities and pores and in the thickness of the cell walls cause some species to have more wood substance per unit volume than others, and therefore to have a higher specific gravity. Thus specific gravity provides an index to one species' density in relation to other species. The higher the number, the higher the specific gravity or density.

SPECIFIC GRAVITY OF WESTERN SOFTWOOD SPECIES Table **24**

Western Species	Specific Gravity[1] (Oven Dry Weight/ Oven Dry Volume)
DOUGLAS FIR-LARCH	.50
Douglas Fir	
Western Larch	
DOUGLAS FIR-SOUTH	.46
Douglas Fir-South	
HEM-FIR	.43
Western Hemlock	
Noble Fir	
California Red Fir	
Grand Fir	
Pacific Silver Fir	
White Fir	
SPRUCE-PINE-FIR (SOUTH)	.36
Engelmann Spruce	
Sitka Spruce	
Lodgepole Pine	
SPRUCE-PINE-FIR (SOUTH)	
MSR 1.2 E to 1.9 E	.42
MSR 2.0 E and higher	.50
ENGELMANN SPRUCE-LODGEPOLE PINE	.38
Engelmann Spruce	
Lodgepole Pine	
ENGELMANN SPRUCE-LODGEPOLE PINE	
MSR 1.5 E and higher grades	.46
WESTERN CEDARS	.36
Western Red Cedar	
Incense Cedar	
Port Orford Cedar	
Alaska Cedar	
WESTERN WOODS	.36
Any of the species in the first four species groups above plus any or all of the following:	
Idaho White Pine	
Ponderosa Pine	
Sugar Pine	
Alpine Fir	
Mountain Hemlock	

[1] **Source:** *National Design Specification for Wood Construction.*

THERMAL CONDUCTIVITY

The relatively low thermal conductivity or "k" of Western softwoods provides a significant amount of insulation. k is the amount of heat (BTUs) transferred in one hour through one square foot of material one inch thick with a difference in temperature of 1° F.

The thermal conductivity of wood increases with increased moisture content and with increased density. The k values for the Western Woods are shown in the table below.

THERMAL CONDUCTIVITY OF WESTERN SOFTWOOD SPECIES Table **25**

Species	*k*[1]	*R*/in
Douglas Fir-Larch	1.06	.94
Douglas Fir-South	.99	1.01
Hem-Fir	.92	1.08
Spruce-Pine-Fir (South)		
Engelmann Spruce	.80	1.25
Lodgepole Pine	.92	1.08
Western Woods		
Ponderosa Pine/Sugar Pine	.89	1.12
Idaho White Pine	.84	1.19
Alpine Fir	.75	1.33
Mountain Hemlock	.98	1.02
Western Cedars	.75	1.33

[1] *k* value is shown for wood with 12% moisture content. For other moisture contents, there is a change in *k* of approximately .01 for each 1% moisture content difference—an increase in *k* for an increase in moisture content and a decrease in *k* for a decrease in moisture content.

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A/07C9/Rev 5 93/8M

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4.4.8 Specifying Rough Carpentry Materials

SPECIFYING ROUGH CARPENTRY MATERIALS

All lumber should be gradestamped by an agency certified by the Board of Review of the American Lumber Standard Committee and manufactured in accordance with *Product Standard PS 20* as published by the U.S. Department of Commerce.

The following guidelines are intended to assist the designer and specifier in establishing the most economical and efficient use of soft lumber products and to eliminate potential misunderstandings between specifier and supplier.

A specification should include all species suited to the job. This broadens availability which can lower costs. Specify standard grades as described in WWPA's *Western Lumber Grading Rules*. Consider all grades suitable for the intended use. For economy in construction, it is recommended that the lowest grade suited to a job be specified.

Verify availability of species and grades with local suppliers. Not all species, grades or patterns are available in all locations.

Structural design values vary depending on size, grade and species. Values assigned to lumber 2" to 4" (nominal) in thickness are assigned to the dry size. Unseasoned lumber is manufactured oversized so that when it reaches 19% moisture content it will be approximately the same size as the dry (S-DRY or KD) size*. Therefore, when unseasoned (S-GRN) lumber is shipped, the same design values that are assigned and used for dry lumber will apply. Design values assigned to lumber 5x5 and larger are assigned to the unseasoned (S-GRN) green size.

2" to 4" thick by 2" to 4" wide Framing Lumber - The most widely available grades are STANDARD & BETTER (STAND & BTR) and STUD, in all of the commercial softwood species.

These grades are appropriate for most general wall framing applications.

STUD, STAND & BTR, and the other grades (CONSTRUCTION and UTILITY) are available in any conventional length. Dimension lumber grades apply to both solid sawn and certified structural-glued lumber.

UTILITY, in any commercial softwood species, may be used for plates, blocking, etc. and some walls. UTILITY grade lumber provides economical construction where good appearance of framing lumber is not needed. Building codes permit the use of UTILITY grade lumber in lightly loaded structural applications.

When small posts or beams (2x4, 4x4) require specific design values, refer to Table 1 to determine appropriateness of CONSTRUCTION, STANDARD and UTILITY grades. Specify according to BASE VALUES. Specified BASE VALUES are then modified by adjustments for engineering analysis.

Some 2x2s through 4x4s may require higher design values than available in these grades. In this case, refer to Table 1 for SELECT STRUCTURAL, NO. 1 & BTR, NO. 1, NO. 2 and NO. 3 grades. Specify BASE VALUE structural values. Adjust BASE VALUES from Table 1 for engineering analysis. Or refer to the design values for machine stress-rated lumber in Table 3.

Specifying machine stress-rated lumber is very straightforward because it is generally marketed by strength and stiffness values, F_b and E. When ordering, specify machine rated (MSR), gradestamped lumber and list the strength value (F_b) and corresponding modulus of elasticity (E) values, nominal sizes and lengths required. Species should only be specified when horizontal shear (F_v), compression perpendicular to grain ($F_{c\perp}$) or specific gravity are controlling.

Some MSR lumber producers provide voluntary daily quality control for tension (F_t) in addition to the mandatory F_b and E testing. When this additional level of quality control is provided, the F_t value will appear on the grade stamp (in addition to F_b and E).

2" to 4" thick by 5" and wider Framing Lumber - Joists, rafters and small beams should be specified by minimum required F_b and E BASE VALUES. Refer to Table 1, page 6, with Adjustment Factors, page 7. Wherever possible, design values should be based on NO. 2 grade values of locally available species as most material is marketed NO. 2 & BTR. NO. 1 & BTR J&P may be available in some markets in some species. Higher values should only be used for longer spans or higher loads. Lightly loaded structures should take advantage of the economy of NO. 3 grade. Machine stress rated and certified structural-glued material of some stresses can be used interchangeably with the above.

Where engineering analysis permits, 2x6 studs can be NO. 3 or STUD grade.

5x5 and larger, Beams/Stringers and Posts/Timbers - The grades are SELECT STRUCTURAL, NO. 1 or NO. 2. Grade and species should be determined by required design values. Refer to Tables 4 & 5, page 11, with appropriate adjustments for conditions of use. Where a maximum dimensional stability is a requirement, specify Free of Heart Center (FOHC), realizing costs will be increased and availability limited.

Structural Decking - The grades are SELECTED DECKING and COMMERCIAL DECKING. Decking is manufactured at either a 19% (S-DRY or KD) or 15% (MC15 or KD15) moisture content. Decking should be allowed to acclimate to its surrounding atmosphere prior to installation. Refer to "Seasoning..." on page 23. Edge gluing is not generally recommended. MC15 or KD15 will minimize shrinkage for exposed applications and may be available at an increased cost. Check with local suppliers.

Some tongue and groove product is manufactured to pattern from NO. 2 & BTR or NO. 3, 2x6 or 2x8 framing lumber. It is generally used for concealed subfloors in deck and girder construction. Refer to Table 1, page 9, for Depth Effect increase for Decking grades. (Table 1, page 3, is for Base Value Dimension grades.)

Appearance of Framing Material - Where structural material is to receive a natural finish and appearance is a factor, the top grade in the respective size category may be specified. While such a specification may yield structural products of good appearance, it is important to recognize that structural grades of lumber are graded primarily for strength rather than appearance; even in the highest grades visual imperfections are not eliminated. The added expense and limited availability of the visually perfect structural grades should be evaluated. If limited quantities are required, it may be beneficial to specify hand-selected material, rather than the top grade, directing which visual characteristics are unacceptable.

*__Note:__ S-DRY (or KD) and S-GRN lumber should not be mixed in a horizontal framing system, e.g. floor joists; and the same applies to a vertical framing system e.g. wall studs. While both DRY and GRN are of the same strength and both will eventually reach the same size, the two will season at different rates before achieving equilibrium with the atmosphere.

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4.4.9 Adjustment Factors for Base Values of Western Wood Products

SIZE FACTORS (C_F) — Table A

Apply to Dimension Lumber Base Values

Grades	Nominal Width (depth)	F_b 2" & 3" thick nominal	F_b 4" thick nominal	F_t	$F_{c//}$	Other Properties
Select Structural, No. 1 & Btr., No. 1, No. 2 & No. 3	2", 3" & 4"	1.5	1.5	1.5	1.15	1.0
	5"	1.4	1.4	1.4	1.1	1.0
	6"	1.3	1.3	1.3	1.1	1.0
	8"	1.2	1.3	1.2	1.05	1.0
	10"	1.1	1.2	1.1	1.0	1.0
	12"	1.0	1.1	1.0	1.0	1.0
	14" & wider	0.9	1.0	0.9	0.9	1.0
Construction & Standard	2", 3" & 4"	1.0	1.0	1.0	1.0	1.0
Utility	2" & 3"	0.4	—	0.4	0.6	1.0
	4"	1.0	1.0	1.0	1.0	1.0
Stud	2", 3" & 4"	1.1	1.1	1.1	1.05	1.0
	5" & wider	1.0	1.0	1.0	1.0	1.0

REPETITIVE MEMBER FACTOR (C_r) — Table B

Apply to Size-adjusted F_b

	REPETITIVE MEMBER USE
Where 2" to 4" thick lumber is used repetitively, such as for joists, studs, rafters and decking, the pieces side by side share the load and the strength of the entire assembly is enhanced. Therefore, where three or more members are adjacent or are not more than 24" on center and are joined by floor, roof or other load distributing elements, the F_b value can be increased 1.15 for repetitive member use.	$F_b \times 1.15$

DURATION OF LOAD ADJUSTMENT (C_D) — Table C

Apply to Size-adjusted Values

Wood has the property of carrying substantially greater maximum loads for short durations than for long durations of loading. Tabulated design values apply to normal load duration. (Factors do not apply to MOE or $F_{c\perp}$.)

LOAD DURATION	FACTOR
Permanent	0.9
Ten Years (Normal Load)	1.0
Two Months (Snow Load)	1.15
Seven Day	1.25
One Day	1.33
Ten Minutes (Wind and Earthquake Loads)	1.6
Impact	2.0

Confirm load requirements with local codes. Refer to Model Building Codes or the National Design Specification for high-temperature or fire-retardant treated adjustment factors.

HORIZONTAL SHEAR ADJUSTMENT (C_H) — Table D

Apply to F_v Values

Horizontal shear values published in Table 1 are based upon the maximum degree of shake, check or split that might develop in a piece. When the actual size of these characteristics is known, the following adjustments may be taken.

2" THICK LUMBER

For convenience, the table below may be used to determine horizontal shear values for any grade of 2" thick lumber in any species when the length of split or check is known and any increase in them is not anticipated.

When length of split on wide face is:	Multiply Tabulated Fv value by:
No split	2.00
1/2 of wide face	1.67
3/4 of wide face	1.50
1 of wide face	1.33
1½ of wide face or more	1.00

3" and THICKER LUMBER

Horizontal shear values for 3" and thicker lumber also are established as if a piece were split full length. When specific lengths of splits are known and any increase in them is not anticipated, the following adjustments may be applied.

When length of split on wide face is:	Multiply Tabulated Fv value by:
No split	2.00
1/2 of narrow face	1.67
1 of narrow face	1.33
1½ of narrow or more	1.00

BASE VALUE EQUATIONS

The basic difference between using BASE VALUES and the design values that were published for dimension lumber prior to the results of the In-Grade Testing Program, is that BASE VALUES must be adjusted for SIZE before conditions of use. The table below shows how the adjustments are applied to BASE VALUES.

BASE VALUE EQUATIONS

Apply to Dimension Lumber Values in Table 1

Base Value	x	Size Adjustment Factor	x	Routine Adjustment Factors			x	Special Use Factors							=	Design Value
F_b	x	C_F	x	C_D	x	C_r	x	C_M	x	C_R	x	C_t	x	C_{fu}	=	F'_b
F_t	x	C_F	x	C_D			x	C_M	x	C_R	x	C_t			=	F'_t
F_v			x	C_D	x	C_H	x	C_M	x	C_R	x	C_t			=	F'_v
$F_{c\perp}$*							x	C_M	x	C_R	x	C_t			=	$F'_{c\perp}$
$F_{c//}$	x	C_F	x	C_D	x			C_M	x	C_R	x	C_t			=	$F'_{c//}$
E							x	C_M	x	C_R	x	C_t			=	E'

* For $F_{c\perp}$ value of 0.02" deformation basis, see Table F.

Note:
- C_F = Size Factor
- C_r = Repetitive Member Factor
- C_H = Horizontal Shear
- C_D = Duration of Load
- C_{fu} = Flat Use Factor
- C_M = Wet Use Factor
- C_R = Fire Retardant Factor, refer to the National Design Specification
- C_t = Temperature Factor, refer to the National Design Specification

The following adjustment factors are shown in the WWPA Product Use Manual:

Flat Use Factors (C_{fu})	(Table E)
Adjustments for Compression Perpendicular to Grain ($C_{c\perp}$)	(Table F)
Wet Use Factors (C_M)	(Table G)

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4.4.10 Additional Adjustment Factors for Western Wood Dimension Lumber

FLAT USE FACTORS (C_{fu}) — Table E

Apply to Size-adjusted F_b

NOMINAL WIDTH	NOMINAL THICKNESS 2" & 3"	NOMINAL THICKNESS 4"
2" & 3"	1.00	—
4"	1.10	1.00
5"	1.10	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.20	1.10

ADJUSTMENTS FOR COMPRESSION PERPENDICULAR-TO-GRAIN ($C_{c\perp}$) — Table F

For Deformation Basis of 0.02"
Apply to $F_{c\perp}$ Values

Design values for compression perpendicular-to-grain ($F_{c\perp}$) are established in accordance with the procedures set forth in ASTM Standards D 2555 and D 245. ASTM procedures consider deformation under bearing loads as a serviceability limit state comparable to bending deflection because bearing loads rarely cause structural failures. Therefore, ASTM procedures for determining compression perpendicular-to-grain values are based on a deformation of 0.04" and are considered adequate for most classes of structures. Where more stringent measures need to be taken in design, the following formula permits the designer to adjust design values to a more conservative deformation basis of 0.02":

$$Y_{02} = 0.73\,Y_{04} + 5.60$$

EXAMPLE: Douglas Fir-Larch: Y_{04} = 625 psi
Y_{02} = 0.73 (625) + 5.60 = 462 psi

WET USE FACTORS (C_M) — Table G

Apply to Size-adjusted Values

The design values shown in the accompanying tables are for routine construction applications where the moisture content of the wood does not exceed 19%. When use conditions are such that the moisture content of dimension lumber will exceed 19%, the Wet Use Adjustment Factors below are recommended:

PROPERTY		ADJUSTMENT FACTOR
F_b	Extreme Fiber Stress in Bending	0.85*
F_t	Tension Parallel-to-Grain	1.0
F_c	Compression Parallel-to-Grain	0.8**
F_v	Horizontal Shear	0.97
$F_{c\perp}$	Compression Perpendicular-to-Grain	0.67
E	Modulus of Elasticity	0.9

*Wet Use Factor 1.0 for size-adjusted F_b not exceeding 1150 psi
**Wet Use Factor 1.0 for size-adjusted F_c not exceeding 750 psi

SPECIAL DIMENSION LUMBER

Grades/End Uses - There are two categories of Special Dimension Lumber grades. Design values are shown in Tables 2 and 3.

a. Structural Decking - 2x4 through 4x12
b. Machine Stress-Rated Lumber (MSR) - nominal 2" and less in thickness, 2" and wider

STRUCTURAL DECKING

Grades/End Uses - Standard decking patterns, in nominal 2" single T&G and 3" and 4" double T&G, are available in vee or eased joints to meet most architectural design requirements. For diagrams of available patterns and sizes, order WWPA's *Standard Patterns* (G-16).

While known and used as "roof decking," the load-bearing capacities of structural decking also make it useful as floor decking and solid sidewall construction. Published design values need to be adjusted for depth effect. Refer to Tables 2 and H below.

Decking spans are provided in Table 10, page 15.

STRUCTURAL DECKING DESIGN VALUES* — Table 2

2" to 4" thick, 4" to 12" wide
USE WITH ADJUSTMENTS, TABLES C, G, H
For Flatwise Use Only

		DRY or MC 15			
		Extreme Fiber Stress in Bending "Fb"		Compression Perpendicular "$F_{c\perp}$"	Modulus of Elasticity "E"
Species	Grade	Single Member	Repetitive Member		
Douglas Fir-Larch	Sel.	1750	2000	625	1,800,000
	Com.	1450	1650	625	1,700,000
Douglas Fir-South	Sel.	1750	1900	520	1,400,000
	Com.	1400	1600	520	1,300,000
Hem-Fir	Sel.	1400	1600	405	1,500,000
	Com.	1150	1350	405	1,400,000
SPFs	Sel.	1150	1350	335	1,400,000
	Com.	950	1100	335	1,200,000
Western Cedars	Sel.	1250	1450	425	1,100,000
	Com.	1050	1200	425	1,000,000
Western Woods	Sel.	1150	1300	335	1,200,000
	Com.	950	1100	335	1,100,000

*Design values in pounds per square inch.
See Table 1 (p. 6) for compression perpendicular-to-grain ($F_{c\perp}$) values.

ADJUSTMENT FACTORS FOR DEPTH EFFECT — Table H

For all widths of Structural Decking
Apply to Dimension Lumber Base Values

Decking bending design values may be adjusted for thickness as shown below because the bending values shown in Table 2 are based on a 4" thick member loaded flatwise.

NOMINAL THICKNESS 2"	3"	4"
1.10	1.04	1.00

ADJUSTMENTS FOR STRUCTURAL DECKING — Checklist 2

- ☐ Duration of Load (C_D) — Table C, page 7
- ☐ Wet Use Factor (C_M) (only when appropriate) — Table G, page 9
- ☐ Depth Effect — Table H, page 9

(By permission of Western Wood Products Association.)

4.4.11 Standard Sizes for Western Wood Finish and Selects (Dry Lumber)

The metric dimensions listed in these rules are calculated at 25.4 millimeters (mm) times the actual dimension in inches, rounded to the nearest millimeter. In case of a dispute on size measurements, the conventional (inch) method of measurement shall take precedence.

STANDARD SIZES for FINISH DRY LUMBER

Thicknesses			Widths		
Nominal	Surfaced		Nominal	Surfaced	
	Inch	mm (1)		Inch	mm (1)
3/8"	5/16	8	2"	1 1/2	38
1/2"	7/16	11	3"	2 1/2	64
5/8"	9/16	14	4"	3 1/2	89
3/4"	5/8	16	5"	4 1/2	114
1"	3/4	19	6"	5 1/2	140
1 1/4"	1	25	7"	6 1/2	165
1 1/2"	1 1/4	32	8" and wider	3/4 off nominal	19 off nominal
1 3/4"	1 3/8	35			
2"	1 1/2	38			
2 1/2"	2	51			
3"	2 1/2	64			
3 1/2"	3	76			
4"	3 1/2	89			

(1) See Section 723.00.

STANDARD SIZES for SELECTS DRY LUMBER

Thicknesses			Widths		
Nominal	Surfaced		Nominal	Surfaced	
	Inch	mm (1)		Inch	mm (1)
4/4	3/4	19	2"	1 1/2	38
5/4	1 5/32	29	3"	2 1/2	64
6/4	1 13/32	36	4"	3 1/2	89
7/4	1 19/32	40	5"	4 1/2	114
8/4	1 13/16	46	6"	5 1/2	140
9/4	2 3/32	53	7"	6 1/2	165
10/4	2 3/8	60	8" and wider	3/4 off nominal	19 off nominal
11/4	2 9/16	65			
12/4	2 3/4	70			
16/4	3 3/4	95			

(1) See Section 723.00.

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4.4.12 Standard Sizes for Western Wood Common Boards, Studs, and Battens

STANDARD SIZES for COMMON BOARDS (Including Thick Lumber Shipped Under Board Rules) DRY LUMBER

Thicknesses Nominal	Surfaced Inch	Surfaced mm (1)	Widths Nominal	Surfaced Inch	Surfaced mm (1)
3/4	5/8	16	2"	1 1/2	38
4/4	3/4	19	3"	2 1/2	64
5/4	1 5/32	29	4"	3 1/2	89
6/4	1 13/32	36	5"	4 1/2	114
7/4	1 19/32	40	6"	5 1/2	140
8/4	1 13/16	46	7"	6 1/2	165
9/4	2 3/32	53	8" and wider	3/4 off nominal	19 off nominal
10/4	2 3/8	60			
11/4	2 9/16	65			
12/4	2 3/4	70			
16/4	3 3/4	95			

(1) See Section 723.00.

Surfaced square size shall be governed by thickness.
At manufacturer's option, dry 4/4 may be 25/32"
Standard lengths are 6' and longer in multiples of 1'.

STANDARD SIZES for STUDS

Nominal	Surfaced Dry Inch	Surfaced Dry mm (1)	Surfaced Unseasoned Inch	Surfaced Unseasoned mm (1)
Thicknesses				
2"	1 1/2	38	1 9/16	40
3"	2 1/2	64	2 9/16	65
4"	3 1/2	89	3 9/16	90
Widths				
2"	1 1/2	38	1 9/16	40
3"	2 1/2	64	2 9/16	65
4"	3 1/2	89	3 9/16	90
5"	4 1/2	114	4 5/8	117
6"	5 1/2	140	5 5/8	143
8" and wider	3/4 off nominal	19 off nominal	1/2 off nominal	13 off nominal

(1) See Section 723.00.

BATTENS

All Species

Standard widths are:

Nominal	Net Inch	Net mm (1)
Flat Battens—3"	1/4 x 2 1/2	6 x 64
O.G. Battens—2"	3/4 x 1 3/4	19 x 44
O.G. Battens—2 1/4"	3/4 x 2 1/4	19 x 57
O.G. Battens—3"	3/4 x 2 1/2	19 x 64

(1) See Section 723.00.

(By permission of Western Wood Products Association.)

4.4.13 Appearance Lumber—Western Wood

The lumber grades in this category are intended for applications where strength is not the primary consideration. Grading is by visual inspection and is a judgment of appearance and suitability to end use rather than of strength. Natural characteristics and manufacturing imperfections are taken into account in the assigning of grades. Lumber in this category is often generically referred to as board lumber, although the category also includes run-to-pattern products and Patio Decking. The highest grades of Appearance lumber are seldom gradestamped, unless on the back or ends, as the grade stamp would deface the product. The general purpose grades, such as COMMONS and ALTERNATE BOARDS, are generally stamped. Refer to page 20 for additional information on grade stamps, moisture content and specifying Appearance lumber.

Many of the Western lumber species are grown, harvested, manufactured and shipped together in "Marketing Categories." In addition to the species combinations that share like structural characteristics, Board lumber is often available in combinations related to like appearance characteristics. Refer to the Marketing Categories species list on page 4 and the WWPA *Western Lumber Grading Rules* for additional information.

APPEARANCE LUMBER GRADES Table **14**

	Product	Grades[1]	Equivalent Grades In Idaho White Pine	WWPA Grading Rules Section Number
Highest Quality Appearance Grades	Selects *(all species)*	B & BTR SELECT	SUPREME	10.11
		C SELECT	CHOICE	10.12
		D SELECT	QUALITY	10.13
	Finish *(usually available only in Doug Fir and Hem-Fir)*	SUPERIOR		10.51
		PRIME		10.52
		E		10.53
	Special Western Red Cedar Pattern[2] Grades	CLEAR HEART		20.11
		A GRADE		20.12
		B GRADE		20.13
General Purpose Grades	Common Boards (WWPA Rules) *(primarily in pines, spruces and cedars)*	1 COMMON	COLONIAL	30.11
		2 COMMON	STERLING	30.12
		3 COMMON	STANDARD	30.13
		4 COMMON	UTILITY	30.14
		5 COMMON	INDUSTRIAL	30.15
	Alternate Boards (WCLIB Rules) *(primarily in Doug Fir and Hem-Fir)*			**WCLIB**[3]
		SELECT MERCHANTABLE		118-a
		CONSTRUCTION		118-b
		STANDARD		118-c
		UTILITY		118-d
		ECONOMY		118-e
	Special Western Red Cedar Pattern[2] Grades			**WCLIB**[3]
		SELECT KNOTTY		111-e
		QUALITY KNOTTY		111-f

[1] Refer to WWPA's *Western Wood Species* book for full color photography and to WWPA's *Natural Wood Siding* for complete information on siding grades, specification and installation.
[2] PATTERN includes finish, paneling, ceiling and siding grades.
[3] West Coast Lumber Inspection Bureau's *West Coast Lumber Standard Grading Rules*.

BOARD LUMBER

Grades/End Uses Select grades are determined from the better side or face and are used for applications where only the finest appearance is appropriate. B & BTR is virtually clear, and very limited in availability. The appearance of C SELECT ranks only slightly less than B & BTR SELECT. D SELECT is suitable where the requirements for finishing are less exacting.

Finish grades are determined from the better side or face and from both edges on pieces 5" and narrower and from the better side or face and one edge on pieces 6" and wider. SUPERIOR is virtually clear. PRIME grade exhibits fine appearance although slightly less restrictive than SUPERIOR. E grade is intended for ripping and cross-cutting to obtain small pieces of PRIME or better quality.

The highest quality, premium cedar grades are typically run-to-pattern into siding or paneling products and may be graded to either the surfaced or a saw textured side. CLEAR VG HEART is intended for use where only the highest quality is indicated. The exposed width is all heartwood and free from imperfections. A grade allows only minor imperfections and is of fine appearance. Square-edged cedar boards are generally manufactured in SELECT grades.

Common Board grades are determined from the better face and are varying qualities of knotty material. 1 and 2 COMMON are usually sold as 2 & BTR COMMON and intended for paneling, shelving and other uses where a fine appearance in knotty material is desirable. 3 COMMON is also widely used for siding, paneling and shelving as well as for fences, boxes, crating, sheathing and industrial applications. 4 COMMON is more widely used than any other grade for general construction such as subfloors, roof & wall sheathing, concrete forms, low-cost fencing, crating, etc. 5 COMMON is intended for economy-governed applications.

Alternate Board grades are determined from the better face. SELECT MERCHANTABLE is intended for use in housing and light construction where it is exposed as paneling, shelving and where knotty type lumber of fine appearance is desirable. CONSTRUCTION is used for spaced sheathing, let-in bracing, fences, boxes, crating and industrial applications. The uses for STANDARD are similar to 3 & 4 COMMON, as described above.

Special Western Red Cedar general purpose grades (SELECT KNOTTY or QUALITY KNOTTY) are similar in appearance to 2 COMMON and 3 COMMON, and are widely used for siding and landscape applications. Knot size and quality are defined in the grading rules; sound, tight knots do not adversely affect performance. Dry knotty siding must not exceed 19% moisture content and it may be specified to MC15 or KD15. Knotty siding is also sometimes manufactured unseasoned.

RUN-TO-PATTERN PRODUCTS

Board lumber is the starting material for many products that are run-to-pattern, such as paneling, siding, flooring, ceiling and partition material. In many cases, the grade of the material that has been run-to-pattern reflects the grade of the starting material, adhering to similar requirements for allowable characteristics.

Refer to WWPA's *Natural Wood Siding–Technical Guide* (TG-8) for comprehensive information on WWPA and WCLIB siding grades, patterns, specification and installation. Refer to WWPA's *Standard Patterns* (G-16) for paneling, flooring, ceiling, partition (and siding) patterns in profile with dimensions. Contact the Wood Moulding & Millwork Producers Association (507 First St., Woodland, CA 95695-4025; 530-661-9591) for moulding and trim patterns in profile.

(*By permission from Western Wood Products Association, Portland, Oregon.*)

4.4.14 Framing Lumber—Western Wood, Shear, Compression, Modulus of Elasticity—Illustrated

Horizontal Shear - F_V
(Fig. 3) Horizontal shear stresses tend to slide fibers over each other horizontally. Most predominate in short, heavily loaded deep beams. Increasing beam cross section decreases shear stresses.

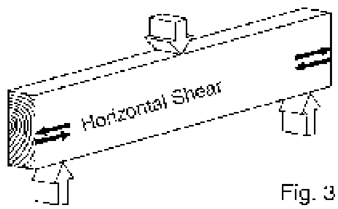


Fig. 3

Compression Perpendicular to Grain - F_C (Fig. 4)
Where a joist, beam or similar piece of lumber bears on supports, the load tends to compress the fibers. It is necessary that the bearing area be sufficient to prevent side-grain crushing.

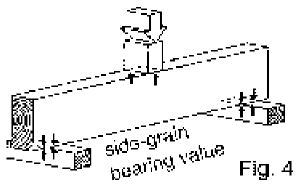


Fig. 4

Compression Parallel to Grain - F_C (Fig. 5)
In many parts of a structure, stress grades are used where the loads are supported on the ends of the pieces. Such uses are as studs, posts, columns and struts. The internal stress induced by this kind of loading is the same across the whole cross section and the fibers are uniformly stressed parallel to and along the full length of the piece.

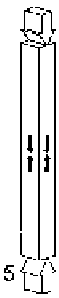
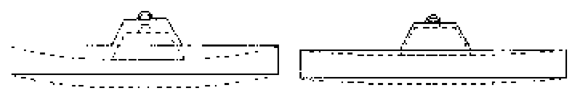


Fig. 5

Modulus of Elasticity - E (Fig. 6)
The modulus of elasticity is a ratio of the amount a material will deflect in proportion to an applied load.



E = 1,000,000 psi
Deflection: 2″

E = 2,000,000 psi
Deflection: 1″

Fig. 6

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.15 Framing Lumber—Western Wood—Nominal and Dressed Sizes

STANDARD SIZES - FRAMING LUMBER
Nominal & Dressed (Based on Western Lumber Grading Rules)

Product	Description	Nominal Size Thickness (inches)	Nominal Size Width (inches)	Dressed Dimensions Thicknesses & Widths Surfaced Dry inches	Surfaced Dry mm	Surfaced Unseasoned inches	Surfaced Unseasoned mm	Length (feet)
		2	2	1½	38	1 9/16	40	
		3	3	2½	64	2 9/16	65	6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)
		4	4	3½	89	3 9/16	90	
			5	4½	114	4⅝	117	
DIMENSION	S4S		6	5½	140	5⅝	143	
			8	7¼	184	7½	191	
			10	9¼	235	9½	241	
			12	11¼	286	11½	292	
			over 12	¾ off nominal	19 off nominal	½ off nominal	13 off nominal	
				Thickness (unseasoned)		Width (unseasoned)		
TIMBERS	Rough or S4S (shipped unseasoned)	5 and larger		½″ (13mm) off nominal (S4S). See 3.20 of WWPA Grading Rules for Rough.				6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)
		Thickness	Width	Thickness (dry) inches	Thickness (dry) mm	Width (dry) inches	Width (dry) mm	
DECKING	2″ (Single T&G)	2	5	1½	38	4	102	6′ (183 cm) and longer, generally shipped in multiples of 2′ (61 cm)
			6			5	127	
			8			6¾	172	
			10			8¾	222	
			12			10¾	273	
	3″ and 4″ (Double T&G)	3	6	2½	64	5¼	133	
		4		3½	89			

Abbreviations: FOHC—Free of Heart Center T&G—Tongued and grooved. Rough Full Sawn—Unsurfaced lumber cut to full specified size S4S—Surfaced four sides

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.16 Dimension Lumber—Western Wood—Grades and Uses

DIMENSION LUMBER

Sizes/Design Values - Dimension lumber includes products that are nominal 2" to 4" in thickness by 2" and wider. It is available in the grades listed in Table 1 (page 6) with assigned design values published as BASE VALUES.

Dimension lumber BASE VALUES must be adjusted for size as well as conditions of use. Adjust the BASE VALUE (Table 1, page 6) according to the correct factor for size (Table A, page 7) before adjusting for conditions of use.

Single member, size-adjusted fiber stress in bending (F_b) design value is for use where the strength of an individual piece, such as a small beam or post, is or may be responsible for carrying a specific design load. Repetitive member use is handled through an adjustment factor, Table B, page 7.

Using BASE VALUES - Dimension lumber values are published as BASE VALUES in Table 1, page 6. BASE VALUES must first be adjusted for size (Table A, page 7) and then for conditions of use (Tables B-D, page 7 and Tables E-F, page 9). The most common condition-of-use adjustments, Repetitive Member, Duration of Load and Horizontal Shear are shown with the SIZE ADJUSTMENT FACTORS on the preceding page. The adjustments for more specific conditions of use, such as Flat Use, Compression Perpendicular, Wet Use and Incising are presented on page 9. **Checklist 1, on page 7, provides a quick reference to all of the adjustments applicable to Dimension lumber BASE VALUES.** Once all appropriate adjustments are taken, the adjusted number becomes the design value for a specific piece in its application. Formulas for BASE VALUES are provided below.

BASE VALUE EQUATIONS Checklist **2**

Apply to Dimension lumber values in Table 1

Base Value	x	Size Adjustment Factor	x	Routine Adjustment Factors			x	Special Use Factors									=	Design Value
F_b	x	C_F	x	C_D	x	C_r	x	C_M	x	C_R	x	C_t	x	C_{fu}	x	C_i	=	F'_b
F_t	x	C_F	x	C_D			x	C_M	x	C_R	x	C_t			x	C_i	=	F'_t
F_v			x	C_D	x	C_H	x	C_M	x	C_R	x	C_t					=	F'_v
$F_{c\perp}$[1]							x	C_M	x	C_R	x	C_t	x	C_i			=	$F'_{c\perp}$
F_c	x	C_F	x	C_D			x	C_M	x	C_R	x	C_t			x	C_i	=	F'_c
E							x	C_M	x	C_R	x	C_t			x	C_i	=	E'

[1] For $F_{c\perp}$ value of 0.02" deformation basis, see Table F.

Note:
C_F = Size Factor
C_r = Repetitive Member Factor
C_H = Horizontal Shear
C_D = Duration of Load
C_{fu} = Flat Use Factor
C_M = Wet Use Factor
C_i = Incising Factor
C_R = Fire Retardant Factor, refer to the National Design Specification
C_t = Temperature Factor, refer to the National Design Specification

Grades/End-Uses - Dimension lumber (2" to 4" thick by 2" and wider) is available in the nine grades listed in Table 1 with BASE VALUES assigned to each grade in a species group. The grades are organized in the *National Grading Rule (NGR)* as Structural Light Framing, Light Framing, Stud and Structural Joists & Planks. These categories are related to size and strength as well as intended end uses.

2x2 through 4x4 - These sizes are available in the Structural Light Framing, Light Framing and Stud strength categories.

Structural Light Framing grades in 2x2 through 4x4 are intended to fit engineering applications where highest design values are needed in light framing sizes. A mix of SELECT STRUCTURAL and NO. 1 may be grade-stamped as NO. 1 & BTR in Douglas Fir, Douglas Fir-Larch or Hem-Fir. Typical uses include trusses, concrete forms, engineered applications, etc. (Numbers in parentheses below are references to paragraph numbers in the *Western Lumber Grading Rules*.)

Structural Light Framing (SLF) grades are:

SELECT STRUCTURAL	(42.10)
NO. 1	(42.11)
NO. 2	(42.12)
NO. 3	(42.13)

Light Framing grades in 2x2 through 4x4 are intended for use where high strength values are not required, such as for wall framing, plates, sills, cripples, blocking, etc.

Light Framing (LF) grades are:

CONSTRUCTION	(40.11)
STANDARD	(40.12)
UTILITY	(40.13)

2x2 through 4x18 - Products within this category can be graded as STUD grade. It is an optional all-purpose grade. (Structural end-glued is limited to 2x2 through 2x6, 12' and shorter.) Characteristics affecting strength and stiffness values are limited so that **STUD** grade is suitable for stud uses, including load-bearing walls.

STUD	(41.13)

2x5 through 4x18 - These sizes, categorized in the *NGR* as Structural Joists and Planks, are intended to fit engineering applications for lumber 5" and wider, such as floor joists, rafters, headers, small beams, trusses and general framing uses. A mix of SELECT STRUCTURAL and NO. 1 may be gradestamped NO. 1 & BTR J&P in Douglas Fir, Douglas Fir-Larch or Hem-Fir.

Structural Joists and Planks (SJ&P) grades are:

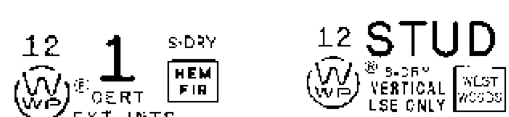
SELECT STRUCTURAL	(62.10)
NO. 1	(62.11)
NO. 2	(62.12)
NO. 3	(62.13)

STRUCTURAL-GLUED LUMBER PRODUCTS

U.S. model building codes have approved the same design values for both solid-sawn Dimension lumber and Structural-glued lumber products.

Currently, WWPA certifies the manufacture of structural-glued Dimension lumber in various species and grades under the following classifications: Light Framing and Studs, Structural Light Framing, Decking, Stress-rated Boards, and Structural Joists and Planks.

A WWPA grade stamp is issued and used only if the material complies with all applicable sections of *WWPA's Glued Products Procedures for Certification and Quality Control.* Order WWPA's *Technical Information Product Sheet, Structural-Glued Lumber* (TG-9) for additional information.



(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.17 Floor Joist Spans—Western Wood

FLOOR JOIST SPANS[1] Table **7**

40# LIVE LOAD

10# DEAD LOAD **L/360**

Design Criteria *Strength* - 10 lb per sq. ft. dead load plus 40 lb per sq. ft. live load.
Deflection - Limited in span in inches divided by 360 for live load only.

Species or Group	Grade	2 x 8 12"	2 x 8 16"	2 x 8 19.2"	2 x 8 24"	2 x 10 12"	2 x 10 16"	2 x 10 19.2"	2 x 10 24"	2 x 12 12"	2 x 12 16"	2 x 12 19.2"	2 x 12 24"	2 x 14 12"	2 x 14 16"	2 x 14 19.2"	2 x 14 24"
Douglas Fir-Larch	Sel. Struc.	15-0	13-7	12-10	11-11	19-1	17-4	16-4	15-2	23-3	21-1	19-10	18-5	27-4	24-10	23-5	21-4
	1 & Btr.	14-8	13-4	12-7	11-8	18-9	17-0	16-0	14-9	22-10	20-9	19-1	17-1	26-10	23-4	21-4	19-1
	No. 1	14-5	13-1	12-4	11-0	18-5	16-5	15-0	13-5	22-0	19-1	17-5	15-7	24-7	21-4	19-6	17-5
	No. 2	14-2	12-9	11-8	10-5	18-0	15-7	14-3	12-9	20-11	18-1	16-6	14-9	23-4	20-3	18-5	16-6
	No. 3	11-3	9-9	8-11	8-0	13-9	11-11	10-11	9-9	15-0	13-10	12-7	11-3	17-10	15-5	14-1	12-7
Douglas Fir-South	Sel. Struc.	13-6	12-3	11-7	10-9	17-3	15-8	14-9	13-9	21-0	19-1	17-11	16-8	24-8	22-5	21-1	19-7
	No. 1	13-2	12-0	11-3	10-6	16-10	15-3	14-5	12-11	20-6	18-4	16-9	15-0	23-8	20-8	18-9	16-9
	No. 2	12-10	11-8	11-0	10-2	16-5	14-11	13-10	12-5	19-11	17-7	16-1	14-4	22-8	19-8	17-11	16-1
	No. 3	11-0	9-6	8-8	7-9	13-5	11-8	10-7	9-6	15-7	13-6	12-4	11-0	17-5	15-1	13-9	12-4
Hem-Fir	Sel. Struc.	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-4	21-11	19-11	18-9	17-5	25-10	23-6	22-1	20-6
	1 & Btr.	13-10	12-7	11-10	11-0	17-8	16-0	15-1	14-0	21-6	19-6	18-2	16-4	25-3	22-4	[illegible]	18-3
	No. 1	13-10	12-7	11-10	10-10	17-8	16-0	14-10	13-3	21-6	18-10	17-2	15-5	24-4	21-1	19-3	17-2
	No. 2	13-2	12-0	11-3	10-2	16-10	15-2	13-10	12-5	20-4	17-7	16-1	14-4	22-6	19-8	17-11	16-1
	No. 3	11-0	9-6	8-8	7-9	13-5	11-8	10-7	9-6	15-7	13-6	12-4	11-0	17-5	15-1	13-9	12-4
Spruce-Pine-Fir (South)	Sel. Struc.	13-2	12-0	11-3	10-6	16-10	15-3	14-5	13-4	20-6	18-7	17-6	16-3	24-1	21-11	20-7	19-2
	No. 1	12-10	11-8	11-0	10-2	16-5	14-11	14-0	12-7	19-11	17-10	16-2	14-7	23-0	19-11	18-2	16-3
	No. 2	12-6	11-4	10-8	9-6	15-11	14-6	13-3	11-10	19-4	16-10	15-4	13-9	21-6	18-9	17-2	15-4
	No. 3	10-5	9-0	8-3	7-5	12-9	11-0	10-1	9-0	14-3	12-10	11-8	10-5	16-6	14-4	13-1	11-8
Western Woods	Sel. Struc.	12-10	11-8	11-0	10-2	16-5	14-11	14-0	12-9	19-11	18-1	16-6	14-9	23-4	20-8	18-5	16-6
	No. 1	12-6	11-1	10-1	9-0	15-7	13-6	12-4	11-0	18-1	15-8	14-4	12-10	20-3	17-6	16-0	14-4
	No. 2	12-1	11-0	10-1	9-0	15-5	13-6	12-4	11-0	18-1	15-8	14-4	12-10	20-3	17-6	16-0	14-4
	No. 3	9-6	8-3	7-6	6-9	11-8	10-1	9-2	8-3	13-6	11-8	10-6	9-6	15-1	13-1	11-11	10-8

Span (feet and inches); spacing on center.

FLOOR JOIST SPANS[1] Table **8**

30# LIVE LOAD

10# DEAD LOAD **L/360**

Design Criteria *Strength* - 10 lb per sq. ft. dead load plus 30 lb per sq. ft. live load.
Deflection - Limited in span in inches divided by 360 for live load only.

Species or Group	Grade	2 x 6 12"	2 x 6 16"	2 x 6 19.2"	2 x 6 24"	2 x 8 12"	2 x 8 16"	2 x 8 19.2"	2 x 8 24"	2 x 10 12"	2 x 10 16"	2 x 10 19.2"	2 x 10 24"	2 x 12 12"	2 x 12 16"	2 x 12 19.2"	2 x 12 24"
Douglas Fir-Larch	Sel. Struc.	12-6	11-4	10-8	9-11	16-6	15-0	14-1	13-1	21-0	19-1	18-0	16-8	25-7	23-3	21-10	20-3
	1 & Btr.	12-3	11-2	10-6	9-9	16-2	14-8	13-10	12-10	20-8	18-9	17-8	16-5	25-1	22-10	21-4	19-1
	No. 1	12-0	10-11	10-4	9-7	15-10	14-5	13-7	12-4	20-3	18-5	16-9	15-0	24-8	21-4	19-6	17-5
	No. 2	11-10	10-9	10-1	9-3	15-7	14-2	13-0	11-8	19-10	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 3	9-11	8-7	7-10	7-0	12-7	10-11	10-0	8-11	15-5	13-4	12-2	10-11	17-10	15-5	14-1	12-7
Douglas Fir-South	Sel. Struc.	11-3	10-3	9-8	8-11	14-11	13-6	12-9	11-10	19-0	17-3	16-3	15-1	23-1	21-0	19-9	18-4
	No. 1	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-6	18-6	16-10	15-10	14-5	22-5	20-6	18-9	16-9
	No. 2	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-2	18-0	16-5	15-5	13-10	21-11	19-8	17-11	16-1
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4
Hem-Fir	Sel. Struc.	11-10	10-9	10-1	9-4	15-7	14-2	13-4	12-4	19-10	18-0	17-0	15-9	24-2	21-11	20-8	19-2
	1 & Btr.	11-7	10-6	9-10	9-2	15-3	13-10	13-0	12-1	19-5	17-8	16-7	15-5	23-7	21-6	20-2	18-3
	No. 1	11-7	10-6	9-10	9-2	15-3	13-10	13-0	12-1	19-5	17-8	16-7	14-10	23-7	21-1	19-3	17-2
	No. 2	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-4	18-6	16-10	15-6	13-10	22-6	19-8	17-11	16-1
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4
Spruce-Pine-Fir (South)	Sel. Struc.	11-0	10-0	9-5	8-9	14-6	13-2	12-5	11-6	18-6	16-10	15-10	14-8	22-6	20-6	19-3	17-11
	No. 1	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-1	21-11	19-11	18-3	16-3
	No. 2	10-5	9-6	8-11	8-3	13-9	12-6	11-9	10-10	17-6	15-11	14-9	13-3	21-4	18-9	17-2	15-4
	No. 3	9-3	8-0	7-3	6-6	11-8	10-1	9-3	8-3	14-3	12-4	11-3	10-1	16-6	14-4	13-1	11-8
Western Woods	Sel. Struc.	10-9	9-9	9-2	8-6	14-2	12-10	12-1	11-3	18-0	16-5	15-5	14-3	21-11	19-11	18-6	16-6
	No. 1	10-5	9-6	8-11	8-0	13-9	12-4	11-4	10-1	17-5	15-1	13-10	12-4	20-3	17-6	16-0	14-4
	No. 2	10-1	9-2	8-8	8-0	13-4	12-1	11-4	10-1	17-0	15-1	13-10	12-4	20-3	17-6	16-0	14-4
	No. 3	8-5	7-3	6-8	5-11	10-8	9-3	8-5	7-6	13-0	11-3	10-3	9-2	15-1	13-1	11-11	10-8

Span (feet and inches); spacing on center.

[1] *Spans for other loads are provided in WWPA's* **Western Lumber Span Tables** *[illegible]. Spans for other grades and Western Cedars may be calculated with either of WWPA's design aids:* **SpanMaster™** *(SM) - an electronic hand held calculator or the WWPA Span Computer (SC), which works like a slide rule.*

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.18 Ceiling Joist Spans—Western Wood

CEILING JOIST SPANS[1] Table **9**

20# LIVE LOAD
10# DEAD LOAD **L/240**

Design Criteria: *Strength* - 10 lb per sq. ft. dead load plus 20 lb per sq. ft. live load.
Deflection - Limited in span in inches divided by 240 for live load only.

Species or Group	Grade	2 x 6 12"	2 x 6 16"	2 x 6 19.2"	2 x 6 24"	2 x 8 12"	2 x 8 16"	2 x 8 19.2"	2 x 8 24"	2 x 10 12"	2 x 10 16"	2 x 10 19.2"	2 x 10 24"	2 x 12 12"	2 x 12 16"	2 x 12 19.2"	2 x 12 24"
Douglas Fir-Larch	Sel. Struc.	16-4	14-11	14-0	13-0	21-7	19-7	18-5	17-2	27-6	25-0	23-7	21-3	33-6	30-2	27-6	24-9
	1 & Btr.	16-1	14-7	13-9	12-9	21-2	19-1	17-5	15-7	26-10	23-3	21-3	19-0	31-2	27-0	24-8	22-0
	No. 1	15-9	13-9	12-6	11-2	20-1	17-5	15-10	14-2	24-6	21-3	19-5	17-4	28-5	24-8	22-6	20-1
	No. 2	15-0	13-0	11-11	10-8	19-1	16-6	15-1	13-6	23-3	20-2	18-5	16-5	27-0	23-4	21-4	19-1
	No. 3	11-6	9-11	9-1	8-1	14-7	12-7	11-6	10-3	17-9	15-5	14-1	12-7	20-7	17-10	16-3	14-7
Douglas Fir-South	Sel. Struc.	14-9	13-5	12-8	11-9	19-6	17-9	16-8	15-6	24-10	22-7	21-3	19-9	30-3	27-6	25-10	23-4
	No. 1	14-5	13-1	12-1	10-9	19-0	16-9	15-3	13-8	23-7	20-5	18-8	16-8	27-4	23-8	21-7	19-4
	No. 2	14-1	12-8	11-7	10-4	18-6	16-0	14-8	13-1	22-7	19-7	17-10	16-0	26-3	22-8	20-9	18-6
	No. 3	11-2	9-8	8-10	7-11	14-2	12-4	11-3	10-0	17-4	15-0	13-8	12-3	20-1	17-5	15-11	14-3
Hem-Fir	Sel. Struc.	15-6	14-1	13-3	12-3	20-5	18-6	17-5	16-2	26-0	23-8	22-3	20-6	31-8	28-9	26-7	23-9
	1 & Btr.	15-2	13-9	12-11	11-9	19-11	18-2	16-8	14-11	25-5	22-3	20-4	18-2	29-10	25-10	23-7	21-1
	No. 1	15-2	13-7	12-4	11-1	19-10	17-2	15-8	14-0	24-3	21-0	19-2	17-1	28-1	24-4	22-2	19-10
	No. 2	14-5	12-8	11-7	10-4	18-6	16-0	14-8	13-1	22-7	19-7	17-10	16-0	26-3	22-8	20-9	18-6
	No. 3	11-2	9-8	8-10	7-11	14-2	12-4	11-3	10-0	17-4	15-0	13-8	12-3	20-1	17-5	15-11	14-3
Spruce-Pine-Fir (South)	Sel. Struc.	14-5	13-1	12-4	11-5	19-0	17-3	16-3	15-1	24-3	22-1	20-9	19-3	29-6	26-10	25-3	22-11
	No. 1	14-1	12-9	11-9	10-6	18-6	16-3	14-10	13-3	22-11	19-10	18-2	16-3	26-7	23-0	21-0	18-10
	No. 2	13-8	12-1	11-0	9-10	17-6	15-4	14-0	12-6	21-7	18-8	17-1	15-3	25-0	21-8	19-9	17-8
	No. 3	10-8	9-3	8-5	7-6	13-6	11-8	10-8	9-6	16-5	14-3	13-0	11-8	19-1	16-6	15-1	13-6
Western Woods	Sel. Struc.	14-1	12-9	11-11	10-9	18-6	16-6	15-1	13-6	23-3	20-2	18-5	16-5	27-0	23-4	21-4	19-1
	No. 1	13-0	11-3	10-4	9-3	16-6	14-3	13-0	11-8	20-2	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 2	13-0	11-3	10-4	9-3	16-6	14-3	13-0	11-8	20-2	17-5	15-11	14-3	23-4	20-3	18-6	16-6
	No. 3	9-8	8-5	7-8	6-10	12-4	10-8	9-9	8-8	15-0	13-0	11-10	10-7	17-5	15-1	13-9	12-4

Span (feet and inches); spacing on center.

STRUCTURAL DECKING SPANS Table **10**

Spans for 4" to 12" wide lumber manufactured and used at a maximum moisture content of 19%.
Spans are given in feet-inches.

Species / Grade	2" Douglas Fir-Larch Sel.	2" Douglas Fir-Larch Com.	2" Douglas Fir-South Sel.	2" Douglas Fir-South Com.	2" Hem-Fir Sel.	2" Hem-Fir Com.	2" Spruce-Pine-Fir (South) Sel.	2" Spruce-Pine-Fir (South) Com.	2" Western Cedars Sel.	2" Western Cedars Com.	2" Western Woods Sel.	2" Western Woods Com.	3" Douglas Fir-Larch Sel.	3" Douglas Fir-Larch Com.	3" Douglas Fir-South Sel.	3" Douglas Fir-South Com.	3" Hem-Fir Sel.	3" Hem-Fir Com.	3" Spruce-Pine-Fir (South) Sel.	3" Spruce-Pine-Fir (South) Com.	3" Western Cedars Sel.	3" Western Cedars Com.	3" Western Woods Sel.	3" Western Woods Com.
FLOOR DECKING - 10 psf Dead Load / 40 psf Live Load (normal load) — L/480 Deflection Limit																								
Simple	5-3	[illegible]	5-1	4-11	5-2	5-1	5-[illegible]	4-[illegible]	4-8	4-7	4-10	4-5	9-3	9-0	8-6	8-0	8-6	8-6	8-6	8-1	7-10	7-7	8-1	7-10
Controlled Random	6-0	5-11	5-7	5-5	5-8	5-7	5-7	5-8	5-1	5-0	[illegible]	[illegible]	10-7	10-4	9-9	9-5	9-1	[illegible]	[illegible]	9-3	9-0	8-8	9-2	9-0
ROOF DECKING - 10 psf Dead Load / 20 psf Live Load (seven-day load) — L/240 Deflection Limit																								
Simple	8-9	8-7	8-4	7-10	8-3	8-1	8-[illegible]	7-6	7-5	7-3	7-8	7-5	14-7	14-4	13-5	13-[illegible]	13-9	13-[illegible]	13-5	12-[illegible]	12-5	12-0	12-9	12-5
Controlled Random	9-7	[illegible]	8-10	8-7	9-0	8-10	8-10	8-4	8-2	7-10	8-4	8-2	16-9	16-[illegible]	15-5	15-[illegible]	15-9	15-[illegible]	15-[illegible]	14-8	14-8	13-8	14-8	14-8
ROOF DECKING - 10 psf Dead Load / 30 psf Live Load (snow load) — L/240 Deflection Limit																								
Simple	7-8	7-6	7-1	6-[illegible]	7-3	7-[illegible]	7-1	6-8	6-5	6-4	6-8	6-6	12-0	12-[illegible]	11-9	11-[illegible]	12-0	11-0	11-0	11-2	10-10	10-6	11-2	10-10
Controlled Random	8-[illegible]	8-8	7-8	7-6	7-0	7-6	7-4	7-[illegible]	7-1	6-1	7-4	7-1	14-5	14-5	13-6	13-[illegible]	13-9	13-6	13-3	12-10	12-5	12-1	12-10	12-5
ROOF DECKING - 10 psf Dead Load / 40 psf Live Load (snow load) — L/240 Deflection Limit																								
Simple	7-0	6-10	6-6	6-3	6-7	6-6	6-5	6-1	6-11	5-9	6-[illegible]	5-11	11-7	11-5	10-8	10-5	10-11	10-8	10-6	10-2	9-10	9-6	10-2	9-0
Controlled Random	7-7	7-5	7-0	6-10	7-2	7-0	7-0	6-8	6-5	6-3	6-8	5-5	13-4	13-1	12-3	11-11	12-6	12-3	12-3	11-6	11-4	10-11	11-6	11-4

Spans for Dimension Lumber (8" & narrower) run-to-pattern as 2" and 3" decking may be used as follows:

No. 2 Grade

- DF-L uses spans for Hem-Fir Selected Decking.
- DF-S uses spans for Western Woods Selected Decking.
- H-F uses spans for Douglas Fir-South Commercial Decking.
- SPFS uses spans for Western Woods Commercial Decking.
- Other species groups use spans for Western Cedars Commercial Decking.

No. 3 Grade (for Roof Decking: use Simple lay-up spans for both Simple and Controlled Random lay-ups.)

- DF-L uses spans for Douglas Fir-South Selected Decking.
- DF-S uses spans for Western Cedars Selected Decking.
- H-F uses spans for Western Woods Selected Decking.
- SPFS uses spans for Western Cedars Commercial Decking with reductions of 3" for 2" Decking, and 5" for 3" Decking.

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.19 Properties of S4S (Square Four Sides) Lumber

PROPERTIES OF STANDARD DRESSED SIZES (S4S)

Certain mathematical expressions of the properties or elements of sections are used in computing the values of structural members of various shapes for the various conditions under which they are subjected to stress. The properties or elements of sections of standard sizes of joists, planks, beams, stringers, posts, timbers and decking are given in the following tables.

NEUTRAL AXIS, X–X in the diagrams, in the cross section of a beam or column in a state of flexure, is the line on which there is neither tension nor compression.

In the following tables, which show the properties of the rectangular and square sections of lumber, the neutral axis has been assumed as perpendicular to the depth of the section at its center, the depth "h" being parallel to and in the direction of the application of the force or load.

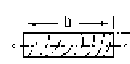
MOMENT OF INERTIA, I, of the cross section of a beam is the sum of the products of each of its elementary areas by the square of their distance from the neutral axis of the section.

SECTION MODULUS, S, is the moment of inertia divided by the distance from the neutral axis to the extreme fiber of the section.

CROSS SECTION is a section taken through the member perpendicular to its longitudinal axis.

SECTION PROPERTIES OF PLANKS

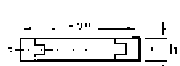
Table **11**



Nominal Size in Inches $b \times h$	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
3 × 2	2.5 × 1.5	3.75	0.938	0.703	0.50
4 × 2	3.5 × 1.5	5.25	1.312	0.984	0.67
6 × 2	5.5 × 1.5	8.25	2.062	1.547	1.00
8 × 2	7.25 × 1.5	10.88	2.719	2.039	1.33
10 × 2	9.25 × 1.5	13.88	3.469	2.602	1.67
12 × 2	11.25 × 1.5	16.88	4.219	3.164	2.00
4 × 3	3.5 × 2.5	8.75	3.646	4.557	1.00
6 × 3	5.5 × 2.5	13.75	5.729	7.161	1.50
8 × 3	7.25 × 2.5	18.12	7.552	9.440	2.00
10 × 3	9.25 × 2.5	23.12	9.635	12.044	2.50
12 × 3	11.25 × 2.5	28.12	11.719	14.648	3.00
14 × 3	13.25 × 2.5	33.12	13.802	17.253	3.50
16 × 3	15.25 × 2.5	38.12	15.885	19.857	4.00
6 × 4	5.5 × 3.5	19.25	11.229	19.651	2.00
8 × 4	7.25 × 3.5	25.38	14.802	25.904	2.67
10 × 4	9.25 × 3.5	32.38	18.885	33.049	3.33
12 × 4	11.25 × 3.5	39.38	22.969	40.195	4.00
14 × 4	13.25 × 3.5	46.38	27.052	47.341	4.67
16 × 4	15.25 × 3.5	53.38	31.135	54.487	5.33

SECTION PROPERTIES OF DECKING (per foot of width)

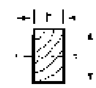
Table **12**



Nominal Size in Inches h	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
2	12 × 1.5	18.00	4.50	3.375	2.00
3	2.5	30.00	12.50	15.625	3.00
4	3.5	42.00	24.50	42.875	4.00

SECTION PROPERTIES OF JOISTS AND BEAMS

Table **13**



Nominal Size in Inches $b \times h$	Surfaced Size for Design in Inches $b \times h$	Area (A) $A = bh$ (in²)	Section Modulus (S) $S = \frac{bh^2}{6}$ (in³)	Moment of Inertia (I) $I = \frac{bh^3}{12}$ (in⁴)	Board Feet per Lineal Foot of Piece
2 × 2	1.5 × 1.5	2.25	0.562	0.422	0.33
2 × 3	1.5 × 2.5	3.75	1.56	1.95	0.50
2 × 4	1.5 × 3.5	5.25	3.06	5.36	0.67
2 × 6	1.5 × 5.5	8.25	7.56	20.80	1.00
2 × 8	1.5 × 7.25	10.88	13.14	47.63	1.33
2 × 10	1.5 × 9.25	13.88	21.39	98.93	1.67
2 × 12	1.5 × 11.25	16.88	31.64	177.98	2.00
2 × 14	1.5 × 13.25	19.88	43.89	290.78	2.33
3 × 3	2.5 × 2.5	6.25	2.60	3.26	0.75
3 × 4	2.5 × 3.5	8.75	5.10	8.93	1.00
3 × 6	2.5 × 5.5	13.75	12.60	34.66	1.50
3 × 8	2.5 × 7.25	18.12	21.90	79.39	2.00
3 × 10	2.5 × 9.25	23.12	35.65	164.89	2.50
3 × 12	2.5 × 11.25	28.12	52.73	296.63	3.00
3 × 14	2.5 × 13.25	33.12	73.15	484.63	3.50
3 × 16	2.5 × 15.25	38.12	96.90	738.87	4.00
4 × 4	3.5 × 3.5	12.25	7.15	12.51	1.33
4 × 6	3.5 × 5.5	19.25	17.65	48.53	2.00
4 × 8	3.5 × 7.25	25.38	30.66	111.15	2.67
4 × 10	3.5 × 9.25	32.38	49.91	230.84	3.33
4 × 12	3.5 × 11.25	39.38	73.83	415.28	4.00
4 × 14	3.5 × 13.25	46.38	102.41	678.48	4.67
4 × 16	3.5 × 15.25	53.38	135.66	1034.42	5.33
6 × 6	5.5 × 5.5	30.25	27.73	76.26	3.00
6 × 8	5.5 × 7.5	41.25	51.56	193.36	4.00
6 × 10	5.5 × 9.5	52.25	82.73	392.96	5.00
6 × 12	5.5 × 11.5	63.25	121.23	697.07	6.00
6 × 14	5.5 × 13.5	74.25	167.06	1127.67	7.00
6 × 16	5.5 × 15.5	85.25	220.23	1706.78	8.00
6 × 18	5.5 × 17.5	96.25	280.73	2456.38	9.00
6 × 20	5.5 × 19.5	107.25	348.56	3398.48	10.00
8 × 8	7.5 × 7.5	56.25	70.31	263.67	5.33
8 × 10	7.5 × 9.5	71.25	112.81	535.86	6.67
8 × 12	7.5 × 11.5	86.25	165.31	950.55	8.00
8 × 14	7.5 × 13.5	101.25	227.81	1537.73	9.33
8 × 16	7.5 × 15.5	116.25	300.31	2327.42	10.67
8 × 18	7.5 × 17.5	131.25	382.81	3349.61	12.00
8 × 20	7.5 × 19.5	146.25	475.31	4634.30	13.33
8 × 22	7.5 × 21.5	161.25	577.81	6211.48	14.67
8 × 24	7.5 × 23.5	176.25	690.31	8111.17	16.00
10 × 10	9.5 × 9.5	90.25	142.90	678.76	8.33
10 × 12	9.5 × 11.5	109.25	209.40	1204.03	10.00
10 × 14	9.5 × 13.5	128.25	288.56	1947.80	11.67
10 × 16	9.5 × 15.5	147.25	380.40	2948.07	13.33
10 × 18	9.5 × 17.5	166.25	484.90	4242.84	15.00
10 × 20	9.5 × 19.5	185.25	602.06	5870.11	16.67
10 × 22	9.5 × 21.5	204.25	731.90	7867.88	18.33
12 × 12	11.5 × 11.5	132.25	253.48	1457.51	12.00
12 × 14	11.5 × 13.5	155.25	349.31	2357.86	14.00
12 × 16	11.5 × 15.5	178.25	460.48	3568.71	16.00
12 × 18	11.5 × 17.5	201.25	586.98	5136.07	18.00
12 × 20	11.5 × 19.5	224.25	728.81	7105.92	20.00
12 × 22	11.5 × 21.5	247.25	885.98	9524.28	22.00
12 × 24	11.5 × 23.5	270.25	1058.48	12437.13	24.00

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4.4.20 Timbers—Western Wood

TIMBERS

Grades/End Uses - "Timbers" is both the general classification for the larger sizes of structural framing lumber and the name of a specific grade and size. There are two basic grade groups within the "Timbers" classification:

- **Beams and Stringers** - 5" and thicker, width more than 2" greater than thickness (6x10, 8x12, etc.);
- **Post and Timbers** - 5x5 and larger, width not more than 2" greater than thickness (6x8, 8x8, etc.).

Design values assigned to each grade and species group are shown in Tables 4 and 5, page [illegible]. End uses include heavy framing applications in both conventional and pre-engineered systems. This classification of grades requires its own Wet Use, Size/Depth Effect and Flat Use adjustments (see below).

ADJUSTMENT FACTORS FOR TIMBERS

WET USE FACTOR (C_M) Table **J**
APPLY TO BEAMS & STRINGERS/ POSTS & TIMBERS
5" and thicker lumber

When lumber 5" and thicker is designed for exposed uses where the moisture content will exceed 19% for an extended period of time, the design values shown in Tables 4 and 5 should be multiplied by the following adjustment factors:

F_b	F_t	F_v	$F_{c\perp}$	F_c	E
1.00	1.00	1.00	0.67	0.91	1.00

SIZE/DEPTH EFFECT ADJUSTMENT (C_F) Table **K**
APPLY TO BEAMS & STRINGERS/ POSTS & TIMBERS
5" and thicker lumber

When the depth of a rectangular sawn lumber bending member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor C_F, as determined by this formula:

$$C_F = \left(\frac{12}{d}\right)^{1/9}$$

Note: The following adjustment factors are derived from the formula above.

Nominal Depth	Net Surfaced Depth (d)	Depth Adjustment Factor (C_F)
14	13.5	0.987
16	15.5	0.972
18	17.5	0.959
20	19.5	0.947
22	21.5	0.937
24	23.5	0.928
26	25.5	0.920
28	27.5	0.912
30	29.5	0.905

In structural designs for loads applied on the wide face, the fiber stress in bending and Modulus of Elasticity (MOE) values in Table 4 should be multiplied by the factors shown in the following table.

FLAT USE FACTOR Table **L**
APPLY TO BEAMS & STRINGERS SUBJECTED TO LOADS APPLIED ON THE WIDE FACE[1]

Grade	F_b	E	Other Properties
Select Structural	0.86	1.00	1.00
No. 1	0.74	0.90	1.00
No. 2	1.00	1.00	1.00

[1] Posts and Timbers graded to Section 70.10, 70.11 and 70.[illegible] of the *Western Lumber Grading Rules* may use the design values in Table 4 without the above flat use adjustment factors.

ADJUSTMENTS FOR BEAMS & STRINGERS/ POSTS & TIMBERS Checklist **5**

☐ Duration of Load (C_D)	Table C, page 7
☐ Horizontal Shear (C_H)	Table D, page 7
☐ Compression Perpendicular ($C_{c\perp}$)	Table F, page 9
☐ Incising Factor (C_i)	Table H, page 9
☐ Wet Use Adjustment (C_M)	Table J, page 12
☐ Depth Effect	Table K, page 12
☐ Flat Use (C_{fu})	Table L, page 12

PHYSICAL PROPERTIES ILLUSTRATED

Extreme Fiber Stress in Bending - F_b (Fig. 1) - When loads are applied, structural members bend, producing tension in the fibers along the faces farthest from the applied load and compression in the fibers along the face nearest to the applied load. These induced stresses in the fibers are designated as "extreme fiber stress in bending" (F_b).

Single Member F_b design values are used in design where the strength of an individual piece, such as a beam, may be solely responsible for carrying a specific design load.

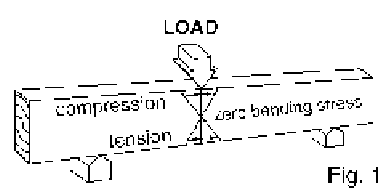

Fig. 1

Repetitive Member F_b design values are used in design when three or more load sharing members, such as joists, rafters, or studs, are spaced no more than 24" apart and are joined by flooring, sheathing or other load-distributing elements. Repetitive members are also used where pieces are adjacent, such as decking.

Fiber Stress in Tension - F_t (Fig. 2) Tensile stresses are similar to compression parallel to grain in that they act across the full cross section and tend to stretch the piece. Length does not affect tensile stresses.

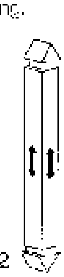
Fig. 2

(By permission from Western Wood Products Association, Portland, Oregon.)

4.4.21 Beams, Stringers, Post, and Timbers—Western Wood

BEAMS & STRINGERS DESIGN VALUES[1] Table **4**

5" and thicker, width more than 2" greater than thickness[2] — Grades described in Sections 53.00 and 70.00 of *Western Lumber Grading Rules*

Species or Group	Grade	Extreme Fiber Stress in Bending F_b[2]	Tension Parallel to Grain F_t	Horizontal Shear F_v	Compression: Perpendicular $F_{c\perp}$	Compression: Parallel to Grain F_c	Modulus of Elasticity E
Douglas Fir-Larch	Dense Select Structural	1850	1100	85	730	1300	1,700,000
	Dense No. 1	1550	775	85	730	1100	1,700,000
	Dense No. 2	1000	500	85	730	700	1,400,000
	Select Structural	1600	950	85	625	1100	1,600,000
	No. 1	1350	675	85	625	925	1,600,000
	No. 2	875	425	85	625	600	1,300,000
Douglas Fir-South	Select Structural	1550	900	85	520	1000	1,200,000
	No. 1	1300	625	85	520	850	1,200,000
	No. 2	825	425	85	520	525	1,000,000
Hem-Fir	Select Structural	1250	725	70	405	925	1,300,000
	No. 1	1050	525	70	405	775	1,300,000
	No. 2	675	325	70	405	475	1,100,000
Spruce-Pine-Fir (South)	Select Structural	1050	625	65	335	675	1,200,000
	No. 1	900	450	65	335	575	1,200,000
	No. 2	575	300	65	335	350	1,000,000
Western Cedars	Select Structural	1150	700	70	425	875	1,000,000
	No. 1	975	475	70	425	725	1,000,000
	No. 2	625	325	70	425	475	800,000
Western Woods (and White Woods)	Select Structural	1050	625	65	335	675	1,100,000
	No. 1	900	450	65	335	575	1,100,000
	No. 2	575	300	65	335	350	900,000

[1] Design Values in pounds per square inch. See Sections 100.00 through 170.00 in the *Western Lumber Grading Rules* for additional information on these values.

[2] When the depth of a rectangular sawn lumber bending member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor in Table 4.

POSTS & TIMBERS DESIGN VALUES[1] Table **5**

5" x 5" and larger, width not more than 2" greater than thickness[2] — Grades described in Sections 53.00 and 80.00 of *Western Lumber Grading Rules*

Species or Group	Grade	Extreme Fiber Stress in Bending F_b[2]	Tension Parallel to Grain F_t	Horizontal Shear F_v	Compression: Perpendicular $F_{c\perp}$	Compression: Parallel to Grain F_c	Modulus of Elasticity E
Douglas Fir-Larch	Dense Select Structural	1750	1150	85	730	1350	1,700,000
	Dense No. 1	1400	950	85	730	1200	1,700,000
	Dense No. 2	800	550	85	730	550	1,400,000
	Select Structural	1500	1000	85	625	1150	1,600,000
	No. 1	1200	825	85	625	1000	1,600,000
	No. 2	700	475	85	625	475	1,300,000
Douglas Fir-South	Select Structural	1400	950	85	520	1050	1,200,000
	No. 1	1150	775	85	520	925	1,200,000
	No. 2	650	400	85	520	425	1,000,000
Hem-Fir	Select Structural	1200	800	70	405	975	1,300,000
	No. 1	950	650	70	405	850	1,300,000
	No. 2	525	350	70	405	375	1,100,000
Spruce-Pine-Fir (South)	Select Structural	1000	675	65	335	700	1,200,000
	No. 1	800	550	65	335	625	1,200,000
	No. 2	450	300	65	335	275	1,000,000
Western Cedars	Select Structural	1100	725	70	425	925	1,000,000
	No. 1	875	600	70	425	800	1,000,000
	No. 2	550	350	70	425	375	800,000
Western Woods (and White Woods)	Select Structural	1000	675	65	335	700	1,100,000
	No. 1	800	550	65	335	625	1,100,000
	No. 2	475	325	65	335	325	900,000

[1] Design Values in pounds per square inch. See Sections 100.00 through 170.00 in the *Western Lumber Grading Rules* for additional information on these values.

[2] When the depth of a rectangular sawn lumber bending member exceeds 12 inches, the design value for extreme fiber stress in bending (F_b) shall be multiplied by the size factor in Table 4.

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4.4.22 MSR Lumber—Western Wood

MSR LUMBER

Machine Stress-rated Lumber (MSR) is Dimension lumber that has been evaluated by mechanical stress-rating equipment. The stress rating equipment measures the stiffness of the material and sorts it into various modulus of elasticity (E) classes.

Research has shown that a direct relationship exists between the bending stiffness of a piece of lumber, its bending strength or modulus of rupture (MOR), and its ultimate tensile strength (UTS).

Since the only way to determine strength values is to actually break the piece, the next best thing is to measure the stiffness, compute the modulus of elasticity, and then predict the strength values.

MSR lumber is distinguished from visually stress-graded lumber in that each piece is nondestructively evaluated for bending stiffness and sorted into modulus of elasticity classes.

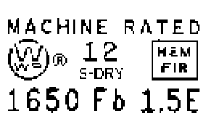
Following this "E" sorting, each piece must also meet certain visual requirements and daily quality control test procedures for both F_b and E.

Voluntary procedures - Because there is a direct relationship between specific gravity values and MSR lumber grades (with higher-strength grades having higher specific gravity values), some MSR lumber producers provide voluntary daily quality control for specific gravity (SG) and/or tension (F_t) in addition to the mandatory F_b and E testing. When these additional levels of quality control are provided, the producer may include the appropriate F_t, SG and specific gravity related compression perpendicular to grain value ($F_{c\perp}$) and horizontal shear (F_v) values on the grade stamp in addition to F_b and E. MSR producers providing one or more of these additional levels of quality control may choose to limit the number of grades which are subject to F_t and SG testing.

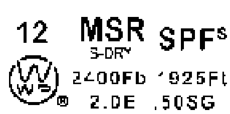
End Uses - One of the prime uses for Machine Stress-rated lumber is trusses; however, this product is also used as floor and ceiling joists, as rafters and for other structural purposes where assured strength capabilities are primary product considerations.

Code Acceptability - MSR lumber produced under an approved grading agency's certification and quality control procedures is accepted by regulatory agencies and all major building codes.

Refer to page 17 for information on specifying MSR lumber. Order WWPA's *Machine Stress-Rated Lumber* (TG 4) for additional information on MSR products and quality control procedures.



Typical MSR Stamp



MSR Stamp with Tension and Specific Gravity Quality Control

DESIGN VALUES

When designing with MSR lumber, the appropriate adjustments in Tables B-H must be applied to the numbers in Table 3.

F_b: For any given value of F_b the average modulus of elasticity (E), may vary depending on species, timber source and other variables. The E values included in the F_b-E grade designations in Table 3 are those usually associated with each F_b level. Grade stamps may show higher or lower E values (in increments of 100,000 psi) if machine rating indicates the assignment is appropriate. When an E value varies from the designated F_b level in the table, the tabulated F_b, F_t and F_c values associated with the designated F_b value are applicable.

$F_{c\perp}$ and F_v: Design values for compression perpendicular to grain ($F_{c\perp}$) and horizontal shear (F_v) are the same as assigned to visually graded lumber of the appropriate species. These average $F_{c\perp}$ and F_v values for Western lumber are provided in Table 1, page 6.

DESIGN VALUES[1] Table **3**
MACHINE STRESS-RATED LUMBER
2" and less in thickness, 2" and wider
Use with appropriate Adjustments in Tables B through H

Grade Designation	F_b Single	E	F_t	F_c
2850 F_b-2.3E	2850	2,300,000	2300	2150
2700 F_b-2.2E	2700	2,200,000	2150	2100
2550 F_b-2.1E	2550	2,100,000	2050	2025
2400 F_b-2.0E	2400	2,000,000	1925	1975
2250 F_b-1.9E	2250	1,900,000	1750	1925
2100 F_b-1.8E	2100	1,800,000	1575	1875
1950 F_b-1.7E	1950	1,700,000	1375	1800
1800 F_b-1.6E	1800	1,600,000	1175	1750
1650 F_b-1.5E	1650	1,500,000	1020	1700
1500 F_b-1.4E	1500	1,400,000	900	1650
1450 F_b-1.3E	1450	1,300,000	800	1625
1350 F_b-1.3E	1350	1,300,000	750	1600
1200 F_b-1.2E	1200	1,200,000	600	1400
900 F_b-1.0E	900	1,000,000	350	1050

[1] Design values in pounds per square inch.

DERIVING COMPRESSION PERPENDICULAR TO GRAIN VALUE ($F_{c\perp}$)

When a grade of MSR lumber is qualified by testing and daily quality control for specific gravity (SG), the allowable $F_{c\perp}$ value may be calculated (rather than drawn from published tables). When SG is included in the grade stamp, the $F_{c\perp}$ may be calculated by the following research-based formula:

$F_{c\perp}$ = (2252.4 x SG) - 480

$F_{c\perp}$ values, determined by the above equation, will be based on a 0.04 inch deformation limit and are for the design of most structures.

DERIVING HORIZONTAL SHEAR VALUE (F_v)

When a grade of MSR lumber is qualified by testing and daily quality control for specific gravity (SG), the allowable F_v value may be calculated (rather than drawn from published tables). When SG is included in the grade stamp, the F_v may be calculated using the following research-based formula:

F_v = 20.6 + (136.08 x SG)

Once the F_v has been calculated, it is subject to the adjustments for wide and narrow face splits, as provided in Table D.

(The above formulas for calculating $F_{c\perp}$ and F_v when SG is known are approved by the ALS Board of Review and provided in the *Western Lumber Grading Rules*.)

ADJUSTMENTS FOR MSR LUMBER Checklist **4**

☐	Repetitive Member Use Factor (C_r)	Table B, page 7
☐	Duration of Load (C_D)	Table C, page 7
☐	Horizontal Shear (C_H)	Table D, page 7
☐	Flat Use Factor (C_{fu})	Table F, page 9
☐	Compression Perpendicular ($C_{c\perp}$)	Table F, page 9
☐	Wet Use Factor (C_M)	Table G, page 9
☐	Incising Factor (C_i)	Table H, page 9

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4.4.23 Patio Decking—Western Wood

RADIUS-EDGED PATIO DECKING

Grades/End-Uses - Western Patio Decking is manufactured to be used flat wise for load bearing applications where spans are maximum 16" on center. This product offers an excellent option for decks and landscaping applications where Structural Decking or other dimension products would not be sufficiently refined in appearance to suit the end use.

Its thin profile, with oversized eased edges, makes it suitable for out door and garden applications such as patio decks, benches, railings, trim and fencing. It may be used for planters and shelving where stock thinner than regular 2"-decking is desirable.

Patio Decking is available in two grades: PATIO 1 and PATIO 2.

PATIO 1 is similar in appearance (in terms of limitations on natural characteristic but allowing fewer restrictions with regards to manufacturing imperfections) to a 2 & BTR COMMON; whereas PATIO 2 is similar in appearance to the upper end of the 3 COMMON. Refer to page 18 for a description of the COMMON grades.

Patio Decking is manufactured primarily in Ponderosa Pine (which has a cell structure very receptive to preservative pressure treating) and the Western Cedars (which are naturally durable). The Patio grades are gradually becoming available in other Western lumber species as well.

Both grades may be manufactured in two sizes. Refer to Table 16.

Nailing - Pre-drill holes near the ends of each piece. Use only non-corrosive (stainless steel, high strength aluminum or hot-dipped galvanized) 10d (3") nails or 8d (minimum) deck screws. Use two nails per piece driven one inch in from each edge. Ring- or spiral-shank nails will provide additional holding capacity. Pre-finish edges, ends and surfaces for best results.

Refer to paragraph on seasoning lumber (p. 20) for additional information.

STANDARD SIZES PATIO DECKING — Table **16**

PATIO 1 & 2	Surfaced DRY	Surfaced GRN
1/4" radius edge	1" × 5 1/2"	1 1/32" × 5 5/8"
5/8" radius edge	1 5/32" × 5 1/2"	1 3/16" × 5 5/8"

STANDARD SIZES - APPEARANCE LUMBER — Table **15**

Nominal & Dressed (Based on *Western Lumber Grading Rules*)

Product	Description	Nominal Size: Thickness inches	Nominal Size: Width inches	Dry Dressed Dimensions: Thickness inches	Dry Dressed Dimensions: Thickness mm	Dry Dressed Dimensions: Width inches	Dry Dressed Dimensions: Width mm	Lengths (feet)
SELECTS AND COMMONS	S1S, S2S, S4S, S1S1E, S1S2E	4/4	2	3/4	19	1 1/2	38	6' (183 cm) and longer in multiples of 1' (31 cm), except Douglas Fir and Larch Selects shall be 4' (122 cm) and longer with 3% of 4' (122 cm) and 5' (152 cm) permitted.
		5/4	3	1 5/32	29	2 1/2	64	
		6/4	4	1 13/32	36	3 1/2	89	
		7/4	5	1 19/32	40	4 1/2	114	
		8/4	6	1 13/16	46	5 1/2	140	
		9/4	7	2 3/32	53	6 1/2	165	
		10/4	8 & wider	2 3/8	60	3/4 off nominal	19 off nominal	
		11/4		2 9/16	65			
		12/4		2 3/4	70			
		16/4		3 3/4	95			
FINISH AND ALTERNATE BOARD GRADES	S1S, S2S, S4S, S1S1E, S1S2E	3/8	2	5/16	8	1 1/2	38	3' (91 cm) and longer. In SUPERIOR grade, 3% of 3' (91 cm) and 4' (122 cm) and 7% of 5' (152 cm) and 6' (183 cm) are permitted. In PRIME grade 20% of 3' (91 cm) to 6' (183 cm) is permitted.
		1/2	3	7/16	11	2 1/2	64	
		5/8	4	9/16	14	3 1/2	89	
		3/4 [1]	5	5/8	16	4 1/2	114	
		1 [1]	6	3/4	19	5 1/2	140	
		1 1/4 [1]	7	1	25	6 1/2	165	
		1 1/2 [1]	8 & wider	1 1/4	32	3/4 off nominal	19 off nominal	
		1 3/4		1 3/8	35			
		2		1 1/2	38			
		2 1/2		2	51			
		3		2 1/2	64			
		3 1/2		3	76			
		4		3 1/2	89			

[1] These sizes apply only to WCLIB Alternate Board grades.

Abbreviations:
S1S—Surfaced one side
S2S—Surfaced two sides
S4S—Surfaced four sides
S1S1E—Surfaced one side, one edge
S1S2E—Surfaced one side, two edges

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4.4.24 Specifying Finish Carpentry Materials—Western Wood

SPECIFYING FINISH CARPENTRY MATERIALS

A specification for a Finish or Board lumber grade should include a reference to the section number, title and edition of the grading rules from which it is written. In other words, if specifying from Section 21.11, Special Western Red Cedar Rules, WWPA *Western Lumber Grading Rules* 98, so state.

Grain patterns, when desired, can also be specified for Selects, Finish and Special Western Red Cedar grades. Three categories are available: vertical grain (VG), flat grain (FG) or a shipment of both VG and FG, generally referred to as mixed grain (MG). The most readily available and least costly is mixed grain. Unless otherwise specified, siding, paneling and finish boards are shipped with mixed grain. Stair treads, stepping, etc., should be vertical grain as it is more durable.

Board Lumber in Combination with Rough Carpentry Materials - Boards, basically, are 1" nominal thickness. Board grades used in conjunction with rough carpentry materials are generally controlled by building code requirements, and the grades are selected from the Common or Alternate Board grades listed in the appearance lumber grades chart on page 18, Table 14.

As an example, major model building codes recognize NO. 3 COMMON or STANDARD grades as equal minimum grades for spaced roof sheathing even though there are differences in grading characteristics. Verify local building code requirements and dealer availability prior to specifying.

Seasoning Lumber - Once in place, lumber adjusts to its surrounding atmospheric conditions. In a covered structure, lumber will stabilize at approximately 6 to 12% moisture content. Size will vary approximately 1% for each 4% change in moisture content. Thus, it is important that all finish materials be stacked and stickered, in the room where they will be applied, for 7-10 days prior to installation. 2x decking material should be allowed to acclimate for 14 to 21 days prior to installation. The lumber should be stored off the ground, well ventilated and loosely covered. The lumber will then stabilize its moisture content for its permanent location. Staining or priming, where economically feasible, should be done before installation. Refer to WWPA's *Paneling Basics* (A-3), *Natural Wood Siding-Technical Guide* (TG-8) and *Lumber Storage* (TG-5) for additional information.

Moisture Content - WWPA Finish and Select grades, as well as special Western Red Cedar grades, are shipped seasoned as follows: S-DRY (or KD) or MC15 (or KD15) with at least 85 percent of items not exceeding 12% in moisture content and no portion exceeding 15% moisture content. Appearance grades of Western Lumber are not shipped S-GRN (with a moisture content above 19% at the time of surfacing) except in some of the knotty grades. Refer to page 4 for additional information on moisture content designations in the grade stamp and to WWPA's *Natural Wood Siding-Technical Guide* (TG-8) for recommendations on handling unseasoned siding products.

Interior and Exterior Trim and Finish Board Materials - Select from appearance grades as indicated in Table 14 and described in the WWPA *Western Lumber Grading Rules*.

Refer to the WWPA publication *Vol. 2: Western Wood Species* (11) for color photographs of Select, Finish, Common and Alternate Board grades in many Western lumber species.

Wood Siding and Paneling Materials - The following publications offer information on selecting pattern type and grade, and summarize installation and handling requirements: *Natural Wood Siding–Technical Guide* (TG-8) and *Paneling Basics* (A-3).

After a general pattern type has been selected, the pattern number should be specified from the WWPA publication *Standard Patterns* (G-16).

When a saw-textured face is desired, the face to be textured and the type of texture (band sawn, rough sawn, circular sawn, etc.) should be specified.

A siding specification should include WWPA's industry recommendations for acclimatization, backpriming, nailing and finishing. Refer to WWPA's *Natural Wood Siding–Technical Guide* (TG-8) for details. A checklist and moisture content guidelines are provided below for convenience.

MOISTURE CONTENT GUIDELINES

Uses of Wood	Recommended Moisture Content at Time of Installation[1]					
	Most Areas of the U.S.		Dry, Southwestern States		Damp, Warm Southeastern Coastal Areas	
Siding, Trim and Sheathing	Average[2]	Individual Pieces	Average[2]	Individual Pieces	Average[2]	Individual Pieces
	12%	9-14%	9%	7-12%	12%	9-14%

[1] **Source:** Wood Handbook, from Table 14-1, USDA Agricultural Handbook 72, 1987.

[2] To obtain a realistic average, test at least 10% of each item, i.e. 10% of the siding pieces, 10% of the trim pieces and random checks of the sheathing material. It is particularly important to check the sheathing prior to the siding application if it has been rewet after it was installed.

SIDING OR PANELING MATERIAL SPECIFICATION

Checklist **6**

- ☐ Select species suited to the project.
- ☐ List grade names, paragraph numbers and rules-writing agency. *(Refer to Table 14.)*
- ☐ Specify surface texture for exposed face.
- ☐ Specify moisture content suited to project.
- ☐ If gradestamped, specify lumber be stamped on back or ends. (WWPA's *Specifying Lumber* [A-2] offers additional information.)
- ☐ Specify VG (vertical grain) if appropriate and available.
- ☐ Specify pattern and size. (WWPA's *Standard Patterns* [G-16] offers additional information.)
- ☐ Specify installation, nailing and finishing. (WWPA's *Natural Wood Siding-Technical Guide* [TG-8] offers additional information.)

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4.4.25 Industrial Lumber—Categories—Western Wood

This broad category of Western lumber products includes structural products (some with applied design values), products for remanufacturing purposes and (nonstructural) miscellaneous products for a variety of specific applications. Classifications and grades are indicated in the chart below.

INDUSTRIAL LUMBER

Structural Products	Remanufacturing Products (nonstructural)	Nonstructural Products
Mining Timbers	Boards	Gutter
Scaffold Plank	Factory	Pickel
Foundation Lumber	Moulding	Lath
Stress-rated Boards	Shop	Battens
		Stepping

STRUCTURAL PRODUCTS

Mining Timbers are designed primarily for use as shoring and bracing materials in mines and tunnels. The grades are designed for serviceability, not necessarily appearance. There are two grades: NO. 1 MINING and NO. 2 MINING. Both are graded full length. No design values are applied. Nominal sizes are 5" and thicker, 5" and wider. Refer to Sections 81.11 & 81.12 in the WWPA *Western Lumber Grading Rules* for additional information.

Scaffold Plank is shipped rough & unseasoned in Douglas Fir-Larch 1¼" and thicker, 8" and wider in two grades (SCAFFOLD NO. 1 and SCAFFOLD NO. 2) with applied design values.

SCAFFOLD PLANK DESIGN VALUES Table **17**

Design Values—for Flatwise Use[1]

Thickness	Grade	Extreme Fiber Stress in Bending (F_b) in psi	Modulus of Elasticity (E) in psi
2" and less	No. 1	2350	1,800,000
	No. 2	2200	1,800,000
These values apply to dry use conditions. For wet use conditions, these values shall be multiplied by 0.86 for F_b and 0.97 for E.			
3"	No. 1	1800	1,600,000
	No. 2	1650	1,600,000
These values apply to both dry and wet use conditions.			

[1] See Sections 100.00 through 170.00 in the *Western Lumber Grading Rules* for information about these values.

Bending Stresses (F_b) for Scaffold Plank grades have incorporated a scaffold use factor according to the American National Standards Institute (ANSI) *Standard A10.8*. This factor modifies the allowable bending stresses to the equivalent safety level of four times the design load without failure.

Foundation Lumber is occasionally used for sill plates. It is available only in Western Red Cedar and Incense Cedar, in nominal sizes 2" and thicker, 4" and wider. There is only one grade: FOUNDATION. It is selected from heartwood (naturally decay resistant) and must be free of heart center and free of sapwood. It is manufactured rough sawn or surfaced. Where surfaced, the sizes are the same as for Dimension lumber or Timbers (Table 6, page 13). Refer to Section 54.00 of WWPA's *Western Lumber Grading Rules* for additional information.

Stress-rated Boards Stress rated boards are available from Western lumber manufacturers in all species to provide a range of products suitable for special applications when Board lumber is to have applied design values. Several such uses include light trusses, belt rails, horizontal bracing, rafters and box beams for mobile and factory built homes. Design values are the same as those shown in Table 1, page 6. Apply all appropriate adjustments for BASE VALUES, Tables A-G. When Stress-rated Boards are gradestamped, the grade name or number for the dimension grades will be shown on the grade stamp along with "SRB" designating Stress-rated Board. Refer to Section 30.60 of the *Western Lumber Grading Rules* for additional information.

STANDARD SIZES[1] Table **18**
STRESS-RATED BOARDS

	Nominal	Surfaced Unseasoned inches	Surfaced Unseasoned mm	Surfaced Dry inches	Surfaced Dry mm
Thickness	1"	25/32	20	¾	19
	1¼"	1 1/32	26	1	25
	1½"	1 9/32	33	1¼	32
Widths	2"	1 9/16	40	1½	38
	3"	2 9/16	65	2½	64
	4"	3 9/16	90	3½	89
	5"	4⅝	117	4½	114
	6"	5⅝	143	5½	140
	8" and wider	½ off nominal	13 off nominal	¾ off nominal	19 off nominal

[1] Standard lengths are 6' (1.83 m) and longer in multiples of 1' (.31 m).

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

REMANUFACTURING PRODUCTS

Factory and Shop Grades provide the remanufacturer with an opportunity to buy industrial lumber intended for the recovery of clear pieces at an economical price. These grades, available primarily in Douglas Fir, Hem Fir, Ponderosa Pine and Sugar Pine, are especially well suited for remanufacture to obtain clear, standard-size cuttings that are based on typical US joinery and millwork cutting sizes. Grades include MOULDING STOCK, CLEAR DOOR, FACTORY SELECT (NO. 3 CLEAR), NO. 1 SHOP, NO. 2 SHOP, NO. 3 SHOP and FINGER JOINT SHOP COMMON. Refer to WWPA's *Vol. 3, Western Wood Species* book on *Factory Lumber* (F2) or the *Western Lumber Grading Rules* for additional information. Standard sizes are shown in Table 19 on the following page.

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4.4.26 Industrial Lumber—Standard Sizes

STANDARD SIZES - FACTORY LUMBER NOMINAL AND DRESSED Table **19**

Product	Description	Nominal Size Thickness (inches)		Width	Dry Dressed Dimensions Thickness (inches)	(mm)	Face Width	Lengths
		4/4	1		¾	19		
FACTORY	S2S	5/4	1¼	See individual	1 5/32	29	Usually	6' (182 cm)
AND	(Surfaced	6/4	1½	descriptions	1 13/32	36	sold	and longer,
SHOP	two sides)	7/4	1¾	WWPA's	1 19/32	40	random	generally
LUMBER		8/4	2	*Western Lumber*	1 13/16	46	width	shipped in
		10/4	2½	*Grading Rules*	2 3/8	60		multiples of
		12/4	3		2 3/4	70		2' (61 cm)
		16/4	4		3 3/4	95		

Note on Metrics: Metric equivalents are provided for surfaced (actual) sizes.

NONSTRUCTURAL PRODUCTS

Gutter (WCLIB grade) is available in some western species and shipped in a number of patterns. It is available in one grade, GUTTER, and usually (but not necessarily) measures 4" x 5" x 20'. Pieces of this grade are of sound wood and are water tight. Refer to paragraph 112 in WCLIB Standard Grading Rules.

Pickets (WCLIB grade) are available in any Western species and are shipped kiln-dried (KD) or unseasoned (S-GRN). Grades, NO. 1 and NO. 2, are based on a piece 1" x 3" x 4'. Standard sizes are shown below.

STANDARD PICKET SIZES Table **20**

Nominal		(Net) Dressed inches	mm
1¼" square	S4S to	1 1/16 x 1 1/16	27 x 27
1½" square	S4S to	1 5/16 x 1 5/16	33 x 33
1" x 3" flat	S4S to	¾ x 2 ½	19 x 64

Lath is available in any Western species, in two grades, NO. 1 & NO. 2, and may be shipped dry or unseasoned. Sizes are ⅜" thick by 1½" wide, 32" or 48" long.

Battens (WCLIB grade) are available in any Western species, in one grade: BATTENS. They are surfaced S1S1E or S4S at shipper's option, unless specified otherwise. Grade is based on a piece 12' long. Standard widths are shown below.

STANDARD BATTEN SIZES Table **21**

Pattern	Nominal	(Net) Dressed inches	mm
Flat	3"	¼ x 2½	6 x 64
O.G.	2"	¾ x 1¾	19 x 44
O.G.	2½"	¾ x 2¼	19 x 57
O.G.	3"	¾ x 2½	19 x 64

Stepping (WCLIB grade) is typically vertical grained (VG) and kiln dried (KD) and customarily surfaced on three sides with a bull nose on one edge. The recommended standard for STEPPING of 1¼" thickness is to round the nosed edge to a radius of ⅝". Grades are based on a piece 12" wide by 12' long. There are two grades: C&BTR-VG STEPPING and D VG STEPPING. Refer to paragraph 109 in WWPA *Western Lumber Grading Rules*.

SPECIFYING INDUSTRIAL LUMBER PRODUCTS

It is important to realize that not all products, grades and sizes in the industrial products category are readily available at all times. These products are rarely available through standard retail outlets as they are usually traded at the wholesale level, often as custom orders, or bought mill direct in large volumes.

WWPA's Vol. 3 *Species* book on *Factory Lumber* includes full-color photographs of the grades intended for cut up. This species brochure aids remanufacturers in determining which grades are best suited for the recovery of specifically sized pieces.

In general, industrial products are specified according to the checklist provided below:

INDUSTRIAL LUMBER MATERIAL SPECIFICATION Checklist **7**

- ☐ Grade Description - refer to specific paragraph number in the *Western Lumber Grading Rules*
- ☐ Moisture Content - specify MC as dictated by grading rules or according to specific requirements for intended end use, realizing that "specific requirements" are available only through manufacturer/customer agreement
- ☐ Species - specify all species that are appropriate
- ☐ Profile/Surface Texture - specify when appropriate
- ☐ Sizes and Lengths - always specify all sizes and lengths that are appropriate to the application

WWPA Technical and Product Support Services may be contacted (503-224-3930) for help with industrial product specification whenever necessary.

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4.5.0 American Softwood Standards for Boards and Timbers

The thicknesses apply to all widths and all widths apply to all thicknesses. Sizes are given in inches and millimeters. Metric units are based on actual size.

Item	Thicknesses					Face Widths				
	Nominal Inch	Minimum Dressed				Nominal Inch	Minimum Dressed			
		Dry[a]		Green[a]			Dry[a]		Green[a]	
		Inch	mm	Inch	mm		Inch	mm	Inch	mm
Boards[b]						2	1-1/2	38	1-9/16	40
						3	2-1/2	64	2-9/16	65
						4	3-1/2	89	3-9/16	90
						5	4-1/2	114	4-5/8	117
	1	3/4	19	25/32	20	6	5-1/2	140	5-5/8	143
						7	6-1/2	165	6-5/8	168
	1-1/4	1	25	1-1/32	26	8	7-1/4	184	7-1/2	190
						9	8-1/4	210	8-1/2	216
	1-1/2	1-1/4	32	1-9/32	33	10	9-1/4	235	9-1/2	241
						11	10-1/4	260	10-1/2	267
						12	11-1/4	286	11-1/2	292
						14	13-1/4	337	13-1/2	343
						16	15-1/4	387	15-1/2	394
Dimension						2	1-1/2	38	1-9/16	40
						3	2-1/2	64	2-9/16	65
	2	1-1/2	38	1-9/16	40	4	3-1/2	89	3-9/16	90
	2-1/2	2	51	2-1/16	52	5	4-1/2	114	4-5/8	117
	3	2-1/2	64	2-9/16	65	6	5-1/2	140	5-5/8	143
	3-1/2	3	76	3-1/16	78	8	7-1/4	184	7-1/2	190
	4	3-1/2	89	3-9/16	90	10	9-1/4	235	9-1/2	241
	4-1/2	4	102	4-1/16	103	12	11-1/4	286	11-1/2	292
						14	13-1/4	337	13-1/2	343
						16	15-1/4	387	15-1/2	394
Timbers	5 & thicker	1/2 off	13 off	1/2 off	13 off	5 & wider	1/2 off	13 off	1/2 off	13 off

[a] See 2.7 and 2.11 for the definitions of dry and green lumber.

[b] Boards less than the minimum thickness for nominal 1-inch but 5/8 inch (16 mm) or greater thickness dry (11/16 inch (17 mm) green) shall be regarded as ALS lumber, but such boards shall be marked to show the size and condition of seasoning at the time of dressing. They shall also be distinguished from nominal 1-inch boards on invoices and certificates.

(National Institute of Standards and Technology.)

4.5.1 American Softwood Standards for Shiplap and Centermatch Lumber

The thicknesses apply to all widths and all widths apply to all thicknesses. Sizes are given in inches and millimeters. Metric units are based on actual size.

Item	Thicknesses					Face Widths				
	Nominal Inch	Minimum Dressed				Nominal Inch	Minimum Dressed			
		Dry		Green			Dry		Green	
		Inch	mm	Inch	mm		Inch	mm	Inch	mm
Shiplap, 3/8-inch (10 mm) lap	1	3/4	19	25/32	20	4 6 8 10 12 14 16	3-1/8 5-1/8 6-7/8 8-7/8 10-7/8 12-7/8 14-7/8	79 130 175 225 276 327 378	3-3/16 5-1/4 7-1/8 9-1/8 11-1/8 13-1/8 15-1/8	81 133 181 232 283 333 384
Shiplap, 1/2 inch (13 mm) lap	1	3/4	19	25/32	20	4 6 8 10 12 14 16	3 5 6-3/4 8-3/4 10-3/4 12-3/4 14-3/4	76 127 171 222 273 324 375	3-1/16 5-1/8 7 9 11 13 15	78 130 178 229 279 330 381
Centermatch, 1/4 inch (6 mm) tongue	1 1-1/4 1-1/2	3/4 1 1-1/4	19 25 32	25/32 1-1/32 1-9/32	20 26 33	4 5 6 8 10 12	3-1/8 4-1/8 5-1/8 6-7/8 8-7/8 10-7/8	79 105 130 175 225 276	3-3/16 4-1/4 5-1/4 7-1/8 9-1/8 11-1/8	81 108 133 181 232 283
2 inch (51 mm) D & M, 3/8 inch (10 mm) tongue	2	1-1/2	38	1-9/16	40	4 6 8 10 12	3 5 6-3/4 8-3/4 10-3/4	76 127 171 222 273	3-1/16 5-1/8 7 9 11	78 130 178 229 279
2 inch (51 mm) Shiplap, 1/2 inch (13 mm) lap	2	1-1/2	38	1-9/16	40	4 6 8 10 12	3 5 6-3/4 8-3/4 10-3/4	76 127 171 222 273	3-1/16 5-1/8 7 9 11	78 130 178 229 279

(National Institute of Standards and Technology.)

4.5.2 American Softwood Standards for Worked Lumber

The thicknesses apply to all widths and all widths apply to all thicknesses. Sizes are given in inches and millimeters. Metric units are based on actual size.

Thicknesses[a]					Face Widths				
	Minimum Dressed					Minimum Dressed			
	Dry		Green			Dry		Green	
Nominal Inch	Inch	mm	Inch	mm	Nominal Inch	Inch	mm	Inch	mm
Tongue and Grooved									
2-1/2	2	51	2-1/16	52	4	3	76	3-1/16	78
3	2-1/2	64	2-9/16	65	6	5	127	5-1/8	130
3-1/2	3	76	3-1/16	78	8	6-3/4	171	7	178
4	3-1/2	89	3-9/16	90	10	8-3/4	222	9	229
4-1/2	4	102	4-1/16	103	12	10-3/4	273	11	279
Shiplap									
2-1/2	2	51	2-1/16	52	4	3	76	3-1/16	78
3	2-1/2	64	2-9/16	65	6	5	127	5-1/8	130
3-1/2	3	76	3-1/16	78	8	6-3/4	171	7	178
4	3-1/2	89	3-9/16	90	10	8-3/4	222	9	229
4-1/2	4	102	4-1/16	103	12	10-3/4	273	11	279
Grooved-for-Splines									
2-1/2	2	51	2-1/16	52	4	3-1/2	89	3-9/16	90
3	2-1/2	64	2-9/16	65	6	5-1/2	140	5-5/8	143
3-1/2	3	76	3-1/16	78	8	7-1/4	184	7-1/2	190
4	3-1/2	89	3-9/16	90	10	9-1/4	235	9-1/2	241
4-1/2	4	102	4-1/16	103	12	11-1/4	286	11-1/2	292

In worked lumber of nominal 2-inch and greater thickness, the tongue shall be 3/8 inch (10 mm) wide in tongued-and-grooved lumber and the lap shall be 1/2 inch (13 mm) wide in shiplapped lumber, with the overall widths 3/8 inch (10 mm) and 1/2 inch (13 mm) wider, respectively, than the face widths shown in the above table. Double tongued-and-grooved decking shall be manufactured with a 3/8 inch (10 mm) or 5/16 inch (8 mm) wide tongue.

(National Institute of Standards and Technology.)

4.5.3 American Softwood Standards for Siding (19% Moisture Content)

The thicknesses apply to all widths and all widths apply to all thicknesses. Sizes are given in inches and millimeters. Metric units are based on actual size.

Item	Thicknesses			Face Widths		
	Nominal[a] Inch	Minimum Dressed		Nominal Inch	Minimum Dressed	
		Inch	mm		Inch	mm
Bevel Siding	1/2 9/16 5/8 3/4 1	7/16 butt, 3/16 tip 15/32 butt, 3/16 tip 9/16 butt, 3/16 tip 11/16 butt, 3/16 tip 3/4 butt, 3/16 tip	11 butt, 5 tip 12 butt, 5 tip 14 butt, 5 tip 17 butt, 5 tip 19 butt, 5 tip	4 5 6 8 10 12	3-1/2 4-1/2 5-1/2 7-1/4 9-1/4 11-1/4	89 114 140 184 235 286
Bungalow Siding	3/4	11/16 butt, 3/16 tip	17 butt, 5 tip	8 10 12	7-1/4 9-1/4 11-1/4	184 235 286
Rustic and Drop Siding (shiplapped, 3/8 inch (10 mm) lap)	5/8 1	9/16 23/32	14 18	4 5 6	3 4 5	76 102 127
Rustic and Drop Siding (shiplapped, 1/2 inch (13 mm) lap)	5/8 1	9/16 23/32	14 18	4 5 6 8 10 12	2-7/8 3-7/8 4-7/8 6-5/8 8-5/8 10-5/8	73 98 124 168 219 270
Rustic and Drop Siding (dressed and matched)	5/8 1	9/16 23/32	14 18	4 5 6 8 10	3-1/8 4-1/8 5-1/8 6-7/8 8-7/8	79 105 130 175 225

[a] For lumber of less than nominal 1-inch thickness, the board measure count is based on the nominal surface dimensions (widt by length). Otherwise, the nominal inch units of designated thicknesses and widths in this table are the same as the boar measure or count sizes. Lumber shall be measured by board or cubic measure.

(National Institute of Standards and Technology.)

4.5.4 American Softwood Standards for Finish, Floor, and Ceiling Partition Lumber

The thicknesses apply to all widths and all widths apply to all thicknesses except as modified. Sizes are given in inches and millimeters. Metric units are based on actual size.

Item	Thicknesses			Face Widths		
	Nominal[a] Inch	Minimum Dressed		Nominal Inch	Minimum Dressed	
		Inch	mm		Inch	mm
Finish	3/8	5/16	8	2	1-1/2	38
	1/2	7/16	11	3	2-1/2	64
	5/8	9/16	14	4	3-1/2	89
	3/4	5/8	16	5	4-1/2	114
	1	3/4	19	6	5-1/2	140
	1-1/4	1	25	7	6-1/2	165
	1-1/2	1-1/4	32	8	7-1/4	184
	1-3/4	1-3/8	35	9	8-1/4	210
	2	1-1/2	38	10	9-1/4	235
	2-1/2	2	51	11	10-1/4	260
	3	2-1/2	64	12	11-1/4	286
	3-1/2	3	76	14	13-1/4	337
	4	3-1/2	89	16	15-1/4	387
Flooring[b]	3/8	5/16	8	2	1-1/8	29
	1/2	7/16	11	3	2-1/8	54
	5/8	9/16	14	4	3-1/8	79
	1	3/4	19	5	4-1/8	105
	1-1/4	1	25	6	5-1/8	130
	1-1/2	1-1/4	32			
Ceiling[b]	3/8	5/16	8	3	2-1/8	54
	1/2	7/16	11	4	3-1/8	79
	5/8	9/16	14	5	4-1/8	105
	3/4	11/16	17	6	5-1/8	130
Partition[b]	1	23/32	18	3	2-1/8	54
				4	3-1/8	79
				5	4-1/8	105
				6	5-1/8	130
Stepping[b]	1	3/4	19	8	7-1/4	184
	1-1/4	1	25	10	9-1/4	235
	1-1/2	1-1/4	32	12	11-1/4	286
	2	1-1/2	38			

[a] For lumber of less than nominal 1-inch thickness, the board measure count is based on the nominal surface dimensions (width by length). Otherwise, the nominal inch units of designated thicknesses and widths in this table are the same as the board measure or count sizes. Lumber shall be measured by board or cubic measure.

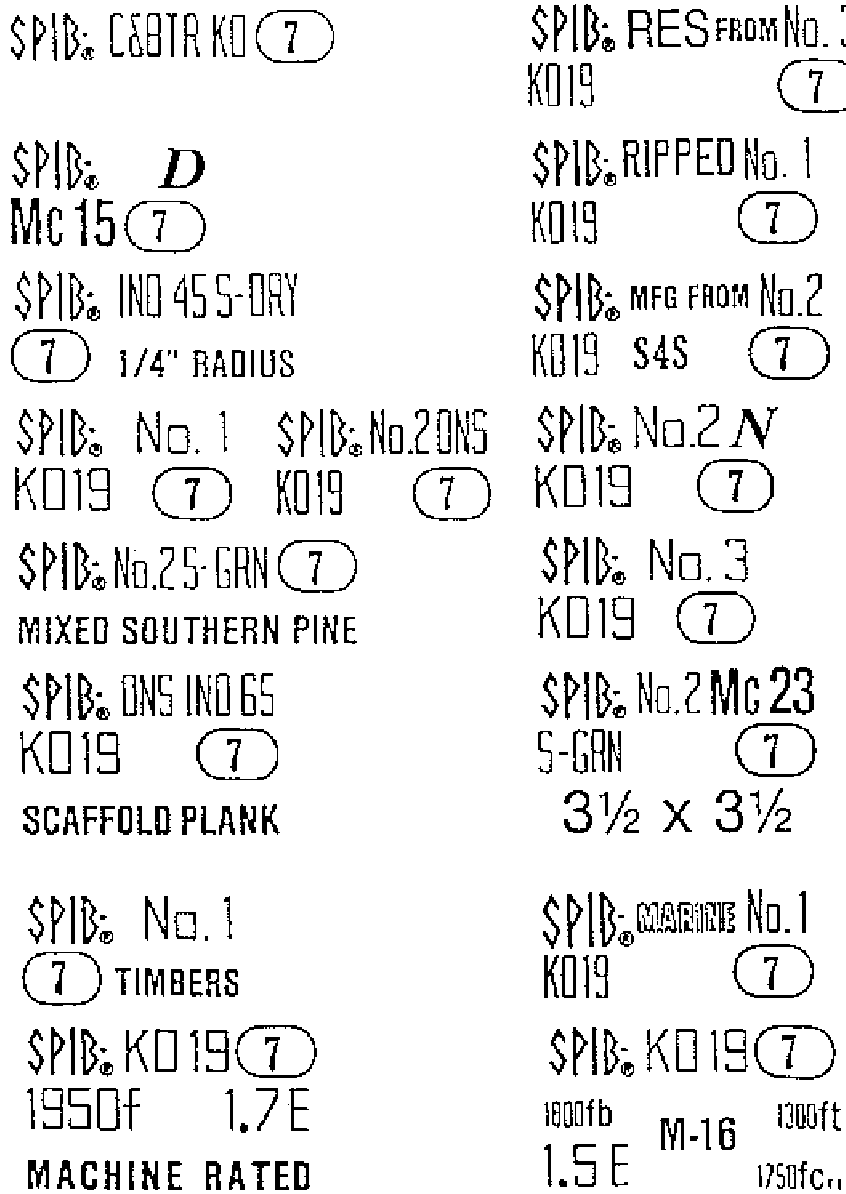
[b] In tongued-and-grooved flooring and in tongued-and-grooved and shiplapped ceiling of 5/16 inch (8 mm), 7/16 inch (11 mm), and 9/16 inch (14 mm) dressed thicknesses, the tongue or lap shall be 3/16 inch (5 mm) wide, with the over-all widths 3/16 inch (5 mm) wider than the face widths shown in the above table. In all other worked lumber of dressed thicknesses of 5/8 inch (16 mm) to 1-1/4 inches (32 mm), the tongue shall be 1/4 inch (6 mm) wide or wider in tongued-and-grooved lumber, and the lap shall be 3/8 inch (10 mm) wide or wider in shiplapped lumber, and the over-all widths shall be not less than the dressed face widths shown in the above table plus the width of the tongue or lap.

(National Institute of Standards and Technology.)

4.6.0 Specifying Southern Pine Lumber (Grade Stamp Markings)

The Southern Pine Inspection Bureau is the rules writing agency for the Southern Pine Industry. For your grade-marked Southern Pine orders specify the SPIB logo for quality.

Typical facsimiles of the approved SPIB registered grade-marks are displayed below:



*Timbers 5" x 5" and larger are not required to be dry unless specified.

Before specifying, consult current editions of the SPIB Standard Grading Rules and/or SPIB Special Product Rules. Please feel free to contact the SPIB office for further information concerning your specifications. Our telephone number is: (904) 434-2611.

(By permission of the Southern Pine Inspection Bureau.)

4.6.1 Southern Pine Span Tables

Southern Pine Span Tables

Maximum spans given in feet and inches
Inside to inside of bearings

Tables 5 thru 11 are abbreviated span tables for the most commonly available grades of Southern Pine lumber. For other grades, loading conditions and spacings, refer to *Maximum Spans for Southern Pine Joists and Rafters* published by the Southern Pine Council.

These spans are based on *1993 AF&PA Span Tables for Joists and Rafters*, and *1994 SPIB Standard Grading Rules for Southern Pine Lumber*. Except for Table 8, they are intended for use in covered structures or where the moisture content in use does not exceed 19 percent for an extended period of time.

Floor Joists

Design Criteria: Deflection – limited to span in inches divided by 360 (live load only).
Strength – based on 30, 40, or 50 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 6			2 x 8			2 x 10			2 x 12		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	30 psf	12 – 0	10 – 11	9 – 7	15 – 10	14 – 5	12 – 7	20 – 3	18 – 5	16 – 1	24 – 8	22 – 5	19 – 6
	40 psf	10 – 11	9 – 11	8 – 8	14 – 5	13 – 1	11 – 5	18 – 5	16 – 9	14 – 7	22 – 5	20 – 4	17 – 5
	50 psf	10 – 2	9 – 3	8 – 1	13 – 5	12 – 2	10 – 8	17 – 1	15 – 6	13 – 4	20 – 9	18 – 10	15 – 11
No. 2	30 psf	11 – 10	10 – 9	9 – 4	15 – 7	14 – 2	12 – 4	19 – 10	18 – 0	14 – 8	24 – 2	21 – 1	17 – 2
	40 psf	10 – 9	9 – 9	8 – 6	14 – 2	12 – 10	11 – 0	18 – 0	16 – 1	13 – 2	21 – 9	18 – 10	15 – 4
	50 psf	9 – 11	9 – 1	7 – 9	13 – 1	11 – 11	10 – 0	16 – 9	14 – 8	12 – 0	19 – 10	17 – 2	14 – 0
No. 3	30 psf	10 – 5	9 – 1	7 – 5	13 – 3	11 – 6	9 – 5	15 – 8	13 – 7	11 – 1	18 – 8	15 – 2	13 – 2
	40 psf	9 – 4	8 – 1	6 – 7	11 – 11	10 – 3	8 – 5	14 – 0	12 – 2	9 – 11	16 – 8	14 – 5	11 – 10
	50 psf	8 – 6	7 – 5	6 – 0	10 – 10	9 – 5	7 – 8	12 – 10	11 – 1	9 – 1	15 – 3	13 – 2	10 – 9

Ceiling Joists – Drywall Ceiling

Design Criteria: Deflection – limited to span in inches divided by 240 (live load only).
Strength – based on 10 or 20 pounds per square foot (psf) live load, plus 5 or 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 4			2 x 6			2 x 8			2 x 10		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	10 psf	12 – 8	11 – 6	10 – 0	19 – 11	18 – 1	15 – 9	26 – 0	23 – 10	20 – 10	26 – 0*	26 – 0*	26 – 0*
	20 psf	10 – 0	9 – 1	8 – 0	15 – 9	14 – 4	12 – 6	20 – 10	18 – 11	15 – 11	26 – 0*	23 – 2	18 – 11
No. 2	10 psf	12 – 5	11 – 3	9 – 10	19 – 6	17 – 8	15 – 6	25 – 8	23 – 4	20 – 1	26 – 0*	26 – 0*	24 – 0
	20 psf	9 – 10	8 – 11	7 – 8	15 – 6	13 – 6	11 – 0	20 – 1	17 – 5	14 – 2	24 – 0	20 – 9	17 – 0
No. 3	10 psf	11 – 7	10 – 0	8 – 2	17 – 1	14 – 9	12 – 1	21 – 8	18 – 9	15 – 4	25 – 7	22 – 2	18 – 1
	20 psf	8 – 2	7 – 1	5 – 9	12 – 1	10 – 5	8 – 6	15 – 4	13 – 3	10 – 10	18 – 1	15 – 8	12 – 10

Floor Joists – Heavy Live Loads

Design Criteria: Deflection – limited to span in inches divided by 360 (live load only).
Strength – based on 75, 100, 125 or 150 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 6			2 x 8			2 x 10			2 x 12		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	75 psf	8 – 10	8 – 1	7 – 1	11 – 8	10 – 8	9 – 3	14 – 11	13 – 7	11 – 3	18 – 2	16 – 4	13 – 4
	100 psf	8 – 1	7 – 4	6 – 5	10 – 8	9 – 8	8 – 4	13 – 7	12 – 1	9 – 10	16 – 6	14 – 5	11 – 9
	125 psf	7 – 6	6 – 10	5 – 11	9 – 10	9 – 0	7 – 6	12 – 7	10 – 11	8 – 11	15 – 0	13 – 0	10 – 7
	150 psf	7 – 1	6 – 5	5 – 6	9 – 3	8 – 5	6 – 11	11 – 7	10 – 0	8 – 2	13 – 9	11 – 11	9 – 9
No. 2	75 psf	8 – 8	7 – 11	6 – 6	11 – 6	10 – 4	8 – 5	14 – 3	12 – 4	10 – 1	16 – 9	14 – 5	11 – 9
	100 psf	7 – 11	7 – 0	5 – 9	10 – 5	9 – 1	7 – 5	12 – 6	10 – 10	8 – 10	14 – 6	12 – 8	10 – 4
	125 psf	7 – 4	6 – 4	5 – 2	9 – 6	8 – 2	6 – 8	11 – 4	9 – 9	8 – 0	13 – 3	11 – 5	9 – 4
	150 psf	6 – 9	5 – 10	4 – 9	8 – 8	7 – 6	6 – 2	10 – 5	9 – 0	7 – 4	12 – 2	10 – 6	8 – 7
No. 3	75 psf	7 – 2	6 – 2	5 – 1	9 – 1	7 – 11	6 – 5	10 – 9	9 – 4	7 – 7	12 – 10	11 – 1	9 – 1
	100 psf	6 – 4	5 – 5	4 – 5	8 – 0	6 – 11	5 – 8	9 – 5	8 – 2	6 – 8	11 – 3	9 – 9	7 – 11
	125 psf	5 – 8	4 – 11	4 – 0	7 – 3	6 – 3	5 – 1	8 – 6	7 – 5	6 – 0	10 – 2	8 – 10	7 – 2
	150 psf	5 – 3	4 – 6	3 – 8	6 – 8	5 – 9	4 – 8	7 – 10	6 – 9	5 – 7	9 – 4	8 – 1	6 – 7

* The listed maximum span has been limited to 26' - 0" based on material availability. Check sources of supply for lumber longer than 20'.

(By permission of the Southern Pine Council.)

4.6.1 Southern Pine Span Tables—Continued

Wet-Service Floor Joists

Design Criteria: Deflection—limited to span in inches divided by 360 (live load only).
Strength—based on 40 or 60 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 6			2 x 8			2 x 10			2 x 12		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	40 psf	10–7	9–7	8–5	13–11	12–8	11–1	17–9	16–2	13–5	21–7	19–8	16–1
	60 psf	9–3	8–5	7–4	12–2	11–1	9–7	15–6	13–11	11–4	18–10	16–7	13–7
No. 2	40 psf	10–4	9–5	7–10	13–8	12–5	10–1	17–5	15–10	13–2	21–2	18–10	15–4
	60 psf	9–1	8–1	6–8	11–11	10–6	8–7	15–2	13–7	11–1	18–4	15–11	13–0
No. 3	40 psf	9–4	8–1	6–7	11–11	10–3	8–5	14–0	12–2	9–11	16–6	14–5	11–10
	60 psf	7–11	6–10	5–7	10–0	8–8	7–1	11–10	10–3	8–5	14–1	12–3	10–0

Rafters—Drywall or No Finished Ceiling—Construction Load ($C_D = 1.25$)[1]

Design Criteria: Deflection—limited to span in inches divided by 240 or 180 (live load only).
Strength—based on 20 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 6			2 x 8			2 x 10			2 x 12		
Grade	Deflection	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	240	15–9	14–4	12–6	20–10	18–11	16–6	26–0*	24–1	21–1	26–0*	26–0*	25–2
	180	17–4	15–9	13–9	22–11	20–10	17–9	26–0*	25–10	21–1	26–0*	26–0*	25–2
No. 2	240	15–6	14–1	12–3	20–5	18–6	15–10	26–0*	23–2	18–11	26–0*	26–0*	22–2
	180	17–0	15–1	12–4	22–5	19–5	15–10	26–0*	23–2	18–11	26–0*	26–0*	22–2
No. 3	240	13–6	11–8	9–6	17–2	14–10	12–2	20–3	17–7	14–4	24–1	20–10	17–0
	180	13–6	11–8	9–6	17–2	14–10	12–2	20–3	17–7	14–4	24–1	20–10	17–0

Rafters—Drywall Ceiling—Snow Load ($C_D = 1.15$)[1]

Design Criteria: Deflection—limited to span in inches divided by 240 (live load only).
Strength—based on 30 or 40 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 6			2 x 8			2 x 10			2 x 12		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	30 psf	13–9	12–6	10–11	18–2	16–6	14–5	23–2	21–1	17–6	26–0*	25–7	20–10
	40 psf	12–6	11–5	9–11	16–6	15–0	13–1	21–1	19–2	15–8	25–7	22–10	18–8
No. 2	30 psf	13–6	12–3	10–2	17–10	16–2	13–2	22–3	19–3	15–9	26–0*	22–7	18–5
	40 psf	12–3	11–2	9–1	16–2	14–5	11–10	19–11	17–3	14–1	23–4	20–2	16–6
No. 3	30 psf	11–2	9–8	7–11	14–3	12–4	10–1	16–10	14–7	11–11	20–0	17–4	14–2
	40 psf	10–0	8–8	7–1	12–9	11–0	9–0	15–1	13–0	10–8	17–11	15–6	12–8

Rafters—No Finished Ceiling—Snow Load ($C_D = 1.15$)[1]

Design Criteria: Deflection—limited to span in inches divided by 180 (live load only).
Strength—based on 30 or 40 pounds per square foot (psf) live load, plus 10 psf dead load.

		Size (inches) and Spacing (inches on center)											
		2 x 4			2 x 6			2 x 8			2 x 10		
Grade	Live Load	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc	12"oc	16"oc	24"oc
No. 1	30 psf	9–8	8–9	7–8	15–2	13–9	11–9	20–0	18–0	14–9	24–9	21–5	17–6
	40 psf	8–9	8–0	7–0	13–9	12–6	10–6	18–2	16–2	13–2	22–2	19–2	15–8
No. 2	30 psf	9–6	8–7	7–1	14–5	12–6	10–2	18–8	16–2	13–2	22–3	19–3	15–9
	40 psf	8–7	7–5	6–4	12–11	11–2	9–1	16–8	14–5	11–10	19–11	17–3	14–1
No. 3	30 psf	7–7	6–7	5–4	11–2	9–8	7–11	14–3	12–4	10–1	16–10	14–7	11–11
	40 psf	6–9	5–10	4–9	10–0	8–8	7–1	12–9	11–0	9–0	15–1	13–0	10–8

*The listed maximum span has been limited to 26'-0" based on material availability. Check sources of supply for lumber longer than 20'.
(1) C_D – duration of load factor. See page 12 for additional information on adjustment factors.

(By permission of the Southern Pine Council.)

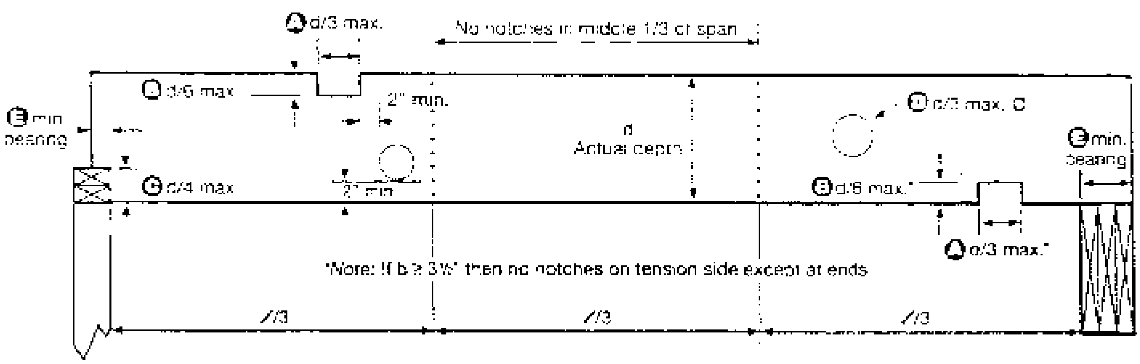
4.6.2 Spans for Various Southern Pine Species

Species and Grade	40 psf live load, 10 psf dead load, $\ell/360$				30 psf live load, 10 psf dead load, $\ell/360$			
	2x10		2x12		2x10		2x12	
	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.
SP No. 1	16'-9"	14'-7"	20'-4"	17'-5"	18'-5"	16'-1"	22'-5"	19'-6"
DFL No. 1	16'-5"	13'-5"	19'-1"	15'-7"	18'-5"	15'-0"	21'-4"	17'-5"
SP No. 2	16'-1"	13'-2"	18'-10"	15'-4"	18'-0"	14'-8"	21'-1"	17'-2"
HF No. 1	16'-0"	13'-1"	18'-7"	15'-2"	17'-8"	14'-8"	20'-10"	17'-0"
SPF Nos. 1 & 2	15'-4"	12'-7"	17'-10"	14'-7"	17'-2"	14'-0"	19'-11"	16'-3"
DFL No. 2	15'-4"	12'-7"	17'-10"	14'-7"	17'-2"	14'-0"	19'-11"	16'-3"
HF No. 2	15'-2"	12'-5"	17'-7"	14'-5"	16'-10"	13'-10"	19'-8"	16'-1"
SP No. 3	12'-2"	9'-11"	14'-5"	11'-10"	13'-7"	11'-1"	16'-2"	13'-2"
DFL No. 3	11'-8"	9'-6"	13'-6"	11'-0"	13'-0"	10'-8"	15'-1"	12'-4"
HF No. 3	11'-8"	9'-6"	13'-6"	11'-0"	13'-0"	10'-8"	15'-1"	12'-4"
SPF No. 3	11'-8"	9'-6"	13'-6"	11'-0"	13'-0"	10'-8"	15'-1"	12'-4"

Note: These spans were calculated using published design values and are for comparison purposes only. They include the repetitive member factor, C_r=1.15, but do not include composite action of adhesive and sheathing. Spans may be slightly different than other published spans due to rounding. SP-Southern Pine, DFL-Douglas Fir-Larch, HF-Hem-Fir, SPF-Spruce-Pine-Fir.

(By permission of the Southern Pine Council.)

4.6.3 Extent of Notching of Structural Pine Framing Members



Joist Size	A Maximum Notch Length	B Maximum Notch Depth	C Maximum End Notch Depth	D Maximum Hole Diameter	E Minimum Bearing Length[5]	
2 x 6	1-13/16"	7/8"	1-3/8"	1-13/16"	1-1/2"	3"
2 x 8	2-3/8"	1-3/16"	1-13/16"	2-3/8"	1-1/2"	3"
2 x 10	3-1/16"	1-1/2"	2-5/16"	3-1/16"	1-1/2"	3"
2 x 12	3-3/4"	1-7/8"	2-13/16"	3-3/4"	1-1/2"	3"

5 Minimum bearing: 1-1/2" on wood or steel; 3" bearing on masonry.

(By permission of the Southern Pine Council.)

4.6.4 Southern Pine Rafter Spans and Birdsmouth Data

Maximum Span Comparisons for Rafters

Southern Pine also demonstrates its strength and performance leadership for rafters. For more detailed rafter span information, see *Southern Pine Maximum Spans for Joists and Rafters.*

Species and Grade	30 psf live, 15 psf dead, l/180, C_D=1.15, 6 on 12 slope						20 psf live, 10 psf dead, l/240, C_D=1.25, 3 on 12 slope					
	2x6		2x8		2x10		2x6		2x8		2x10	
	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.	16" o.c.	24" o.c.
SP No. 1	13'-6"	11'-1"	17'-0"	13'-11"	20'-3"	16'-6"	14'-4"	12'-6"	18'-11"	16'-6"	24'-1"	21'-1"
DFL No. 1	12'-0"	9'-10"	15'-3"	12'-5"	18'-7"	15'-2"	14'-4"	12'-6"	18'-11"	15'-10"	23'-9"	19'-5"
SP No. 2	11'-9"	9'-7"	15'-3"	12'-5"	18'-2"	14'-10"	14'-1"	12'-3"	18'-6"	15'-10"	23'-2"	18'-11"
HF No. 1	11'-9"	9'-7"	14'-10"	12'-1"	18'-1"	14'-9"	13'-9"	12'-0"	18'-1"	15'-6"	23'-1"	18'-11"
DFL No. 2	11'-3"	9'-2"	14'-3"	11'-8"	17'-5"	14'-3"	14'-1"	11'-9"	18'-2"	14'-10"	22'-3"	18'-2"
SPF Nos.1&2	11'-3"	9'-2"	14'-3"	11'-8"	17'-5"	14'-3"	13'-5"	11'-9"	17'-9"	14'-10"	22'-3"	18'-2"
HF No. 2	11'-1"	9'-1"	14'-0"	11'-6"	17'-2"	14'-0"	13'-1"	11'-5"	17'-3"	14'-8"	21'-11"	17'-11"
SP No. 3	9'-1"	7'-5"	11'-7"	9'-6"	13'-9"	11'-3"	11'-8"	9'-6"	14'-10"	12'-2"	17'-7"	14'-4"
DFL No. 3	8'-6"	6'-11"	10'-9"	8'-10"	13'-2"	10'-9"	10'-10"	8'-10"	13'-9"	11'-3"	16'-9"	13'-8"
HF No. 3	8'-6"	6'-11"	10'-9"	8'-10"	13'-2"	10'-9"	10'-10"	8'-10"	13'-9"	11'-3"	16'-9"	13'-8"
SPF No. 3	8'-6"	6'-11"	10'-9"	8'-10"	13'-2"	10'-9"	10'-10"	8'-10"	13'-9"	11'-3"	16'-9"	13'-8"

Note: These spans were calculated using published design values and are for comparison purposes only. They include the repetitive member factor, C_r=1.15, but do not include composite action of adhesive and sheathing. Spans may be slightly different than other published spans due to rounding. SP-Southern Pine, DFL-Douglas Fir-Larch, HF-Hem-Fir, SPF-Spruce-Pine-Fir. C_D - load duration factor.

Cutting a Rafter Birdsmouth

A common roof framing technique is to use a rafter birdsmouth cut for the connection of the rafter to the top plate of the exterior wall. The following steps, tables and figures detail the birdsmouth cut.

Instructional Steps for Cutting a Rafter Birdsmouth

(see diagrams to right)

1. Determine the rafter length.
   Ex: Run = 20', slope = 4.
   Rafter length = 21'-1" using Table 2.
2. Measure θ *(from Table 1)* at top edge of rafter.
3. Draw the building line.
4. Draw 2/3 width line from top edge of rafter.
5. Use square to draw seat cut line from bottom edge of rafter to intersect building line.

Note. The birdsmouth notch should be limited to 1/3 the rafter width to maintain 2/3 of the rafter section.

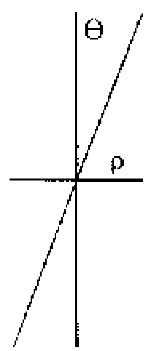


Table 1

Slope	3	4	5	6	7	8	9	10	11	12
θ°	14	18	23	27	30	34	37	40	43	45
ρ°	76	72	67	63	60	56	53	50	47	45

Layout lines for a common rafter

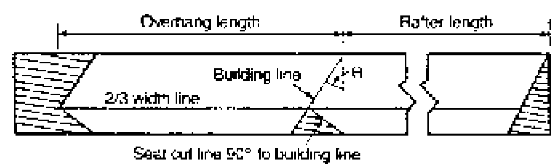
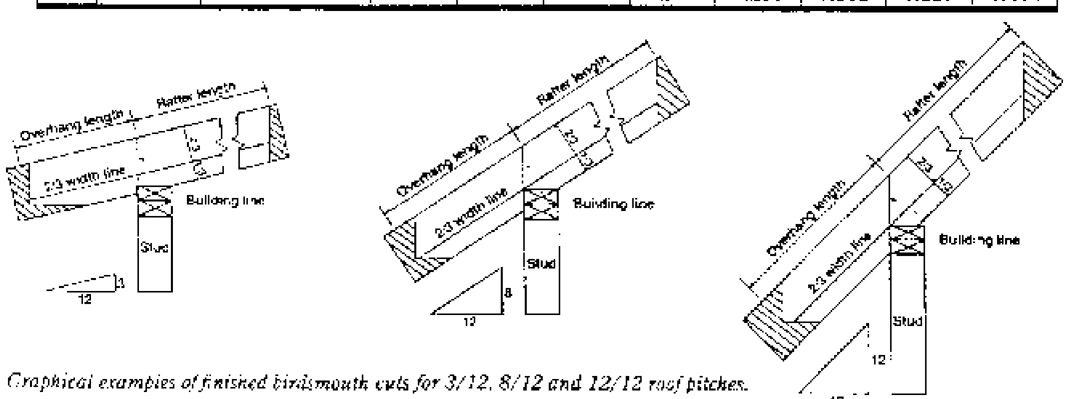


Table 2

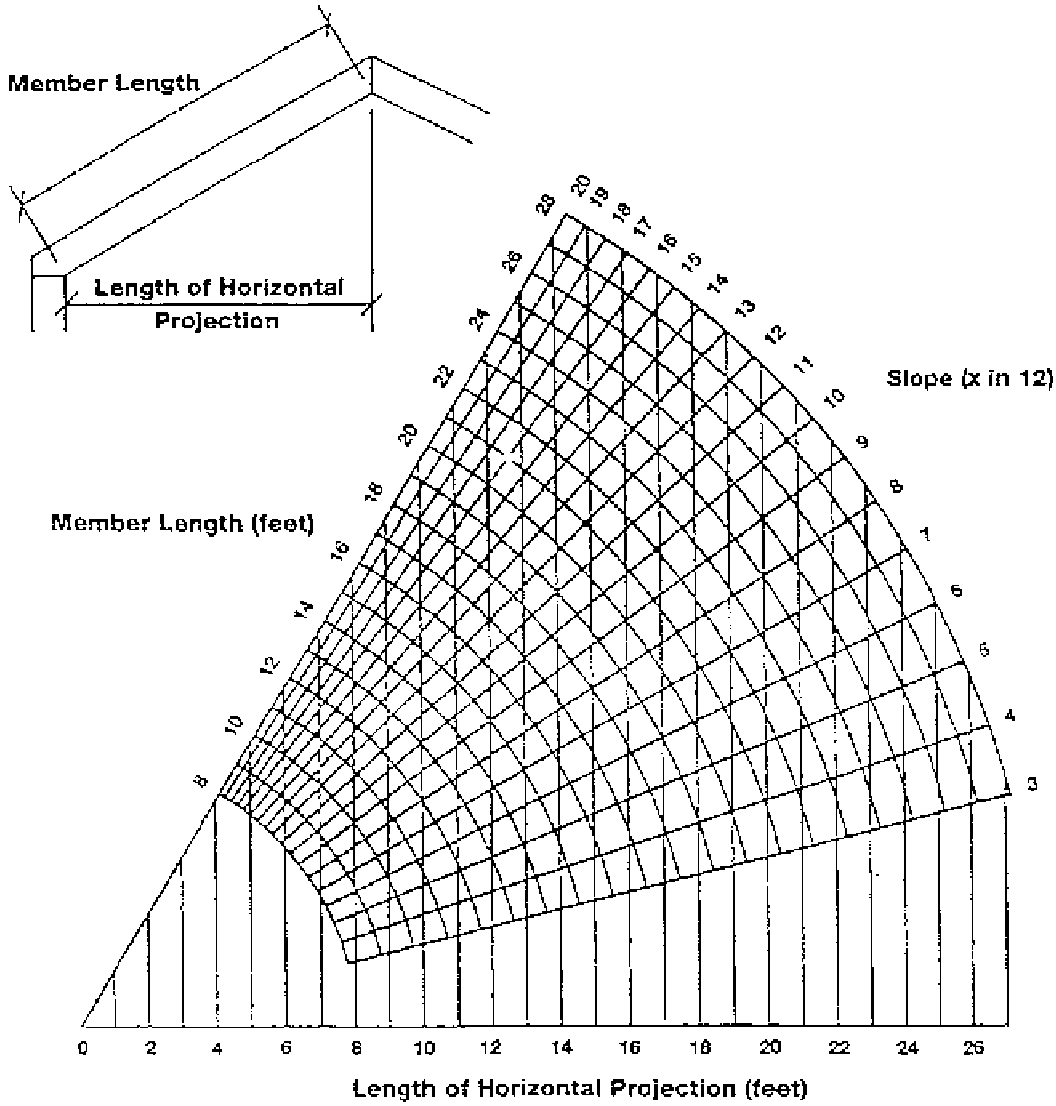
Description	Rafter length = Slope factor times run									
Slope	3	4	5	6	7	8	9	10	11	12
Slope factor	1.031	1.054	1.083	1.118	1.158	1.202	1.250	1.302	1.357	1.414



Graphical examples of finished birdsmouth cuts for 3/12, 8/12 and 12/12 roof pitches.

(By permission of the Southern Pine Council.)

4.6.5 Conversion Diagram for Southern Pine Rafters



To use the diagram, select the known horizontal distance and follow the vertical line to its intersection with the radial line of the specified slope. Then proceed along the arc to read the sloping distance. In some cases it may be desirable to interpolate between the one-foot separations. The diagram also may be used to find the horizontal distance corresponding to a given sloping distance, or to find the slope when the horizontal and sloping distances are known.

Example: With a roof slope of 8 in 12, and a horizontal distance of 20 feet, the sloping distance may be read as 24 feet.

(By permission of the Southern Pine Council.)

4.6.6 Properties of Sections of Southern Pine Framing Members

Nominal Size (inches) b d	Actual Size (inches) b d	Area (in²)	AXIS XX S (in³)	AXIS XX I (in⁴)	AXIS YY S (in³)	AXIS YY I (in⁴)	Board Measure per Lineal Foot	Weight per Lineal Foot (lb)
2 x 2	1-1/2 x 1-1/2	2.250	0.563	0.422	0.563	0.422	0.33	0.73
3	2-1/2	3.750	1.563	1.953	0.938	0.703	0.50	1.10
4	3-1/2	5.250	3.063	5.359	1.313	0.984	0.67	1.47
5	4-1/2	6.750	5.063	11.391	1.688	1.266	0.83	1.83
6	5-1/2	8.250	7.563	20.797	2.063	1.547	1.00	2.20
8	7-1/4	10.875	13.141	47.635	2.719	2.039	1.33	2.93
10	9-1/4	13.875	21.391	98.932	3.469	2.602	1.67	3.84
12	11-1/4	16.875	31.641	177.979	4.219	3.164	2.00	4.60
14	13-1/4	19.875	43.891	290.775	4.969	3.727	2.33	5.59
3 x 3	2-1/2 x 2-1/2	6.250	2.604	3.255	2.604	3.255	0.75	1.80
4	3-1/2	8.750	5.104	8.932	3.646	4.557	1.00	2.30
6	5-1/2	13.750	12.604	34.661	5.729	7.161	1.50	3.45
8	7-1/4	18.125	21.901	79.391	7.552	9.440	2.00	4.60
10	9-1/4	23.125	35.651	164.886	9.635	12.044	2.50	6.00
12	11-1/4	28.125	52.734	296.631	11.719	14.648	3.00	7.20
14	13-1/4	33.125	73.151	484.626	13.802	17.253	3.50	8.40
4 x 4	3-1/2 x 3-1/2	12.250	7.146	12.505	7.146	12.505	1.33	3.19
6	5-1/2	19.250	17.646	48.526	11.229	19.651	2.00	5.00
8	7-1/4	25.375	30.661	111.148	14.802	25.904	2.67	6.68
10	9-1/4	32.375	49.911	230.840	18.885	33.049	3.33	8.33
12	11-1/4	39.375	73.828	415.283	22.969	40.195	4.00	10.00
14	13-1/4	46.375	102.411	678.476	27.052	47.341	4.67	11.68
*6 x 6	5-1/2 x 5-1/2	30.250	27.729	76.255	27.729	76.255	3.00	11.40
8	7-1/2	41.250	51.563	193.359	37.813	103.984	4.00	15.20
10	9-1/2	52.250	82.729	392.964	47.896	131.714	5.00	19.00
12	11-1/2	63.250	121.229	697.068	57.979	159.443	6.00	22.80
14	13-1/2	74.250	167.063	1127.672	68.063	187.172	7.00	26.60
*8 x 8	7-1/2 x 7-1/2	56.250	70.313	263.672	70.313	263.672	5.33	20.25
10	9-1/2	71.250	112.813	535.859	89.063	333.984	6.67	25.35
12	11-1/2	86.250	165.313	950.547	107.813	404.297	8.00	30.40
14	13-1/2	101.250	227.813	1537.734	126.563	474.609	9.33	35.45
*10x10	9-1/2 x 9-1/2	90.250	142.896	678.755	142.896	678.755	8.33	31.65
12	11-1/2	109.250	209.396	1204.026	172.979	821.651	10.00	38.00
14	13-1/2	128.250	288.563	1947.797	203.063	964.547	11.67	44.35
*12x12	11-1/2 x 11-1/2	132.250	253.479	1457.505	253.479	1457.505	12.00	45.60
14	13-1/2	155.250	349.313	2357.859	297.563	1710.984	14.00	53.20
*14x14	13-1/2 x 13-1/2	182.250	410.063	2767.922	410.063	2767.922	16.33	62.05

* *Note:* Properties are based on minimum dressed green size which is 1/2 inch off nominal in both b and d dimensions.

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4.6.7 Standard Sizes of Southern Pine Dimension Lumber, Boards, and Decking

Based on 1994 SPIB Grading Rules

	Thickness (inches)			Width (inches)		
	Nominal	Dressed Dry	Dressed Green	Nominal	Dressed Dry	Dressed Green
Dimension Lumber and Timbers, dressed[1]	2	1-1/2		2	1-1/2	
	2-1/2	2	2-1/16	3	2-1/2	2-9/16
	3	2-1/2	2-9/16	4	3-1/2	3-9/16
	3-1/2	3	3-1/16	5	4-1/2	4-5/8
	4	3-1/2	3-9/16	6	5-1/2	5-5/8
				8	7-1/4	7-1/2
				10	9-1/4	9-1/2
				12	11-1/4	11-1/2
				14	13-1/4	13-1/2
				16	15-1/4	15-1/2
				18	17-1/4	17-1/2
				20	19-1/4	19-1/2
	Timbers 5" & thicker	1/2" off nominal	1/2" off nominal	5" & wider	1/2" off nominal	1/2" off nominal
	Nominal	Dressed		Nominal	Dressed	
Boards, S4S	1	3/4[2]		2	1-1/2	
	1-1/4	1		3	2-1/2	
	1-1/2	1-1/4		4	3-1/2	
				5	4-1/2	
				6	5-1/2	
				7	6-1/2	
				8	7-1/4	
				9	8-1/4	
				10	9-1/4	
				11	10-1/4	
				12	11-1/4	
				over 12	3/4" off nominal	
	Nominal	Dressed		Nominal	Dressed	
Finish, dry	3/8	5/16		2	1-1/2	
	1/2	7/16		3	2-1/2	
	5/8	9/16		4	3-1/2	
	3/4	5/8		5	4-1/2	
	1	3/4		6	5-1/2	
	1-1/4	1		7	6-1/2	
	1-1/2	1-1/4		8	7-1/4	
	1-3/4	1-3/8		9	8-1/4	
	2	1-1/2		10	9-1/4	
	2-1/2	2		11	10-1/4	
	3	2-1/2		12	11-1/4	
	3-1/2	3		14	13-1/4	
	4	3-1/2		16	15-1/4	
	Nominal	Dressed		Nominal	Dressed	
Radius Edge Decking	1-1/4	1		4	3-1/2	
				5	4-1/2	
				6	5-1/2	

(1) Dimension Lumber 2" thick and less than 14" wide is required to be dry with a moisture content of 19% or less. Heavy Dimension Lumber (2 x 14 and wider, 2-1/2" thick by all widths, and 3 x 3 and larger) and Timbers are not required to be dry unless specified. Thicknesses apply to their corresponding widths as squares and wider, except a thickness to 1-9/16" applies to nominal 2" in widths of 14" and wider if dressed green. (In 2" Dimension, widths over 12" are not customary stock sizes, so 2 x 14 and wider sizes are usually produced only on special order.)

(2) Boards less than the minimum dressed thickness for 1" nominal but which are 5/8" or greater thickness dry may be regarded as American Standard Lumber, but such Boards shall be marked to show the size and condition of seasoning at the time of dressing. They shall also be distinguished from 1" Boards on invoices and certificates.

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4.6.8 Southern Pine Header Load Tables and Connection Details

Maximum Load Comparisons for Headers *(plf)*

Total load / live load

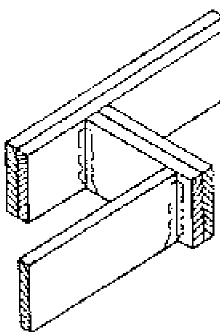
Clear Opening	Size	SP No. 1	DFL No. 1	SP No. 2	HF No. 1	DFL No. 2	SPF Nos. 1&2	HF No. 2
18' *(two-car garage)*	2-2x10	107/ 85	90 / 85	85 / 80	86 / 75	79	79 / 70	77 / 65
	2-2x12	153 / 152	122	118	116	106	107	104
9' *(single-car garage)*	2-2x10	440	375	356	354	329	326	317
	2-2x12	560*	502	487	467*	439	436*	423*
6' *(window opening)*	2-2x10	740	782	740	617*	733	576	617*
	2-2x12	974*	1029*	974*	812*	973*	757*	812*

Note: This table is for comparison purposes only. Values shown are the maximum uniformly distributed loads in pounds per lineal foot (plf) that can be applied to the header in addition to its own weight. When different, total load deflection limit = $\ell/240$ (left) and live load deflection limit = $\ell/360$ (right); otherwise these values are the same. The load duration factor, C_D = 1.00. SP = Southern Pine, DFL = Douglas Fir-Larch, HF = Hem-Fir, SPF = Spruce-Pine-Fir.

*Requires two trimmers (3" bearing); all others require one trimmer (1.5" bearing).

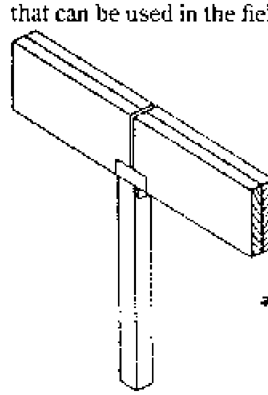
Header Connection Details

The key to header performance is the manner in which they are connected. The graphical examples below provide guidance on the types of connections that can be used in the field.



Beam-to-beam or header-to-header connection

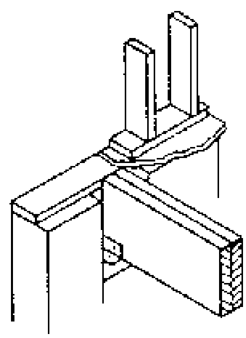
Note: Follow code or connector manufacturer requirements for nailing schedules and allowable loads for headers and connections.



Support beam or header attached to a wood column

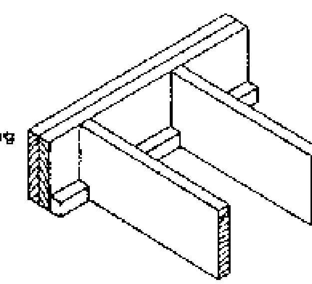
Note: Follow code or connector manufacturer requirements for nailing schedules and allowable loads for headers and connections.

Concrete wall beam pocket connection

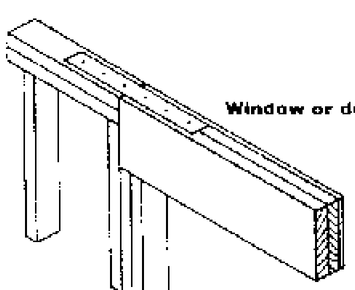


Note: Follow code requirements for wood in contact with concrete and bearing support connections.

Beam or header with ledger bearing

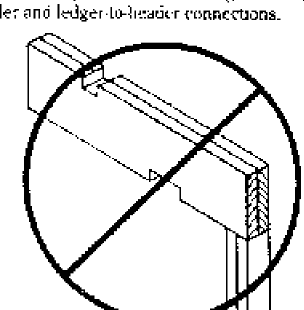


Note: Follow code requirements for nailing schedules for joist-to-header and ledger-to-header connections.



Window or door header detail

Note. Follow code requirements for nailing schedules, allowable loads, proper straps and proper bearing connections.



Caution: *Do not cut, drill or notch beams or headers.*

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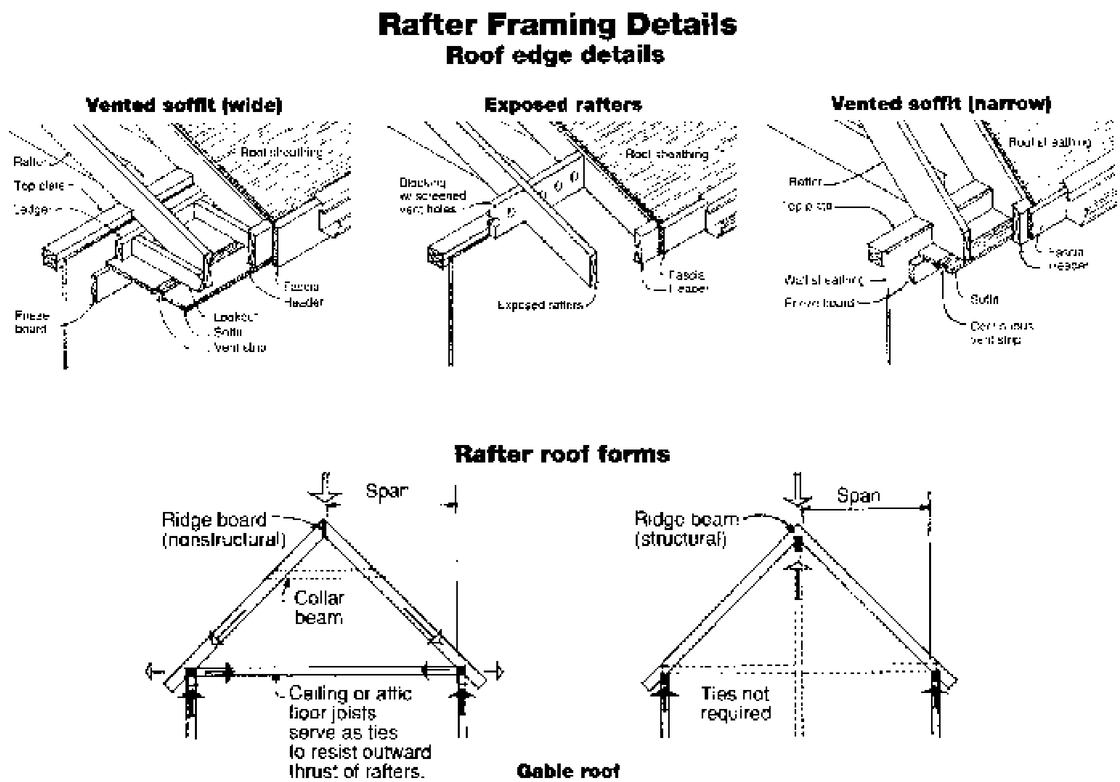
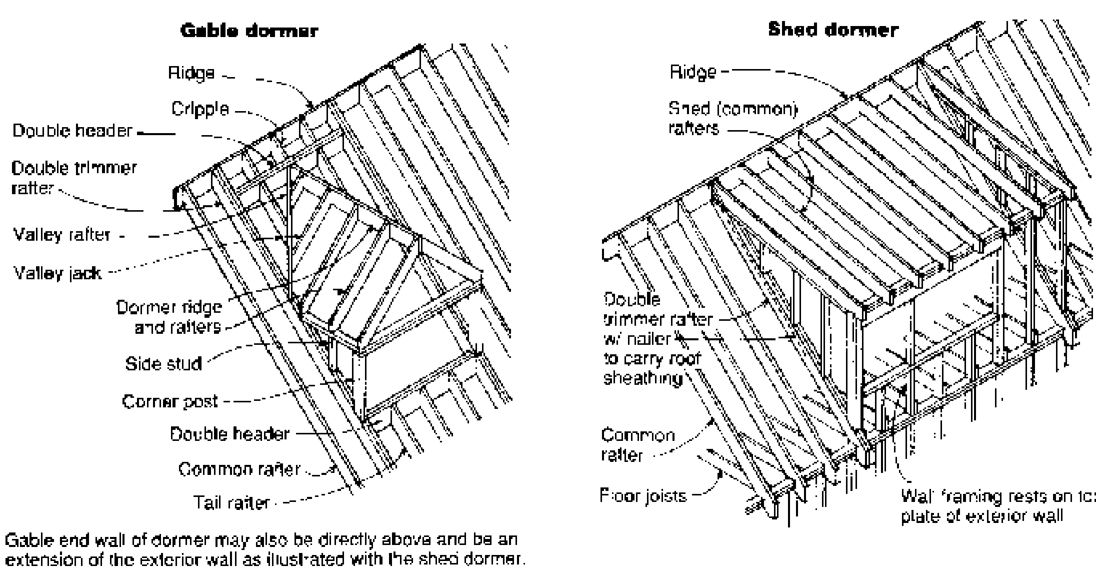
4.6.9 Southern Pine Rafter Framing Details



Typical roof framing types are shown in the figures above. The arrows show the flow of force on the roof framing members.



Dormers are framed into the roof system to add style to the roof and provide light for the attic space or upper floor living area.

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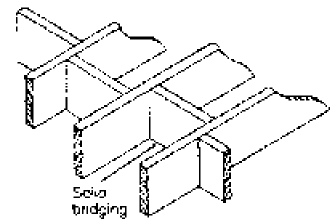
4.6.10 Southern Pine Floor Joist Framing Details

Lateral Support

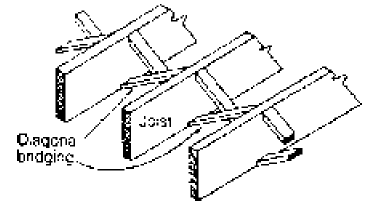
Typically, joists are laterally supported by:
1) a rim joist applied to both ends of the joist to provide stability and to prevent rotation, and
2) sheathing attached to the top of the joist to provide compression edge support. No additional lateral support is required for most common joist applications. There are some conditions, however, where additional lateral support provided by blocking, bridging or cross bracing will be required. For example, the need for lateral support becomes greater as the depth to breadth (d/b) ratio of a joist increases.

The model building codes and the *National Design Specification (NDS)*[1] *for Wood Construction* provide additional guidance on lateral support requirements. The local building code, however, will determine the lateral support required for a particular building. Examples of blocking and cross bracing are shown to the right.

Solid blocking

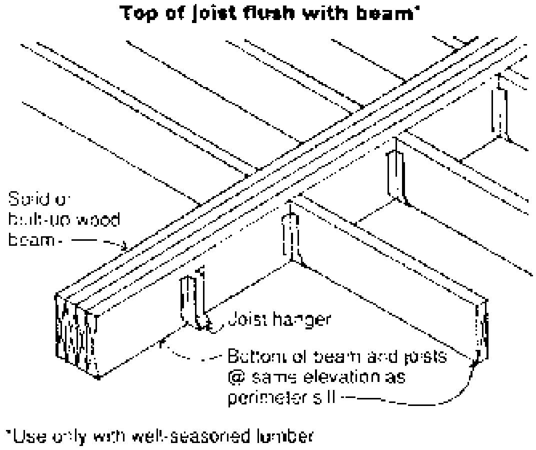


Wood or steel cross bracing

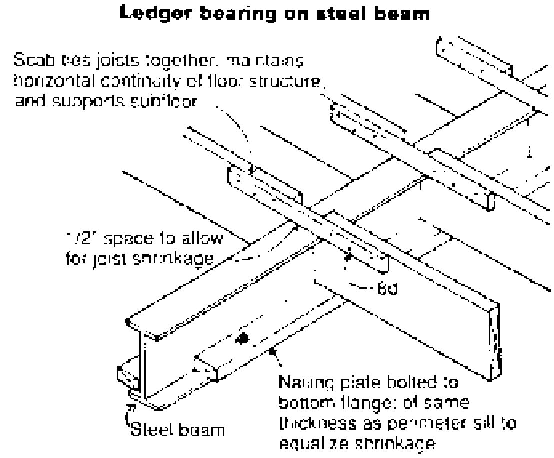


Floor Joist Framing Details
Beam support conditions

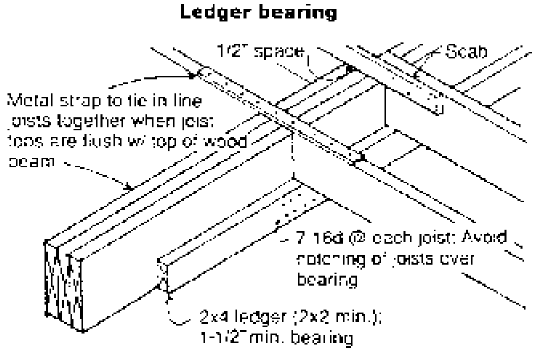
Top of joist flush with beam*



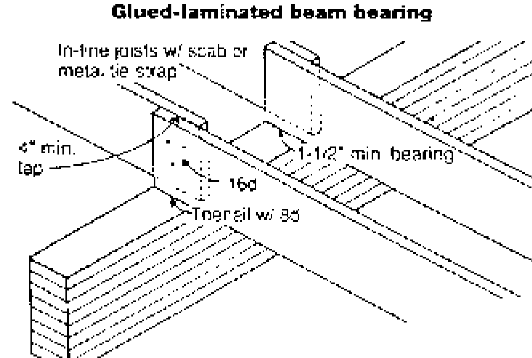
Ledger bearing on steel beam



Ledger bearing



Glued-laminated beam bearing



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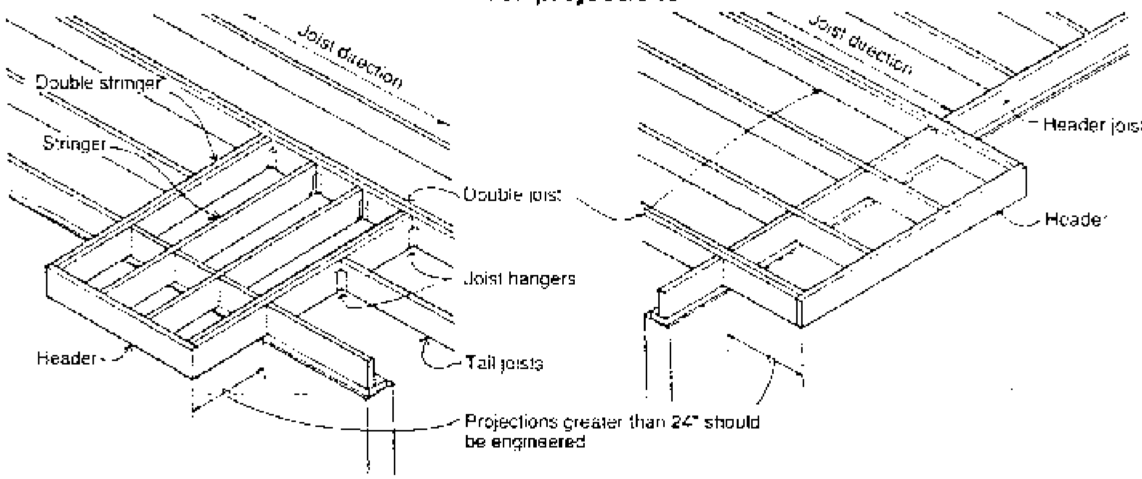
4.6.11 Additional Floor Joist Framing Details

Additional Floor Joist Framing Details

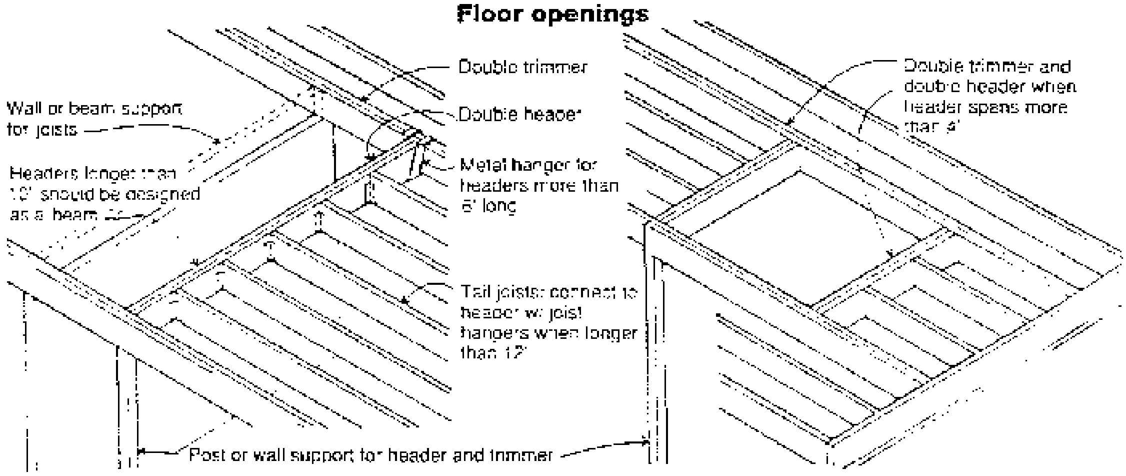
Floor projections



Projection perpendicular to joists **Projection parallel to joists**

Balconies, room extensions, and bay windows can easily be added to a floor plan.

Floor openings



Length perpendicular to joists **Length parallel to joists**

Stairwell and chimney openings are also easily framed. The versatility of joist construction even allows some of these changes to be made when construction is in progress for maximum design flexibility.

Floor Performance

Spans given in the previous joist span comparison table meet all model code requirements. However, meeting the minimum code requirements may not always be sufficient to satisfy the customer. A stricter deflection criteria, such as L/480, can be used to provide a more solid-feeling floor system. In addition to this, floor performance may be enhanced by: glue-nailing the floor sheathing to the joists; using thicker sheathing material (e.g., 3/4" versus 5/8" plywood); and/or using 12" o.c. spacing versus 16" o.c. Most important is the proper installation of the joists—making sure walls and girders are level and nailing the sheathing to joists accurately.

Floor vibrations can also occur in some floors. Continuous solid blocking or cross bracing can improve the floor's vibration performance. Vibrations can also be minimized by attaching a gypsum ceiling directly to the bottom of the joists where no ceiling previously existed.

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4.7.0 Southern Pine Inspection Bureau Grading Rules for Decking

SPIB GRADING RULES FOR RADIUS EDGE DECKING			
DEFECTS	PREMIUM	STANDARD	REVERSE SIDE STANDARD
Checks	1/32" wide x 10" long. If through - 1/32" wide by width of piece	Surface - not limited Through - 2 times width	No limit
Compression Wood	None if readily identifiable and damaging form		
Decay	None	None	1/3 width by 1/3 thickness
Firm Red Heart	25% of face	No limit	No limit
Holes	One 1/4" hole every 4'	Well scattered - 1/4"	No limit
Knots	Sound-Firm-Encased-Pith, if tight and well spaced: 4" width - 1" 6" width - 1-1/2" Decayed knots with serious pits and cavities - 1/2 the sound knot size. All knots in any 4' may not be over twice the maximum size knot	Sound-Firm-Encased-Pith, if tight and well spaced: 4" width - 1-1/2" 6" width - 2-1/2" Decayed knots with serious pits and cavities: 4" width - 1" 6" width - 1-1/2"	No limit except to 55% of the cross section as noted directly below
	Premium: Knot average on front and back cannot be larger than 45% of the cross section using the displacement method (between lines parallel to the edges)		
	Well-Spaced - The sum of all knots in any 6" of length may not be larger than twice the size of maximum size knot.		
Manufacture	Same as No.2 Boards STD E	Same as No.2 Boards STD E	No limit
Pitch	Medium	Medium	Heavy
Pitch Pockets	Medium	Medium	No limit
Pitch Streaks	1/6 width by 1/3 length	1/6 width by 1/3 length	No limit
Pith	No limit if sound	No limit if sound	No limit
Shakes	Surface - 1/32" wide Through at end - Width of piece	Surface - 1/8" wide Through at end - Two times width, but not over 1/6 length	No limit
Splits	Width of piece	Two times width	
Skips	1/64" for 6" or equivalent Same on edge	1/32" on 10% face 1/16" on edge (Hit or Miss)	1/32" full length
Slope of Grain	1" in 8"	1" in 8"	1" in 6"
Stain	Medium	Medium	Heavy
Wane	1/8" deep by 1/2" wide Reverse side - 1/2" deep by 1" wide	1/8" deep by 1/2" wide	1/2" deep by 1" wide
Crook For 6" width	10: 5/8; 12: 7/8; 14: 1-1/8; 16: 1-3/8; 18: 1-1/2	8: 5/8; 10: 1; 12: 1-1/4; 14: 1-1/2; 16: 1-3/4; 18: 2	
Loosened Grain	1/8" separation	1/8" separation	No limit
Offset	1/16" deep	1/16" deep	1/16" deep
Bites	1/16" deep	1/16" deep	1/16" deep

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4.8.0 Southern Pine Inspection Bureau Grading Rules for Finish and Boards

SPIB GRADING RULES FOR FINISH AND BOARDS

DEFECTS	C&BTR	D	NO. 2	NO. 3
Compression Wood	None	Not Limited	Not Limited	Not Limited
Firm Red Heart	25% Face Not Limited if Otherwise B&B	Not Limited	Not Limited	Not Limited
Decay	None	None	Heart Center Only 1/2" Wide by 1/4 Length	Allowed if Suitable for Nailing Throughout
Holes	1/16" Limited to 6 per ft	1/16" Limited to 12 per ft	1/4" Not Limited One 1" Per Piece	1-1/2" in 1x4 and 1x6 1/4 W in 1x8 1x10 1x12
Knots	Sound or Firm and Tight 3/4"-All Widths 1 - 1-1/2" in 6" Width 2 - 1-1/2" in 8, 10 & 12" All Knots in Any 4 Ft Must Not Exceed Twice Diameter of Maximum Knot Allowed	Decayed 3/4" - All Widths if Smooth and Even with surface Sound, Firm, Encased & Pith 3/4" - 1x4 1-1/2" - 1x6 2" - 1x8, 1x10 & 1x12 All Knots Must Be Tight-All Knots in Any 4 Ft Must Not Exceed Twice Diameter of Maximum Knot Allowed	No. 1 Knot Size* 1x4 - 2-1/2" 1-1/2" 1x6 - 3" 2" 1x8 - 3-1/2" 2" 1x10 - 4" 2-1/2" 1x12 - 4-1/2" 2-1/2" * Decayed and Hollow Knots Limited to No. 1 Sizes - Knot Holes & Loose Knots Same as Holes	Not Limited In-Size Except Must be Able to Handle Without Breaking Loose Knots and Through Openings in Hollow Knots Limited Same as Holes
Pith	3/4 of Square Inch	1/6 Length	Not Limited	Not Limited
Stain	15% Face - Medium	25% Face - Medium	Not Limited if Medium	Not Limited if Medium
Pitch	Light - Medium if B&B	Medium, if C - Heavy (1/4W x 1/2L)	Not Limited	Not Limited
Pitch Streak	1/6 Width x 1/3 Length	1/6 Width x 1/3 Length If C-1/4 Width x 1/2 Length	Not Limited Worm-Eaten Area=Knot Size	Not Limited
Pitch Pocket	1/4" x 2" All Widths (Small) 1-3/8" x 4" In 1x6 (Medium) 2-3/8" x 4" in 1x8, 1x10 and 1x12	All Widths 3/8" x 4" (Med) 1x6 - 1 Large (4 sq") 1x8, 10, 12 - 2 Large (4 sq") If C: Through Pocket 3/8x4"	Not Limited	Not Limited
Shakes	1/32" Wide by Width of Piece - None Through	1/32" Wide - None Through	1/4 Length if Close Fitting	1/2 Length if Close Fitting
Skips	Face and Edge 1/64" for 6" or Equivalent	1/32" on 10% Face 1/16" on Edge (Full Length) If C - 1/32" Scant in Width for Each Inch of Width	1/32" on 25% Face 1/16" on Edge (Full Length) 10% of Pieces up to 1/8" Scant in Width	1/16" Full Length 1/8" on 10% of Pieces 1/4" in Width if Not Over 2 Ft Long
Split	Width of Piece	Twice Width But Cannot Exceed 1/6 Length	1/4 Length if Close Fitting	1/2 Length if Close Fitting
Checks	Surface - 1/32" x 10" Through - 1/32" x Width of Piece	Surface - 1/16" x 20" Through - 1/32" x 10" If C - Through 1/16" x 20"	Through - 1/4 Length if Close Fitting	If Through 1/2 Length
Wane	Face: 1/8" Deep x 1/2" Wide Reverse Side 1/4" Deep x 1/8 Width x 1/3 Length	Face: 1/4" Deep x 1/8 Width x 1/3 Length - Reverse: 1/2" Deep x 1/4 Width - Not Exceed 2" Wide	1/4 Width or 2" Wide - 1/8" of Wood on Edge - Sharp Edge for 6" on Occasional Piece	Face: 1/3 Width Reverse 3/4 Width Sharp Edge

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4.8.1 Southern Pine Inspection Bureau Grading Rules for 2" Dimensions

CHARACTERISTICS	SEL STR	NO.1	NO.2	NO.3
COMPRESSION WOOD	← NOT ALLOWED IN DAMAGING FORM FOR THE GRADE CONSIDERED →			
SLOPE OF GRAIN	1" in 12"	1" in 15"	1" in 8"	1" in 4"
DECAY	Not Permitted	Not Permitted	Heart center, 1/3 thickness X 1/3 width	Heart Center, 1/3 cross section. Must not destroy nailing edge. See para. 710(a)
HOLES	Same as unsound knots	Same as unsound knots	See chart below	See chart below

KNOTS	SEL STR Edge	SEL STR Centerline	SEL STR Unsound Knots	NO.1 Edge	NO.1 Centerline	NO.1 Unsound Knots	NO.2 Edge	NO.2 Centerline	NO.2 Holes	NO.3 Edge	NO.3 Centerline	NO.3 Holes
2x4	3/4"	7/8"	3/4"	1"	1-1/2"	1"	1-1/4"	2"	1-1/4"	1-3/4"	2-1/2"	1-3/4"
2x5	1"	1-1/2"	7/8"	1-1/4"	1-7/8"	1-1/8"	1-5/8"	2-3/8"	1-3/8"	2-1/4"	3"	1-7/8"
2x6	1-1/8"	1-7/8"	1"	1-1/2"	2-1/4"	1-1/4"	1-7/8"	2-7/8"	1-1/2"	2-3/4"	3-3/4"	2"
2x8	1-1/2"	2-1/4"	1-1/4"	2"	2-3/4"	1-1/2"	2-1/2"	3-1/2"	2"	3-1/2"	4-1/2"	2-1/2"
2x10	1-7/8"	2-5/8"	1-1/4"	2-1/2"	3 1/4"	1-1/2"	3-1/4"	4-1/4	2-1/2"	4-1/2"	5-1/2"	3"
2x12	2-1/4"	3"	1-1/4"	3"	3-3/4"	1-1/2"	3-3/4"	4-3/4"	3"	5-1/2"	6-1/2"	3 1/2"
	Sound, firm, encased, pith, tight & well spaced. One hole or equivalent smaller holes per 4 lin. ft			Sound, firm, encased, pith, tight & well spaced. One hole or equivalent smaller holes per 3 lin. ft.			Well spaced knots of any quality. One hole or equivalent smaller holes per 2 lin. ft			Well spaced knots of any quality. One hole or equivalent smaller holes per 1 lin. ft.		

CHARACTERISTICS	SEL STR	NO.1	NO.2	NO.3
SHAKES	← Ends: same as splits Elsewhere. 2' surface, none through →		Ends: same as splits Elsewhere: surface 3' or 1/4 length; 2' through	1/6 length if through at edges or ends, elsewhere through shakes 1/3 length
CHECKS	← Surface seasoning checks not limited Through checks at ends limited as splits →			
SKIPS	← Hit and miss in 10% of the pieces. See para. 720(f) →		Hit and miss. 5% of the pieces may be hit or miss or heavy skip for 2'. See para. 720(e, f, and g)	Hit or miss. 10% of the pieces may have heavy skip. See para. 720(e and g)
SPLITS	← Equal to the width →		Equal to 1-1/2 times the width	Equal to 1/6 length
WANE	← 1/4 thickness x 1/4 width x full length or equivalent; must not exceed 1/2 thickness x 1/3 width for up to 1/4 length. Also see para. 750. →		1/3 thickness x 1/3 width x full length or equivalent; must not exceed 2/3 thickness x 1/2 width for up to 1/4 length. Also see para. 750.	1/2 thickness x 1/2 width x full length or equivalent; must not exceed 7/8 thickness or 3/4 width for up to 1/4 length. Also see para. 750.
BOW	← 10' /1-3/8"; 12' /1-1/2"; 14' /2"; 16' /2-1/2" →		10' /1-1/2"; 12' /2"; 14' /2-1/2"; 16' / 3-1/4"	10' /2-3/4"; 12' /3"; 14' /4"; 16' /5"

CROOK Size	SEL STR / NO.1 10'	12'	14'	16'	NO.2 10'	12'	14'	16'	NO.3 10'	12'	14'	16'
2x4	3/8"	1/2"	5/8"	3/4"	1/2"	11/16"	7/8"	1"	3/4"	1"	1-1/4"	1-1/2"
2x6	5/16"	7/16"	9/16"	11/16"	7/16"	5/8"	3/4"	7/8"	5/8"	7/8"	1-1/8"	1-3/8"
2x8	1/4"	13/32"	1/2"	9/16"	3/8"	1/2"	5/8"	3/4"	1/2"	13/16"	1"	1-1/8"
2x10	7/32"	3/8"	7/16"	1/2"	1/4"	7/16"	1/2"	5/8"	7/16"	3/4"	7/8"	1"
2x12	3/16"	9/32"	3/8"	7/16"	3/16"	3/8"	3/8"	1/2"	3/8"	9/16"	3/4"	7/8"

DENSE GRAIN: Requires 6 rings/inch & 1/3 summerwood or 4 rings/inch & 1/2 summerwood.
EXCEPTIONALLY LIGHT WEIGHT PIECES. Should not be placed in No.2N and higher grades (exceptionally light weight pieces have less than 15% summerwood).

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4.9.0 Southern Pine Wood-Preservative Retention Standards

	Waterborne Preservatives[2]				Creosote and Oilborne Preservatives[3]			
	Ammoniacal Copper Arsenate (ACA)	Ammoniacal Copper Zinc Arsenate (ACZA)	Chromated Copper Arsenate (CCA)	AWPA Standard(s)[1]	Creosote	Creosote-Petroleum	Creosote Solutions	Pentachlorophenol (Penta)
	Retention Assay of Treated Wood – lbs./cu.ft.							
Lumber, Timbers & Plywood								
Above Ground	0.25	0.25	0.25	C2/C9	8[5]	8[5]	8[5]	0.40
Soil & Freshwater use	0.40	0.40	0.40	C2/C9	10[5]	10[5]	10[5]	0.50
Permanent Wood Foundation (PWF)	0.60	0.60	0.60	C22	NR	NR	NR	NR
Saltwater use	2.5	2.5	2.5	C2/C9	25	NR	25	NR
Piles								
Land or freshwater use & foundations	0.80	0.80	0.80	C3	12	12	12	0.60
Marine								
Prevalent Marine Organism								
Teredo only	2.5[4] and 1.5	2.5[4] and 1.5	2.5[4] and 1.5	C18	20	NR	20	NR
Pholads only	NR	NR	NR	C18	20	NR	20	NR
Limnoria tripunctata only	2.5[4] and 1.5	2.5[4] and 1.5	2.5[4] and 1.5	C18	NR	NR	NR	NR
Sphaeroma terebrans or for both pholads and limnoria tripunctata use a dual treatment								
First treatment	1.0	1.0	1.0	C18	–	–	–	–
Second treatment	–	–	–	C18	20	–	20	–
Poles								
Utility								
Normal	0.60	0.60	0.60	C4	7.5	7.5	7.5	0.38
Severe service conditions (high incidence of decay and termite attack)	0.60	0.60	0.60	C4	9.0	9.0	9.0	0.45
Building Construction – Round	0.60	0.60	0.60	C23	9.0[5]	NR	NR	0.45
Posts								
Commercial-Residential								
Fence								
Round, half-round, and quarter-round	0.40	0.40	0.40	C5	8[5]	8[5]	8[5]	0.40
Sawn four sides	0.40	0.40	0.40	C2	10[5]	10[5]	10[5]	0.50
Highway Construction								
Fence, Guide, Sign, and Sight Posts								
Round, half-round, and quarter-round	0.40	0.40	0.40	C14	8	8	8	0.40
Sawn four sides	0.40	0.40	0.40	C14	10	10	10	0.50
Guardrail and Spacer Blocks								
Round	0.50	0.50	0.50	C14	10	10	10	0.50
Sawn four sides	0.60	0.60	0.60	C14	12	12	12	0.60

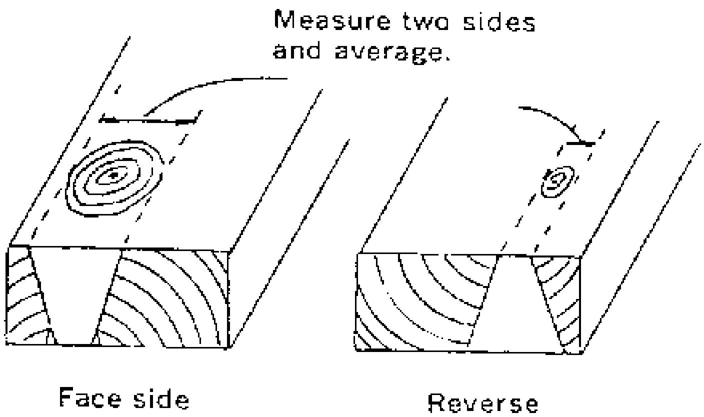
NR – Not Recommended

(1) AWPA Standards detail plant operating procedures for pressure treatment of wood. These Standards include minimum vacuum, pressure, penetration requirements, and maximum steaming parameters. AWPA also details minimum retention requirements, sampling zones for assay and maximum redrying temperature allowance for each preservative, commodity, and wood species. For a copy of the AWPA Standards booklet, please write to the American Wood Preservers' Association, P.O. Box 286, Woodstock, Maryland 21163-0286. (2) ACA, ACZA and CCA are the most commonly available waterborne preservatives. Ammoniacal Copper Quat (ACQ) – Type B, Copper Citrate and CDDC are also approved by AWPA as waterborne preservatives for Southern Pine as lumber, timbers, and ties. (3) Copper Naphthenate is also approved by AWPA as an oilborne preservative for specific wood species and applications excluding saltwater use. (4) The assay retentions are based on two assay zones – 0 to 0.5 inch, and 0.5 to 2.0 inches. (5) Not recommended where cleanliness and freedom from odor are necessary.

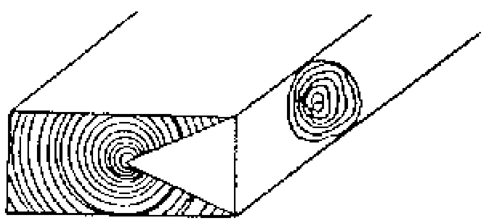
(By permission of the Southern Pine Council.)

4.10.0 Knots and How to Measure Them

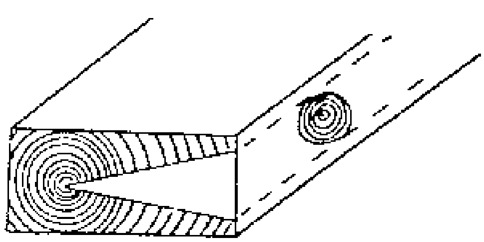
Measuring of knots for Southern Pine lumber.



GRADE	KNOT SIZE ON NARROW FACE	KNOT MAY EXTEND INTO PIECE
No. 1	1-1/2"	1/2 of width (Fig. 1)
	1"	3/4 of width (Fig. 2)
No. 2	1-1/2"	Slightly less than 3/4 of width.
No. 3	1-1/2"	Slightly less than width



1-1/2" Narrow face knot extending 1/2 of width.



1" Narrow face knot extending 3/4 of width.

(By permission of the Southern Pine Council.)

4.11.0 Permissible Deviations from True Plane—Bows, Crooks, Cup

CROOK TABLE for FRAMING and ALTERNATE BOARD RULES

Length in Feet	Crook	Face Width 2"	3"	4"	5"& 6"	8"	10"	12"
4 & 6	Very Light	1/8	1/8	1/8	1/8	1/16	1/16	1/16
	Light	1/4	1/4	1/4	3/16	1/8	1/16	1/16
	Medium	3/8	3/8	3/8	1/4	3/16	1/8	1/8
	Heavy	1/2	1/2	1/2	3/8	1/4	3/16	3/16
8	Very Light	1/4	1/4	3/16	1/8	1/8	1/16	1/16
	Light	3/8	3/8	3/8	5/16	1/4	3/16	1/8
	Medium	1/2	1/2	1/2	1/2	3/8	1/4	3/16
	Heavy	3/4	3/4	3/4	5/8	1/2	3/8	1/4
10	Very Light	3/8	5/16	1/4	3/16	3/16	1/8	1/8
	Light	3/4	5/8	1/2	7/16	3/8	1/4	3/16
	Medium	1 3/8	1	3/4	5/8	1/2	7/16	3/8
	Heavy	1 3/4	1 1/4	1 1/8	1	7/8	3/4	5/8
12	Very Light	1/2	3/8	3/8	5/16	1/4	1/4	3/16
	Light	1	3/4	11/16	5/8	1/2	7/16	3/8
	Medium	1 1/2	1 1/8	1	7/8	13/16	3/4	9/16
	Heavy	2	1 1/2	1 3/8	1 1/4	1 1/8	1	13/16
14	Very Light	5/8	1/2	7/16	3/8	5/16	1/4	3/16
	Light	1 1/4	1	7/8	3/4	5/8	1/2	3/8
	Medium	2	1 1/2	1 1/4	1 1/8	1	7/8	3/4
	Heavy	2 3/4	2	1 3/4	1 1/2	1 1/4	1 1/8	1
16	Very Light	3/4	5/8	1/2	7/16	3/8	5/16	1/4
	Light	1 5/8	1 1/4	1	7/8	3/4	5/8	1/2
	Medium	2 1/2	1 7/8	1 1/2	1 3/8	1 1/8	1	7/8
	Heavy	3 1/4	2 1/2	2	1 3/4	1 1/2	1 1/4	1 1/8

CROOK TABLE for FRAMING and ALTERNATE BOARD RULES, CONT.

Length in Feet	Crook	Face Width 2"	3"	4"	5"& 6"	8"	10"	12"
18	Very Light	1	3/4	5/8	1/2	7/16	3/8	5/16
	Light	2	1 3/8	1 1/8	1	7/8	3/4	5/8
	Medium	3	2 1/16	1 5/8	1 1/2	1 1/4	1 1/8	1
	Heavy	4	2 3/4	2 1/4	2	1 3/4	1 1/2	1 1/4
20	Very Light	1 1/8	7/8	3/4	5/8	1/2	7/16	3/8
	Light	2 1/4	1 1/2	1 3/8	1 1/4	1	7/8	3/4
	Medium	3 3/8	2 1/4	2 1/16	1 7/8	1 1/2	1 5/16	1 1/8
	Heavy	4 1/2	3	2 3/4	2 1/2	2	1 3/4	1 1/2
22	Very Light	1 1/4	1	7/8	3/4	5/8	1/2	7/16
	Light	2 1/2	1 3/4	1 5/8	1 1/2	1 1/4	1	7/8
	Medium	3 3/4	2 5/8	2 7/16	2 1/4	1 7/8	1 1/2	1 1/4
	Heavy	5	3 1/2	3 1/4	3	2 1/2	2	1 3/4
24	Very Light	1 1/2	1 1/8	1	7/8	3/4	5/8	1/2
	Light	3	2	1 7/8	1 3/4	1 1/2	1 1/4	1
	Medium	4 1/2	3	2 3/4	2 5/8	2 1/4	1 7/8	1 5/8
	Heavy	6	4	3 3/4	3 1/2	3	2 1/2	2 1/4

CROOK TABLE for COMMON BOARDS

Length		Face Width 4"	6"	8"	10"	12"
8 Feet	2 & Btr. Com.	1/2	7/16	3/8	5/16	1/4
	3 Com.	13/16	3/4	11/16	5/8	1/2
	4 Com.	1	15/16	7/8	13/16	3/4
10 Feet	2 & Btr. Com.	13/16	11/16	9/16	1/2	3/8
	3 Com.	1 1/4	1 3/16	1 1/16	1	13/16
	4 Com.	1 9/16	1 7/16	1 3/8	1 1/4	1 3/16
12 Feet	2 & Btr. Com.	1 1/8	1	7/8	11/16	9/16
	3 Com.	1 13/16	1 11/16	1 9/16	1 7/16	1 1/8
	4 Com.	2 1/4	2 1/8	2	1 13/16	1 11/16
14 Feet	2 & Btr. Com.	1 9/16	1 5/16	1 1/8	15/16	3/4
	3 Com.	2 1/2	2 5/16	2 1/8	1 15/16	1 9/16
	4 Com.	3 1/16	2 7/8	2 11/16	2 1/2	2 5/16
16 Feet	2 & Btr. Com.	2	1 3/4	1 1/2	1 1/4	1
	3 Com.	3 1/4	3	2 3/4	2 1/2	2
	4 Com.	4	3 3/4	3 1/2	3 1/4	3

Maximum crook is limited to the amount shown in the above table for the appropriate length, width and grade. Pieces differing in length and width from these basic sizes may have crook in proportion to the amounts shown. Maximum crook is limited to occasional pieces of any item.

CROOK TABLE for SELECTS and FINISH

Length		Face Width 4"	6"	8"	10"	12"
8 Feet	C Sel. (Choice IWP) & Btr. Superior	1/4	1/4	3/16	3/16	1/8
	D Sel. (Quality IWP) Prime	3/8	3/8	5/16	5/16	1/4
10 Feet	C Sel. (Choice IWP) & Btr. Superior	3/8	5/16	5/16	1/4	3/16
	D Sel. (Quality IWP) Prime	9/16	9/16	1/2	7/16	3/8
12 Feet	C Sel. (Choice IWP) & Btr. Superior	9/16	1/2	7/16	3/8	5/16
	D Sel. (Quality IWP) Prime	7/8	3/4	11/16	5/8	9/16
14 Feet	C Sel. (Choice IWP) & Btr. Superior	3/4	11/16	9/16	1/2	3/8
	D Sel. (Quality IWP) Prime	1 1/8	1 1/16	15/16	7/8	3/4
16 Feet	C Sel. (Choice IWP) & Btr. Superior	1	7/8	3/4	5/8	1/2
	D Sel. (Quality IWP) Prime	1 1/2	1 3/8	1 1/4	1 1/8	1

In the grades of Selects and Finish, maximum crook is limited to the amount shown in the above table for the appropriate length, width and grade. Pieces differing in length and width from these basic sizes may have crook in proportion to the amounts shown. Maximum crook is limited to occasional pieces of any item.

(By permission from Western Wood Products Association, Portland, Oregon.)

TWIST TABLE

Length In Feet	Twist	Face Width 2"	3" & 4"	5" & 6"	8"	10"	12"
4	Very Light	1/16	1/8	3/16	1/4	5/16	3/8
	Light	1/8	1/4	3/8	1/2	5/8	3/4
	Medium	3/16	3/8	9/16	3/4	7/8	1 1/8
	Heavy	1/4	1/2	3/4	1	1 1/4	1 1/2
6	Very Light	3/32	3/16	5/16	3/8	7/16	9/16
	Light	3/16	3/8	1/2	3/4	7/8	1 1/8
	Medium	9/32	1/2	3/4	1 1/8	1 3/8	1 5/8
	Heavy	3/8	3/4	1 1/8	1 1/2	1 7/8	2 1/4
8	Very Light	1/8	1/4	3/8	1/2	5/8	3/4
	Light	1/4	1/2	3/4	1	1 1/4	1 1/2
	Medium	3/8	3/4	1 1/8	1 1/2	1 7/8	2 1/4
	Heavy	1/2	1	1 1/2	2	2 1/2	3
10	Very Light	5/32	5/16	7/16	5/8	3/4	15/16
	Light	5/16	5/8	7/8	1 1/4	1 1/2	1 7/8
	Medium	1/2	7/8	1 5/16	1 7/8	2 3/8	2 3/4
	Heavy	5/8	1 1/4	1 7/8	2 1/2	3 1/8	3 3/4
12	Very Light	3/16	3/8	9/16	3/4	15/16	1 1/8
	Light	3/8	3/4	1 1/8	1 1/2	1 7/8	2 1/4
	Medium	9/16	1 1/8	1 5/8	2 1/4	2 3/4	3 3/8
	Heavy	3/4	1 1/2	2 1/4	3	3 3/4	4 1/2
14	Very Light	7/32	7/16	5/8	7/8	1 1/16	1 5/16
	Light	7/16	7/8	1 1/4	1 3/4	2 1/8	2 5/8
	Medium	5/8	1 1/4	1 7/8	2 5/8	3 1/4	3 7/8
	Heavy	7/8	1 3/4	2 5/8	3 1/2	4 3/8	5 1/4
16	Very Light	1/4	1/2	3/4	1	1 1/4	1 1/2
	Light	1/2	1	1 1/2	2	2 1/2	3
	Medium	3/4	1 1/2	2 1/4	3	3 3/4	4 1/2
	Heavy	1	2	3	4	5	6
18	Very Light	9/32	9/16	13/16	1 1/8	1 3/8	1 11/16
	Light	9/16	1 1/8	1 5/8	2 1/4	2 3/4	3 3/8
	Medium	7/8	1 5/8	2 1/2	3 3/8	4 1/4	5
	Heavy	1 1/8	2 1/4	3 3/8	4 1/2	5 5/8	6 3/4
20 and Longer	Very Light	5/16	5/8	15/16	1 1/4	1 9/16	1 7/8
	Light	5/8	1 1/4	1 7/8	2 1/2	3 1/8	3 3/4
	Medium	1	1 7/8	2 3/4	3 3/4	4 5/8	5 5/8
	Heavy	1 1/4	2 1/2	3 3/4	5	6 1/4	7 1/2

Maximum twist is limited to the amount shown in the above table for the appropriate lengths and widths. Pieces differing in length and width may have twist proportionate to the amount shown. Maximum twist is limited to occasional pieces of an item.

CROOK TABLE for FRAMING and ALTERNATE BOARD RULES

Length In Feet	Crook	Face Width 2"	3"	4"	5" & 6"	8"	10"	12"
4 & 6	Very Light	1/8	1/8	1/8	1/16	1/16	1/16	1/16
	Light	1/4	1/4	1/4	3/16	1/8	1/16	1/16
	Medium	3/8	3/8	3/8	1/4	3/16	1/8	1/8
	Heavy	1/2	1/2	1/2	3/8	1/4	3/16	3/16
8	Very Light	1/4	1/4	3/16	1/8	1/8	1/16	1/16
	Light	3/8	3/8	3/8	5/16	1/4	3/16	1/8
	Medium	1/2	1/2	1/2	1/2	3/8	1/4	3/16
	Heavy	3/4	3/4	3/4	5/8	1/2	3/8	1/4
10	Very Light	3/8	5/16	1/4	3/16	3/16	1/8	1/8
	Light	3/4	5/8	1/2	7/16	3/8	1/4	3/16
	Medium	1 3/8	1	3/4	5/8	1/2	7/16	3/8
	Heavy	1 3/4	1 1/4	1 1/8	1	7/8	3/4	5/8
12	Very Light	1/2	3/8	3/8	5/16	1/4	1/4	3/16
	Light	1	3/4	11/16	5/8	1/2	7/16	3/8
	Medium	1 1/2	1 1/8	1	7/8	13/16	3/4	9/16
	Heavy	2	1 1/2	1 3/8	1 1/4	1 1/8	1	13/16
14	Very Light	5/8	1/2	7/16	3/8	5/16	1/4	3/16
	Light	1 1/4	1	7/8	3/4	5/8	1/2	3/8
	Medium	2	1 1/2	1 1/4	1 1/8	1	7/8	3/4
	Heavy	2 3/4	2	1 3/4	1 1/2	1 1/4	1 1/8	1
16	Very Light	3/4	5/8	1/2	7/16	3/8	5/16	1/4
	Light	1 5/8	1 1/4	1	7/8	3/4	5/8	1/2
	Medium	2 1/4	1 7/8	1 1/2	1 3/8	1 1/8	1	7/8
	Heavy	3 1/4	2 1/2	2	1 3/4	1 1/2	1 1/4	1 1/8

CROOK TABLE for FRAMING and ALTERNATE BOARD RULES, CONT.

Length In Feet	Crook	Face Width 2"	3"	4"	5" & 6"	8"	10"	12"
18	Very Light	1	3/4	5/8	1/2	7/16	3/8	5/16
	Light	2	1 3/8	1 1/8	1	7/8	3/4	5/8
	Medium	3	2 1/16	1 5/8	1 1/2	1 1/4	1 1/8	1 1/4
	Heavy	4	2 3/4	2 1/4	2	1 3/4	1 1/2	1 1/2
20	Very Light	1 1/8	7/8	3/4	5/8	1/2	7/16	3/8
	Light	2 1/4	1 1/2	1 3/8	1 1/4	1	7/8	3/4
	Medium	3 3/8	2 1/4	2 1/16	1 7/8	1 1/2	1 5/16	1 1/8
	Heavy	4 1/2	3	2 3/4	2 1/2	2	1 3/4	1 1/2
22	Very Light	1 1/4	1	7/8	3/4	5/8	1/2	7/16
	Light	2 1/2	1 3/4	1 5/8	1 1/2	1 1/4	1	7/8
	Medium	3 3/4	2 5/8	2 7/16	2 1/4	1 7/8	1 1/2	1 1/4
	Heavy	5	3 1/2	3 1/4	3	2 1/2	2	1 3/4
24	Very Light	1 1/2	1 1/8	1	7/8	3/4	5/8	1/2
	Light	3	2	1 7/8	1 3/4	1 1/2	1 1/4	1
	Medium	4 1/2	3	2 3/4	2 5/8	2 1/4	1 7/8	1 5/8
	Heavy	6	4	3 3/4	3 1/2	3	2 1/2	2 1/4

Continued

4.12.0 Commercial Names of the Principal Softwood Species

Commercial Species or Species Group Names	Official Common Tree Names	Botanical Names
CEDAR:		
Alaska Cedar	Alaska-cedar	*Chamaecyparis nootkatensis*
Incense Cedar	incense-cedar	*Libocedrus decurrens*
Port Orford Cedar	Port-Orford-cedar	*Chamaecyparis lawsoniana*
Eastern Red Cedar	eastern redcedar	*Juniperus virginiana*
	southern redcedar	*J. silicicola*
Western Red Cedar	western redcedar	*Thuja plicata*
Northern White Cedar	northern white-cedar	*T. occidentalis*
Southern White Cedar	Atlantic white-cedar	*Chamaecyparis thyoides*
CYPRESS:		
Baldcypress	baldcypress	*Taxodium distichum*
Pond cypress	pondcypress	*T. distichum var. nutans*
FIR:		
Balsam Fir	balsam fir	*Abies balsamea*
	Fraser fir	*A. fraseri*
Douglas Fir	Douglas-fir	*Pseudotsuga menziesii*
Noble Fir	noble fir	*Abies procera*
White Fir	subalpine fir	*A. lasiocarpa*
	California red fir	*A. magnifica*
	grand fir	*A. grandis*
	noble fir	*A. procera*
	Pacific silver fir	*A. amabilis*
	white fir	*A. concolor*

4.13.0 Fasteners for Lumber

Gone are the days when a carpenter bought their hardware supplies at the neighborhood hardware store. They would reach into a fifty-pound wooden keg and with calloused hands grab handfuls of the various nail sizes they needed, put them in the scoop provided by the store owner so they could be placed on a scale and weighed. Those days are gone forever.

Power driven nails and staples and screw guns have made serious in-roads in the application of the "standard" nail as we know it. And the standard 2 × 4 wood framing stud has certainly changed over the years; it is no longer 2-inches thick and 4-inches wide. Today's "2 × 4" measures only 1½ inches in thickness so those old 16d common nails which were 3½ inches in length and regularly used to hold a double plate or double 2 × 4s together now protrude out of the doubled stud by ½ inch when driven home. Advances in framing technology resulted in the development of the pneumatically powered tools using "collated" nails rather than "bulk" nails. And these power "nailers" also use staples manufactured by wire that has been drawn to size and glued together to form a staple strip. Both power tools offer significant labor savings, while providing consistent performance.

Nails and staples have been the target of considerable engineering studies by the National Evaluation Service (NER) and the International Staple, Nail and Tool Association (ISNTA). The following charts, tables, and diagrams further elevate the status of the ordinary nail and staple, and provide effective guidelines for practitioners of the carpentry trade.

4.13.1 Nailing Schedule for Framing Lumber

CONNECTION	NAILING[1]
1. Joist to sill or girder, toenail	3-8d
2. Bridging to joist, toenail each end	2-8d
3. 1″ × 6″ (25 mm × 152 mm) subfloor or less to each joist, face nail	2-8d
4. Wider than 1″ × 6″ (25 mm × 152 mm) subfloor to each joist, face nail	3-8d
5. 2″ (51 mm) subfloor to joist or girder, blind and face nail	2-16d
6. Sole plate to joist or blocking, typical face nail Sole plate to joist or blocking, at braced wall panels	16d at 16″ (406 mm) o.c. 3-16d 16″ (406 mm)
7. Top plate to stud, end nail	2-16d
8. Stud to sole plate	4-8d, toenail or 2-16d, end nail
9. Double studs, face nail	16d at 24″ (610 mm) o.c.
10. Double top plates, typical face nail Double top plates, lap splice	16d at 16″ (406 mm) o.c. 8-16d
11. Blocking between joists or rafters to top plate, toenail	3-8d
12. Rim joist to top plate, toenail	8d at 6″ (152 mm) o.c.
13. Top plates, laps and intersections, face nail	2-16d
14. Continuous header, two pieces	16d at 16″ (406 mm) o.c. along each edge
15. Ceiling joists to plate, toenail	3-8d
16. Continuous header to stud, toenail	4-8d
17. Ceiling joists, laps over partitions, face nail	3-16d
18. Ceiling joists to parallel rafters, face nail	3-16d
19. Rafter to plate, toenail	3-8d
20. 1″ (25 mm) brace to each stud and plate, face nail	2-8d
21. 1″ × 8″ (25 mm × 203 mm) sheathing or less to each bearing, face nail	2-8d
22. Wider than 1″ × 8″ (25 mm × 203 mm) sheathing to each bearing, face nail	3-8d
23. Built-up corner studs	16d at 24″ (610 mm) o.c.
24. Built-up girder and beams	20d at 32″ (813 mm) o.c. at top and bottom and staggered 2-20d at ends and at each splice
25. 2″ (51 mm) planks	2-16d at each bearing
26. Wood structural panels and particleboard:[2] Subfloor and wall sheathing (to framing): $^{1}/_{2}$″ (12.7 mm) and less $^{19}/_{32}$″-$^{3}/_{4}$″ (15 mm-19 mm) $^{7}/_{8}$″-1″ (22 mm-25 mm) $1^{1}/_{8}$″-$1^{1}/_{4}$″ (29 mm-32 mm) Combination subfloor-underlayment (to framing): $^{3}/_{4}$″ (19 mm) and less $^{7}/_{8}$″-1″ (22 mm-25 mm) $1^{1}/_{8}$″-$1^{1}/_{4}$″ (29 mm-32 mm)	 6d[3] 8d[4] or 6d[5] 8d[3] 10d[4] or 8d[5] 6d[5] 8d[5] 10d[4] or 8d[5]
27. Panel siding (to framing)[2]: $^{1}/_{2}$″ (12.7 mm) or less $^{5}/_{8}$″ (16 mm)	 6d[6] 8d[6]
28. Fiberboard sheathing:[7] $^{1}/_{2}$″ (12.7 mm) $^{25}/_{32}$″ (20 mm)	 No. 11 ga.[8] 6d[4] No. 16 ga.[9] No. 11 ga.[8] 8d[4] No. 16 ga.[9]
29. Interior paneling $^{1}/_{4}$″ (6.4 mm) $^{3}/_{8}$″ (9.5 mm)	 4d[10] 6d[11]

[1]Common or box nails may be used except where otherwise stated.
[2]Nails spaced at 6 inches (152 mm) on center at edges, 12 inches (305 mm) at intermediate supports except 6 inches (152 mm) at all supports where spans are 48 inches (1219 mm) or more. For nailing of wood structural panel and particleboard diaphragms and shear walls, refer to Sections 2315.3.3 and 2315.4. Nails for wall sheathing may be common, box or casing.
[3]Common or deformed shank.
[4]Common.
[5]Deformed shank.
[6]Corrosion-resistant siding or casing nails conforming to the requirements of Section 2304.3.
[7]Fasteners spaced 3 inches (76 mm) on center at exterior edges and 6 inches (152 mm) on center at intermediate supports.
[8]Corrosion-resistant roofing nails with $^{7}/_{16}$-inch-diameter (11 mm) head and $1^{1}/_{2}$-inch (38 mm) length for $^{1}/_{2}$-inch (12.7 mm) sheathing and $1^{3}/_{4}$-inch (44 mm) length for $^{25}/_{32}$-inch (20 mm) sheating conforming to the requirements of Section 2304.3.
[9]Corrosion-resistant staples with nominal $^{7}/_{16}$-inch (11 mm) crown and $1^{1}/_{8}$-inch (29 mm) length for $^{1}/_{2}$-inch (12.7 mm) sheathing and $1^{1}/_{2}$-inch (38 mm) length for $^{25}/_{32}$-inch (20 mm) sheathing conforming to the requirements of Section 2304.3.
[10]Panel supports at 16 inches (406 mm) [20 inches (508 mm) if strength axis in the long direction of the panel, unless otherwise marked]. Casing or finish nails spaced 6 inches (152 mm) on panel edges, 12 inches (305 mm) at intermediate supports.
[11]Panel supports at 24 inches (610 mm). Casing or finish nails spaced 6 inches (152 mm) on panel edges, 12 inches (305 mm) at intermediate supports.

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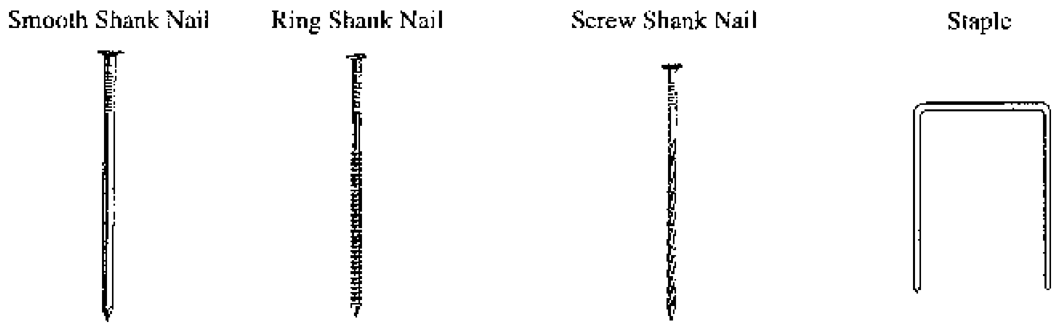
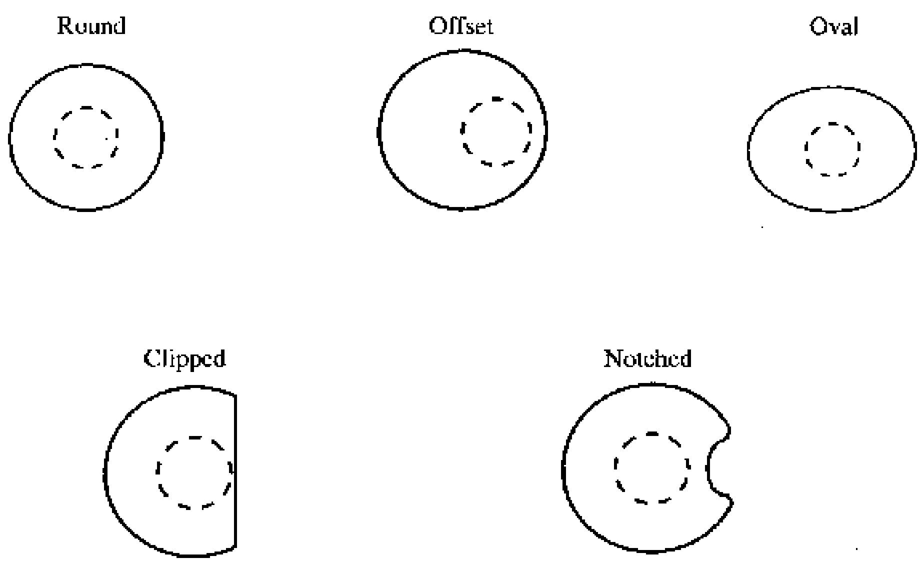
4.13.2 Basic Fastener Styles

Basic Fastener Styles



Nail Head Styles

(Solid line represents head perimeter; dashed line represents shank perimeter.)



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4.13.3 Nominal Dimensions of Nails and Staples

NOMINAL DIMENSIONS OF NAILS FREQUENTLY LISTED IN MODEL BUILDING CODES

PENNYWEIGHT	LENGTH, IN INCHES	SHANK DIAMETER, IN INCHES
	Box	
6d	2	0.099
8d	2-1/2	0.113
10d	3	0.128
	Casing	
6d	2-1/4	0.099
8d	2-1/2	0.113
10d	3	0.128
	Common	
6d	2	0.113
8d	2-1/2	0.131
10d	3	0.148
16d	3-1/2	0.162
20d	4	0.192
	Cooler	
5d	1 5/8	0.086
6d	1-7/8	0.092
8d	2 3/8	0.113
	Deformed [1]	
3d	1-1/4	0.099
4d	1-1/2	0.099
6d	2	0.120
8d	2-1/2	0.120
	Finish	
8d	2-1/2	0.099
10d	3	0.113
	Siding	
6d	1-7/8	0.106
8d	2-3/8	0.128

[1]A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank.

STAPLE DIMENSIONS AND NORMAL, LATERAL DESIGN LOADS [1,2]

STAPLE [3]		LATERAL LOAD	
Gage	Diameter, in inches	Minimum Penetration, [4] in inches	Load [5] (lbf)
14	0.080	1	75
15	0.072	1	64
16	0.0625	1	52

[1]Design values are based on a 10 year "normal" load duration.

[2]Table values shall be multiplied by applicable adjustment factors such as for load duration, wet service, temperature, end grain, and toe-nailing. Where metal side plates are used, lateral strength values may be increased 25 percent.

[3]Staples shall have a 7/16-inch minimum outside dimension crown width.

[4]The tabulated penetrations are for staples installed in Group I or II species. Penetration shall be increased to 13 diameters for Group III and 14 diameters for Group IV species.

[5]The tabulated allowable lateral values are for staples installed in Douglas Fir, Larch or Southern Pine (Group II species). Species groups are described in Table A of the Appendix. To determine the allowable values when both the attached wood member and the supporting (main) wood member are in the same group, but are not Group II, multiply the values listed in the above table by the following conversion factors: I-1.23, III-0.82, IV-0.65. If the attached and supporting members are in different groups, use the conversion factor for the wood in the higher group.

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4.13.4 Nail and Staples Withdrawal Design Values

NAIL AND STAPLE NORMAL WITHDRAWAL DESIGN VALUES [1,2,3,4] POUNDS PER INCH OF PENETRATION

SPECIFIC GRAVITY	SMOOTH SHANK NAILS, DIAMETER IN INCHES									DEFORMED SHANK[5] NAILS, DIAMETER IN INCHES								STAPLE GAGE AND DIAMETER, IN INCHES		
	0.091	0.094	0.097 / 0.099	0.105	0.113	0.120	0.131	0.148	0.162	0.091	0.094	0.097 / 0.099	0.113	0.120	0.120	0.135	0.148	16 gage 0.063	15 gage 0.072	14 gage 0.080
0.31	7	7	7	8	8	9	10	11	12	7	8	8	9	10	10	11	12	9	11	12
0.35	9	9	10	11	11	12	13	15	16	10	10	11	12	13	14	15	16	13	14	16
0.36	10	10	11	11	12	13	14	16	17	11	11	11	13	14	15	16	17	13	15	17
0.37	10	11	11	12	13	14	15	17	19	12	12	12	14	15	16	17	19	14	17	18
0.38	11	12	12	13	14	15	16	18	20	12	13	13	15	16	17	18	20	15	18	20
0.39	12	12	13	14	15	16	17	19	21	13	14	14	16	17	18	19	21	16	19	21
0.4	13	13	14	15	16	17	18	21	23	14	14	15	17	18	20	21	23	17	20	22
0.41	14	14	15	16	17	18	19	22	24	15	15	16	18	20	21	22	24	19	21	24
0.42	14	15	16	17	18	19	21	23	26	16	16	17	20	21	22	23	26	20	23	25
0.43	15	16	17	18	19	20	22	25	27	17	17	18	21	22	24	25	27	21	24	27
0.44	16	17	18	19	20	21	23	26	29	18	18	19	22	23	25	26	29	22	26	28
0.46	18	19	20	21	22	24	26	29	32	20	20	21	25	26	28	29	32	25	29	32
0.47	19	20	21	22	24	25	27	31	34	21	22	22	26	28	29	31	34	26	30	33
0.49	21	22	23	24	26	28	30	34	38	23	24	25	29	31	33	34	38	29	33	37
0.5	22	23	24	26	28	29	32	36	40	24	25	26	30	32	34	35	40	30	35	39
0.51	23	24	25	27	29	31	34	38	42	26	27	27	32	34	36	38	42	32	37	41
0.55	28	29	31	33	35	37	41	46	50	31	32	33	38	41	44	46	50	39	45	50
0.58	32	33	35	37	40	42	46	52	57	35	37	38	44	47	50	53	58	44	51	57
0.67	46	48	50	53	57	61	66	75	82	51	52	54	63	67	71	75	83	63	73	81
0.68	48	49	52	55	59	63	69	78	85	53	54	56	65	69	74	78	86	66	76	84
0.71	53	55	58	62	66	70	77	87	95	59	61	63	73	77	83	87	95	73	84	94
0.73	57	59	62	66	71	75	82	93	102	63	65	67	78	83	88	93	102	79	90	101

[1]Design values are based on a normal (10 year) duration of load.

[2]Table values shall be multiplied by applicable adjustment factors such as for load duration, wet service, temperature, and toe-nailing.

[3]Withdrawal strengths are for fasteners driven perpendicular to the grain.

[4]For connections between solid lumber members, the permitted withdrawal strength of fasteners shall be limited to two times the tabulated values, regardless of increased penetrations. For connections between wood structural panels and solid lumber with a specific gravity up to 0.51, the permitted withdrawal strength shall be limited to 1.34 times the tabulated values, regardless of penetration. For connections between wood structural panels and solid lumber with a specific gravity of 0.55 or greater, permitted withdrawal strength is limited to 1.17 times the tabulated values at 0.55 specific gravity, regardless of increased penetration or greater specific gravity.

[5]A deformed shank (threaded) nail shall have either a helical (screw) shank or an annular (ring) shank.

NORMAL[1] DESIGN[2] LATERAL STRENGTH OF FACE-NAILED SINGLE SHEAR CONNECTIONS OF "2-BY" MEMBERS [3] TO OTHER MEMBERS[4] OF THE SAME SPECIES [5]

FASTENER		CONNECTION LATERAL STRENGTH, IN POUNDS, IF BOTH FRAMING MEMBERS HAVE SPECIFIC GRAVITY OF...			
Length (in inches)	Nail Shank Diameter [6] (in inches), or Staple Gage	0.42 (e.g., Spruce-Pine-Fir)	0.43 (e.g., Hem-Fir)	0.50 (e.g., Douglas Fir-larch)	0.55 (e.g. Southern Pine)
3-1/2	0.162	92	94	109	119
3	0.148	84	86	99	109
3-1/4	0.131	79	80	93	101
3	0.131	79	80	93	101
2-1/2	0.131	52	54	62	67
3-1/4	0.120	69	71	81	89
3	0.120	69	71	81	89
2-3/8	0.113	40	40	47	51
2-1/4	0.105	30	31	37	41
2-1/4	0.099	30	30	35	38
3-1/4	14 gage	61	61	75	75
3	14 gage	61	61	75	75

[1]Design values are based on a 10 year "normal" load duration.

[2]Table values shall be multiplied by applicable adjustment factors such as for load duration, wet service, temperature, and toe-nailing.

[3]Table is based upon a 1-1/2" actual thickness of both attached member and receiving ("main") member.

[4]Design values are for connections in which the nail shank or staple leg are driven in side grain with shank/leg axis perpendicular to wood fibers. Tabulated values for nailed connections require that the nail has a minimum fastener bending yield strength (F_{yb}) as listed in Section 3.3.2 of this report.

[5]Calculations are based on a connection in which both members have the same specific gravity. The "European Yield Model" formulas in the Appendix permit calculation of the design lateral strength for nailed connections consisting of different wood species. For stapled connections consisting of different wood species, the "proportional limit theory" formula in the Appendix shall be used with the calculations based on the density of the less-dense wood member.

[6]Nails shall have a smooth shank or deformed shank - with helical (screw) or annular (ring) threads

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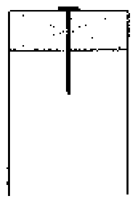
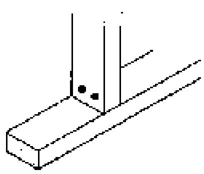
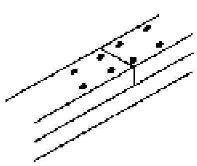
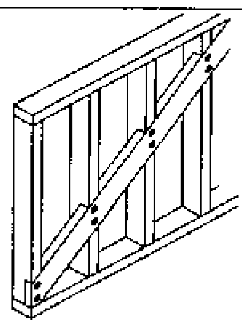
4.13.5 Wall Framing Nailing Schedule with Illustrations

WALL FRAMING[1]

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.)	QUANTITY PER CONNECTION, OR SPACING BETWEEN FASTENERS (inches on-center)[5]
Top or sole plate to stud (face nail)	3-1/2" x 0.162" nail (16d common)[4]	2
	3" x 0.148" nail (10d common)	3
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	4
	3" x 0.120" nail	
	3-1/4" 14 gage staple	3
	3" 14 gage staple	
Stud to top or sole plate (toe nail)	2-1/2" x 0.131" nail (8d common)[4]	4
	3-1/2" x 0.162" nail (16d common)	3
	3" x 0.148" nail (10d common)	4
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	2-3/8" x 0.113" nail	5
	2" x 0.113" nail	
	2-1/4" x 0.105" nail	
	2-1/4" x 0.099" nail	
	3-1/4" 14 gage staple	3
	3" 14 gage staple	
Cap/top plate laps and intersections	3-1/2" x 0.162" nail (16d common)[4]	2 each side of lap
	3" x 0.148" nail	3 each side of lap
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Diagonal bracing	2-1/2" x 0.131" nail (8d common)[4]	2
	3-1/2" x 0.162" nail (16d common)	
	3" x 0.148" nail (10d common)	
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	3
	3" x 0.120" nail	
	2-3/8" x 0.113" nail	
	2" x 0.113" nail	4
	2-1/4" x 0.105" nail	
	2-1/4" x 0.099" nail	
	3-1/4" 14 gage staple	2
	3" 14 gage staple	

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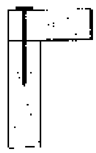
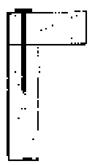
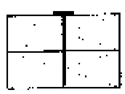
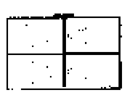
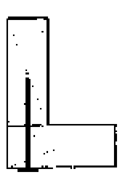
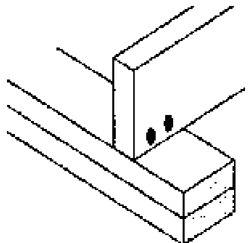
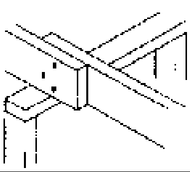
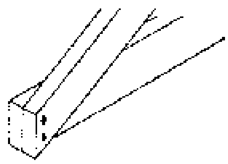
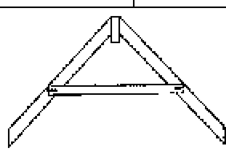
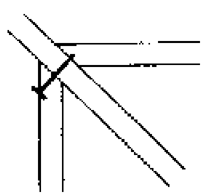
WALL FRAMING[1]

CONNECTION [2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple [3] gage.)	QUANTITY PER CONNECTION, OR SPACING BETWEEN FASTENERS (inches on-center) [5]
Sole plate to joist or blocking at braced panels 	3-1/2" x 0.135" nail (16d box) [4]	3 per 16" space
	3-1/2" x 0.162" nail (16d common)	2 per 16" space
	3" x 0.148" nail (10d common)	3 per 16" space
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	4 per 16" space
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Sole plate to joist or blocking 	3-1/2" x 0.162" nail (16d common) [4]	16" o.c.
	3" x 0.148" nail (10d common)	8" o.c.
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	12" o.c.
	3" 14 gage staple	
Double top plate 	3" x 0.148" nail (10d common) [4]	16" o.c.
	3-1/2" x 0.162" nail (16d common)	
	3-1/4" x 0.131" nail	12" o.c.
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Double studs 	3" x 0.148" nail (10d common) [4]	12" o.c.
	3-1/2" x 0.162" nail (16d common)	
	3-1/4" x 0.131" nail	8" o.c.
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Corner studs 	3-1/2" x 0.162" nail (16d common) [4]	24" o.c.
	3" x 0.148" nail (10d common)	16" o.c.
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	12" o.c.
	3" x 0.120" nail	
	3-1/4" 14 gage staple	16" o.c.
	3" 14 gage staple	

Continued

4.13.6 Ceiling and Roof Framing Nailing Schedule with Illustrations

CEILING AND ROOF FRAMING[1]

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.)	QUANTITY PER CONNECTION[5]
Ceiling joist to plate 	3-1/2" x 0.162" nail (16d common)[4]	3
	3" x 0.148" nail (10d common)	4
	3-1/4" x 0.131" nail	5
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-3/8" x 0.113" nail	6
	3-1/4" 14 gage staple	5
	3" 14 gage staple	
Ceiling joists, laps over partitions  Ceiling joist to parallel rafter 	3-1/2" x 0.162" nail (16d common)[1]	3
	3" x 0.148" nail (10d common)	4
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Collar tie to rafter 	3" x 0.148" nail (10d common)[4]	3
	3-1/2" x 0.162" nail (16d common)	
	3-1/4" x 0.131" nail	4
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	
Jack rafter to hip, toe-nailed 	3" x 0.148" nail (10d common)[4]	3
	3-1/2" x 0.162" nail (16d common)	
	3-1/4" x 0.131" nail	4
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	
	3-1/4" 14 gage staple	
	3" 14 gage staple	

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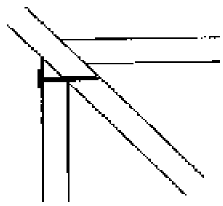
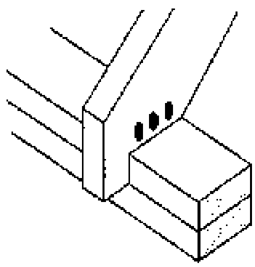
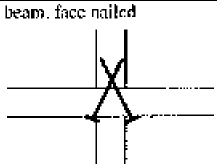
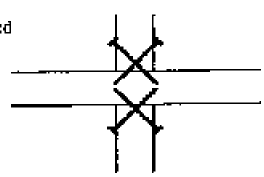
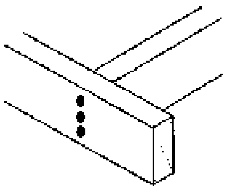
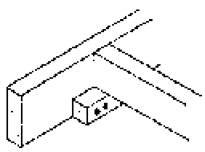
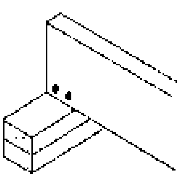
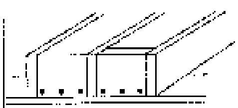
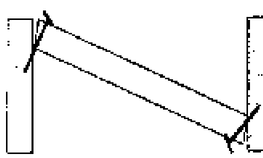
CEILING AND ROOF FRAMING[1]

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.)	QUANTITY PER CONNECTION[5]
Jack rafter to hip, face nailed 	3-1/2" x 0.162" nail (16d common)[4]	2
	3" x 0.148" nail (10d common)	3
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	4
	3" x 0.120" nail	
	3-1/4" 14 gage staple	3
	3" 14 gage staple	
Roof rafter to plate (toe-nailed) 	2-1/2" x 0.131" nail (8d common)[4]	3
	3-1/2" x 0.162" nail (16d common)	
	3" x 0.148" nail (10d common)	
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	4
	3" x 0.120" nail	
	2-3/8" x 0.113" nail	5
	2" x 0.113" nail	
	2-1/4" x 0.105" nail	
	2-1/4" x 0.099" nail	6
	3-1/4" 14 gage staple	3
	3" 14 gage staple	
Roof rafter to 2 by ridge beam, face nailed  (Only the attachment of the top rafter is illustrated.)	3-1/2" x 0.162" nail (16d common)[4]	2
	3" x 0.148" nail (10d common)	3
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	4
	3" x 0.120" nail	
	3-1/4" 14 gage staple	3
	3" 14 gage staple	
Roof rafter to 2-by ridge beam, toe-nailed 	3-1/2" x 0.162" nail (16d common)[4]	2
	3" x 0.148" nail (10d common)	3
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	4
	3" x 0.120" nail	
	3-1/4" 14 gage staple	3
	3" 14 gage staple	

Continued

4.13.7 Floor Framing Nailing Schedule with Illustrations

FLOOR FRAMING[1]

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.)	QUANTITY PER CONNECTION OR MAXIMUM SPACING[5]
Joist to band joist 	3-1/2″ x 0.162″ nail (16d common)[4]	3
	3″ x 0.148″ nail (10d common)	5
	3-1/4″ x 0.131″ nail	
	3″ x 0.131″ nail	
	3-1/4″ x 0.120″ nail	6
	3″ x 0.120″ nail	
	3-1/4″ 14 gage staple	5
	3″ 14 gage staple	
Ledger strip 	3-1/2″ x 0.162″ nail (16d common)[4]	3
	3″ x 0.148″ nail (10d common)	1
	3-1/4″ x 0.131″ nail	
	3″ x 0.131″ nail	
	3-1/4″ x 0.120″ nail	4
	3″ x 0.120″ nail	
	3-1/4″ 14 gage staple	4
	3″ 14 gage staple	
Joist to sill or girder (toe-nailed)  Blocking between joist or rafter to top plate (toe-nailed) 	2-1/2″ x 0.131″ nail (8d common)[4]	3
	3″ x 0.148″ nail (10d common)	
	3-1/4″ x 0.131″ nail	
	3″ x 0.131″ nail	
	3-1/4″ x 0.120″ nail	4
	3″ x 0.120″ nail	
	3-1/4″ 14 gage staple	3
	3″ 14 gage staple	
Bridging to joist (listed number of fasteners at each end) 	2-1/2″ x 0.131″ nail (8d common)[4]	2
	3-1/4″ x 0.120″	3
	3″ x 0.120″ nail	
	2-3/8″ x 0.113″ nail	
	2″ x 0.113″ nail (6d common)	4
	2-1/4″ x 0.105″ nail	3
	2-1/4″ x 0.099″ nail	4
	3-1/4″ 14 gage staple	2
	3″ 14 gage staple	

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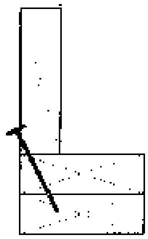
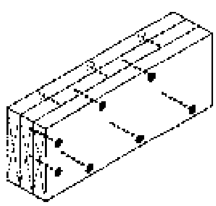
FLOOR FRAMING[1]

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.)	QUANTITY PER CONNECTION OR MAXIMUM SPACING[5]
Rim joist to top plate (toe-nailed) 	2-1/2" x 0.113" nail (8d box)[4]	6" o.c.
	3-1/2" x 0.162" nail (16d common)	8" o.c.
	3" x 0.148" nail (10d common)	6" o.c.
	3-1/4" x 0.131" nail	
	3" x 0.131" nail	
	3-1/4" x 0.120" nail	
	3" x 0.120" nail	4" o.c.
	2-3/8" x 0.113" nail	6" o.c.
	2" x 0.113" nail (6d common)	3" o.c.
	2-1/4" x 0.105" nail	
	2-1/4" x 0.099" nail	
	3-1/4" 14 gage staple	6" o.c.
	3" 14 gage staple	

CONNECTION[2] (Nail size and position exaggerated for purpose of illustration.)	FASTENER (Minimum nominal length in inches x minimum nominal nail diameter in inches, or staple[3] gage.	SPACING OF FASTENERS ALONG TOP AND BOTTOM OF BEAM, STAGGERED ON EACH SIDE OF EACH LAYER	NUMBER OF FASTENERS AT EACH END AND SPLICE FOR EACH LAYER
Built-up Girders and Beams 	4" x 0.192" nail (20d common)[4]	32" o.c.	2
	3-1/2" x 0.162" nail (16d common) 3" x 0.148" nail (10d common) 3-1/4" 14 gage staple 3" 14 gage staple 3-1/4" x 0.131" nail 3" x 0.131" nail	24" o.c.	3
	3-1/4" x 0.120" nail 3" x 0.120" nail	16" o.c.	3
	2-1/2" x 0.131" nail (8d common)	16" o.c.	4

Footnotes

[1]This fastening schedule applies to framing members having an actual thickness of 1-1/2" (nominal "2-by" lumber).

[2]Fastenings listed above may also be used for other connections that are not listed but that have the same configuration and the same code requirement for fastener quantity/spacing and fastener size (pennyweight and style, e.g., 8d common, "8-penny common nail").

[3]Staple shall have a minimum nominal crown width of 7/16 inch, outside legs.

[4]This fastener, in the quantity or spacing shown in the far-right column, comprises the most stringent fastening of the connection listed in the National, One and Two Family Dwelling, Standard and Uniform Building Codes.

[5]Fastening schedule only applies to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening shall be determined by structural analysis. ICBO *Uniform Building Code* requires structural analysis in areas where design wind speeds prescribed by the code are 80 mph or higher. SBCCI *Standard Building Code* requires structural analysis in areas where design wind speeds prescribed by the code exceed 80 mph.

Continued

4.13.8 Summary of Use of Fasteners for Framing

SUMMARY OF USE OF FASTENERS FOR FRAMING [1]

CONNECTION [2,4]	NUMBER, OR SPACING, OF FASTENERS REQUIRED PER CONNECTION												
	Nail lengths are minimum, nominal lengths, in inches. Nail shank diameters are minimum, nominal diameters, in inches.											14 Gage Staples [3]	
	3-1/2 x 0.162	3 x 0.148	3-1/4 x 0.131	3 x 0.131	2-1/2 x 0.131	3-1/4 x 0.120	3 x 0.120	2-3/8 x 0.113	2 x 0.113	2-1/4 x 0.105	2-1/4 x 0.099	3-1/4"	3"
Floor Framing													
Joist to band joist	3	5	5	5	N/A	6	6	N/A	N/A	N/A	N/A	5	5
Ledger strip	3	4	4	4	6	4	4	N/A	N/A	N/A	N/A	4	4
Joist to sill or girder	3	3	3	4	3	4	4	N/A	N/A	N/A	N/A	3	3
Blocking between joist or rafter to top plate	3	3	3	4	3	4	4	N/A	N/A	N/A	N/A	3	3
Bridging to joist	N/A	N/A	N/A	N/A	2	3	3	3	4	3	4	2	2
Rim joist to top plate	8" o.c.	6" o.c.	6" o.c.	6" o.c.	6" o.c.	6" o.c.	4" o.c.	6" o.c.	3" o.c.	3" o.c.	3" o.c.	6" o.c.	6" o.c.
Built-up Girders & Beams - Spacing along edges. # at ends & splices	24" o.c., 3	24" o.c., 3	24" o.c., 3	24" o.c., 3	16" o.c., 4	16" o.c., 3	16" o.c., 3	N/A	N/A	N/A	N/A	24" o.c., 3	24" o.c., 3
Ceiling and Roof Framing													
Ceiling joist to plate	3	4	5	5	5	5	5	6	N/A	N/A	N/A	5	5
Ceiling joists, laps over partitions	3	4	4	4	6	4	4	N/A	N/A	N/A	N/A	4	4
Ceiling joist to parallel rafter	3	4	4	4	6	4	4	N/A	N/A	N/A	N/A	4	4
Collar tie to rafter	3	3	4	4	5	4	4	N/A	N/A	N/A	N/A	4	4
Jack rafter to hip, toe-nailed	3	3	4	4	5	4	4	N/A	N/A	N/A	N/A	4	4
Jack rafter to hip, face-nailed	2	3	3	3	3	4	4	N/A	N/A	N/A	N/A	3	3
Roof rafter to plate	3	3	3	3	3	4	4	5	5	5	6	3	3
Roof rafter to 2-by ridge beam (driven through beam into end of ridge)	2	3	3	3	N/A	4	4	N/A	N/A	N/A	N/A	3	3
Roof rafter to 2-by ridge beam (toe nail rafter to beam)	2	3	3	3	3	4	4	N/A	N/A	N/A	N/A	3	3
Wall Framing													
Top or sole plate to stud (end nailed)	2	3	3	3	5	4	4	N/A	N/A	N/A	N/A	3	3
Stud to top or sole plate (toe nailed)	3	4	4	4	4	4	4	5	5	5	5	3	3
Cap/top plate laps and intersections (each side of lap)	2	3	3	3	4	3	3	N/A	N/A	N/A	N/A	3	3
Diagonal bracing	2	2	2	2	2	3	3	3	4	4	4	2	2
Sole plate to joist or blocking at braced panels (number per 16" joist space)	2	3	3	4	N/A	4	4	N/A	N/A	N/A	N/A	4	4
Sole plate to joist or blocking	16" o.c.	8" o.c.	8" o.c.	8" o.c.	6" o.c.	8" o.c.	8" o.c.	N/A	N/A	N/A	N/A	12" o.c.	12" o.c.
Double top plate	16" o.c.	16" o.c.	12" o.c.	12" o.c.	8" o.c.	12" o.c.	12" o.c.	N/A	N/A	N/A	N/A	12" o.c.	12" o.c.
Double studs	12" o.c.	12" o.c.	8" o.c.	8" o.c.	6" o.c.	8" o.c.	8" o.c.	N/A	N/A	N/A	N/A	8" o.c.	8" o.c.
Corner studs	24" o.c.	16" o.c.	16" o.c.	16" o.c.	8" o.c.	12" o.c.	12" o.c.	N/A	N/A	N/A	N/A	16" o.c.	16" o.c.

N/A = Fastener not applicable to connection.

[1]This fastening schedule applies to framing members having an actual thickness of 1-1/2" (nominal "2-by" lumber).

[2]Fastenings listed above may also be used for other connections that are not listed but that have the same configuration and the same code requirement for fastener quantity/spacing and fastener size (pennyweight and style; e.g., 8d common, "8-penny common nail").

[3]Staple shall have a minimum nominal crown width of 7/16 inch, outside legs.

[4]Fastening schedules only apply to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening shall be determined by structural analysis. ICBO *Uniform Building Code* requires structural analysis in areas where design wind speeds prescribed by the code are 80 mph or higher. SBCCI *Standard Building Code* requires structural analysis in areas where design wind speeds prescribed by the code exceed 80 mph.

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4.13.9 Allowable Spacing of Fasteners for Subfloor Underlayment

ALLOWABLE SPACING OF ALTERNATE FASTENINGS [1] FOR THE ATTACHMENT OF 19/32", 5/8", 23/32" & 3/4" WOOD STRUCTURAL PANEL AND PARTICLEBOARD COMBINATION SUBFLOOR/UNDERLAYMENT TO WOOD FRAMING MEMBERS

FASTENER TYPE (Minimum Nominal Nail [2] Shank Diameter, In Inches, or Staple [3] Gage)[4]	MINIMUM NOMINAL LENGTH, INCHES	SPACING OF FASTENERS	
		At Edges, and At Intermediate Supports Where Spans Are 48" or More	At Intermediate Supports
0.131" nail (8 common nail)	2-1/2	6	12
0.120" deformed shank nail	2		
0.092" nail	2-1/4	3	6
0.099" nail	2-1/4	4	8
0.099" deformed shank nail	2-1/4	4	8
0.113" nail	2	3	6
0.113" deformed shank nail	2	4	8
0.113" nail (8d cooler)	2-3/8	4	8
0.113" deformed shank nail	2 3/8	4	8
0.120" nail	3	4	8
0.131" deformed shank nail	2-1/2	6	12
16 gage staple	1-3/4	3	6
	2	4	8
15 gage staple	1-3/4	3	6
	2	4	8
	2-1/4		
	2-1/2		
14 gage staple	2	4	8
	2-1/4		
	2-1/2		
	3		

[1] For fastening of wood structural panel horizontal diaphragms and shear walls, refer to design tables (Tables 12 through 21) for sufficient lateral strength.
[2] A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank
[3] Staples shall have minimum 7/16" crown widths.
[4] In areas using the *Standard Building Code*, only deformed shank nails are permitted to fasten combination subfloor/underlayment.

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4.13.10 Allowable Spacing of Fasteners for Sheathing to Wood Framing

ALLOWABLE SPACING OF ALTERNATE FASTENINGS [1] EQUIVALENT TO THE ATTACHMENT OF 19/32", 5/8", 23/32" AND 3/4" WOOD STRUCTURAL PANEL AND PARTICLEBOARD SHEATHING TO WOOD FRAMING MEMBERS USING AN 8D DEFORMED SHANK NAIL

FASTENER TYPE (minimum nominal nail [2] shank diameter, in inches, or staple [3] gage)	MINIMUM NOMINAL LENGTH, INCHES	IF MODEL CODE REQUIRES: 8d Deformed Shank Nail Spaced 4" o.c.	8d Deformed Shank Nail Spaced 6" o.c.	8d Deformed Shank Nail Spaced 12" o.c.
		Spacings of Fasteners to Achieve Equivalent Withdrawal and Lateral Strength to an 8d Deformed Shank Nail (inches)		
0.120" nail (8d deformed shank nail)	2-1/2	4	6	12
0.092" nail	2-1/4	2	3	6
0.099" nail	2-1/4	2	3 (See Footnote 5)	6 (See Footnote 4)
0.099" deformed shank nail	2-1/4	2	4	8
0.113" nail	2	2	3	6
0.113" deformed shank nail	2	2	4	8
0.113" nail (8d cooler)	2-3/8	3	4	8
0.113" deformed shank nail	2-3/8	3	4	8
0.120" nail	3	4	6	12
0.131" nail (8d common)	2-1/2	4	6	12
0.131" deformed shank nail	2-1/2	4	6	12
16 gage staple	1-3/4	2	3	6
	2	2	4	8
15 gage staple	1-3/4	2	3 (See Footnote 5)	6 (See Footnote 4)
	2	3	4	8
	2-1/4			
	2-1/2			
14 gage staple	2	3	4	8
	2-1/4			
	2-1/2			
	3			

[1] For fastening of wood structural panel horizontal diaphragms and shear walls, refer to design tables (Tables 12 through 21) for sufficient lateral strength.
[2] A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank.
[3] Staples shall have minimum 7/16" crown widths.
[4] For 19/32" and 5/8" panel thicknesses, spacing up to 8" o.c. is permitted.
[5] For 19/32" and 5/8" panel thicknesses, spacing up to 4" o.c. is permitted.

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4.13.11 Wall Sheathing, Panel Siding, and Underlayment Nailing Schedules

WALL SHEATHING, PANEL SIDING AND FLOOR UNDERLAYMENT ATTACHED TO WOOD MEMBERS

DESCRIPTION OF ATTACHED MATERIAL	ATTACHED MATERIAL NOMINAL THICKNESS (in inches)	SPACING SPECIFICATIONS (in inches)[4]		FASTENER SPECIFICATIONS[1,2]	
		Edges	Intermediate	Minimum Leg Length (in inches)	Fastener Style[3]
Plywood Panel Siding	3/8	6	12	1-1/2	6d Galv. Casing Nail
					6d Galv. Siding Nail
					0.097 Galv. Finish Nail
	1/2	6	12	1-5/8	6d Galv. Casing Nail
					6d Galv. Siding Nail
					0.097 Galv. Finish Nail
	5/8	6	12	1-7/8	8d Galv. Casing Nail
					8d Galv. Siding Nail
					0.113 Galv. Finish Nail
Fiberboard Wall Sheathing	1/2	6	12	1-1/2	14 Gage Staple
		4	10		15 Gage Staple
					16 Gage Staple
	25/32	5	10	1-3/4	14 Gage Staple
		4	8		15 Gage Staple
					16 Gage Staple
Gypsum Wall Sheathing	1/2	5	10	1-1/2	14 Gage Staple
		4	8		15 Gage Staple
					16 Gage Staple
Floor Underlayment	1/4	3	6-Grid	1-1/4	3d Ring Shank Nail
		2	5-Grid	7/8	18 Gage Staple 3/16" Crown Width
		2	4-Grid	1-1/4	0.080 Nail
	11/32	6	8-Grid	1-1/4	3d Ring Shank Nail
					16 Gage Staple
		4	6-Grid		0.080 Nail
	15/32 - 19/32	6	8-Grid		3d Ring Shank Nail
					16 Gage Staple
		5	6-Grid		0.097" Nail
	3/4	6	8-Grid	1-1/2	4d Ring Shank Nail
					16 Gage Staple
		5	6-Grid		0.097" Nail

[1]Except as noted above, all staples shall have a minimum crown width of 7/16 inch.

[2]Steel wire fasteners exposed to the weather in service shall be zinc-coated by a hot-dip, mechanical-deposition or electro-deposition galvanizing process.

[3]0.080 nails and No. 18 gage staples are not listed in Tables 1 through 4, and are for nonstructural use only as tabulated above.

[4]Fastening schedule only applies to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening shall be determined by structural analysis. The ICBO *Uniform Building Code* requires structural analysis in areas where design wind speeds prescribed by the code are 80 mph or higher. The SBCCI *Standard Building Code* requires structural analysis in areas where the design wind speed exceeds 80 mph.

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4.13.12 Fasteners for Roof and Wall Shingles

FASTENERS FOR ATTACHING WALL AND ROOF COVERING MATERIALS [1]

SPACING SPECIFICATIONS	FASTENER SPECIFICATIONS [2] Fastener Style	Minimum Crown Width, or Nail Head Diameter	Minimum Leg Length [3]
	Composition Roof Shingles and Wall Shingles		
A Minimum of Four Fasteners Per Each 36"–40" Section of Shingle [4]	16 Gage Staples	15/16"	See Footnotes 3 & 5
	0.120" Roof Nail	3/8"	See Footnote 3
	Composition Ridge and Hip Caps		
A Minimum of Two Fasteners Per Cap	16 Gage Staples	15/16"	See Footnotes 3 & 5
	0.120" Roof Nail	3/8"	See Footnote 3
	Wood Roof and Wall Shingles [6, 7, 8]		
A Minimum of Two Fasteners Per Shingle	16 Gage Staples	7/16"	1-1/4"
	0.080" Nail	-	1-1/4"
	Wood Shakes [6, 7, 8]		
A Minimum of Two Fasteners Per Shingle	16 Gage Staples	7/16"	1-3/4"
	0.080" Nail	-	1-3/4"
	Tin Capping for Roof Felts		
All tin caps placed and fastened 12 inches on center	16 Gage Staples	7/16"	7/8"
	0.120" Roof Nail	3/8"	7/8"
	Aluminum and Vinyl Siding [9]		
Vertical Siding 10" o.c., [10] Horizontal Siding 16" o.c. [10]	16 Gage Staples	7/16"	See Footnote 9
	0.120" Nail	3/8"	2"
	Built-Up Roof Base Sheets to Wood Substrates		
Staples spaced 12" o.c. straddling 1/4-inch-wide rayon cord tape [11]	16 Gage Staples	7/16"	See Footnote 11

[1] In areas covered by the *Standard Building Code*, use of this table is limited to areas where design wind speeds prescribed by the code do not exceed 80 mph and building heights do not exceed 30 feet.

[2] Steel wire fasteners exposed to the weather in service shall be zinc-coated by a hot-dip, mechanical deposition or electro-deposition galvanizing process. Fasteners manufactured from aluminum 5056 or 6061 alloy wire or other nonferrous alloys do not require protective coatings.

[3] The staples or nail leg length shall be long enough to penetrate through the sheathing and extend beyond 1/8 inch or penetrate the sheathing 3/4 inch, whichever is less; all other provisions of this table will prevail.

[4] The BOCA *National Building Code* requires that asphalt strip shingles shall have a minimum of six fasteners per shingle where the structure is located in hurricane ocean-line areas along the Atlantic and Gulf of Mexico coastal areas and 100 miles inland where the basic wind speed is 80 miles per hour or greater, determined in accordance with the Basic Wind Speed map in the Code (Figure 1609.3).

[5] Composition shingles shall be attached with staples that are driven so that the staple crown bears tightly against the shingle but does not cut the shingle surface. The crown is parallel to the long dimension of the shingle course.

[6] Wood shingles and shakes shall be attached with staples that are driven so that the staple crown is parallel to the butt edge, compressing the wood surface no more than the total thickness of the staple crown wire.

[7] Nails for wood shingles and shakes shall be long enough to penetrate into the sheathing 3/4 inch or through the thickness of the sheathing, whichever is less.

[8] No. 18 gage staples with a 7/16-inch crown may be used to attach roof and wall shingles, provided the butt ends do not exceed 3/4 inch. The staple leg length shall be long enough to penetrate into the sheathing 3/4 inch or through the thickness of the sheathing, whichever is less. Two staples shall be used to attach each shingle or shake.

[9] Staples shall be corrosion resistant and have a minimum penetration of 3/4 inch into the wood supporting member. One leg of the staple shall be driven through the pre-punched hole in the sealing rib, with the crown perpendicular to the width of the siding. The staple shall not deform the siding.

[10] As required by manufacturer and approved by the building official.

[11] Legs of sufficient length to penetrate the opposite side of the roof deck 1/8-inch or penetrate into the sheathing 3/4 inch, whichever is less. The rayon cord tape is located 16 inches on center, parallel to the long dimension of the base sheet. At points where the head lap occurs between base sheets, the tape is installed below the center of the overlapping portion of the base sheets.

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4.13.13 Staple Usage for Wall, Ceilings, Soffits

STAPLES FOR ATTACHING WALL, CEILING AND SOFFIT COVERING MATERIALS TO WOOD RECEIVING MEMBERS ONLY [1]

MINIMUM LEG LENGTH (O.D.) (In Inches)	DESCRIPTION OF COVERING MATERIALS [2,3,5,6,7]	MAXIMUM SPACING (in inches)	
		Vertical Surfaces	Horizontal Surfaces
7/8	3/8-inch Gypsum Lath - Plain, Type X	8 [8]	8 [8]
1	3/8-inch Gypsum Lath and Metal or Wire Stripping	-	5
1-1/2	1/2-inch Gypsum Lath - Plain, Type X	8 [8]	8 [8] / 6 [4]
	1/2-inch Fiber Insulation Lath	4	4
1 3/4	1-inch Fiber Insulation Lath	5	
	Laminating 3/8-inch Gypsum Lath and 3/8-inch Gypsum Wallboard		
7/8	3/8-inch Gypsum Lath Panels, Wallboard and Backer Board	7	7
1-1/8	1/2-inch Gypsum Lath Panels, Wallboard and Backer Board		
1-1/4	5/8-inch Gypsum Wallboard and Backer Board		
1-3/4	Laminating 1/2-inch and 1/2-inch Type X Wallboard		
2	Laminating 5/8-inch and 5/8-inch Type X Wallboard		
7/8	Metallic Plaster Reinforcement — Welded or woven wire fabric; Expanded metal lath: Regular (non-furred and no ribs) Self-furred	6	6
1-1/4	Metallic Plaster Reinforcement — Expanded metal lath: 1/8 inch high Rib Metal Lath	at ribs	at ribs
1-3/4	Metallic Plaster Reinforcement — Expanded metal lath: 1/8-inch-high Rib Metal Lath		

[1]Staples shall be manufactured from No. 16 gage round, semi-round or flattened wire and shall have, if used for attaching gypsum wallboard or gypsum lath, a minimum 3/4-inch crown, measured outside the legs.

[2]Staples for attachment of exterior lath must be galvanized. When attached over fiberboard, rigid, expanded polystyrene or gypsum sheathing, the leg length shall be sufficient to provide a 1-inch penetration into the stud.

[3]Lath shall be furred and provided with backing when required by the applicable model code. The welded or woven wire netting shall be pre-hung by conventional temporary nailing prior to staple installation.

[4]Supports spaced 24 inches o.c. Four attachments per 16-inch-wide lath per bearing. Five attachments per 24-inch-wide lath per bearing.

[5]Staples attaching metal or wire lath, stucco mesh and welded or woven wire netting shall have a minimum 7/16-inch crown, measured outside the legs.

[6]For attaching covering materials to redwood supporting members, add a minimum of 3/8-inch to fastener leg length.

[7]Steel wire fasteners exposed to the weather in service shall be zinc-coated by a hot-dip, mechanical-deposition or electro-deposition galvanizing process. Fasteners manufactured from aluminum 5056 or 6061 alloy wire or other nonferrous alloys do not require protective coatings.

[8]Three attachments per 16-inch-wide lath per bearing. Four attachments per 24-inch-wide lath per bearing.

STAPLES FOR ATTACHING WALL, CEILING AND SOFFIT COVERING MATERIALS TO METAL RECEIVING MEMBERS ONLY

WIRE GAGE NO.	MINIMUM LEG LENGTH (O.D.) (in inches)	DESCRIPTION OF COVERING MATERIALS [1]	STAPLE [2] SPACING (in inches)	TYPE OF RECEIVING MEMBER
16	1-1/8	3/8-Inch Gypsum Lath	5	Approved Load and Nonload-bearing Nailable Studs "Only" Designed for Receiving Round Wire Staples or Conventional Nails
14			8	
16	1 1/4	1/2 Inch Gypsum Lath, Panels & Wallboard [3]	5	
14			8	
16	1-3/8	1/2-Inch Gypsum Lath, Panels & Wallboard	5	
14			8	
16	1-1/4	Metal Lath & Welded or Woven Wire Lath & Masonry Veneer Wire Mesh	6	
16	1 3/8	3/8-Inch High Rib Metal Lath	At Ribs	
16	1-3/4	3/4-Inch High Rib Metal Lath		

[1]Staples shall be manufactured from round, semi-round or flat wire and shall have a minimum 7/16 inch crown.

[2]Steel wire fasteners exposed to the weather in service shall be zinc coated by a hot-dip, mechanical-deposition or electro-deposition galvanizing process. Fasteners manufactured from aluminum 5056 or 6061 alloy wire or other nonferrous alloys do not require protective coatings.

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4.13.14 Wood Dowel Bearing Strength—by Species

WOOD SPECIES' SPECIFIC GRAVITY, DOWEL BEARING STRENGTH AND GROUP NUMBERS

GROUP	SPECIES	SPECIFIC GRAVITY[1], G	DOWEL-BEARING STRENGTH IN POUNDS PER SQUARE INCH (psi), F_e	"K" VALUES FOR STAPLE LATERAL STRENGTH CALCULATIONS
I	Beech-birch-hickory	0.71	8,850	2,040
	Red Oak	0.67	7,950	
	White Oak	0.73	9,300	
II	Douglas Fir-larch	0.50	4,650	1,650
	Southern Pine	0.55	5,550	
III	Douglas Fir-south	0.46	4,000	1,350
	Eastern Hemlock	0.41	3,200	
	Eastern Hemlock-tamarack	0.41	3,200	
	Eastern Hemlock-tamarack (north)	0.47	4,150	
	Eastern softwoods	0.36	2,550	
	Eastern Spruce	0.41	3,200	
	Hem-Fir	0.43	3,500	
	Mountain Hemlock	0.47	4,150	
	Northern Pine	0.42	3,350	
	Ponderosa Pine	0.43	3,500	
	Red Pine	0.44	3,650	
	Sitka Spruce	0.43	3,500	
	Spruce-Pine-Fir	0.42	3,350	
	Western Hemlock	0.47	4,150	
	Yellow Poplar	0.43	3,500	
IV	Aspen	0.39	2,950	1,080
	Balsam Fir	0.36	2,550	
	Coast Sitka Spruce	0.39	2,950	
	Eastern White Pine	0.36	2,550	
	Engelmann Spruce - Alpine Fir[2] (MSR 1650f and higher grades)	0.46	4,000	
	Engelmann Spruce - Alpine Fir[2] (MSR 1500f and lower grades)	0.38	2,800	
	Northern Species	0.35	2,400	
	Northern White Cedar	0.31	1,900	
	Western Cedars	0.36	2,550	
	Western Cedars	0.35	2,400	
	Western White Pine	0.40	3,600	
	White Woods	0.36	2,550	

[1]Specific gravity based on weight and volume when oven-dry.

[2]Applies only to Engelmann spruce-lodgepole pine machine stress-rated (MSR) structural lumber.

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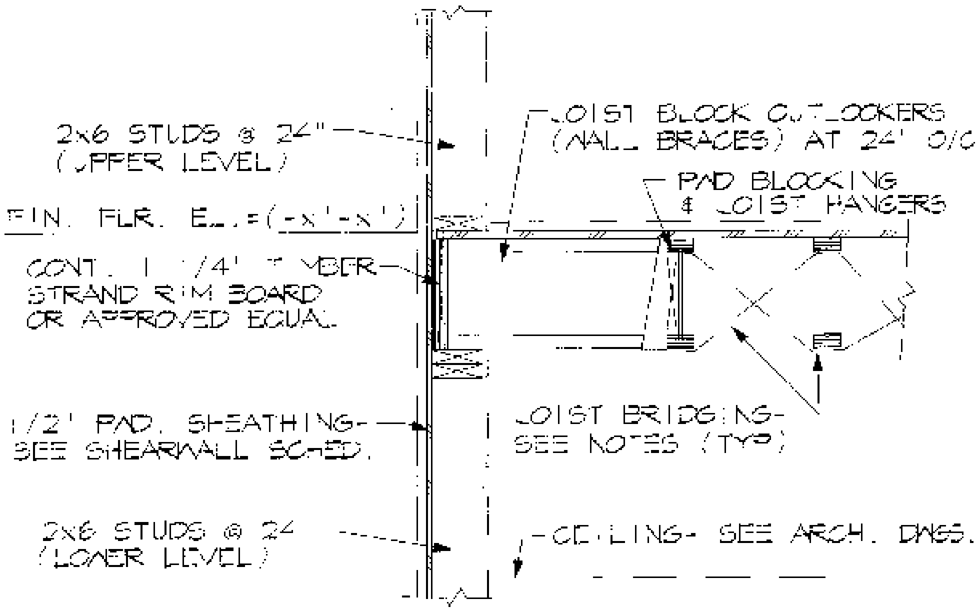
4.14.0 Typical Joist Perimeter Framing Details

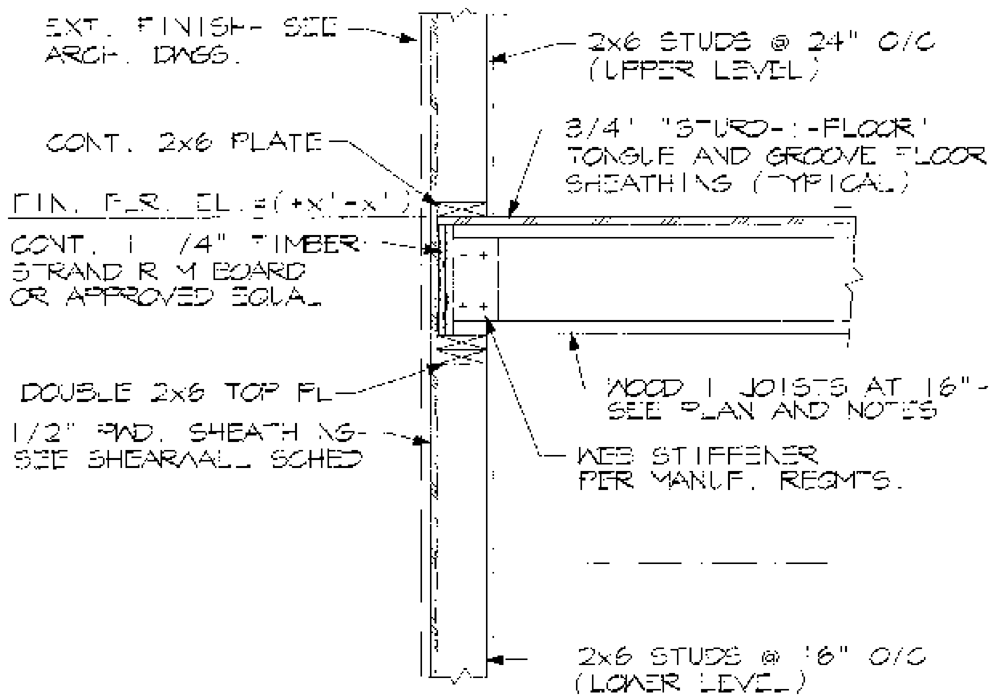


TYP. I–JOIST PERIMETER FRMG. DETAIL

NOT TO SCALE (DETAIL TO IJ2)

(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

4.15.0 Typical Joist Bearing on Studwall Detail



TYP. I–JOIST BEARING ON STUDWALL

NOT TO SCALE (DETAIL T6-IJ1)

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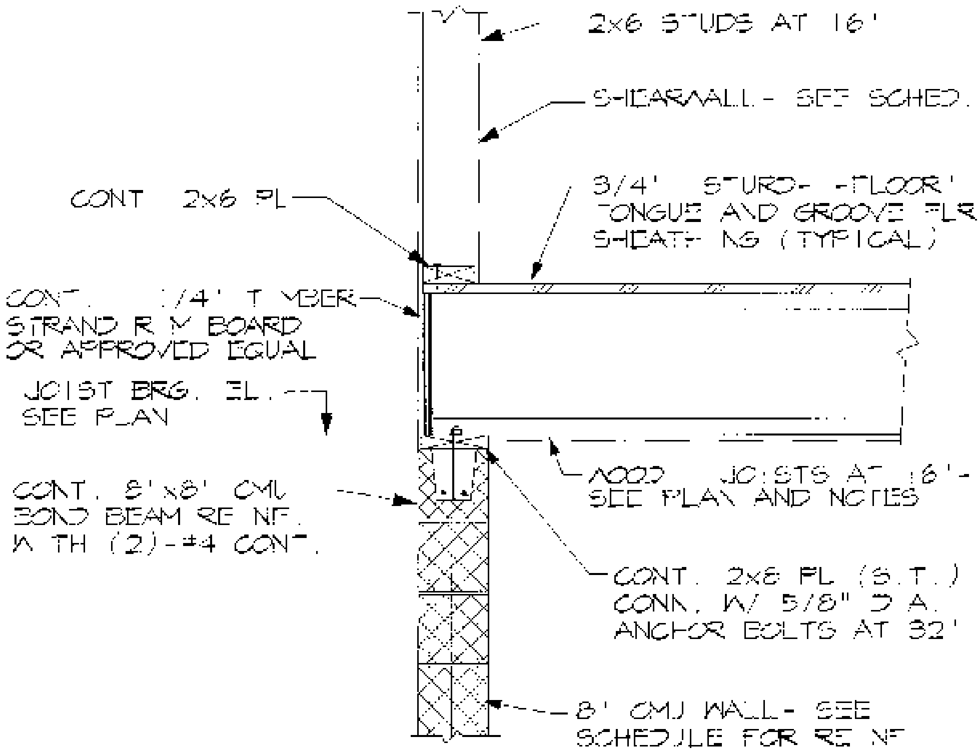
4.16.0 Typical Joist Bearing on CMU Wall Detail



TYP. I–JOIST BEARING ON CMU WALL

NOT TO SCALE (DETAIL T6–IJ6)

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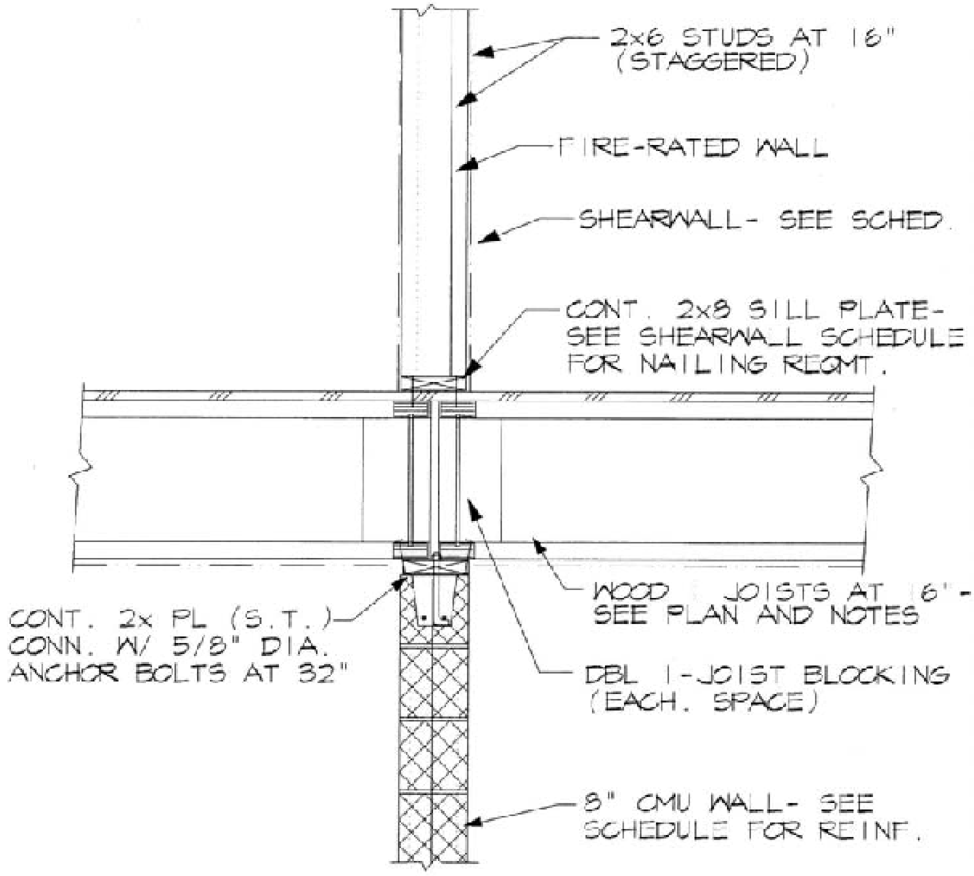
4.17.0 Typical Joist Bearing on Interior CMU Wall Detail



TYP. I–JOIST BEARING ON INT. CMU

NOT TO SCALE (DETAIL T6–IJ7)

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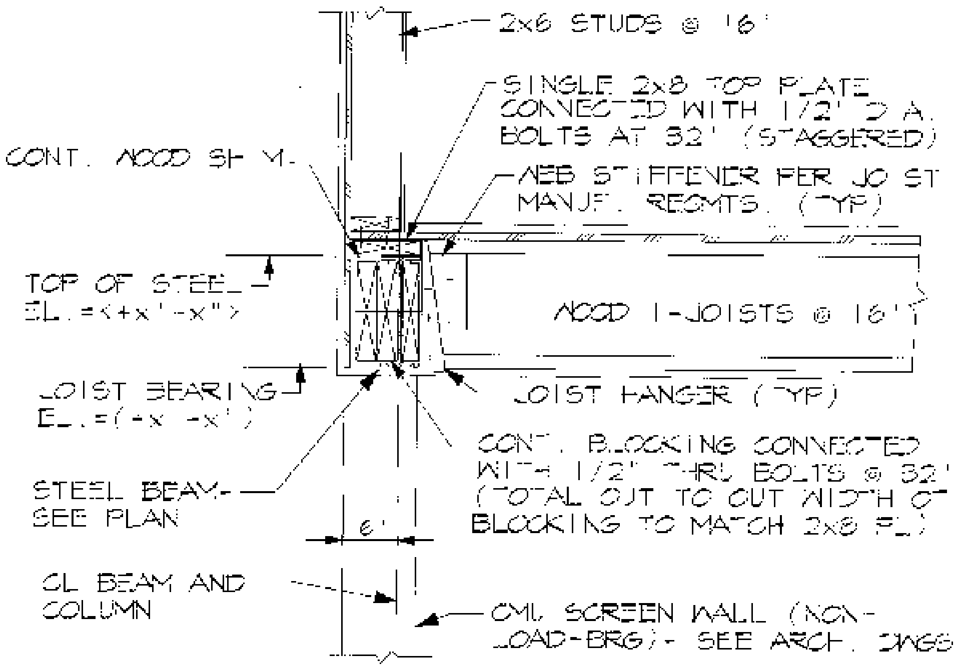
4.18.0 Typical Joist Connections to Steel Detail



DETAIL AT PERIMETER, LOADBEARING JOISTS

MISC. I–JOIST CONNECTIONS TO STEEL

NOT TO SCALE (DETAIL T6-IJ17)

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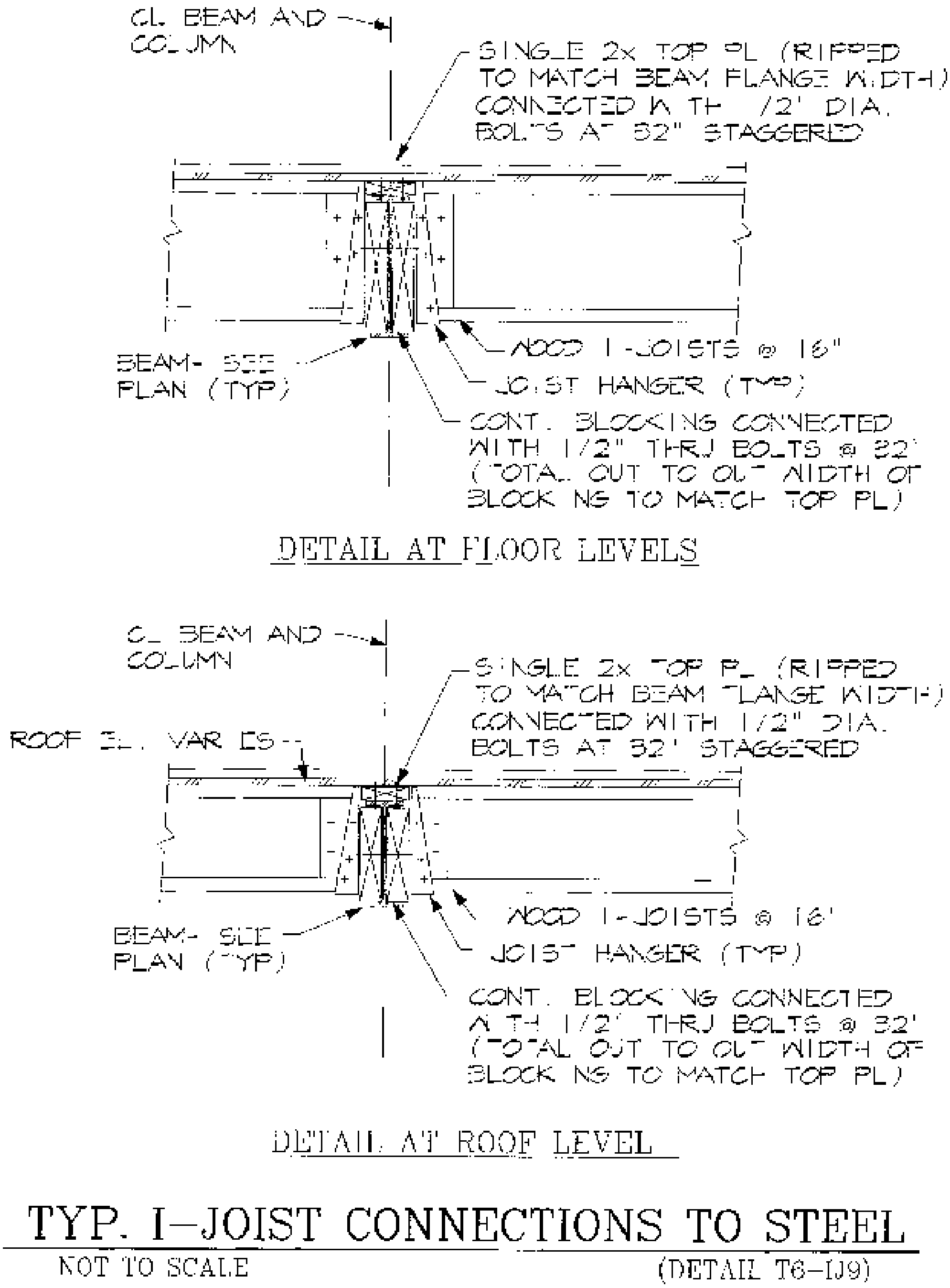
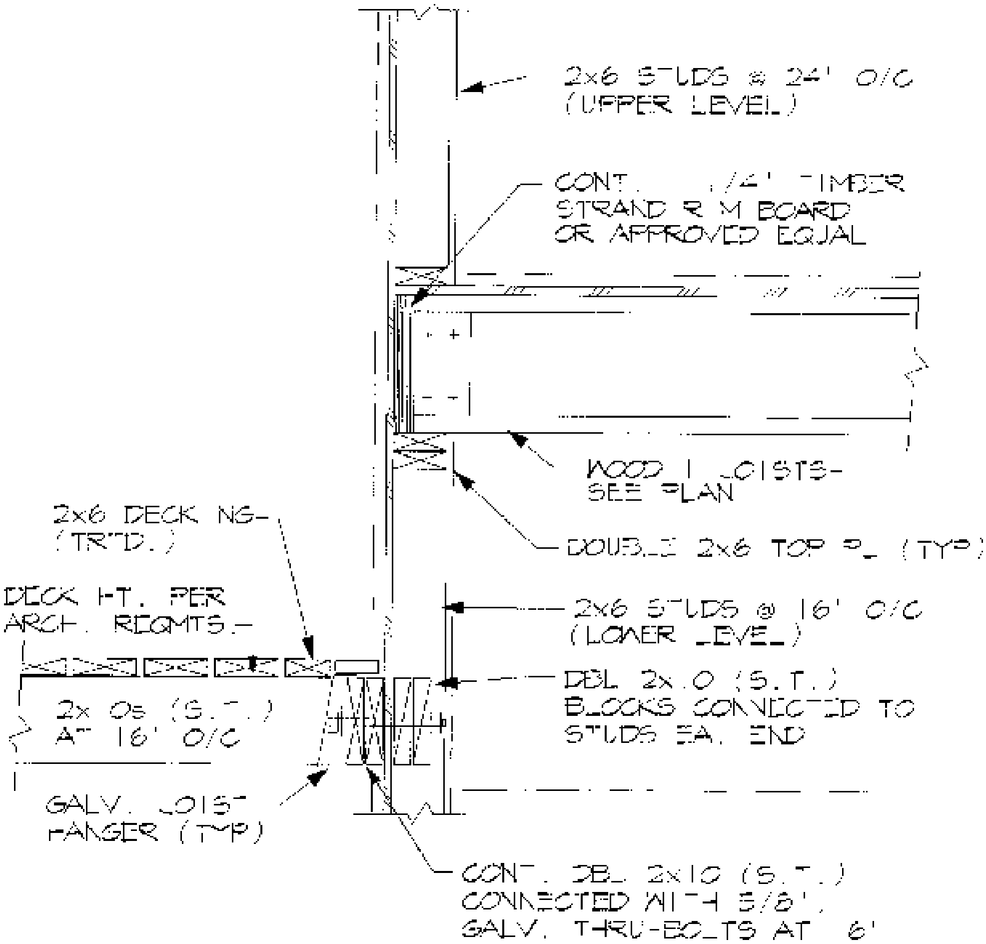
4.19.0 Typical Joist Connections to Steel—at Roof and Floor Level



(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

4.20.0 Typical Joint and Exterior Deck Detail



TYP. I–JOIST & EXTERIOR DECK DETAIL
NOT TO SCALE
(DETAIL T6–1.5)

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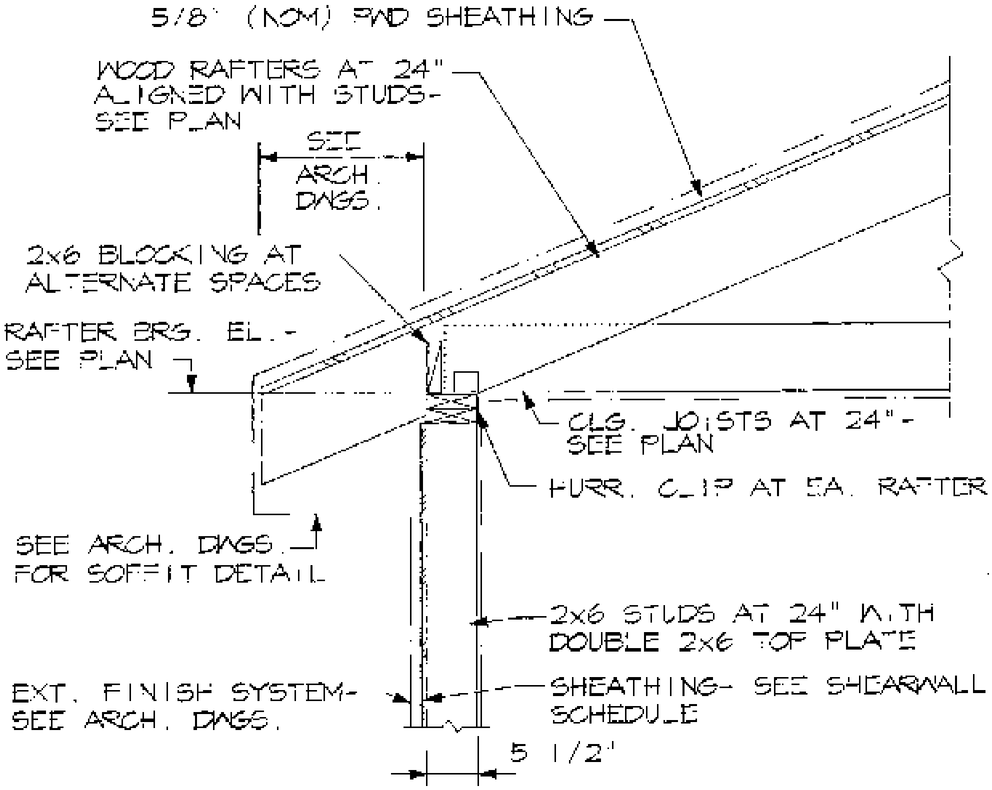
4.21.0 Typical 2× Rafter Bearing on Studwall Detail



TYP. 2x RAFTER BRG. ON STUDWALL

NOT TO SCALE (DETAIL T6-R2x1)

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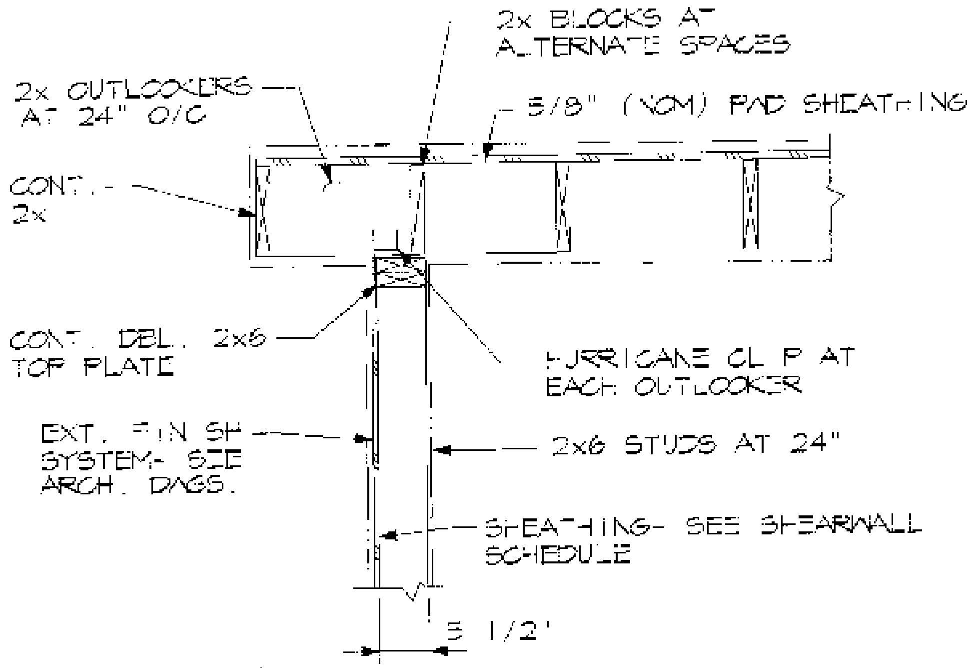
4.22.0 Typical 2× Rafter Nonbearing Wall Detail

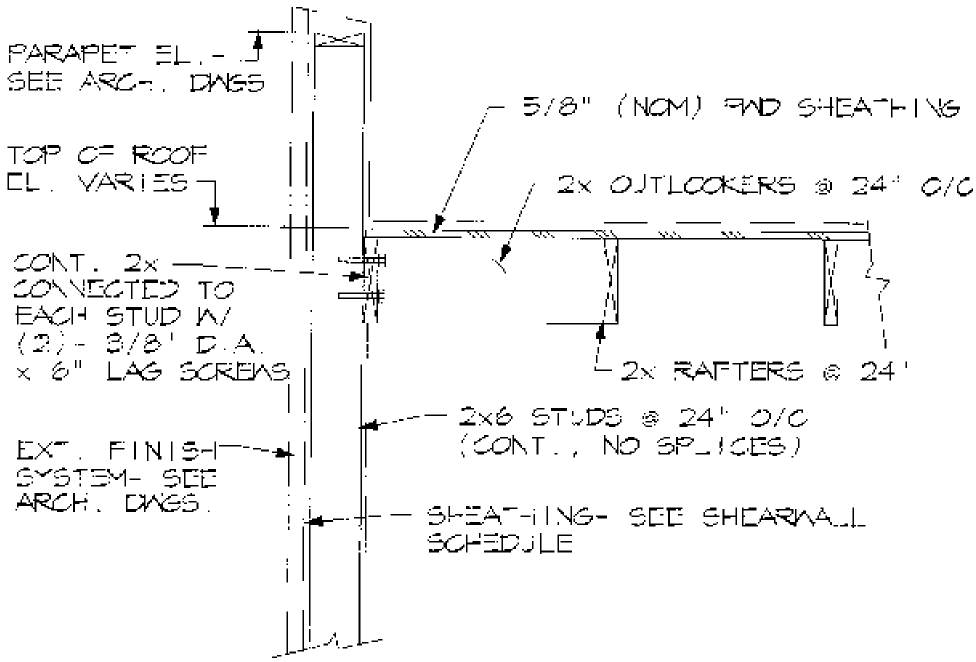


TYP. 2x RAFTER NONBEARING DETAIL

NOT TO SCALE (DETAIL T6-R2x6)

(By permission from The McGraw-Hill Co., Structural Details Manual, David R. Williams.)

4.23.0 Another Typical 2× Rafter Nonbearing Wall Detail



TYP. 2x RAFTER NONBEARING DETAIL

NOT TO SCALE (DETAIL T6-R2x5)

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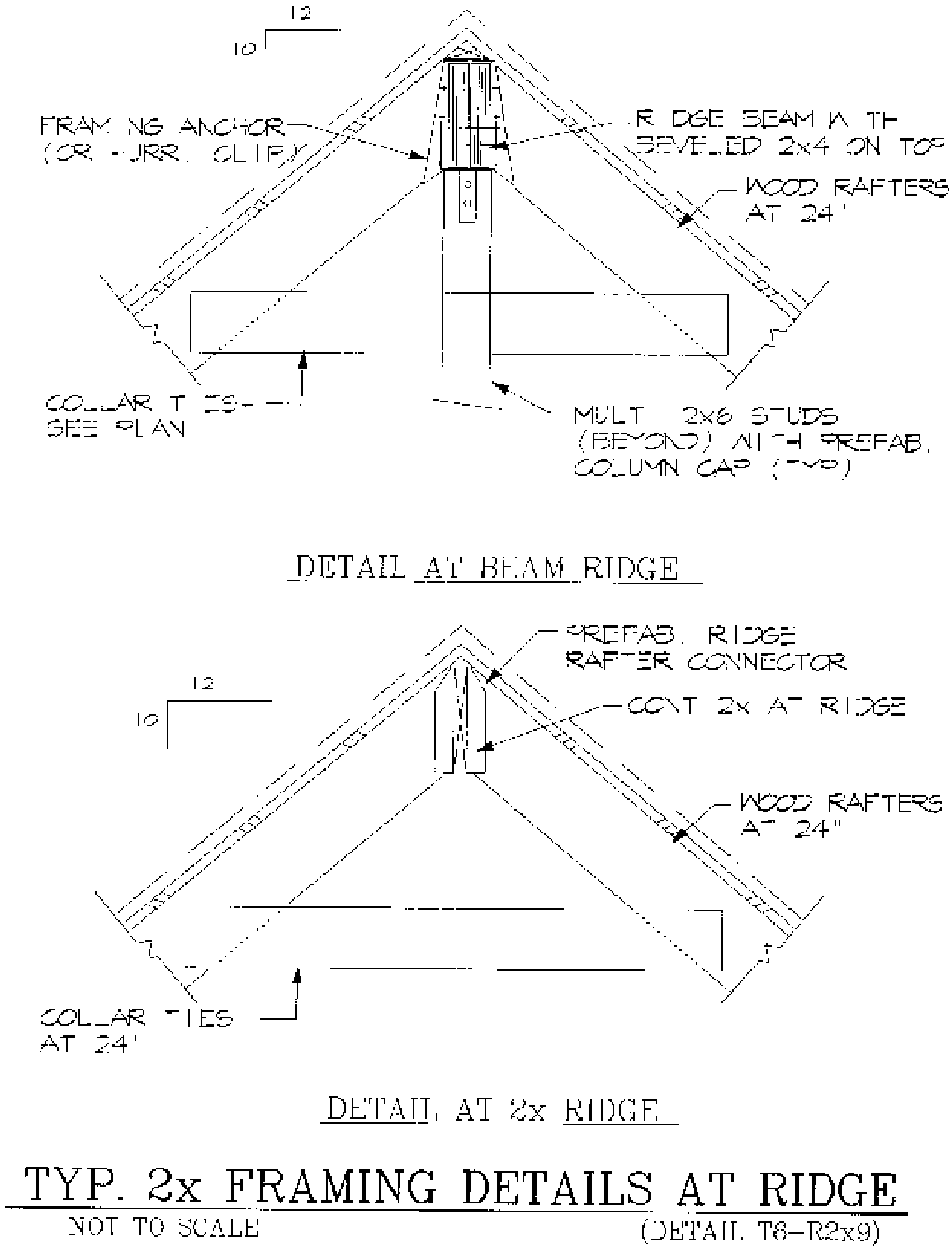
4.24.0 Typical 2× Framing Details at Roof Ridge



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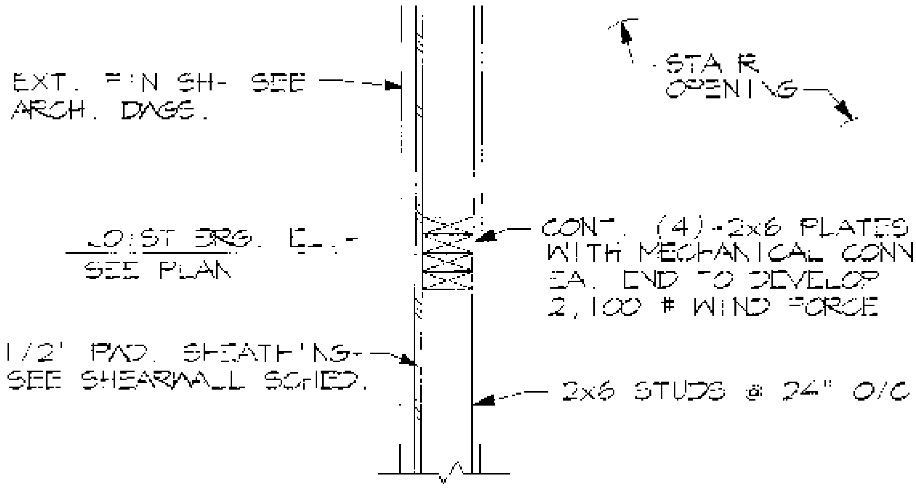
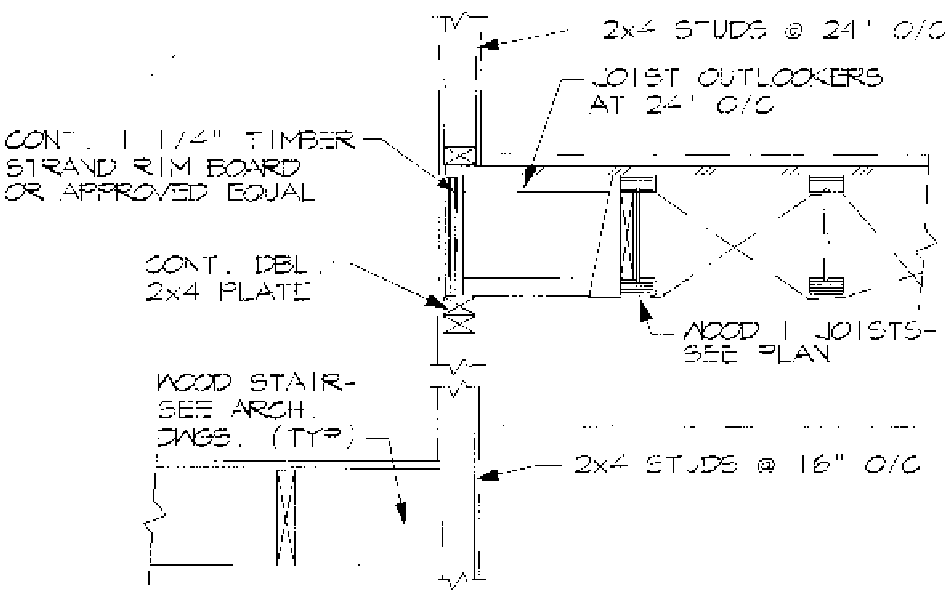
4.25.0 Typical Framing Details at Stairs



DETAIL AT EXTERIOR STUDWALL



DETAIL AT INTERIOR STUDWALL

TYPICAL FRAMING DETAILS AT STAIRS

NOT TO SCALE (DETAIL T6–IJ4)

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4.26.0 Lumber Industry Abbreviations

These abbreviations are commonly used for softwood lumber, although all of them are not necessarily applicable to all species. Additional abbreviations, which are applicable to a particular region or species, shall not be used unless included in certified grading rules.

Abbreviations are commonly used in the forms indicated, but variations such as the use of upper- and lower-case type, and the use or omission of periods and other forms of punctuation are not required.

AD	Air-dried
ADF	After deducting freight sides
ALS	American Softwood Lumber Standard
AV or AVG	Average
Bd	Board
Bd ft	Board foot or feet
Bdl	Bundle
Bev	Beveled
B/L	Bill of lading
BM	Board Measure
Btr	Better
B&B or B&Btr	B and better
B&S	Beams and stringers
CB1S	Center bead one side
CB2S	Center bead two sides
CF	Cost and freight
CG2E	Center groove two edges
CIF	Cost, insurance, and freight
CIFE	Cost, insurance, freight, and exchange
Clg	Ceiling
Clr	Clear
CM	Center matched
Com	Common
CS	Caulking seam
Csg	Casing
Cu Ft	Cubic foot or feet
CV1S	Center Vee on side
CV2S	Center Vee two sides
D&H	Dressed and headed
D&M	Dressed and matched
DB Clg	Double-beaded ceiling (E&CB1S)
DB Part	Double-beaded partition (E&CB2S)
DET	Double end trimmed
Dim	Dimension
Dkg	Decking
D/S or D/Sdg	Drop siding

4.26.0 Lumber Industry Abbreviations—Continued

EB1S	Edge bead one side
EB2S	Edge bead two sides
E&CB1S	Edge and center bead one side
E&CB2S	Edge and center bead two sides
E&CV1S	Edge and center Vee on side
E&CV2S	Edge and center Vee two sides
EE	Eased edges
EG	Edge (vertical) grain
EM	End matched
EV1S	Edge Vee on side
EV2S	Edge Vee two sides
Fac	Factory
FAS	Free alongside (named vessel)
FBM	Foot or board measure
FG	Flat (slash) grain
Flg	Flooring
FOB	Free on board (named point)
FOHC	Free of heart center or centers
FOK	Free of knots
Frt	Freight
Ft	Foot or feet
GM	Grade marked
G/R or G/Rfg	Grooved roofing
HB	Hollow back
H&M	hit-and-miss
H or M	hit-or-miss
Hrt	Heart
Hrt CC	Heart cubical content
Hrt FA	Heart facial area
Hrt G	Heart girth
IN	Inch or inches
J&P	Joists and planks
KD	Kiln-dried
Lbr	Lumber
LCL	Less than carload
LFT or Lin Ft	Linear foot or feet
Lgr	Longer
Lgth	Length
Lin	Linear
Lng	Lining
M	Thousand

4.26.0 Lumber Industry Abbreviations—Continued

MBM	Thousand (feet) board measure
MC	Moisture content
Merch	Merchantable
Mldg	Moulding
mm	Millimeter
No	Number
N1E	Nosed one edge
N2E	Nosed two edges
Og	Ogee
Ord	Order
Par	Paragraph
Part	Partition
Pat	Pattern
Pc	Piece
Pcs	Pieces
PE	Plain end
PO	Purchase order
P&T	Post and timbers
Reg	Regular
Res	Resawed or resawn
Rfg	Roofing
Rgh	Rough
R/L	Random lengths
R/W	Random widths
R/W&L	Random widths and lengths
Sdg	Siding
Sel	Select
S&E	Side and Edge (surfaced on)
SE Sdg	Square edge siding
SE & S	Square edge and sound
S/L or S/LAP	Shiplap
SL&C	Shipper's load and count
SM or Std M	Standard matched
Specs	Specifications
Std	Standard
Stpg	Stepping
Str or Struc	Structural
S1E	Surfaced one edge
S1S	Surfaced one side
S1S1E	Surfaced one side and one edge
S1S2E	Surfaced one side and two edges

4.26.0 Lumber Industry Abbreviations—Continued

S2E	Surfaced two edges
S2S	Surfaced two sides
S2S1E	Surfaced two sides and one edge
S2S&CM	Surfaced two sides and center matched
S4S	Surfaced four sides
S4S&CS	Surfaced four sides and caulking seam
T&G	Tongued and grooved
VG	Vertical grain
Wdr	Wider
Wt	Weight

4.27.0 Rough Carpentry—Quality Control Checklist

Quality Control Checklist

Project no.

Section

Rough Carpentry

No.

06101

Date

1. Delivered lumber is of proper species and grade and has treatment required.
2. Framing lumber is grade-stamped or suitably identified.
3. Generally spot check for splits, shake, decay, pockets, wane, crook, bow, cup, loose knots, or other defects not in compliance with grade.
4. Lumber is suitably stored off of the ground, stacked to prevent warp, and protected to prevent increase in moisture content.
5. Grade stamp indicates that moisture content is as specified.
6. Preservative treatment is as required. Affidavits are supplied if required.
7. Materials in contact with concrete or masonry or near earth are treated or of suitably graded species of lumber for these conditions.
8. Surfaces to be painted are treated with proper preservatives.
9. Framing is in alignment, plumb and level, and temporary bracing is provided during construction.
10. Nails, bolts, and connectors are as required. Observe usage of box and common nails. Observe spacing of nails. No coatings are provided on nails such as to reduce friction.
11. Allowance is made for expansion or contraction of lumber, concrete, masonry, and steel.
12. Observe that bridging, blocking and bracing are provided as required. Fire blocking is provided as required.
13. Blocking is provided for equipment and other features to be attached.
14. Plates are lapped and properly connected.
15. Metal connectors will not protrude or interfere with finish surfaces.
16. Connections to metal are as required.
17. Framing members are doubled where required.
18. Framing members are spaced as required: plumb, horizontal, parallel, and aligned.
19. Headers are of size required, have proper bearing, and are suitably connected.
20. Plywood sheathing is applied as specified: grade, dimension, staggering, nailing, blocking, etc.
21. Clearances are provided, such as 2 inches for hot pipes and flues; or other space requirements as indicated.
22. Furring and grounds are as required, properly aligned and plumb.
23. All bolts are tight or retightened before closing up.
24. Sealing, especially for acoustical or waterproofing purposes, is provided where required.
25. Sheathing paper is provided as required, installed properly and not damaged.
26. Seasoned, preservative-treated, or fire-resistive lumber is identified and is provided where required.
27. Agency inspection is provided before closing-up if required.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________

4.28.0 Finish Carpentry—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Finish Carpentry

No.
06200

Date

1. Shop drawings and samples are approved and on site.
2. Furring and blocking are provided to receive materials as required.
3. Certificates or grade stamps are provided.
4. Materials are not delivered before closing in building, and are suitably stored.
5. Materials have adequate temporary bracing, skids, etc. to prevent wracking, loosened members, or other defects due to handling.
6. Substrate and finishes are as required. Visually inspect exposed for evenness.
7. Method of attachment is as required.
8. Verify Contractor has coordinated work with other trades.
9. Accessories such as scribe and trim molds are provided.
10. Installed materials suitably protected against damage.
11. Tops are provided as required. Cutting of holes for sinks and other appliances is performed as required.
12. Surfaces are thoroughly cleaned and finished as required.
13. Surfaces are protected as required.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________________

Section

5

Plywood, Composite Wood Products, High-Pressure Laminates

Contents

Used as sheathing, flooring, in the production of cabinetry, and millwork, plywood and composite wood products play a key role in the construction industry.

5.0.0 American Plywood Association (APA) Grading Guidelines

The American Plywood Association, headquartered in Tacoma, Washington, establishes grades and specifications for plywood products. The National Particleboard Association, located in Gaithersburg, Maryland, is the authority on composite wood products.

Plywood

Similar to the grading agencies for Western wood products and Southern pine lumber, the American Plywood Association (APA) provides the industry with specification guidelines and grade stamps by which to identify these grades. The term *grade* can apply to the type of veneer being used or the use for which the panel is best suited.

5.1.0 Plywood Types and Typical Applications

Where interior usage for cabinetry, shelving, built-ins, and so forth, is required, APA-Sanded and Touch-Sanded designations apply:

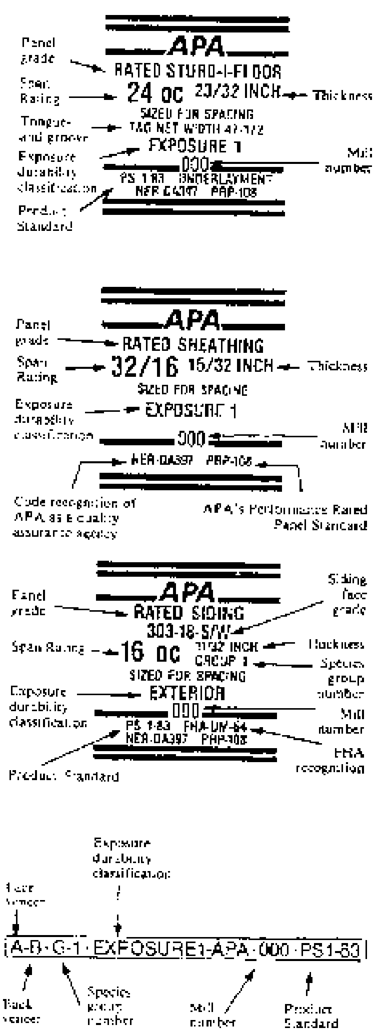
- *A-A* For use where appearance on both sides is important.
- *A-B* For use where appearance on only one side is important, but where two solid sides are required.
- *A-C* For use where appearance on one side is important in exterior applications, such as soffits, truck lining, and structural uses.
- *A-D* For use where appearance on one side is important in interior applications, such as paneling and partitions.
- *B-B* Utility panel with two sides. Interior use primarily; limited exterior use.
- *B-C* Utility panel for farm-service work, box cars, and truck linings for exterior use.
- *B-D* Utility panel for backing, sides of built-ins, separator boards, and slip sheets for interior and exterior use.
- *C-C plugged* For use as an underlayment over structural subfloor, pallet fruit bins, and for use in areas to be covered by carpet.
- *C-D plugged* For open soffits, cable reels, walkways, interior, or protected applications. Not to be used as underlayment.
- *Underlayment* For application over structural subfloor, it provides a smooth surface for carpet and, touch sanded, for resilient floors.

Specialty Panels

- *APA high-density overlay (HDO)* Manufactured with a semi-opaque resin-fiber overlay on both sides. It is used for concrete forms, industrial bins, and exhaust ducts.
- *APA marine* Plywood made only with Douglas fir or Western larch have highly restrictive limitations on core gaps and face repairs. As the name implies, it is ideal for boat hulls and other marine uses.
- *APA B-B plyform Class 1* Used for concrete formwork and designed for multi-use applications.
- *APA medium-density overlay MDO* Made with a smooth, opaque, resin-treated fiber overlay, producing an ideal base for finish painting, signs, and shelving.
- *APA decorative* Plywood with a rough-sawn, brushed, and grooved surface for interior accent walls, paneling, exhibit displays, etc.

- *APA plyron* Plywood with a hardboard face adhered on both sides, for countertops, cabinet doors, and shelving.
- *Plyform* Exterior-grade plywood used for concrete forms.
- *B-B plyform* It has a smooth, solid surface. It can be re-used many times.
- *B-C EXT* Sanded panel used where only one smooth side is needed.
- *HDO plyform* High-density overlay with hard, semi-opaque resin-fiber finish. Resists abrasion up to 200 re-uses. Requires a release agent.
- *Structural 1 plyform* Stronger and stiffer than B-B and HDO. Recommended for high-pressure applications.

5.1.1 APA-Registered Trademarks Explained



APA PERFORMANCE STANDARDS

APA performance standards are the result of new manufacturing technology that makes possible the manufacture of structural panel products from wood by-products and species not provided for in *U.S. Product Standard PS 1-83*. APA performance standards deal exclusively with how a product must perform in a designated application rather than from what or how the product must be manufactured.

Panels produced under APA performance standards — called APA Performance Rated Panels — must meet several performance baseline requirements according to the panel's designated end use. These performance requirements include uniform and concentrated static and impact load capacity, fastener-holding ability, racking resistance, dimensional stability, and bond durability.

In addition to conventional veneer plywood, APA performance standards encompass such other panel products as composites, waferboard and oriented strand board. (See APA Performance Rated Panels," page 8.)

For complete performance testing and qualification information, write APA for ***PRP-108, Performance Standards and Policies for Structural-Use Panels***, Form E445.

GRADE

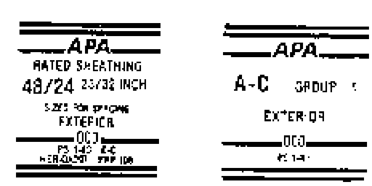
The term "grade" may refer to *panel* grade or to *veneer* grade. Panel grades are generally identified in terms of the veneer grade used on the face and back of the panel (e.g., A-B, B-C, etc.), or by a name suggesting the panel's intended end use (e.g., APA Rated Sheathing, Underlayment, etc.).

Veneer grades define veneer appearance in terms of natural unrepaired growth characteristics and allowable number and size of repairs that may be made during manufacture. The highest quality veneer is "A."[1] the lowest "D." The minimum grade of veneer permitted in Exterior plywood is "C." "D" veneer is used only in panels intended for interior use or for applications protected from permanent exposure to the weather.

EXPOSURE DURABILITY

APA trademarked panels may be produced in four exposure durability classifications — Exterior, Exposure 1, Exposure 2, and Interior.

Exterior panels have a fully waterproof bond and are designed for applications subject to permanent exposure to the weather or to moisture.



(1) Some manufacturers also produce a premium "N" grade (natural finish) veneer, available only on special order.

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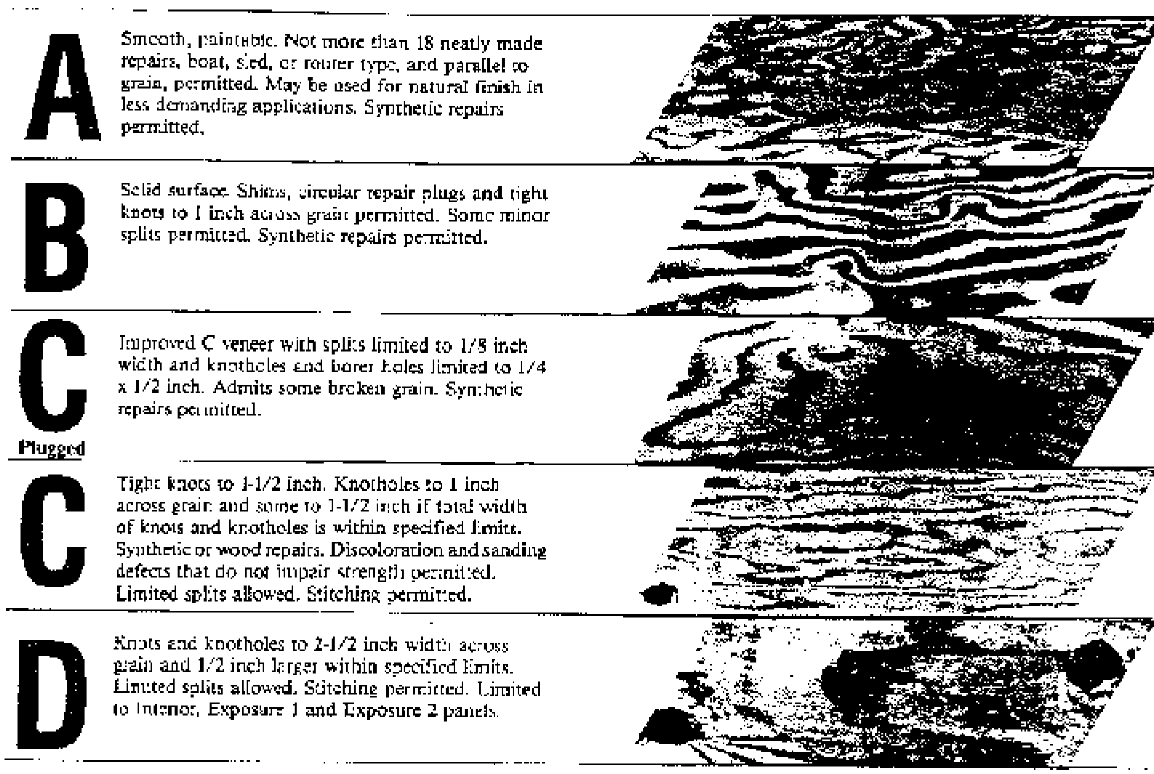
5.1.2 Plywood Veneer Grades



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5.2.0 Exposure Ratings (Exposure 1 and 2)

Exposure 1 is for exterior use and has a fully waterproof bond designed for applications where the plywood will be permanently exposed to the weather or to moisture. Plywood so designated is stamped Exposure 1. Exposure 2 is for protected construction applications and is constructed with intermediate glue. This product is identified as Exposure 2 on the ADA grade stamp.

5.3.0 Plywood Species Group Numbers

Plywood manufactured in accordance with U.S. Product Standard (PS) 183 can be made of more than 70 species of wood and these species are divided into 5 groups. Group 1 is the strongest and stiffest and Group 5 the least strong and least stiff.

5.3.1 Chart of Classification of Species

Group 1	Group 2	Group 3	Group 4	Group 5
Apitong	Cedar, Port	Alder, Red	Aspen	Basswood
Beech,	Orford	Birch, Paper	Bigtooth	Poplar,
American	Cypress	Cedar, Alaska	Quaking	Balsam
Birch	Douglas-	Fir,	Cativo	
Sweet	Fir 2[a]	Subalpine	Cedar	
Yellow	Fir	Hemlock,	Incense	
Douglas-	Balsam	Eastern	Western	
Fir 1[a]	California	Maple	Red	
Kapur	Red	Bigleaf	Cottonwood	
Keruing	Grand	Pine	Eastern	
Larch,	Noble	Jack	Black	
Western	Pacific	Lodgepole	(Western	
Maple, Sugar	Silver	Ponderosa	Poplar)	
Pine	White	Spruce	Pine	
Caribbean	Hemlock,	Redwood	Eastern	
Ocote	Western	Spruce	White	
Pine, South.	Lauan	Engelmann	Sugar	
Loblolly	Almon	White		
Longleaf	Bagtikan			
Shortleaf	Mayapis			
Slash	Red			
Tanoak	Tangile			
	White			
	Maple, Black			
	Mengkulang			
	Meranti,			
	Red[b]			
	Mersawa			
	Pine			
	Pond			
	Red			
	Virginia			
	Western			
	White			
	Spruce			
	Black			
	Red			
	Sitka			
	Sweetgum			
	Tamarack			
	Yellow-			
	Poplar			

(a) Douglas-Fir from trees grown in the states of Washington, Oregon, California, Idaho, Montana, Wyoming, and the Canadian Provinces of Alberta and British Columbia shall be classed as Douglas-Fir No. 1. Douglas-Fir from trees grown in the states of Nevada, Utah, Colorado, Arizona and New Mexico shall be classed as Douglas-Fir No. 2.

(b) Red Meranti shall be limited to species having a specific gravity of 0.41 or more based on green volume and oven dry weight.

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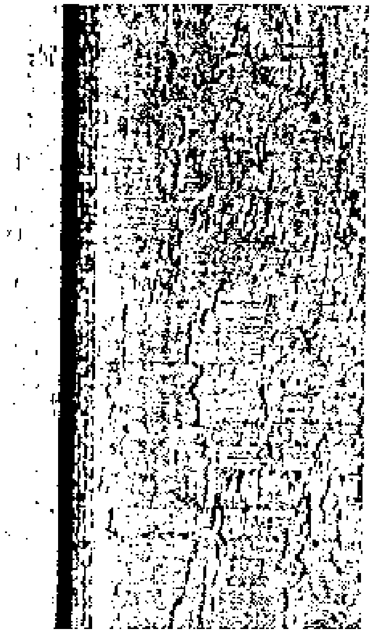
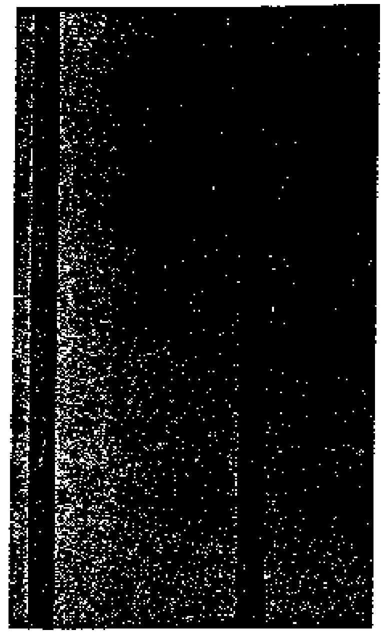
5.4.0 Variety of Surface Textures Available on APA-Rated Siding



(a)



(b)

(c)

COM-PLY®

APA Rated Siding composite panel with rough-sawn veneer faces bonded to solid, reconstituted structural wood core. Available with grooves typically 4" or 8" oc, similar to Texture 1-11; or 1-1/2"-wide grooves spaced 12" oc, similar to reverse board-and-batten pattern. Available in 19/32", and 5/8" thicknesses. Long edges shiplapped for continuous pattern. Available with Douglas-fir or cedar veneer faces.

MEDIUM DENSITY OVERLAY

Available without grooving; with V-grooves (spaced 6" or 8" oc usually standard); or in T 1-11 or reverse board-and-batten grooving as illustrated above. MDO panel siding available in 11/32", 3/8", 15/32", 1/2", 19/32", or 5/8" thicknesses; also in lap siding. MDO siding is overlaid on one side and available with texture-embossed or smooth surface.

BRUSHED

Brushed or relief-grain textures accent the natural grain pattern to create striking surfaces. Generally available in 11/32", 3/8", 15/32", 1/2", 19/32", and 5/8" thicknesses. Available in Douglas-fir, cedar and other species.

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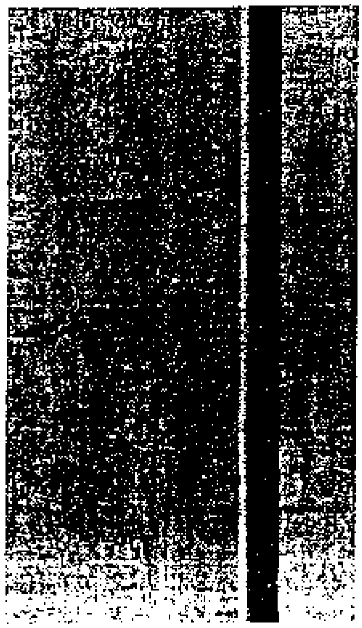
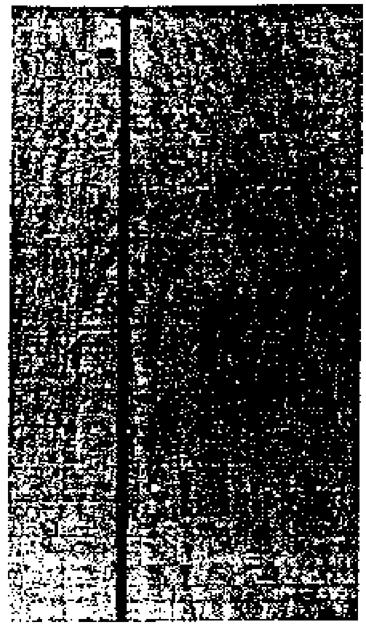
5.4.0 Variety of Surface Textures Available on APA-Rated Siding—Continued



(d)



(e)

APA TEXTURE 1-11

Special Rated Siding 303 panel with shiplapped edges and parallel grooves 1/4" deep, 3/8" wide; grooves 4" or 8" oc are standard. Other spacings may be available on special order. T1-11 is available only in 19/32" and 5/8" thicknesses. Rough-sanded panel shown above. Also available with scratch-sanded, overlaid, brushed and other surfaces. Available in Douglas-fir, cedar, redwood, southern pine and other species.

ROUGH SAWN

Manufactured with a slight, rough-sawn texture running across panel. Available without grooves, or with grooves of various styles; in lap sidings, as well as in panel form. Generally available in 11/32", 3/8", 15/32", 1/2", 19/32" and 5/8" thicknesses. Rough sawn also available in kerfed (shown) with grooves typically 4" oc in multiples of 2". Texture 1-11, reverse board-and-batten, channel groove and V-groove (15/32", 1/2", 19/32", or 5/8" thick). Available in Douglas-fir, redwood, cedar, southern pine and other species.

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5.5.0 Plywood Panel Dimensions (U.S. Customary and Metric)

Metric Conversions

Metric equivalents of nominal thicknesses and common sizes of APA Rated Siding products are tabulated below. (1 inch = 25.4 millimeters):

APA RATED SIDING NOMINAL THICKNESS

in.	mm
11/32	8.7
3/8	9.5
7/16	11.1
15/32	11.9
1/2	12.7
19/32	15.1
5/8	15.9

PANEL SIDING NOMINAL DIMENSIONS (Width x Length)

ft	mm	m (approx.)
4 x 8	1219 x 2438	1.22 x 2.44
4 x 9	1219 x 2743	1.22 x 2.74
4 x 10	1219 x 3048	1.22 x 3.05

LAP SIDING NOMINAL DIMENSIONS (Width x Length)

in. x ft	mm	m (approx.)
6 x 16	152.4 x 4877	0.15 x 4.88
8 x 16	203.2 x 4877	0.20 x 4.88
12 x 16	304.8 x 4877	0.30 x 4.88

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5.6.0 Span Tables for Plywood Sheathing and Subfloors

Wood Structural Panel Sheathing[a][c] – Panel Continuous Over 2 or More Spans

PANEL SPAN RATING	MAXIMUM STUD SPACING (inches)	MAXIMUM FASTENER SPACING (inches)[b]	
		PANEL EDGES (when over framing)	INTERMEDIATE (each stud)
12/0, 16/0, 20/0 or Wall-16 oc	16	6	12
24/0, 24/16, 32/16 or Wall-24 oc	24	6	12

(a) When wood structural panel is used, building paper and diagonal wall bracing are not required.
(b) Use fastener recommended by metal-framing manufacturer.
(c) See requirements for nailable panel sheathing when exterior covering is to be nailed to sheathing.

Recommended Uniform Floor Live Loads for APA RATED STURD-I-FLOOR and APA RATED SHEATHING with Long Dimension Perpendicular to Supports.

STURD-I-FLOOR SPAN RATING	SHEATHING SPAN RATING	MAXIMUM SPAN (in.)	ALLOWABLE LIVE LOADS (psf)[a]						
			JOIST SPACING (in.)						
			12	16	20	24	32	40	48
16 oc	24/16, 32/16	16	185	100					
20 oc	40/20	20	270	150	100				
24 oc	48/24	24	430	240	160	100			
32 oc	60/32	32		430	295	185	100		
48 oc		48			460	290	160	100	55

(a) 10 psf dead load assumed. Live load deflection limit is l/360.
Note: Shaded joist spacing meet Code Plus recommendations.

APA Panel Subflooring (APA RATED SHEATHING)[a]

PANEL SPAN RATING	MINIMUM PANEL THICKNESS (in.)	MAXIMUM SPAN (in.)	MAXIMUM FASTENER SPACING (in.)[c][e]	
			SUPPORTED PANEL EDGES	INTERMEDIATE SUPPORTS
24/16	7/16	16	6	12
32/16	15/32	16[b]	6	12
40/20	19/32	20[b][d]	6	12
48/24	23/32	24	6	12
60/32	7/8	32	6	12

(a) For subfloor recommendations under ceramic tile, refer to APA Design/Contruction Guide: Residential and Commercial. For subfloor recommendations under gypsum concrete, contact manufacturer of floor topping.
(b) Span may be 24 inches if 3/4-inch wood strip flooring is installed at right angles to joists.
(c) Use fastener recommended by metal-framing manufacturer.
(d) Span may be 24 inches if a minimum 1-1/2 inches of lightweight concrete is applied over panels.
(e) Other code-approved fasteners may be used.

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5.7.0 Recommended Spans for Roof Sheathing and Fastening Schedules

Recommended Uniform Roof Live Loads for APA RATED SHEATHING[c] and APA RATED STURD-I-FLOOR with Long Dimension Perpendicular to Supports[e]

PANEL SPAN RATING	MINIMUM PANEL THICKNESS (in.)	MAXIMUM SPAN (in.)		ALLOWABLE LIVE LOADS (psf)[d]							
		WITH EDGE SUPPORT [a]	WITHOUT EDGE SUPPORT	SPACING OF SUPPORTS CENTER-TO-CENTER (in.)							
				12	16	20	24	32	40	48	60
APA RATED SHEATHING[c]											
12/0	5/16	12	12	30							
16/0	5/16	16	16	70	30						
20/0	5/16	20	20	120	50	30					
24/0	3/8	24	20[b]	190	100	60	30				
24/16	7/16	24	24	190	100	65	40				
32/16	15/32	32	28	325	180	120	70	30			
40/20	19/32	40	32	—	305	205	130	60	30		
48/24	23/32	48	36	—	--	280	175	95	45	35	
60/32	7/8	60	48	—	—	—	305	165	100	70	35
APA RATED SHEATHING[f]											
16 oc	19/32	24	24	185	100	65	40				
20 oc	19/32	32	32	270	150	100	60	30			
24 oc	23/32	40	36	—	240	160	100	50	30	25	
32 oc	7/8	48	48	—	—	295	185	100	60	40	
48 oc	1-3/32	60	48	—	—	—	290	160	100	65	40

(a) Tongue-and-groove edges, panel edge clips (one midway between each support, except two equally spaced between supports 48 inches on center), lumber blocking, or other. For low slope roofs, see Table 5.
(b) 24 inches for 15/32-inch and 1/2-inch panels.
(c) Includes APA Rated Sheathing/ceiling deck.
(d) 10 psf dead load assumed.
(e) Applies to panels 24 inches or wider.
(f) Also applies to C-C Plugged grade plywood.
Note: Shaded support spacing meet Code Plus recommendations

Recommended Maximum Spans for APA Panel Roof Decks for Low Slope Roofs[a]
(Long panel dimension perpendicular to supports and continuous over two or more spans.)

Grade	Minimum Nominal Panel Thickness (in.)	Minimum Span Rating	Maximum Span (in.)	Panel Clips Per Span[b] (number)
apa rated sheathing	15/32	32/16	24	1
	19/32	40/20	32	1
	23/32	48/24	48	2
	7/8	60/32	60	2

(a) Low slope roofs are applicable to built-up, single-ply and modified bitumen roofing systems. For guaranteed or warranted roofs contact membrane manufacturer for acceptable deck.
(b) Edge support may also be provided by tongue-and-groove edges or solid blocking.

FASTENER SCHEDULES

When attaching wood structural panels to metal decking, the main purpose of the fasteners is to keep the panels flat. The fastener schedule should be at least the same as if the panel was applied to framing that is spaced in accordance with the panel's Span Rating. For example, a 32/16 span rated sheathing panel should have fasteners spaced at 6 inches on center along the 4-foot ends, and at no more than 32 inches on center by 12 inches on center across the width of the panel (28 fasteners per panel). If wind uplift is a consideration, additional fasteners may be required.

Recommended Minimum Fastening Schedule for APA Panel Roof Sheathing (Increased fastener schedules may be required in high wind or seismic zones.)

Panel Thickness[b] (in.)	Fasteners[c]	
	Maximum Spacing (in.)	
	Panel Edges	Intermediate
5/16-1	6	12[a]
1-1/8	6	12[a]

(a) For spans 48 inches or greater, space fasteners 6 inches at all supports.
(b) For stapling asphalt shingles to 5/16-inch and thicker panels, use staples with a 15/16-inch minimum crown width and a 1-inch leg length. Space according to shingle manufacturer's recommendations.
(c) Use fastener recommended by metal-framing manufacturer.

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5.7.1 Recommended Spans for Roof Decks—Low Slopes

RECOMMENDED MAXIMUM SPANS FOR APA PANEL ROOF DECKS FOR LOW SLOPE ROOFS[a]
(PANEL STRENGTH AXIS PERPENDICULAR TO SUPPORTS AND CONTINUOUS OVER TWO OR MORE SPANS)

Grade	Minimum Nominal Panel Thickness (in.)	Minimum Span Rating	Maximum Span (in.)	Panel Clips Per Span[b] (number)
APA RATED SHEATHING	15/32, 1/2	32/16	24	[illegible]
	19/32, 5/8	40/20	32	1
	23/32, 3/4	48/24	48	2
	7/8	60/32[c]	60	2

(a) Low slope roofs are applicable to built-up, single-ply and modified bitumen roofing systems. For guaranteed or warranted roofs contact membrane manufacturer for acceptable deck.

(b) Edge support may also be provided by tongue-and-groove edges or solid blocking.

(c) Check with supplier for availability.

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5.7.2 Stiffener Load-Span Tables for Preframed APA Panel Roof Decks

STIFFENER LOAD-SPAN TABLES FOR PREFRAMED APA PANEL ROOF DECKS

Douglas Fir-Larch — Allowable Roof Live Load (psf)[a]

Center-to Center Purlin Spacing[b] (ft)	Stiffener Size and Spacing (in.)	Select Structural Defl.[c]	Select Structural Strength[d] 1.15	Select Structural Strength[d] 1.25	No. 1 & Btr Defl.[c]	No. 1 & Btr Strength[d] 1.15	No. 1 & Btr Strength[d] 1.25	No. 1 Defl.[c]	No. 1 Strength[d] 1.15	No. 1 Strength[d] 1.25	No. 2 Defl.[c]	No. 2 Strength[d] 1.15	No. 2 Strength[d] 1.25
	2×4@16	37	67	73	35	51	57	33	41	46	31	36	40
	2×4@24	23	41	46	21	31	34	19	24	27	18	21	23
8	2×6@16	144	154	168	136	121	133	129	99	109	121	88	97
	2×6@24	96	99	109	91	78	85	86	63	69	81	56	61
	2×6@32	72	61	68	68	47	52	64	38	42	61	33	37

Southern Pine — Allowable Roof Live Load (psf)[a]

Center-to Center Purlin Spacing[b] (ft)	Stiffener Size and Spacing (in.)	Select Structural Defl.[c]	Select Structural Strength[d] 1.15	Select Structural Strength[d] 1.25	No. 1 Dense Defl.[c]	No. 1 Dense Strength[d] 1.15	No. 1 Dense Strength[d] 1.25	No. 1 Defl.[c]	No. 1 Strength[d] 1.15	No. 1 Strength[d] 1.25	No. 2 Defl.[c]	No. 2 Strength[d] 1.15	No. 2 Strength[d] 1.25
	2×4@16	35	87	96	35	58	64	33	53	59	31	41	46
	2×4@24	21	55	60	21	35	39	19	32	36	18	24	27
8	2×6@16	136	205	223	136	137	150	129	129	141	121	95	104
	2×6@24	91	133	146	91	88	97	86	83	91	81	60	66
	2×6@32	68	83	91	68	54	60	64	50	56	61	36	40

(a) Final allowable load is the lesser of the loads as determined by deflection and stress.

(b) Actual span of stiffeners taken as 3 1/2 inches less than center-to-center spacing of purlins.

(c) Deflection limitations: Span/240 under live load only; Span/180 under total load, assuming a dead load of 10 psf.

(d) Loads limited by stress are based on two conditions of duration of load: 2 months, such as for snow (1.15); and 7 days (1.25); includes effects of 10 psf dead load.

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5.7.3 Plywood Thickness and Maximum Spans for Roof Decks Under Special Coatings

PLYWOOD THICKNESS AND MAXIMUM SPANS FOR ROOF DECKS UNDER SPECIAL COATINGS[c]

Grade	Minimum Plywood Thickness (in.)	Maximum Support Spacing (in.) Group 1	Groups 2 & 3	Group 4	Nail Type & Size[b]	Maximum Nail Spacing (in.) Supported Panel Edges	Intermediate Supports
APA A-C EXT APA B-C EXT APA C-C PLUGGED EXT	11/32	16	—	—	8d common smooth[a] or ring- or screw-shank	6	12
	15/32, 1/2	24	24	16	8d common smooth[a] or ring- or screw-shank	6	12
	19/32, 5/8	32	24	24	8d ring- or screw-shank	6	12
	23/32, 3/4	40	32	32	8d ring- or screw-shank	6	12
	7/8	48	40	40	8d ring- or screw-shank	6	12[d]

(a) Use only deformed-shank nails for curved surfaces.
(b) Nail type, size and spacing may vary for diaphragm designs.
(c) All panels will support at least 30 psf live load plus 10 psf dead load at maximum span.
(d) For spans 48 inches or greater, space nails maximum 6 inches at all supports.

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5.7.4 Spans for Open Soffit or Combined Roof Decking and Ceilings

APA PANELS FOR OPEN SOFFIT OR FOR COMBINED ROOF DECKING-CEILING[a][b]
(Long dimension across supports. For APA RATED SHEATHING, where appearance is not a major concern, see Table 21.)

Maximum Span (inches)	Panel Description (All panels Exterior or Exposure 1)	Species Group for Plywood
16	15/32" APA RATED SIDING 303	1, 2, 3, 4
	15/32" APA MDO, Sanded and Touch-Sanded Plywood	1, 2, 3, 4
24	15/32" APA RATED SIDING 303	1
	15/32" APA MDO, Sanded and Touch-Sanded Plywood	1, 2, 3
	19/32" APA RATED SIDING 303	1, 2, 3, 4
	19/32" APA MDO, Sanded and Touch-Sanded Plywood	1, 2, 3, 4
	APA RATED STURD-I-FLOOR 16 oc	
32	19/32" APA RATED SIDING 303	1
	19/32" APA MDO, Sanded and Touch-Sanded Plywood	1
	23/32" APA Textured Plywood[c]	1, 2, 3, 4
	23/32" APA MDO, Sanded and Touch-Sanded Plywood	1, 2, 3, 4
	APA RATED STURD-I-FLOOR 20 oc	
48	1-1/8" APA Textured Plywood[c]	1, 2, 3, 4
	APA RATED STURD-I-FLOOR 48 oc	—

(a) All panels will support at least 30 psf live load plus 10 psf dead load at maximum span.
(b) For appearance purposes, blocking, tongue-and-groove edges or other suitable edge supports should be provided.
(c) Also see Table 24 for APA RATED SHEATHING/CEILING DECK.

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5.7.5 Spans for Closed Soffit or Nonstructural Ceilings

APA PANELS FOR CLOSED SOFFIT OR NONSTRUCTURAL CEILINGS[a][c] (Long dimension across supports)

Maximum Span (in.) All Edges Supported	Nominal Panel Thickness	Species Group	Nail Size and Type[a]
24	11/32" APA[b]	All Species Groups	6d nonstaining box or casing
32	15/32" APA[b]		
48	19/32" APA[b]		8d nonstaining box or casing

(a) Space nails maximum 6 inches at panel edges and 12 inches at intermediate supports for spans less than 48 inches; 6 inches at all supports for 48-inch spans.

(b) Any suitable grade panel which meets appearance requirements – Exterior for closed soffits, Exposure 1 or Exterior for nonstructural ceiling.

(c) For appearance purposes, blocking, tongue-and-groove edges or other suitable edge supports should be provided.

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5.7.6 Plywood Supports for Uniformly Loaded Heavy Duty Floors

PS 1 PLYWOOD RECOMMENDATIONS FOR UNIFORMLY LOADED HEAVY DUTY FLOORS[a] (Deflection limited to 1/240 of span.) (Span Ratings apply to APA RATED SHEATHING and APA RATED STURD-I-FLOOR, respectively, marked PS 1.)

Uniform Live Load (psf)	Center-to-Center Support Spacing (inches) (Nominal 2-Inch-Wide Supports Unless Noted)					
	12[b]	16[b]	20[b]	24[b]	32	48[c]
50	32/16, 16 oc	32/16, 16 oc	40/20, 20 oc	48/24, 24 oc	48 oc	48 oc
100	32/16, 16 oc	32/16, 16 oc	40/20, 20 oc	48/24, 24 oc	48 oc	1-1/2[d]
125	32/16, 16 oc	32/16, 16 oc	40/20, 20 oc	48/24, 24 oc	48 oc	1-3/4[d], 2[d]
150	32/16, 16 oc	32/16, 16 oc	40/20, 20 oc	48/24, 48 oc	48 oc	1-3/4[e], 2[d]
200	32/16, 16 oc	40/20, 20 oc	48/24, 24 oc	48 oc	1-1/8[e], 1-3/8[d]	2[e], 2-1/2[d]
250	32/16, 16 oc	40/20, 24 oc	48/24, 48 oc	48 oc	1-3/8[e], 1-1/2[d]	2-1/4[e]
300	32/16, 16 oc	48/24, 24 oc	48 oc	48 oc	1-1/2[e], 1-5/8[d]	2-1/4[e]
350	40/20, 20 oc	48/24, 48 oc	48 oc	1-1/8[e], 1-3/8[d]	1-1/2[e], 2[d]	
400	40/20, 20 oc	48 oc	48 oc	1-1/4[e], 1-3/8[d]	1-5/8[e], 2[d]	
450	40/20, 24 oc	48 oc	48 oc	1-3/8[e], 1-1/2[d]	2[e], 2-1/4[d]	
500	48/24, 24 oc	48 oc	48 oc	1-1/2[d]	2[e], 2-1/4[d]	

(a) Use plywood with T&G edges, or provide structural blocking at panel edges, or install a separate underlayment.

(b) A-C Group 1 sanded plywood panels may be substituted for span-rated Sturd-I-Floor panels (1/2-inch for 16 oc; 5/8-inch for 20 oc; 3/4-inch for 24 oc).

(c) Nominal 4-inch-wide supports.

(d) Group 1 face and back, any species inner plies, sanded or unsanded, single layer.

(e) All Group 1 or Structural I plywood, sanded or unsanded, single layer.

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5.7.7 Plywood Recommendations for Floor Carrying Fork-Truck Traffic

PS 1 PLYWOOD RECOMMENDATIONS FOR FLOORS CARRYING FORK-TRUCK TRAFFIC[a][b][c] (Plywood grade is all-Group 1 or Structural I A-C or C-C Plugged, except where 2-4-1 [STURD-I-FLOOR 48 or marked PS 1] is noted).

Tire Tread Print Width (in.)	Load per Wheel (lb)	Center-to-Center Support Spacing (in.) (Minimum 3-Inch-Wide Supports)			
		12	16	20	24
3	500	2-4-1	2-4-1	2-4-1	2-4-1
	1000	1-1/4"	1-1/4	1-1/4"	1-1/4"
	1500	1-1/2"	1-3/4	1-3/4"	1-3/4"
	2000	2"	2"	2-1/4"	2-1/4"
5	1000	2-4-1	2-4-1	1-1/8"	1-1/8"
	1500	1-1/8"	1-1/8	1-1/4"	1-1/4"
	2000	1-1/4"	1-1/2	1-1/2"	1-3/4"
	2500	1-1/2"	2"	2"	2"
	3000	1-3/4"	2"	2-1/4"	2-1/4"
7	2000	1-1/8	1-1/8	1-1/4"	1-1/4"
	3000	1-1/4	1-1/2	1-1/2"	1-3/4"
	4000	1-3/4	1-3/4"	1-3/4"	2"
	5000	2"	2"	2-1/4"	2-1/2"
	6000	2-1/4	2-1/2"	2-3/4"	3"
9	3000	1-1/4	1-1/4"	1-1/4"	1-1/4"
	4000	1-1/2	1-1/2"	1-3/4"	1-3/4"
	5000	1-3/4	1-3/4"	2	2"
	6000	2"	2"	2-1/4"	2-1/4"
	7000	2-1/4	2-1/4"	2-3/4"	2-3/4"

(a) Structural blocking (3x4 or 2x6 min.) required at all panel edges. Support blocking with framing anchors of adequate capacity or similar devices.

(b) Provide a wearing surface such as Plyron, polyethylene or a separate layer of plywood, hardboard or other hard surface when loads are due to casters or small, hard wheels. A wearing surface should also be considered for areas where fork-truck traffic is stopping, starting or turning in a tight radius.

(c) Use ring- or screw-shank nails with length sufficient to penetrate framing 1-1/2" or panel thickness, whichever is greater. Space nails maximum 4" o.c. at panel edges and 8" o.c. at intermediate supports.

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5.7.8 Recommended Shear for Horizontal APA Panel Diaphragms with Wood Framing

RECOMMENDED SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING

Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing[f] (inches)	Minimum Nominal Panel Thickness (inch)	Minimum Nominal Width of Framing Member (inches)	Blocked Diaphragms: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)[b]: 6	4	2-1/2[c]	2[c]	Unblocked Diaphragms: Nails Spaced 6" max. at Supported Edges[b]: Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
					Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4)[b]: 6	6	4	3		
APA STRUCTURAL I grades	6d[e]	1-1/4	5/16	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	1-1/2	3/8	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[d]	1-5/8	15/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240
APA RATED SHEATHING APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d[e]	1-1/4	5/16	2	170	225	335	380	150	110
				3	190	250	380	430	170	125
			3/8	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d	1-1/2	3/8	2	240	320	480	545	215	160
				3	270	360	540	610	240	180
			7/16	2	255	340	505	575	230	170
				3	285	380	570	645	255	190
			15/32	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d[d]	1-5/8	15/32	2	290	385	575	655	255	190
				3	325	430	650	735	290	215
			19/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240

(a) For framing of other species: (1) Find specific gravity for species of lumber in AFPA National Design Specification. (2) Find shear value from table above for nail size for Structural I panels (regardless of actual grade). (3) Multiply value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species. See footnote (f).

(b) Space nails maximum 12 inches o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c. or greater). Fasteners shall be located a minimum 3/8 inch from panel edges.

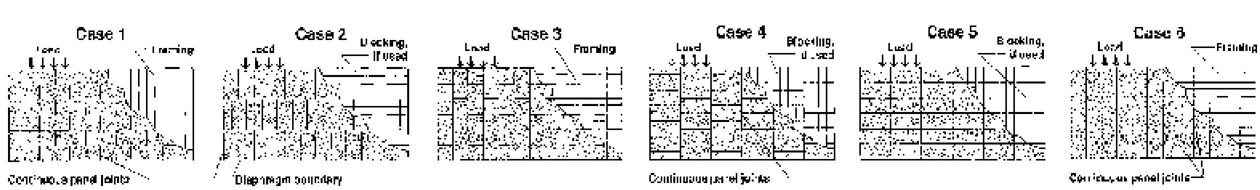
(c) Framing at adjoining panel edges shall be 3 in. nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

(d) Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c.

(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

(f) Contact APA for engineered alternative.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.



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5.7.9 Recommended Shear for APA Panel Shear Walls with Wood Framing for Wind or Seismic Loading

RECOMMENDED SHEAR (POUNDS PER FOOT) FOR APA PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING[b]

Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing[h] (in.)	Panels Applied Direct to Framing: Nail Size (common or galvanized box)	Nail Spacing at Panel Edges (in.): 6	4	3	2[e]	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Size (common or galvanized box)	Nail Spacing at Panel Edges (in.): 6	4	3	2[e]
APA STRUCTURAL I grades	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
	3/8	1-1/2	8d	230[d]	360[d]	460[d]	610[d]	10d	280	430	550[f]	730
	7/16			255[d]	395[d]	505[d]	670[d]					
	15/32			280	430	550	730					
	15/32	1-5/8	10d	340	510	665[f]	870	—	—	—	—	—
APA RATED SHEATHING; APA RATED SIDING[g] and other APA grades except species Group 5	5/16 or 1/4[c]	1-1/4	6d	180	270	350	450	8d	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-1/2	8d	220[d]	320[d]	410[d]	530[d]	10d	260	380	490[f]	640
	7/16			240[d]	350[d]	450[d]	585[d]					
	15/32			260	380	490	640					
	15/32	1-5/8	10d	310	460	600[f]	770	—	—	—	—	—
	19/32			340	510	665[f]	870					
			Nail Size (galvanized casing)					**Nail Size (galvanized casing)**				
APA RATED SIDING[g] and other APA grades except species Group 5	5/16[c]	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-1/2	8d	160	240	310	410	10d	160	240	310[f]	410

(a) For framing of other species: (1) Find specific gravity for species of lumber in the AFPA National Design Specification. (2)(a) For common or galvanized box nails, find shear value from table above for nail size for STRUCTURAL I panels (regardless of actual grade). (b) For galvanized casing nails, take shear value directly from table above. (3) Multiply this value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species. See footnote [illegible].

(b) All panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-inch and 7/16-inch panels installed on studs spaced 24 inches o.c. For other conditions and panel thicknesses, space nails maximum 12 inches o.c. on intermediate supports. Fasteners shall be located a minimum of 3/8 inch from panel edges.

(c) 3/8-inch or APA RATED SIDING 16 oc is minimum recommended when applied direct to framing as exterior siding.

(d) Shears may be increased to values shown for 15/32-inch sheathing with same nailing provided (1) studs are spaced a maximum of 16 inches o.c., or (2) if panels are applied with long dimension across studs.

(e) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. Check local code for variations of these requirements.

(f) Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 inches are spaced 3 inches o.c. Check local code for variations of these requirements.

(g) Values apply to all-veneer plywood APA RATED SIDING panels only. Other APA RATED SIDING panels may also qualify on a proprietary basis. APA RATED SIDING 16 oc plywood may be 11/32 inch, 3/8 inch or thicker. Thickness at point of nailing on panel edges governs shear values.

(h) Contact APA for engineered alternative.

Typical Layout for Shear Walls

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5.7.10 Allowable Spans for APA I-Joists—Simple- and Multiple-Span Applications

ALLOWABLE SPANS FOR APA PERFORMANCE RATED I-JOISTS — SIMPLE-AND MULTIPLE-SPAN APPLICATIONS
(40 PSF LIVE LOAD AND 10 PSF DEAD LOAD)

APA PRI™		Floor I-Joist Spacing (o.c.)			
		12 in.	16 in.	19.2 in.	24 in.
Ix10 - C4	(PRI-15)	17 ft 0 in.	15 ft 6 in.	14 ft 8 in.	13 ft 7 in.
Ix10 - C6	(PRI-25)	17 ft 9 in.	16 ft 2 in.	15 ft 3 in.	14 ft 2 in.
Ix12 - C10	(PRI-15)	20 ft 3 in.	18 ft 5 in.	17 ft 5 in.	15 ft 0 in.
Ix12 - C12	(PRI-25)	21 ft 1 in.	19 ft 3 in.	18 ft 2 in.	16 ft 1 in.
Ix14 - C14	(PRI-25)	24 ft 0 in.	21 ft 10 in.	20 ft 2 in.	16 ft 11 in.
Ix14 - C16	(PRI-35)	25 ft 11 in.	23 ft 7 in.	22 ft 2 in.	18 ft 5 in.
Ix16 - C18	(PRI-25)	26 ft 7 in.	24 ft 3 in.	20 ft 2 in.	16 ft 11 in.
Ix16 - C20	(PRI-35)	28 ft 8 in.	26 ft 1 in.	23 ft 1 in.	18 ft 5 in.
Ix10 - S2	(PRI-30)	18 ft 0 in.	16 ft 2 in.	14 ft 9 in.	13 ft 2 in.
Ix10 - S4	(PRI-32)	19 ft 0 in.	17 ft 4 in.	16 ft 4 in.	15 ft 4 in.
Ix12 - S6	(PRI-30)	21 ft 6 in.	18 ft 9 in.	17 ft 1 in.	15 ft 3 in.
Ix12 - S8	(PRI-32)	22 ft 8 in.	20 ft 8 in.	19 ft 6 in.	18 ft 3 in.
Ix12 - S10	(PRI-42)	24 ft 11 in.	22 ft 8 in.	21 ft 4 in.	19 ft 11 in.
Ix14 - S12	(PRI-32)	25 ft 9 in.	23 ft 6 in.	22 ft 2 in.	19 ft 9 in.
Ix14 - S14	(PRI-42)	28 ft 3 in.	25 ft 9 in.	24 ft 3 in.	22 ft 8 in.
Ix16 - S16	(PRI-32)	28 ft 7 in.	26 ft 1 in.	24 ft 7 in.	19 ft 9 in.
Ix16 - S18	(PRI-42)	31 ft 4 in.	28 ft 6 in.	26 ft 11 in.	23 ft 11 in.

Notes:

1. This span chart is based on uniform loads. For applications with other than uniformly distributed loads, an engineering analysis may be required based on the use of the design properties in *APA Product Guide: I-Joists for Residential Floors*, Form X710.

2. Allowable clear span is applicable to simple- or multiple-span residential floor construction. For I-joists with simple spans only, or multiple-span conditions only, refer to *APA Product Guide: I-Joists for Residential Floors*, Form X710.

3. This span chart is for applications with a design live load of 40 psf and a design dead load of 10 psf.

4. Deflection under live load is limited to L/480.

5. Maximum spans shown are clear distances between supports. Minimum bearing length shall be 1-3/4 inches for end bearings, and 3-1/2 inches for intermediate bearings.

6. For multiple-span applications using this table, the end spans shall be 40% or more of the adjacent span.

7. Spans are based on a composite floor with glued-nailed sheathing meeting the requirements for APA Rated Sheathing or APA Rated STURD-I-FLOOR conforming to PRP-108, PS 1 or PS 2 with a minimum thickness of 19/32 inch (40/20 or 20 oc) for a joist spacing of 19.2 inches or less, or 23/32 (48/24 or 24 oc) for a joist spacing of 24 inches. Adhesive shall meet APA Specification AFG-01. Spans shall be reduced 12 inches when the floor sheathing is nailed only.

8. Web stiffeners are not required when PRIs are used with the spans and spacings given in this table, with some exceptions for hangers or cantilevers (see *APA Product Guide: I-Joists for Residential Floors*, Form X710).

9. Those products most commonly available for each depth and flange type are shaded. Check for availability.

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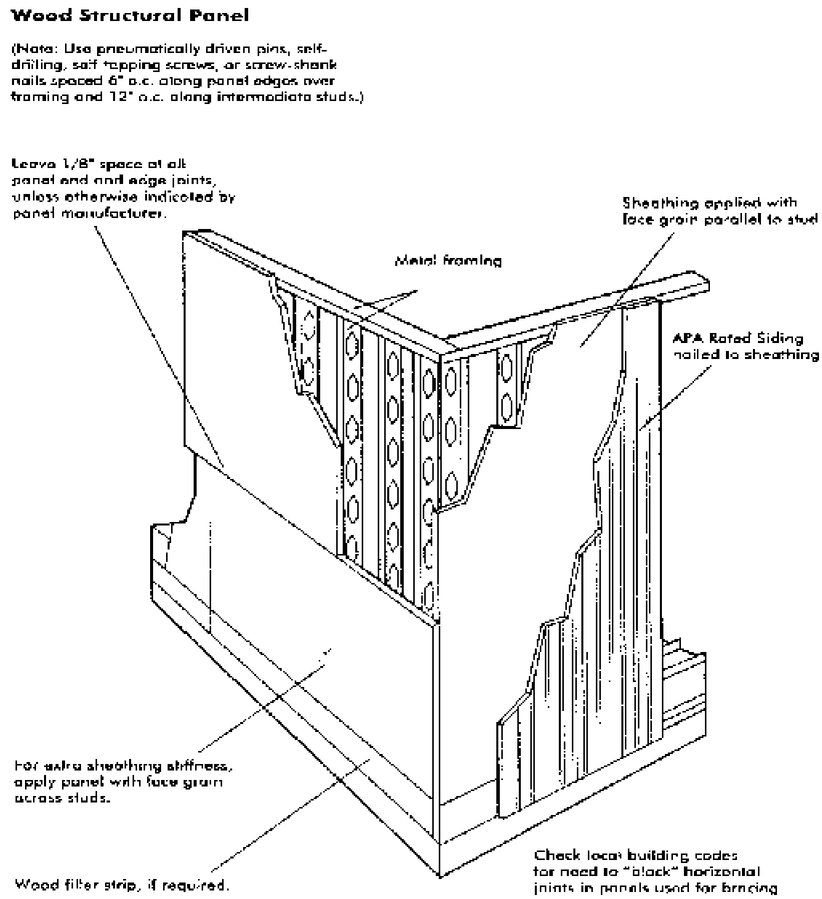
5.8.0 Typical Plywood Sheathing Construction

APA Rated Sheathing easily meets building code requirements for bending and racking strength without diagonal straps. Building paper is not required over wall sheathing, except under stucco, and under brick veneer where required by local building code. Rated Sheathing provides an excellent nail base for exterior siding. For information on installing exterior panel siding over nailable sheathing, refer to the APA *Design/Construction Guide: Residential & Commercial*, Form E30.



Wood Structural Panel Sheathing[a][c] – Panel Continuous Over 2 or More Spans

PANEL SPAN RATING	MAXIMUM STUD SPACING (inches)	MAXIMUM FASTENER SPACING (inches)[b]	
		PANEL EDGES (when over framing)	INTERMEDIATE (each stud)
12/0, 16/0, 20/0 or Wall-16 oc	16	6	12
24/0, 24/16, 32/16 or Wall-24 oc	24	6	12

(a) When wood structural panel is used, building paper and diagonal wall bracing are not required.
(b) Use fastener recommended by metal-framing manufacturer.
(c) See requirements for nailable panel sheathing when exterior covering is to be nailed to sheathing.

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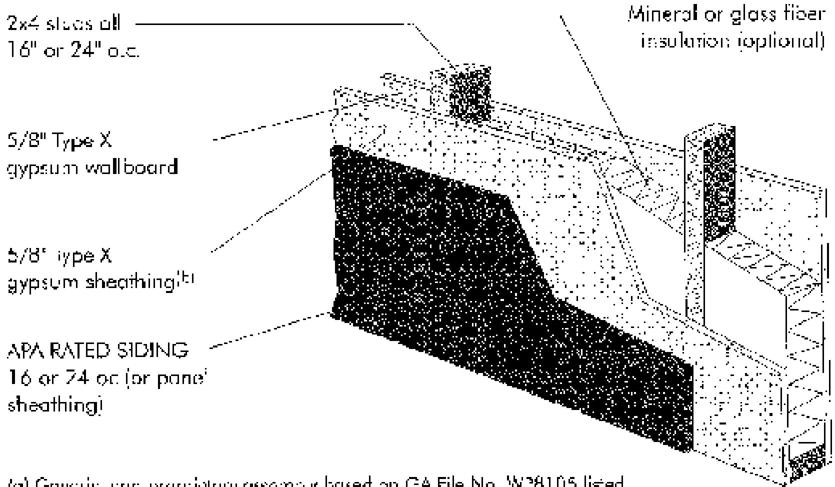
5.8.1 One-Hour Fire-Rated Exterior Load-Bearing Wall Assembly—Illustrated

ONE-HOUR FIRE-RATED EXTERIOR LOAD-BEARING WALL ASSEMBLY[a]



(a) Generic non-proprietary assembly based on GA File No. WP8105 listed in Gypsum Association Fire Resistance Design Manual, referenced in the model building codes. Mineral or glass fiber batt insulation (optional).

(b) Exterior layer of gypsum sheathing not required under the National and Standard Building Codes when separation is greater than 5 feet. Check local provisions. See U.L. Design U356 in U.L. Fire Resistance Directory.

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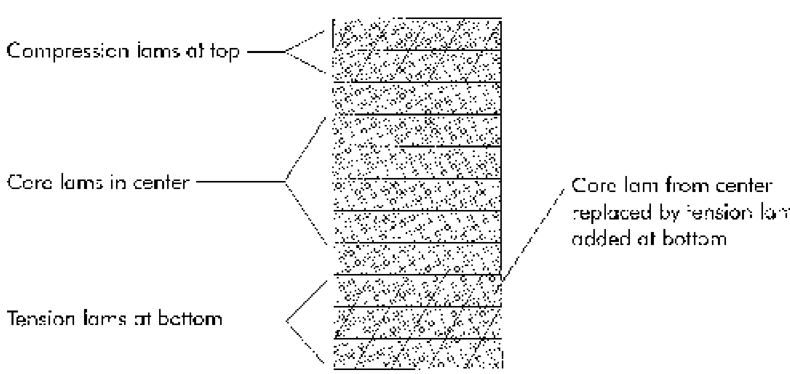
5.8.2 One-Hour Fire-Rated Glulam Beam Assembly

ONE-HOUR FIRE-RATED GLULAM BEAM
(Layup for simple span)



ONE-HOUR FIRE-RATED GLULAM BEAMS – MINIMUM DEPTHS FOR 6-3/4" AND 8-3/4" WIDE BEAMS

Beam Width (inches)	Minimum Depth (inches) 3 Sides Exposed	4 Sides Exposed
6-3/4	13-1/2	27
8-3/4	7-1/2	13-1/2

ONE-HOUR FIRE-RATED GLULAM COLUMNS – MINIMUM DEPTHS FOR 8-3/4" AND 10-3/4" COLUMN WIDTHS

ℓ/d Criteria	Column Width (in.)	Minimum Depth (inches) 3 Sides Exposed	4 Sides Exposed
$\ell/d > 11$	8-3/4	15	30
	10-3/4	10-1/2	13-1/2
$\ell/d \leq 11$	8-3/4	9	12
	10-3/4	7-1/2	10-1/2

ℓ = column length in inches.
d = column least cross-sectional dimension in inches.

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5.8.3 APA Rated Siding Over Nailable Sheathing—Recommendations/Illustrations

APA RATED SIDING OVER NAILABLE SHEATHING

(For siding over types of nonstructural sheathing, see Sturd-I-Wall recommendations.)

	Siding Description[a]	Nominal Thickness (in.) or Span Rating	Max. Spacing of Vertical Rows of Nails (in.): Long Dimension Vertical	Max. Spacing of Vertical Rows of Nails (in.): Long Dimension Horizontal	Nail Size (Use nonstaining box, siding or casing nails)[b][c]	Max. Nail Spacing[c] (in.): Panel Edges[d]	Max. Nail Spacing[c] (in.): Intermediate Supports
Panel Siding	APA MDO EXT	11/32 & 3/8	16	24	6d for siding 1/2" thick or less; 8d for thicker siding	6	12
		15/32 & thicker	24	24			
	APA RATED SIDING EXT	16 oc (including T1-11)	16	24			
		24 oc	24	24			
Lap Siding	APA MDO EXT	11/32 & thicker			6d for siding 1/2" thick or less; 8d for thicker siding	8 along bottom edge	
	APA RATED SIDING – LAP EXT	11/32 & thicker, or 16 oc or 24 oc	—	—			

(a) For veneered APA RATED SIDING, including APA 303 Siding, recommendations apply to all species groups.

(b) Hot-dipped or hot-tumbled galvanized steel nails are recommended for most siding applications. For best performance, stainless steel nails or aluminum nails should be considered. APA tests also show that electrically or mechanically galvanized steel nails appear satisfactory when plating meets or exceeds thickness requirements of ASTM A641 Class 3 coatings, and is further protected by yellow chromate coating.

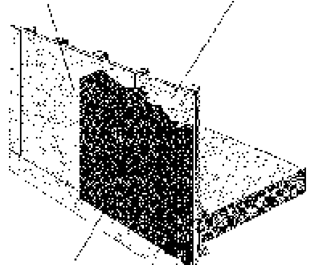
Note: Galvanized fasteners may react under wet conditions with the natural extractives of some wood species and may cause staining if left unfinished. Such staining can be minimized if the siding is finished in accordance with APA recommendations, or if the roof overhang protects the siding from direct exposure to moisture and weathering.

(c) Recommendations of siding manufacturer may vary.

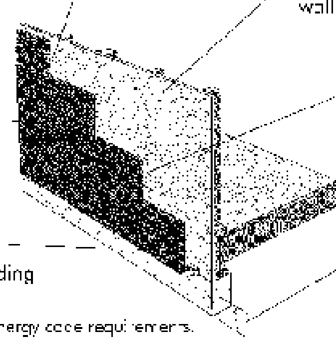
(d) Fasten panels 3/8 inch from panel edges.

Note: Shaded nail spacing meets Code Plus wall recommendations.

APA RATED SIDING (PANEL SIDING) OVER NAILABLE SHEATHING



APA RATED SIDING (LAP SIDING) OVER NAILABLE SHEATHING



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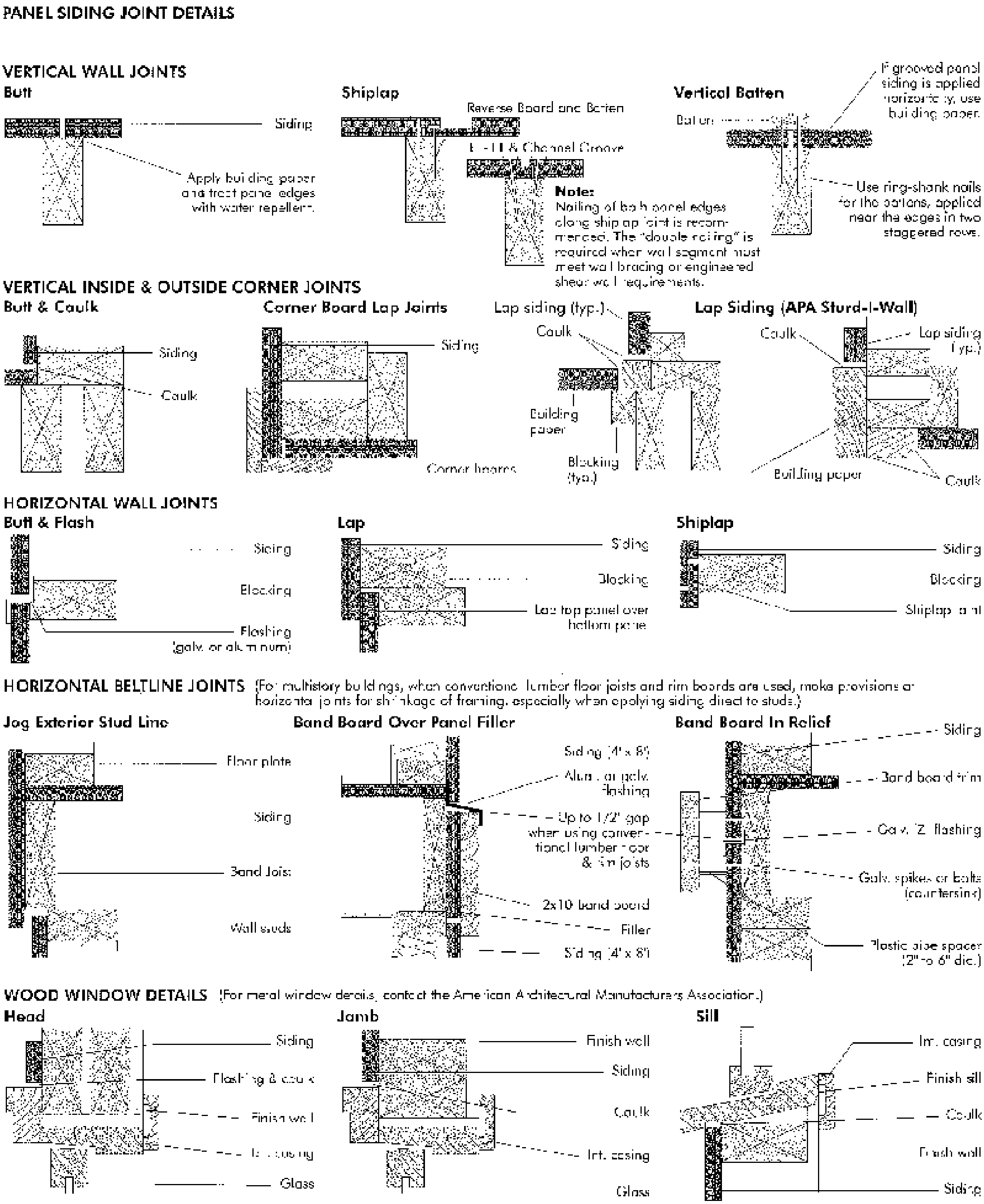
5.8.4 Panel Siding Joint Details—Diagrammed



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5.8.5 Recommended Procedures for Applying Stucco Over APA Panel Sheathing

RECOMMENDED THICKNESS AND SPAN RATING FOR APA PANEL WALL SHEATHING FOR STUCCO EXTERIOR FINISH

		APA Rated Sheathing[c]	
Stud Spacing (in.)	Panel Orientation[a]	Minimum Thickness (in.)	Minimum Span Rating
16	Horizontal[b]	5/16[d] 5/16[e] 3/8	20/0 Wall-24 24/0
	Vertical	15/32[f], 1/2[f]	32/16
24	Horizontal[b]	7/16	24/16
	Vertical	19/32[f], 5/8[f]	40/20

(a) Strength axis (long panel dimension) perpendicular to studs for horizontal application; or parallel to studs for vertical application.

(b) Blocking recommended between studs along horizontal panel joints.

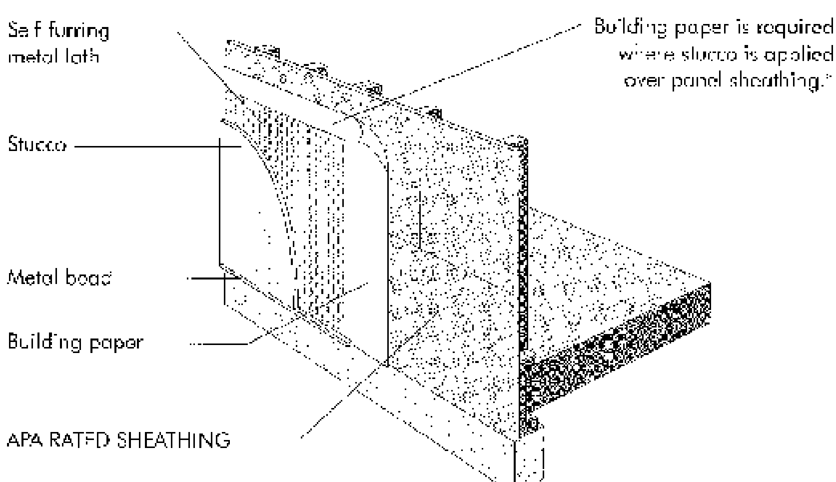
(c) Recommendations apply to all-veneer plywood, oriented strand board (OSB) or composite (APA COM-PLY) panels except as noted.

(d) Plywood panels only.

(e) OSB panels only.

(f) OSB or 5 ply/5 layer plywood.

STUCCO OVER APA PANEL SHEATHING



*Check local building and applicator for specific requirements.

Note:
Uniform Building Code requires two layers of grade D paper for stucco over wood-based sheathing

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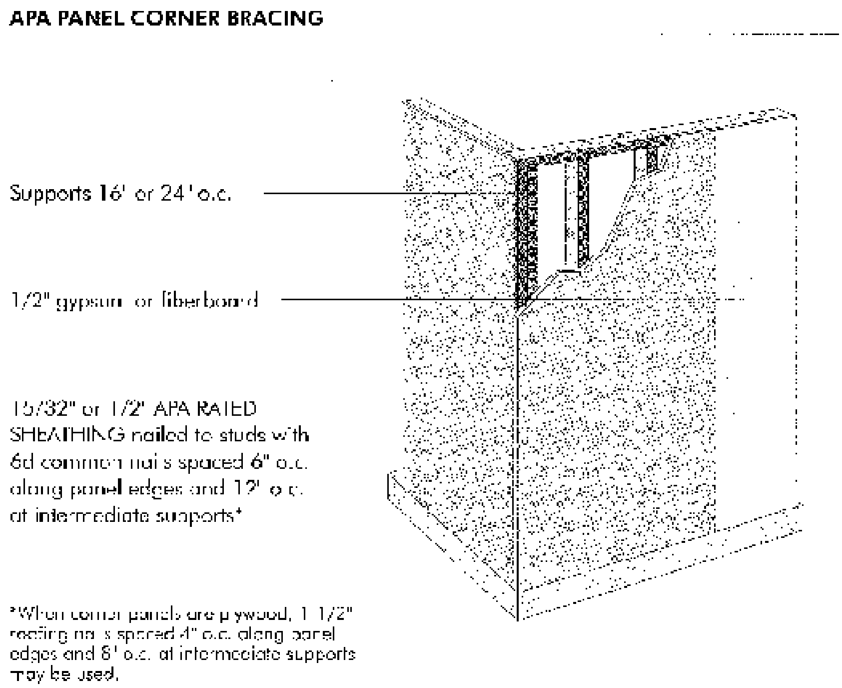
5.8.6 APA Panel Corner Bracing—Illustrated



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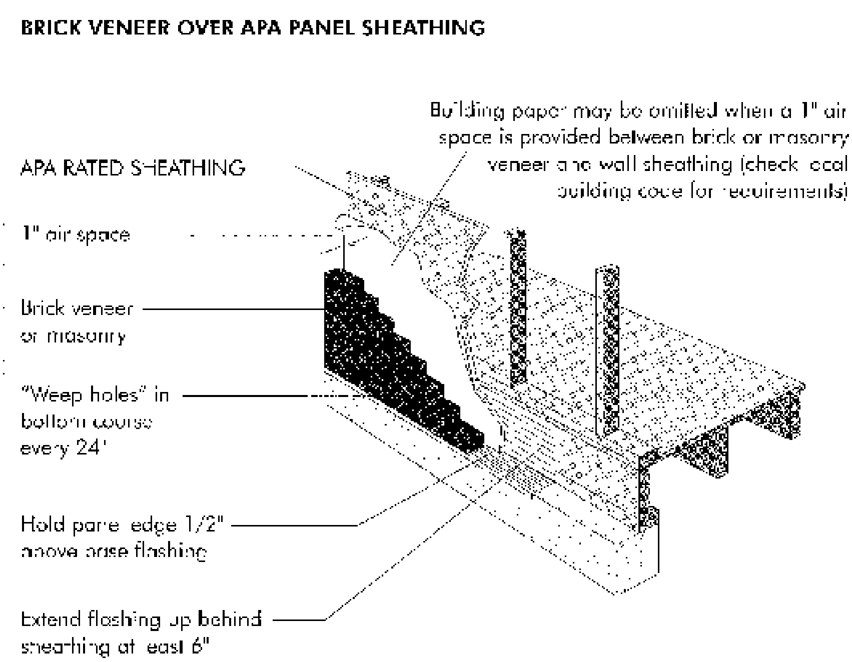
5.8.7 Brick Veneer Application Over Plywood Sheathing



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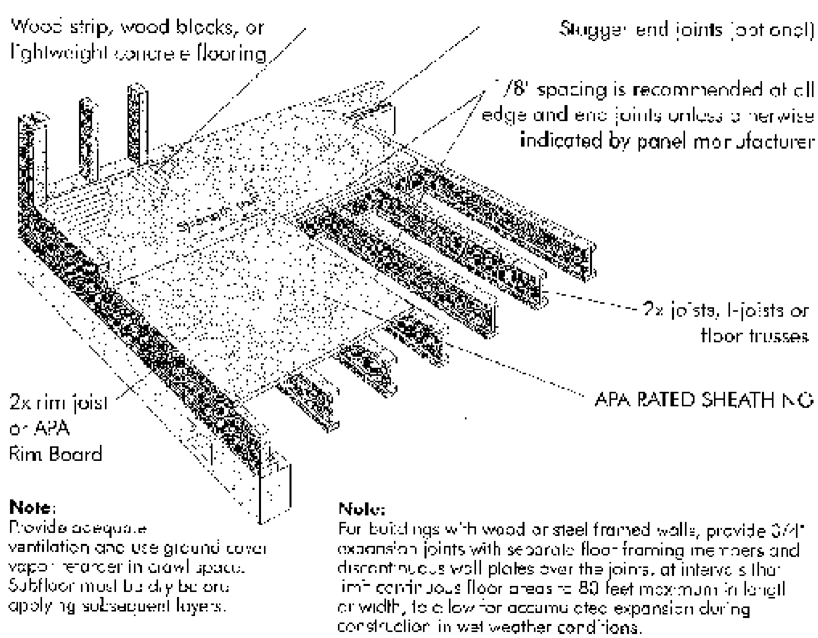
5.8.8 APA Panel Subflooring—Maximum Span, Fastening—Tables and Diagrams

APA PANEL SUBFLOORING



APA PANEL SUBFLOORING (APA RATED SHEATHING)[a][b]

Panel Span Rating	Panel Thickness (in.)	Maximum Span (in.)	Nail Size & Type[f]	Maximum Nail Spacing (in.) Supported Panel Edges[h]	Intermediate Supports
24/16	7/16	16	6d common	6	12
32/16	15/32, 1/2	16[c]	8d common[d]	6	12
40/20	19/32, 5/8	20[c][e]	8d common	6	12
48/24	23/32, 3/4	24	8d common	6	12
60/32[g]	7/8	32	8d common	6	12

(a) For subfloor recommendations under ceramic tile, refer to Table 12. For subfloor recommendations under gypsum concrete, contact manufacturer of floor topping.

(b) APA RATED STURD-I-FLOOR may be substituted when the Span Rating is equal to or greater than tabulated maximum span.

(c) Span may be 24 inches if 3/4-inch wood strip flooring is installed at right angles to joists.

(d) 6d common nail permitted if panel is 1/2 inch or thinner.

(e) Span may be 24 inches if a minimum 1-1/2 inches of lightweight concrete is applied over panels.

(f) Other code-approved fasteners may be used.

(g) Check with supplier for availability.

(h) Fasteners shall be located a minimum 3/8 inch from panel edges.

APA PLYWOOD UNDERLAYMENT[c]

Plywood Grades[a]	Application	Minimum Plywood Thickness (in.)	Fastener Size and Type	Maximum Fastener Spacing (in.)[e] Panel Edges[d]	Intermediate
APA UNDERLAYMENT APA C-C Plugged EXT APA RATED STURD-I-FLOOR (19/32" or thicker)	Over smooth subfloor	1/4	3d x 1-1/4-in. ring-shank nails[b] min. 12-1/2 gage (0.099 in.) shank dia.	3	6 each way
	Over lumber subfloor or uneven surfaces	11/32		6	8 each way

(a) In areas to be finished with resilient floor coverings such as tile or sheet vinyl, or with fully adhered carpet, specify Underlayment, C-C Plugged or veneer-faced STURD-I-FLOOR with "sanded face." Underlayment A-C, Underlayment B-C, Marine EXT or sanded plywood grades marked "Plugged Crossbands Under Face," "Plugged Crossbands (or Core)," "Plugged Inner Plies" or "Meets Underlayment Requirements" may also be used under resilient floor coverings.

(b) Use 4d x 1-1/2-in. ring-shank nails, minimum 12-1/2 gage (0.099 in.) shank diameter, for underlayment panels 19/32 inch to 3/4 inch thick.

(c) For underlayment recommendations under ceramic tile, refer to Table 12.

(d) Fasten panels 3/8 inch from panel edges.

(e) Fasteners for 5-ply plywood underlayment panels and for panels greater than 1/2 inch thick may be spaced 6 inches on center at edges and 12 inches each way intermediate.

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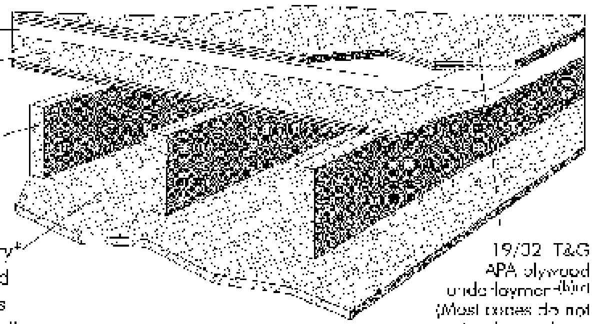
5.8.9 One-Hour Fire-Rated Combustible Floor/Ceiling Assemblies

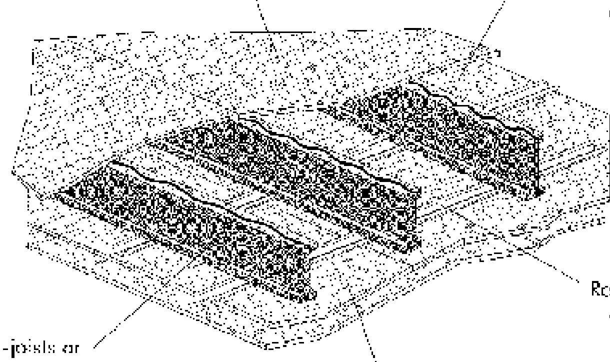
ONE-HOUR FIRE-RATED COMBUSTIBLE FLOOR/CEILING (OR ROOF/CEILING) ASSEMBLIES

Some rated assemblies incorporate proprietary products. When designing and specifying, check the Underwriters Laboratories Fire Resistance Directory for complete details on a particular assembly. A change in details may affect fire resistance of the assembly.

1. Two-layer floor systems with joists.[a] For details, see U.L. Design Nos. L001, L003, L004, L005, L006, L201, L202, L206, L209, L210, L211 (2 hr), L212, L501, L502, L503, L505 (2 hr), L511 (2 hr), L512, L514, L515, L516, L519, L522, L523, L525, L526, L533, L535, L536 (2 hr), L537, L541 (2 hr) and L545. Also see U.L. Designs No. L524 with steel joists spaced 24" o.c., and L521 with wood trusses spaced 24" o.c.



2. Single-layer floor systems with wood I-joists or trusses. For details, see U.L. Design Nos. L528, L529, L534, L542 and L544 (shown). Also see U.L. Design No. L513 for single-layer floor system with lumber joists spaced 24" o.c.



*For proprietary names see latest U.L. *Fire Resistance Directory*

Note:

(a) Substitution of 1-1/8" APA RATED STURD-I-FLOOR 48 oc for the combination of subfloor, paper, and underlayment is often allowed. Check with local Building Official.

(b) Tests have shown that substitution of OSB or composite APA RATED SHEATHING subfloor and APA RATED STURD-I-FLOOR underlayment for the plywood panels in rated assemblies will not jeopardize fire resistance ratings. Substitution is based on equivalent panel thickness, except that 7/16" OSB subfloor panels may be used in place of 15/32" plywood subfloor panels in two-layer assemblies. OSB panels are listed as alternates to plywood subflooring or finish flooring in U.L. Design Nos. L501, L503, L505 (2hr), L508, L511 (2hr), L513, L514, L516, L521, L526, L528, L529, L539, L540, L543 and L544.

(c) Lightweight concrete or gypsum concrete floor topping permitted over single layer floor or as alternate to plywood underlayment in many assemblies (check details)

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5.8.10 Interior Plywood Paneling Span, Fastening Schedules

INTERIOR PANELING

Panel Thickness (in.)	Maximum Support Spacing (in.)	Nail Size (Use casing or finishing nails)	Maximum Nail Spacing (in.) Panel Edges	Maximum Nail Spacing (in.) Intermediate Supports
1/4	16[a]	4d	6	12
5/16	16[b]	6d	6	12
11/32 - 1/2	24	6d	6	12
19/32 - 3/4	24	8d	6	12
Texture 1-11	24	8d	6	12

(a) Can be 20 inches if long dimension of paneling is across supports.
(b) Can be 24 inches if long dimension of paneling is across supports

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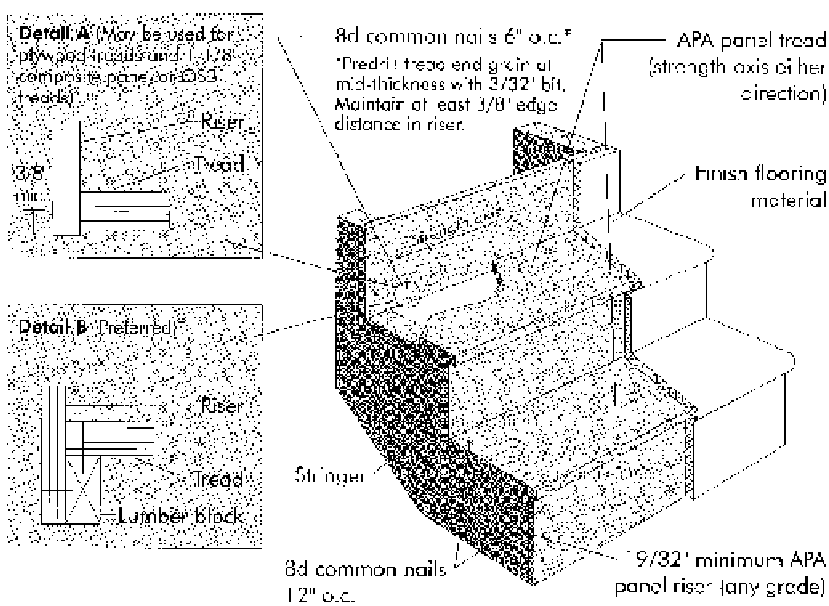
5.8.11 APA Panel Stair Treads and Riser Applications

APA PANEL STAIR TREADS AND RISERS



APA PANEL STAIR TREADS

Panel Grade[a]	Minimum Thickness (in.) Nail-Glued	Minimum Thickness (in.) Nailed-Only
APA RATED STURD-I-FLOOR	19/32	23/32

(a) Other appropriate APA panel grades may be substituted for Sturd-I-Floor, providing minimum thickness complies with recommendations above.

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5.8.12 APA Plywood Systems for Ceramic Tile Flooring

APA PLYWOOD SYSTEMS FOR CERAMIC TILE FLOORING (Based on ANSI Standard A108 and specifications of the Tile Council of America)

Joist Spacing (in.)	Minimum Panel Thickness (in.) Subfloor[a][g]	Underlayment[b][g]	Tile Installation
Residential			
16	19/32	(c), (d)	"Dry-Set" mortar or latex portland cement mortar
16	19/32	–	Cement mortar (1-1/4")[f]
16	19/32	11/32	Organic adhesive
16	19/32	15/32[e]	Epoxy mortar and grout
Commercial			
16	19/32	(c), (d)	"Dry-Set" mortar or latex – portland cement mortar
16	19/32	–	Cement mortar (1-1/4")[f]
16	19/32	19/32[e]	Epoxy mortar and grout

(a) APA RATED SHEATHING with Span Rating of 40/20 (19/32" panel).

(b) APA Underlayment or sanded Exterior grade, except as noted.

(c) Attach Cementitious Backer Units (CBU) over a supporting plane of "Dry-Set" or latex-portland cement mortar with galvanized nails, screw-type nails or other corrosion-resistant fasteners. 7/16" minimum thickness CBU required for light commercial service.

(d) Leave 1/8" space at panel ends and edges. Fill joints with "Dry-Set" or latex-portland cement mortar.

(e) Leave 1/4" space at panel ends and edges; trim panels as necessary to maintain end spacing and panel support on framing. Fill joints with epoxy mortar when it is spread for setting tile.

(f) Use No. 15 asphalt felt or 4-mil polyethylene sheeting over subfloor. Reinforce mortar with wire mesh.

(g) See Table 8, 10 or 11, as applicable, for panel fastening recommendations.

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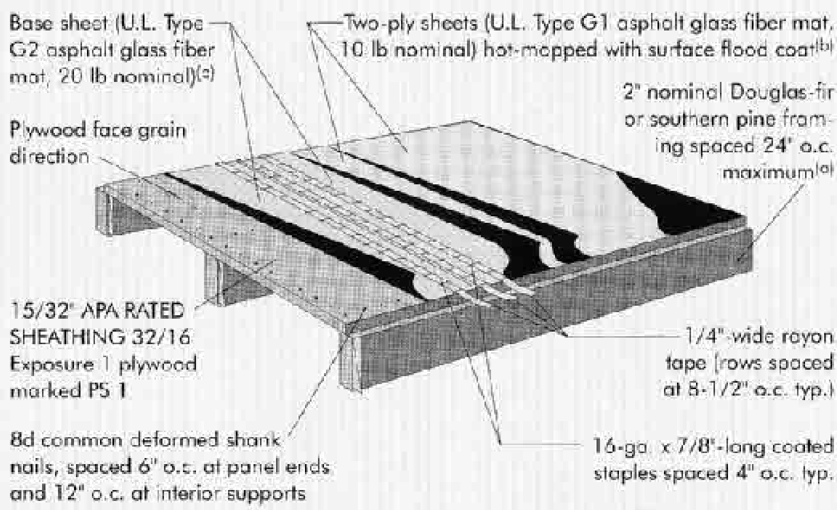
5.8.13 Fully Wind-Resistive Roof Assemblies

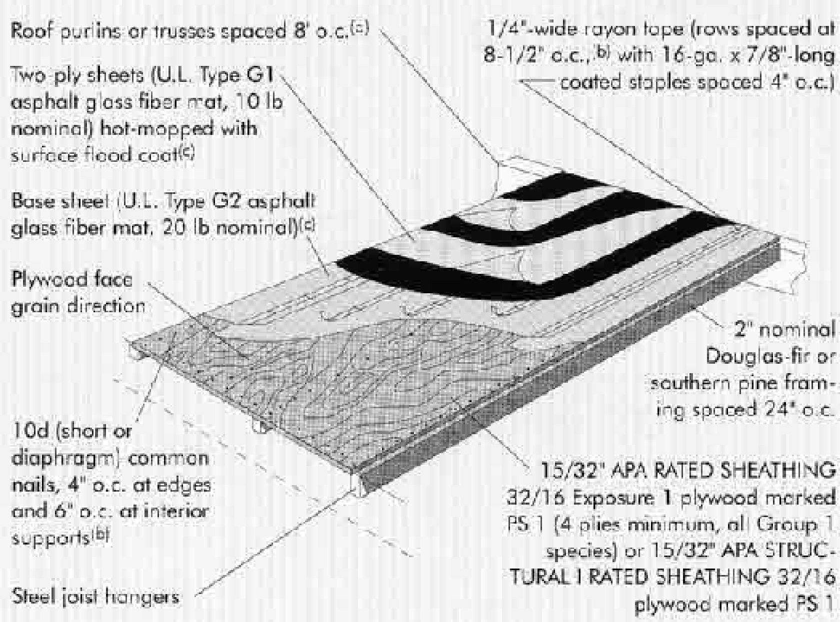
FULLY WIND-RESISTIVE ROOF ASSEMBLY — U.L. CLASS 90 (NM519)



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must have 2" nominal or greater width for plywood deck nailing.

(b) Install roofing base and ply sheets with roll direction parallel to plywood face grain directions.

FULLY WIND-RESISTIVE ROOF ASSEMBLY — U.L. CLASS 90 (NM520)



(a) Trusses or I-joists used for purlins must have chords or flanges of 1-3/4" minimum depth for plywood deck nailing.

(b) For semi-wind-resistive assemblies (Class 60), plywood deck nailing spaced 6" o.c. at all supports and roofing base sheet attached with rayon tape rows spaced 11-1/3" o.c.

(c) Install roofing base and ply sheets with roll direction parallel to plywood face grain direction.

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5.8.14 Recommended Roof Loads for APA Rated Sheathing with Strength Axis Parallel to Supports

RECOMMENDED ROOF LOADS (PSF) FOR APA RATED SHEATHING WITH STRENGTH AXIS PARALLEL TO SUPPORTS[a][f] (OSB, composite and 5-ply/5-layer plywood panels unless otherwise noted)

Panel Grade	Thickness (in.)	Span Rating	Maximum Span (in.)	Load at Maximum Span: Live	Load at Maximum Span: Total
APA STRUCTURAL I RATED SHEATHING	7/16	24/0, 24/16	24[d]	20	30
	15/32	32/16	24	35[e]	45[e]
	1/2	32/16	24	40[e]	50[e]
	19/32, 5/8	40/20	24	70	80
	23/32, 3/4	48/24	24	90	100
APA RATED SHEATHING	7/16[b]	24/0, 24/16	16	40	50
	15/32[b]	32/16	24[d]	20	25
	1/2[b]	24/0, 32/16	24[d]	25	30
	19/32	40/20	24	40[c]	50[c]
	5/8	32/16, 40/20	24	45[c]	55[c]
	23/32, 3/4	40/20, 48/24	24	60[c]	65[c]

(a) For 4-ply plywood marked PS 1, reduce load by 15 psf.
(b) Composite panels must be 19/32 inch or thicker.
(c) For composite and 4-ply plywood panels, reduce load by 15 psf.
(d) Solid blocking recommended at panel ends for 24-inch span.
(e) For guaranteed or warranted roofs, contact membrane manufacturer for acceptable deck.
(f) Provide edge support.

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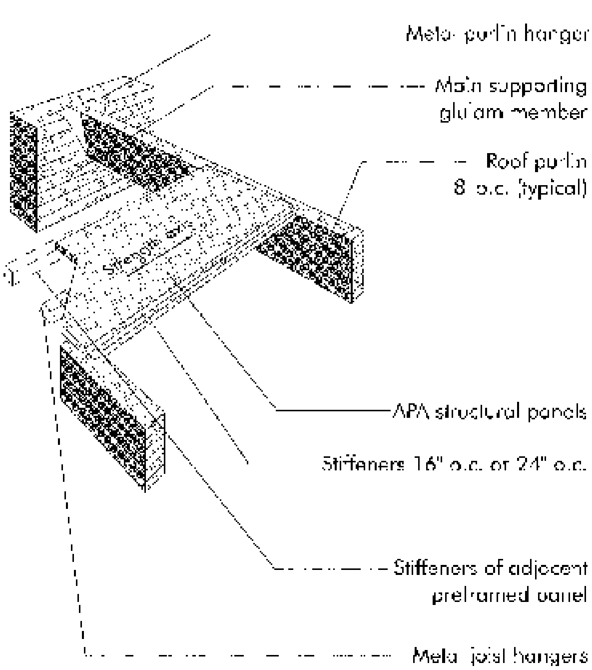
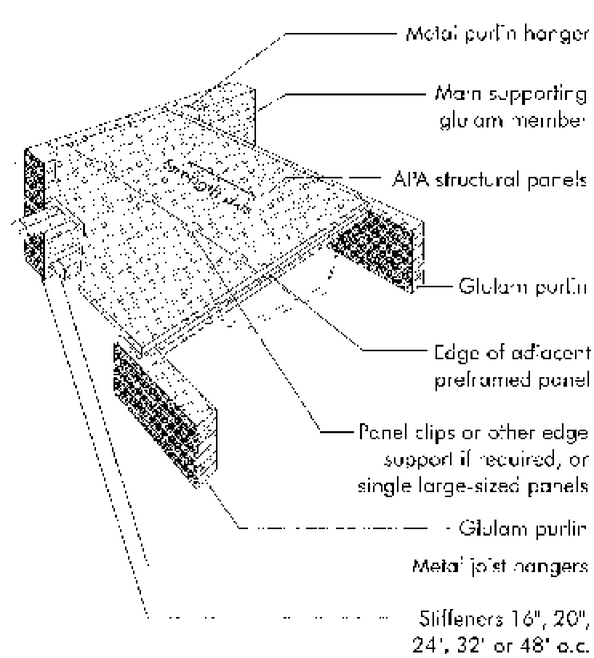
5.8.15 Preframed Roof Panels

PREFRAMED ROOF PANEL (4' x 8' – APA Structural Panels Parallel to Supports)



PREFRAMED ROOF PANEL (8' x 8' or larger – APA Structural Panels Perpendicular to Supports)



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5.8.16 Roof Sheathing—Construction Details

RECOMMENDED MINIMUM FASTENING SCHEDULE FOR APA PANEL ROOF SHEATHING (Increased nail schedules may be required in high wind zones.)

Panel Thickness[b] (in.)	Nailing[c][d] Size	Maximum Spacing (in.) Supported Panel Edges[e]	Intermediate
5/16 - 1	8d	6	12[a]
1-1/8	8d or 10d	6	12[a]

(a) For spans 48 inches or greater, space nails 6 inches at all supports.

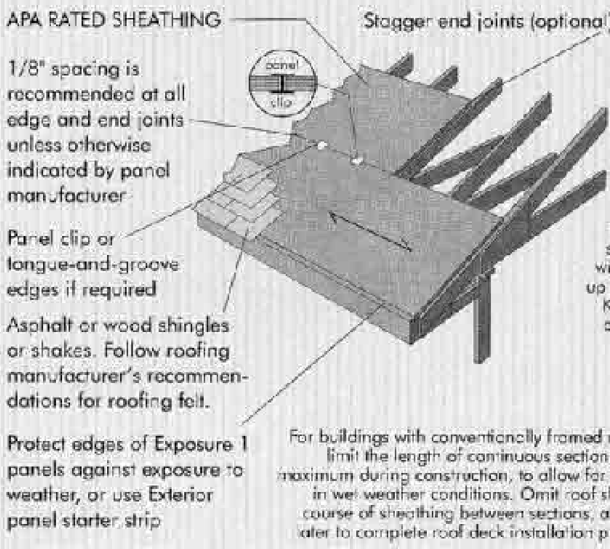
(b) For stapling asphalt shingles to 5/16-inch and thicker panels, use staples with a 15/16-inch minimum crown width and a 1-inch leg length. Space according to shingle manufacturer's recommendations.

(c) Use common smooth or deformed shank nails with panels to 1 inch thick. For 1-1/8-inch panels, use 8d ring- or screw-shank or 10d common smooth-shank nails.

(d) Other code-approved fasteners may be used.

(e) Fasteners shall be located a minimum 3/8 inch from panel edges.

APA PANEL ROOF SHEATHING



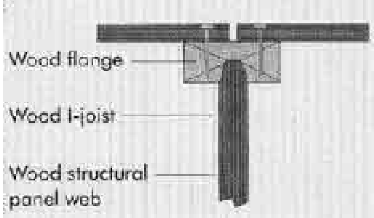
Note: Cover sheathing as soon as possible with roofing felt for extra protection against excessive moisture prior to roofing application.

Note: For pitched roofs, place screened surface or side with skid-resistant coating up if OSB panels are used. Keep roof surface free of dirt, sawdust and debris, and wear skid-resistant shoes when installing roof sheathing.

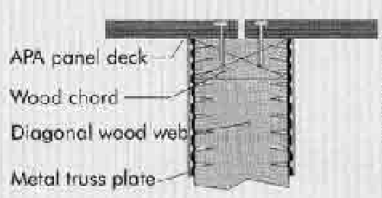
Note: For buildings with conventionally framed roofs (trusses or rafters), limit the length of continuous sections of roof area to 80 feet maximum during construction, to allow for accumulated expansion in wet weather conditions. Omit roof sheathing panels in each course of sheathing between sections, and install "fill in" panels later to complete roof deck installation prior to applying roofing.

TYPICAL CONNECTIONS TO ENGINEERED FLAT ROOF MEMBERS

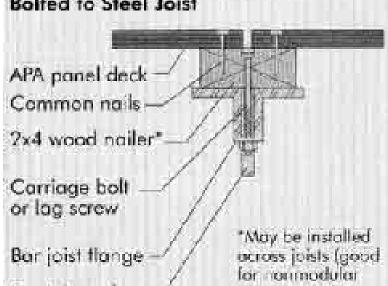
Panels Nailed to Wood I-Joist



Panels Nailed to Open-Web Parallel-Chord Wood Truss



Panels Nailed to Nailer Bolted to Steel Joist



*May be installed across joists (good for nonmodular joist spacing).

Panels Nailed to Glulam Beam

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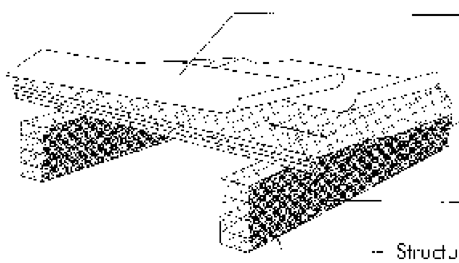
5.8.17 Heavy Timber Roof Construction Utilizing Plywood

HEAVY TIMBER ROOF CONSTRUCTION



DIMENSIONS OF COMPONENTS FOR HEAVY TIMBER CONSTRUCTION (TYPICAL CODE PROVISIONS)

Heavy Timber construction is generally defined in building codes and standards by the following minimum sizes for the various members or portions of a building:

	Inches, nominal
Columns—supporting floor loads	8 x 8
Supporting roof and ceiling loads only	6 x 8
Floor framing	
Beams and girders	6 wide x 10 deep
Arches and trusses	8 in any dimension
Roof framing – not supporting floor loads	
Arches springing from grade	6 x 8 lower half 6 x 6 upper half
Arches, trusses, other framing springing from top of walls, etc.	4 x 6
Floor (covered with 1-inch nominal flooring, 15/32- or 1/2-inch plywood, or other approved surfacing)	
Splined or tongue-and groove plank	3
Planks set on edge	4
Roof decks	
Splined or tongue-and-groove plank	2
Plank set on edge	3
Tongue-and groove plywood	1 1/8

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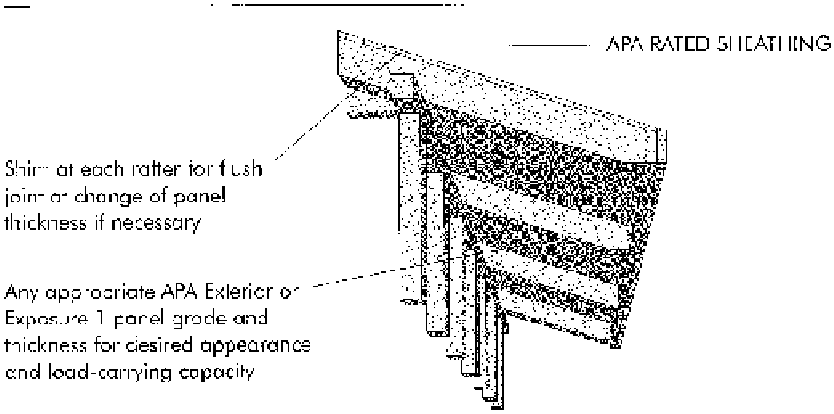
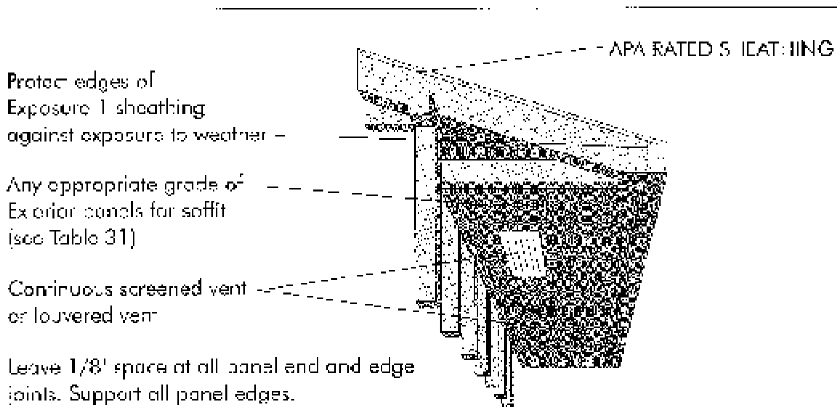
5.8.18 Open and Closed Soffit Construction Details Utilizing Plywood

OPEN SOFFIT



CLOSED SOFFIT



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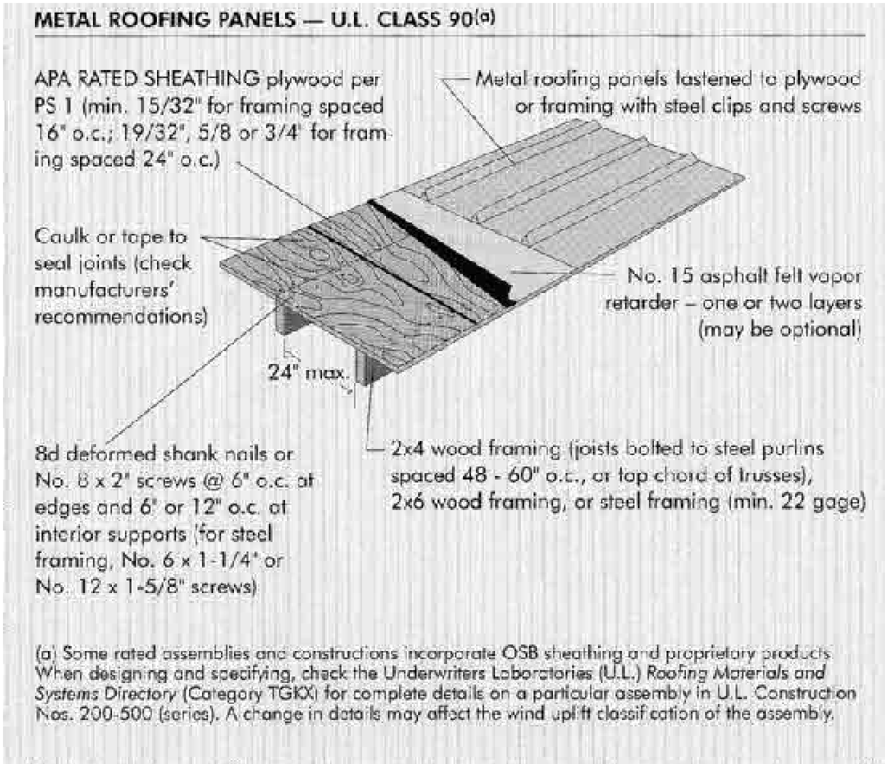
5.8.19 Plywood as Roof Support for Metal Roof Panels



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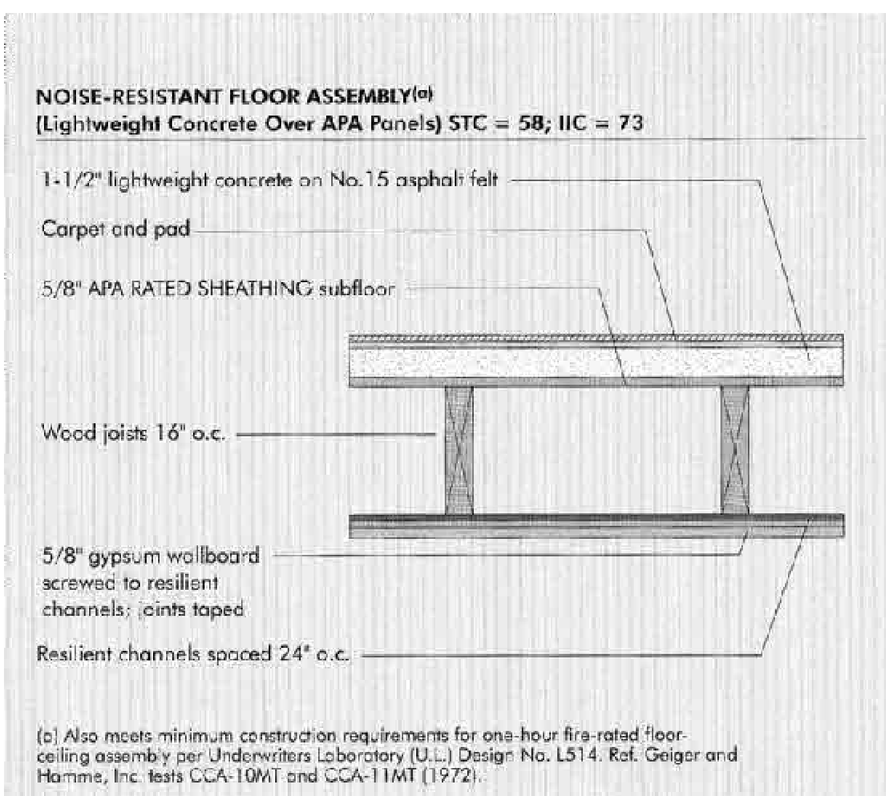
5.8.20 Noise Resistance Plywood Floor Construction Details



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5.8.21 APA Siding Face Grades and Metric Conversions

PANEL NOMINAL DIMENSIONS (WIDTH X LENGTH)

ft.	mm	m (approx.)
4 x 8	1219 x 2438	1.22 x 2.44
4 x 9	1219 x 2743	1.22 x 2.74
4 x 10	1219 x 3048	1.22 x 3.05

PANEL NOMINAL THICKNESS

in.	mm
1/4	6.4
5/16	7.9
11/32	8.7
3/8	9.5
7/16	11.1
15/32	11.9
1/2	12.7
19/32	15.1
5/8	15.9
23/32	18.3
3/4	19.1
7/8	22.2
1	25.4
1-3/32	27.8
1-1/8	28.6

APA 303 SIDING FACE GRADES[a]

303 Series Plywood Siding Grades	Type of Patch: Wood		Synthetic
303-OC	Not permitted	Not applicable for overlays	Not permitted
303-OL			
303-NR	Not permitted		Not permitted
303-SR	Not permitted		Permitted as natural-defect shape
303-6-W	Limit 6		Not permitted
303-6-S	Not permitted		Limit 6
303-6-S/W		Limit 6 – any combination	
303-18-W	Limit 18		Not permitted
303-18-S	Not permitted		Limit 18
303-18-S/W		Limit 18 – any combination	
303-30-W	Limit 30		Not permitted
303-30-S	Not permitted		Limit 30
303-30-S/W		Limit 30 – any combination	

(a) All panels except 303-NR allow restricted minor repairs such as shims. These and such other face appearance characteristics as knots, knotholes, splits, etc., are limited by both size and number in accordance with panel grades, 303-OC being most restrictive and 303-30 being least. Multiple repairs are permitted only on 303-18 and 303-30 panels. Patch size is restricted on all panel grades.

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5.9.0 Thermal Resistance of Wood Structural Panels

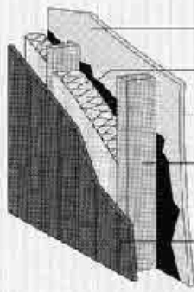
THERMAL RESISTANCE

Panel Thickness (in.)	Thermal Resistance, R[a]
1/4	0.31
5/16	0.39
3/8	0.47
7/16	0.55
15/32	0.59
1/2	0.62
19/32	0.74
5/8	0.78
23/32	0.90
3/4	0.94
7/8	1.09
1	1.25
1-1/8	1.41

(a) Degree F-hr.-sq.ft./BTU

ENERGY-CONSERVING STURD-I-WALL ASSEMBLIES

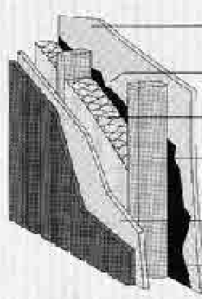
APA RATED SIDING DIRECT TO STUDS



	R
Outside surface (15 mph wind)	0.17
APA RATED SIDING	0.43–0.78
Batt insulation	
Option A – R11	11.00
Option B – R15HD (high density)	15.00
Option C – R19	18.00[a]
Option D – R21HD (high density)	21.00
1/2" gypsum wallboard	0.45
Inside surface (still air)	0.68

Insulation Option	Average U	Minimum Effective R = 1/U
A	0.096	10.46
B	0.081	12.41
C	0.063	15.85
D	0.058	17.32

APA RATED SIDING OVER RIGID FOAM INSULATION SHEATHING



	R
Outside surface (15 mph wind)	0.17
APA RATED SIDING	0.43–0.78
Rigid foam insulation	4.00 (min.)
Batt insulation	
Option E – R11	11.00
Option F – R15HD (high density)	15.00
Option G – R19	18.00[a]
Option H – R21HD (high density)	21.00
1/2" gypsum wallboard	0.45
Inside surface (still air)	0.68

Insulation Option	Average U	Minimum Effective R = 1/U
E	0.068	14.79
F	0.058	17.13
G	0.049	20.30
H	0.045	21.99

(a) When compressed to 5-1/2" thickness.

(b) Average U values include adjustment for 20% framing area with studs spaced 16" o.c. When studs are spaced 24" o.c. (15% framing area), average U values are slightly lower and corresponding R values are higher. Average U value is based on R value at framing of 4.38 for 2x4 wood studs and 7.14 for 2x6 wood studs.

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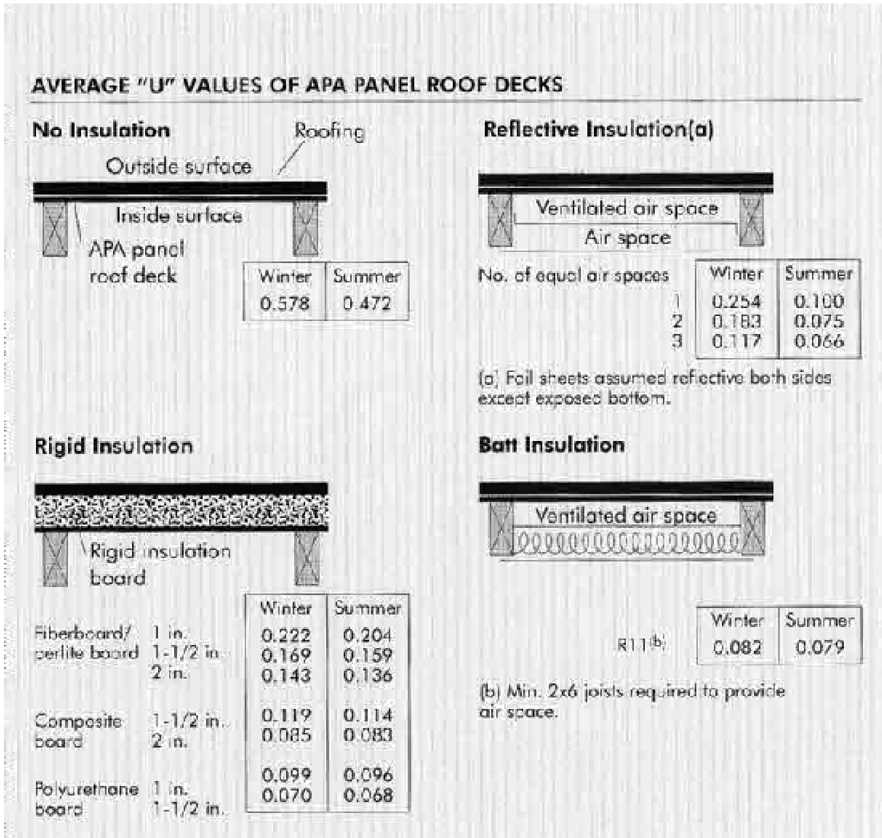
5.9.1 Average "U" Values of APA Panel Roof Decks



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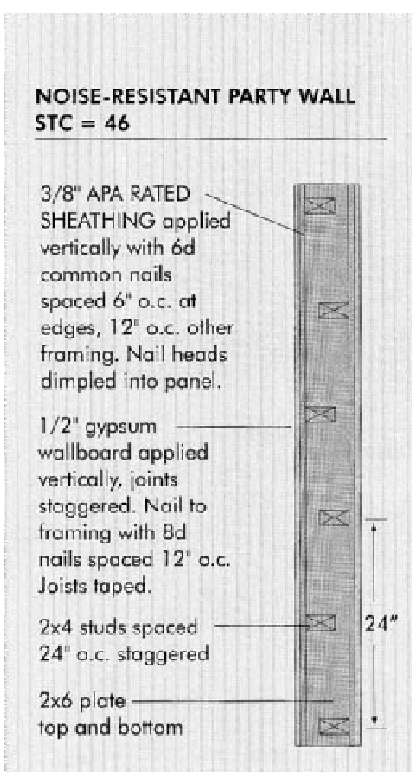
5.9.2 STC 46 Party Wall Construction



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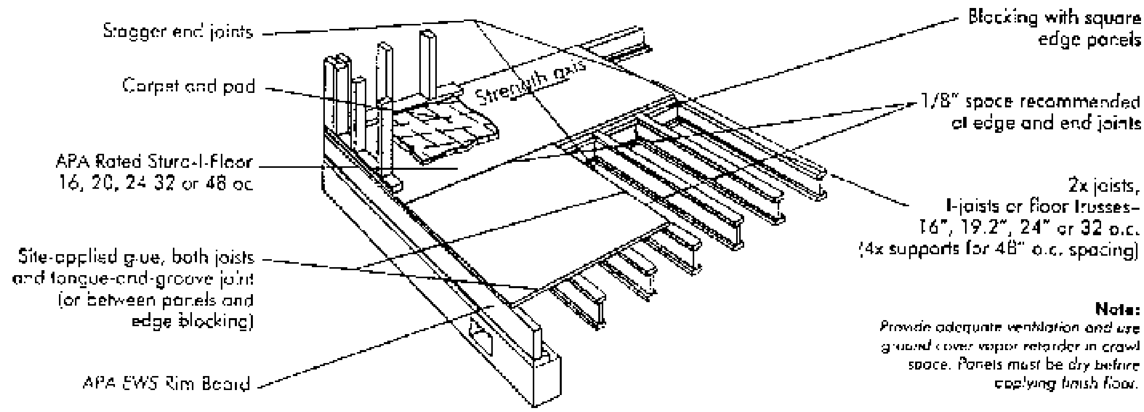
5.10.0 APA-Rated Sturdi-Floor Subfloor and Floor Framing for Hardwood Floors

APA Rated Sturd-I-Floor 16, 20, 24, 32 and 48 oc



Subflooring and Spacing of Floor Framing for Hardwood Flooring

APA Rated Sheathing or Sturd-I-Floor Span Rating	Spacing (in.) of Floor Framing	
	Maximum Spacing	Code Plus Spacing
40/20, 20 oc*	19.2	12
48/24, 24 oc	24	19.2
32 oc	32	24
48 oc	48	32

* The National Oak Flooring Manufacturers Association (NOFMA) and the National Wood Floor Association (NWFA) both recommend the use of 23/32" minimum thickness OSB or plywood as a subfloor material.

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5.11.0 Composite Wood Products

Along with lumber and plywood, within the past 40 years, a new wood product has gained wide acceptance in the industry, composite wood products. These products are panels and laminated materials made up of small pieces of wood glued together, oftentimes with plastic fillers. These products are frequently referred to as *engineered wood products*.

5.11.1 Hardboard (Compressed Fiberboard)

A board manufactured from interfelted lignocellulosis fibers, consolidated under heat and pressure to form a dense material.

- *Available thicknesses* Typically ⅛" (12.7 mm) to ½" (38.1 mm).
- *Density* 45 to 70 pounds/cubic foot (705 to 112 kg/cubic meter).
- *Uses* Exterior siding, peg board, decorative wall paneling, underlayment, drawer bottoms, furniture backs, and simulated wood shingles and shakes.

5.11.2 Cellulosic Fiberboard (Softboard)

Made from wood fibers, recycled paper, bagasse (a plant residue, such as from sugar cane), and other agricultural by-products

- *Available thicknesses* Typically ½" (12.7 mm) to 2" (50.8 mm).
- *Density* Typically 10 to 25 pounds/cubic foot (160 to 400 kg/cubic meter).
- *Uses* Wall sheathing, roof insulation, and sound insulation.

5.11.3 Oriented Strand Board (OSB)

This material evolved from waferboard and is constructed of strands of softwood or hardwood ½" (12.7 mm) wide by 3" (76.2 mm) to 4'6" (1.37 m) in length.

- *Available thicknesses* Typically ¼" (6.4 mm) to 1⅛" (28.6 mm).
- *Density* 36 to 44 pounds/cubic foot (577 to 705 kg/cubic meter).
- *Uses* Interchangeably used in structural applications in the same way as plywood. Phenolic paper overlaid OSB is used for siding.

5.11.4 Waferboard

Similar to OSB, except that it is composed of large flakes of wood bonded together and generally made from low-density hardwoods, such as aspen. Once used a great deal as sheathing, it has largely been replaced by OSB.

5.11.5 Laminated Veneer Lumber (LVL)

Primarily a structural member made of veneer laid up in one grain direction and made in billets 27" (68.6 cm) to 50" (127 cm) wide and 1½" (38.1 mm) or 1¾" (44.5 mm) thick. Produced under pressure to cure the adhesives, mostly phenolic glues. This material is nondestructively tested to ensure consistent strength. TrusJoist MacMillan uses this material as flanges in their I-joists.

5.11.6 Parallel-Strand Lumber (PSL)

These products are made of oriented strands of waste softwood veneer. The ½" (12.7 mm) wide by 37" (94 cm) long strands are oriented and laid up into a mat, which is processed through a microwave-heating system into billets of 11" (279 mm) × 18" (457 mm) or 11" (279 mm) × 14" (355 mm). These billets are sawn into lengths and thicknesses, as required. PSL members are used where high-strength lumber or timber materials are required. TrusJoist MacMillan's Parallam is a PSL product.

5.11.7 Oriented Strand Lumber (OSL)

OSL is made with nominal 12" (300 mm) long strands and pressed in a steam-injection press machine to produce uniform density throughout. This material, developed by McMillan Bloedel, Ltd., is also used in joist construction.

5.11.8 Com-Ply

Com-Ply is a material developed by the USDA Forest Service in the 1970s and composed of random or oriented wood flakes or particles sandwiched between two layers of veneer. One or more layers of veneer are also placed on the faces or edges of the lumber. This material is not widely used today.

5.12.0 Medium-Density Fiberboard (MDF)

Dry-formed panels manufactured from lignocellulosis fibers, combined with a synthetic resin or other suitable binder.

- *Available thicknesses* $\frac{3}{16}$" (4.74 mm) to 1½" (38.1 mm) (3", 76.2 mm, is available on special order).
- *Density* 40 to 50 pounds/cubic foot (641 to 801 kg/cubic meter).
- *Uses* Moldings or millwork where it replaces solid wood.

5.12.1 MDF Product Certifications and Uses

Medium Density Fiberboard (MDF) is widely used in the manufacture of furniture, kitchen cabinets, door parts, mouldings, millwork and laminate flooring. MDF panels are manufactured in a variety of sizes and densities, providing the opportunity to design the end product with the specific MDF needed.

MDF is a composite panel product typically consisting of cellulosic fibers combined with a synthetic resin or other suitable bonding system and joined together under heat and pressure. Additives may be introduced during manufacturing to improve certain properties.

The surface of MDF is flat, smooth, uniform, dense and free of knots and grain patterns, all of which make finishing operations easier and consistent, especially for demanding uses such as direct printing and thin laminates. The homogeneous edge of MDF allows intricate and precise machining and finishing techniques for superior finished products. Trim waste is significantly reduced when using MDF compared to other substrates. Stability and strength are important assets of MDF, and it holds precise tolerances in accurately cut parts.

Product Standards and Certification

ANSI Standard A208.2, Medium Density Fiberboard is the North American industry standard for MDF. This standard classifies MDF by density and use (interior or exterior) and identifies product grades. Specifications identified in the standard include physical and mechanical properties, dimensional tolerances and formaldehyde emission limits. Copies of the ANSI Standard for MDF are available from the CPA.

Third party certification to the ANSI Standards is required for many applications of composite panels. For example, HUD requires the physical properties of manufactured home decking to be third-party certified. Many building code jurisdictions require the physical properties of particleboard underlayment and stair tread to be third-party certified. Also, HUD as well as the state of Minnesota require third-party certification of formaldehyde emissions for nearly all particleboard and MDF under their jurisdiction.

Kitchen Cabinets

Cabinet manufacturers use MDF when they require a smooth, defect-free panel, shelf, or other printed or wrapped surface. Custom cabinet shops often specify MDF because of its tight edge and the ease of routing, sawing and shaping.

Paneling

MDF is used as a core material for paneling with veneers, printed surfaces, vinyl and low pressure laminates. It is stable, flat, smooth, has no grain to telegraph through the overlay, and can be installed quickly and easily.

Doors, Jambs and Millwork

MDF is a superior product for these applications because of its warp resistance, smoothness and insulating qualities. It is recommended for baseboards, door jambs, casings, stiles, rails, hollow core doors and trim. It is referenced in I.S.1 Industry Standard for Wood Flush Doors, sponsored by the Window and Door Manufacturers Association for use as a stile, rail or lock block material for hollow core doors.

Laminating and Finishing

MDF is a premier substrate for high quality veneer, thin vinyls, hot transfer foils, low pressure and resin saturated papers, and direct finishes. MDF's smooth surface, edge-finishing qualities, workability, dimensional stability, flatness, close tolerances, dent resistance, lower glue usage, bond strength, screw-holding, resistance to compression and warp and lack of grain-telegraphing have also contributed to its wide acceptance.

Mouldings

MDF is easily shaped into almost any form and is commonly available in lengths up to 20 feet. This makes MDF an excellent material for vinyl, veneer or paper wrapped and pre-primed interior mouldings. Information about moulding standards is available from the Wood Moulding and Millwork Producers Association. See also the CPA's Technical Bulletin *MDF Mouldings* for installation information.

Edge Shaping and Machining

One of the prime attributes of MDF is its sharp, clean edge-machining with minimal treatment prior to finishing. The need for edge-banding or mouldings is eliminated with the right finish.

With the proper selection of equipment and cutting tools, MDF can be machined into intricate patterns as easily as natural wood. The homogeneous nature of MDF results in clean, sharp reproduction of designs free from fuzzing or chip-out, provided properly designed carbide or diamond tools are used.

Embossing

Manufacturers often use embossing–pressing cast die patterns into the MDF surface–to produce three-dimensional designs. MDF's even texture and consistent properties make it an excellent material for embossing.

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5.12.2 MDF Raw Material Composition

Particleboard (PB) and MDF are composite panels manufactured primarily from two materials - cellulosic fiber and synthetic adhesives, or resins. The fibrous material can be wood or agricultural crop residues. The resins can be of several different configurations.

Fiber

Particleboard and MDF have traditionally been manufactured from wood fiber, typically "residual" wood left over from the primary manufacturing of other wood products. Today an increasing number of alternative fibers from agricultural residue are in use:

Wood species
The wood species used by each manufacturer is noted in this guide. Different species may impart unique characteristics to the panel such as color, weight, and strength.

Wood source
Most wood used in particleboard and MDF today is classified as residual wood, or wood recovered from other manufacturing processes in the form of shavings, chips, sawdust, and trim. Occasionally fiber from round wood, typically from precommercial thinnings or other lower quality logs, is used to impart specific strength characteristics to the panel. Another growing source of fiber is urban wood, typically postconsumer wood from industrial or construction waste. Demolition wastes are not generally used because of contamination potential.

Agricultural fiber
Known as "agrifiber," the use of this source of fiber is creating new opportunities for the composite panel industry. Agrifiber sources include cereal straw (wheat, barley, rice), soy and kanaf, and sugar cane pulp, known as bagasse. Agrifiber is both plentiful and readily convertible into PB/MDF panels.

Resins

Urea-Formaldehyde (UF) resins have been the workhorse of the North American composite panel industry since its beginnings in the 1950's, and the vast majority of PB/MDF manufactured today is based on UF technology. UF resins are strong, colorless, and economical. Panels made from UF resins have limitations in that they are not very water resistant, and tend to emit small amounts of formaldehyde when new. Melamine fortified UF resins (MUF) are frequently used to improve a panel's water resistance but can add substantially to the cost. Phenol-formaldehyde (PF) resins, widely used in the manufacture of plywood and OSB, are occasionally used in the manufacture of PB/MDF to produce panels with even greater water resistance characteristics. While providing durability to a panel, they are dark in color and may create a darker panel. Methyl diisocyanate (MDI) adhesives are used in some PB/MDF applications and typically result in a strong and more water-resistant bond. MDI adhesives are widely used today in the manufacture of agrifiber-based panels.

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5.12.3 MDF Wood and Vinyl Veneers and Dimensional Characteristics

Wood Veneers

A major application of wood veneer is as a decorative laminate material over PB/MDF substrates. The general handling and storage requirements discussed previously also apply to veneer and PB/MDF combinations. In addition, the materials should be laminated with their moisture content in the 6-9 percent range. And, since balanced panel construction is essential to prevent warp, the same thickness and grade veneer should be used on both sides.

Different veneer species can be used, but they must have similar strength properties and dimensional behavior patterns. Problem areas, such as tension wood, burls, and knots, and their effect on stress must be specifically considered. Finally, the glue spread rate should be uniform.

The natural variability of the laminate and substrate properties is a common cause of warping, particularly in the case of a thin substrate with relatively thick laminate faces. Controlling the variability between the laminates can effectively reduce warp in laminated panels.

The concept of balance does not end with the manufacture of a balanced panel. The installation and the end use environments can also be sources of moisture imbalance that create internal stresses resulting in warp. To ensure acceptable laminated product performance, design and engineering must consider the product application and environment.

Other Overlays

Vinyl films, low-basis-weight papers, and foils should all be applied using good balanced-lamination practices. Generally, the application of a film or paper to one side only, or different overlays on each side of a PB/MDF substrate will not result in warp. However, one-sided application of any laminate may act as a moisture barrier creating a transitory imbalance which can result in warp over time.

Summary

An imbalance in moisture-related expansion or contraction frequently causes warping of laminated panels. Such an imbalance is activated by changes in moisture content. A change might be temporary, as in the case of wetting one side of a flat panel. The resulting "transient warping" is beyond the control of the laminated-panel manufacturer. In theory, "structural warp" resulting from a built-in imbalance can sometimes be prevented.

Balanced lamination is the key to consistently manufacturing flat panels.

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5.12.4 Dimensional Stability as a Critical Factor

Moisture is always present in wood or wood products. Driven by physical forces, moisture enters and leaves wood, changing its volume and properties.

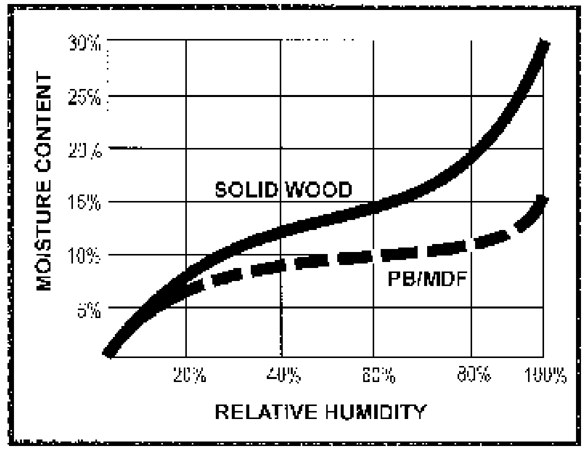
Since there is no guaranteed method for keeping moisture out of wood, appropriate design measures must be taken when building with wood products.

Balance of Moisture in Wood and Air

When wood is green it is saturated with water in both the cell cavities and the cell walls. The water in the cell cavities is called "free water" and the water in the cell walls is called "bound water."

Normally, free water is removed completely during the drying process. Some bound water remains and is in equilibrium with the relative humidity of the air. This equilibrium is defined by the "sorption isotherm."

All wood species more or less follow the curve shown at right. Particleboard and medium density fiberboard (MDF) follow a somewhat modified curve as indicated by the dashed line. As the relative humidity of the air changes, all wood products gain or lose water, including wood-based laminating materials like resin impregnated papers or high pressure laminates (HPL).



"Expansion or contraction in wood products is directly related to moisture content changes. The degree of movement depends on the expansion/shrinkage coefficient of the product."

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5.12.5 Particleboard and MDF Grades and Property Requirements

Grade	Length and Width mm (inches)	Thickness Tolerance: Panel Average from Nominal mm (inches)	Thickness Tolerance: Variance from Panel Average mm (inches)	Modulus of Rupture N/mm² (psi)	Modulus of Elasticity N/mm² (psi)	Internal Bond N/mm² (psi)	Screwholding: Face N (pounds)	Screwholding: Edge N (pounds)	Formaldehyde (ppm)
ANSI A208.1-1999 PARTICLEBOARD									
H-1	±2.0 (0.080)	±0.200 (0.008)	±0.100 (0.004)	16.5 (2393)	2400 (348100)	0.90 (130)	1800 (405)	1325 (298)	0.30
H-2	±2.0 (0.080)	±0.200 (0.008)	±0.100 (0.004)	20.5 (2973)	2400 (348100)	0.90 (130)	1900 (427)	1550 (348)	0.30
H-3	±2.0 (0.080)	±0.200 (0.008)	±0.100 (0.004)	23.5 (3408)	2750 (398900)	1.00 (145)	2000 (450)	1550 (348)	0.30
M-1	±2.0 (0.080)	±0.250 (0.010)	±0.125 (0.005)	11.0 (1595)	1725 (250200)	0.40 (58)	NS	NS	0.30
M-S	±2.0 (0.080)	±0.250 (0.010)	±0.125 (0.005)	12.5 (1813)	1900 (275600)	0.40 (58)	900 (202)	800 (180)	0.30
M-2	±2.0 (0.080)	±0.200 (0.008)	±0.100 (0.004)	14.5 (2103)	2250 (326300)	0.45 (65)	1000 (225)	900 (202)	0.30
M-3	±2.0 (0.080)	±0.200 (0.008)	±0.100 (0.004)	16.5 (2393)	2750 (398900)	0.55 (80)	1100 (247)	1000 (225)	0.30
LD-1	±2.0 (0.080)	+0.125 (0.005) -0.375 (0.015)	±0.125 (0.005)	3.0 (435)	550 (79800)	0.10 (15)	400 (90)	NS	0.30
LD-2	±2.0 (0.080)	+0.125 (0.005) -0.375 (0.015)	±0.125 (0.005)	5.0 (725)	1025 (148700)	0.15 (22)	550 (124)	NS	0.30
PBU	+0.0 (0.000) -4.0 (0.160)	±0.375 (0.015)	±0.250 (0.010)	11.0 (1595)	1725 (250200)	0.40 (58)	NS	NS	0.20
D-2	±2.0 (0.080)	±0.375 (0.015)	±0.250 (0.010)	16.5 (2393)	2750 (398900)	0.55 (80)	NS	NS	0.20
D-3	±2.0 (0.080)	±0.375 (0.015)	±0.250 (0.010)	19.5 (2828)	3100 (449600)	0.55 (80)	NS	NS	0.20
ANSI A208.2-1994 MDF									
HD	±1.0 (1/64)	±0.125 (0.005)	±0.125 (0.005)	34.5 (5000)	3450 (500000)	0.75 (110)	1555 (350)	1335 (300)	0.30
MD ≤ 21 mm (0.825")	±1.0 (1/64)	±0.125 (0.005)	±0.125 (0.005)	24.0 (3500)	2400 (350000)	0.60 (90)	1445 (325)	1110 (250)	0.30
MD > 21 mm (0.825")	±1.0 (1/64)	±0.125 (0.005)	±0.125 (0.005)	24.0 (3500)	2400 (350000)	0.55 (80)	1335 (300)	1000 (225)	0.30
LD	±1.0 (1/64)	±0.125 (0.005)	±0.125 (0.005)	14.0 (2000)	1400 (200000)	0.30 (40)	780 (175)	670 (150)	0.30

Particleboard Grades

H High Density, generally above 800 kg/m³ (50 lb/ft³)
M Medium Density, generally between 640-800 kg/m³ (40-50 lb/ft³)
LD Low Density, generally less than 640 kg/m³ (40 lb/ft³)
D Manufactured home decking
PBU Underlayment

MDF Grades

HD High Density, generally above 800 kg/m³ (50 lb/ft³)
MD Medium Density, generally between 640-800 kg/m³ (40-50 lb/ft³)
LD Low Density, generally less than 640 kg/m³ (40 lb/ft³)

* Please call the CPA for a complete table of all property requirements.

Formaldehyde Emission Limits

ANSI A208.2 sets the formaldehyde emission limit for MDF at 0.30 parts per million (ppm) at a loading of 0.26m²/m³ (0.08 ft²/ft³). The addition of finishes or overlays may significantly alter product emissions.

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5.12.6 Effect of Moisture on Cross Lamination of Veneered Lumber Products

Water's Effect on Dimensions

Residing in the cell wall, bound water affects the wood's bulk. This in turn effects the gross dimensions of the wood. As a general rule, wood swells and shrinks in proportion to the volume of water gained or lost.

For solid wood, swelling and shrinking is quite different in longitudinal vs tangential or radial directions. These differences are significant and could result in practical problems.

Control Dimensional Changes

One important method for reducing dimensional changes is cross lamination, a key characteristic of plywood, particleboard, and medium density fiberboard (MDF) products.

Cross lamination is accomplished in plywood by alternating the grain direction of the veneer layers in the panel or in the case of particleboard and MDF, by using randomly placed particles and fibers.

To see how cross lamination controls dimensional changes, let's use the example of a veneered lumber panel.

When there's an increase in moisture, an edge-glued lumber panel freely expands.

When restraining members, such as cross veneers, are applied to both the top and the bottom panel — prior to moisture gain — they act like steel straps nailed to the panel. They are strong enough to greatly reduce, if not totally eliminate, the expansion of the panel.

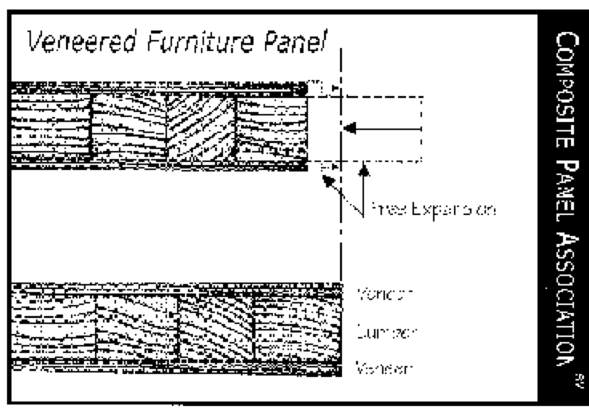
As the moisture content of the lumber panel increases, the restraining members will be stressed in tension, the lumber panel in compression.

Although significant stress occurs, the panel will stay flat as long as the forces in the restraining members are exactly equal or balanced.

An extreme imbalance occurs when the top strap is cut, resulting in a warp that's easy to see.

The problem with cross lamination is that sometimes it can be difficult to maintain balance. For exact balance, the two restraining members must be identical in:

- Thickness.
- Resistance to deformation, such as stretching.
- Modulus of elasticity (MOE).
- Expansion characteristics.



Even minor imbalances in the characteristics of the restraining members can cause significant warping. The greater the potential expansion of the lumber panel, the greater the warp when a restraint is removed on one side.

Alternating Grain Direction

Consider a furniture panel where the veneer layers serve the same function as steel straps, except that they absorb moisture and expand.

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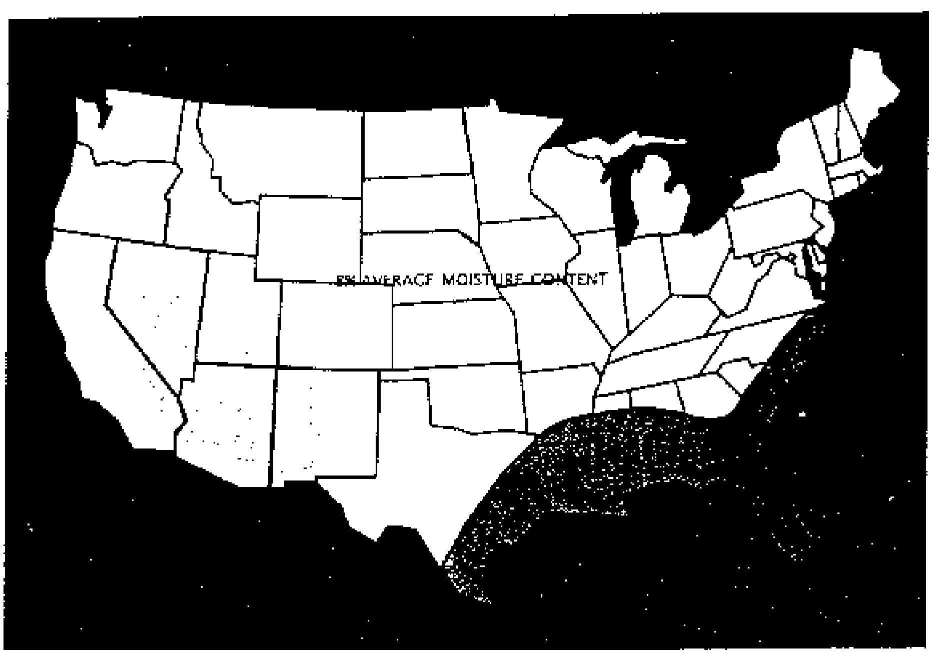
5.12.7 Moisture Content of Particleboard and the Impact on Warpage

When used as a substrate for plastic laminate facings, these particleboard and fiberboard panels are subject to warpage if not stored properly. Warpage can also occur when an unbalanced laminated panel is produced—one with a face sheet of high-pressure laminate, but no backer sheet. Moisture content building up in the unfaced panel causes stresses to accumulate. When these stresses become excessive and are no longer equally balanced, cracks can occur in the laminate. This unbalance can occur because of a number of factors:

- Selection of laminate other than HPL, such as a wood veneer.
- The environment in which laminating is to occur.
- Conditioning (or lack thereof) of each component of the assembly.
- Product design problems.
- Installation procedures

Unusually moist or dry conditions should be avoided in both the storage of the substrate and the laminating environment.

5.12.8 Moisture Content Zones in the U.S.



Approximate equilibrium moisture content zones for wood-based products. Values may vary with local and seasonal conditions.

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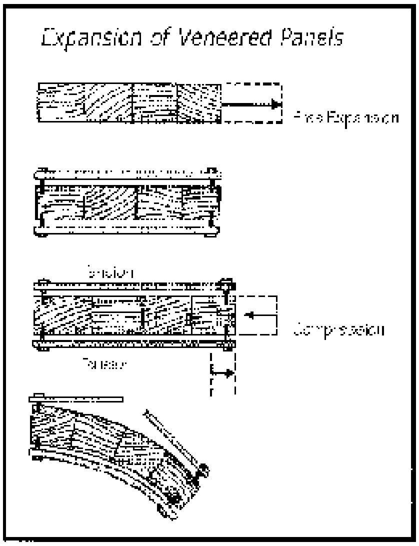
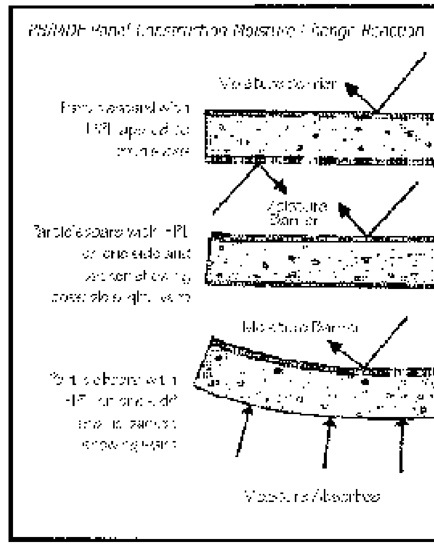
5.12.9 Particleboard and MDF Dimensional Changes Compared to Wood



Using Randomly Placed Particles or Fibers

Particleboard and MDF also benefit from cross lamination because of the random orientation of their elements.

Expansion of the particles or fibers in the plane of the board is greatly reduced and is substantially the same in both directions. These properties make particleboard and MDF core materials with equal expansion characteristics in all directions.



By design, the veneer grain is arranged at 90 degrees relative to the grain of the core lumber, pairing the minimum expansion of the veneer along its grain with maximum expansion of the core across its grain.

The veneer layers effectively restrain the lumber core because of:

- Very high resistance to stretching (MOE) of the veneer along the grain.
- Relatively low resistance to compression (also MOE) of the lumber core across the grain.

Balance is vital. If the bottom veneer was only half as thick as the top veneer, it would not restrain the core as effectively and the panel would warp concavely upwards.

Relative expansion and direction of stresses are reversed when considering the other principal direction of the panel, but the mechanism is the same.

Providing Additional Restraints

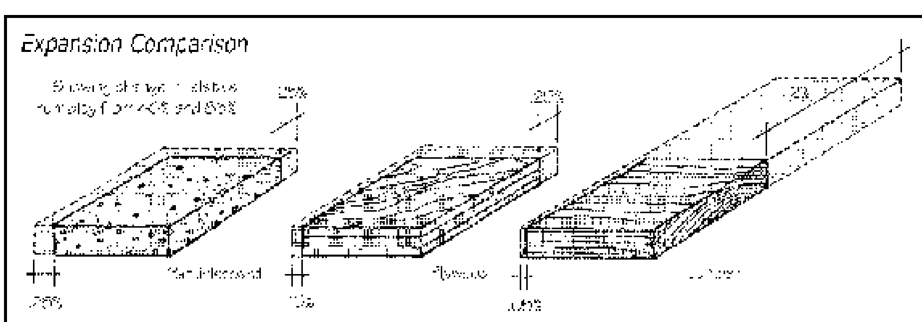
Laminating particleboard provides additional restraint, but even here allowances must be made for dimensional change as potential for warping still exists.

Consider particleboard or MDF overlaid with high pressure laminates (HPL), with and without backing:

- Equal thickness of HPL on both sides provides maximum stability.
- Thinner backing cannot restrain the panel with the same force as the HPL, making it vulnerable.
- If the restraint is completely one-sided, it is equivalent to the snapped steel strap in the prior example.

Both unbalanced constructions would warp concavely upwards upon moisture gain.

"The most certain way to minimize the degree of warp is to use balanced construction practices."



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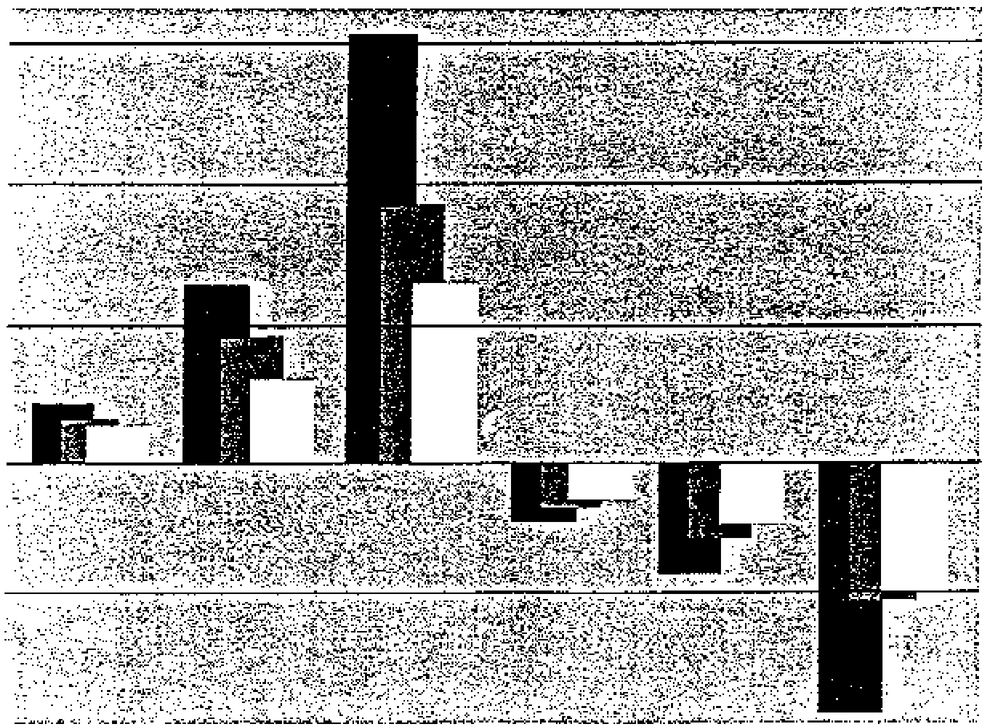
5.12.10 Dimensional Changes in Medium-Density Fiberboard (MDF) and Industrial-Grade Particle Board (PBI)



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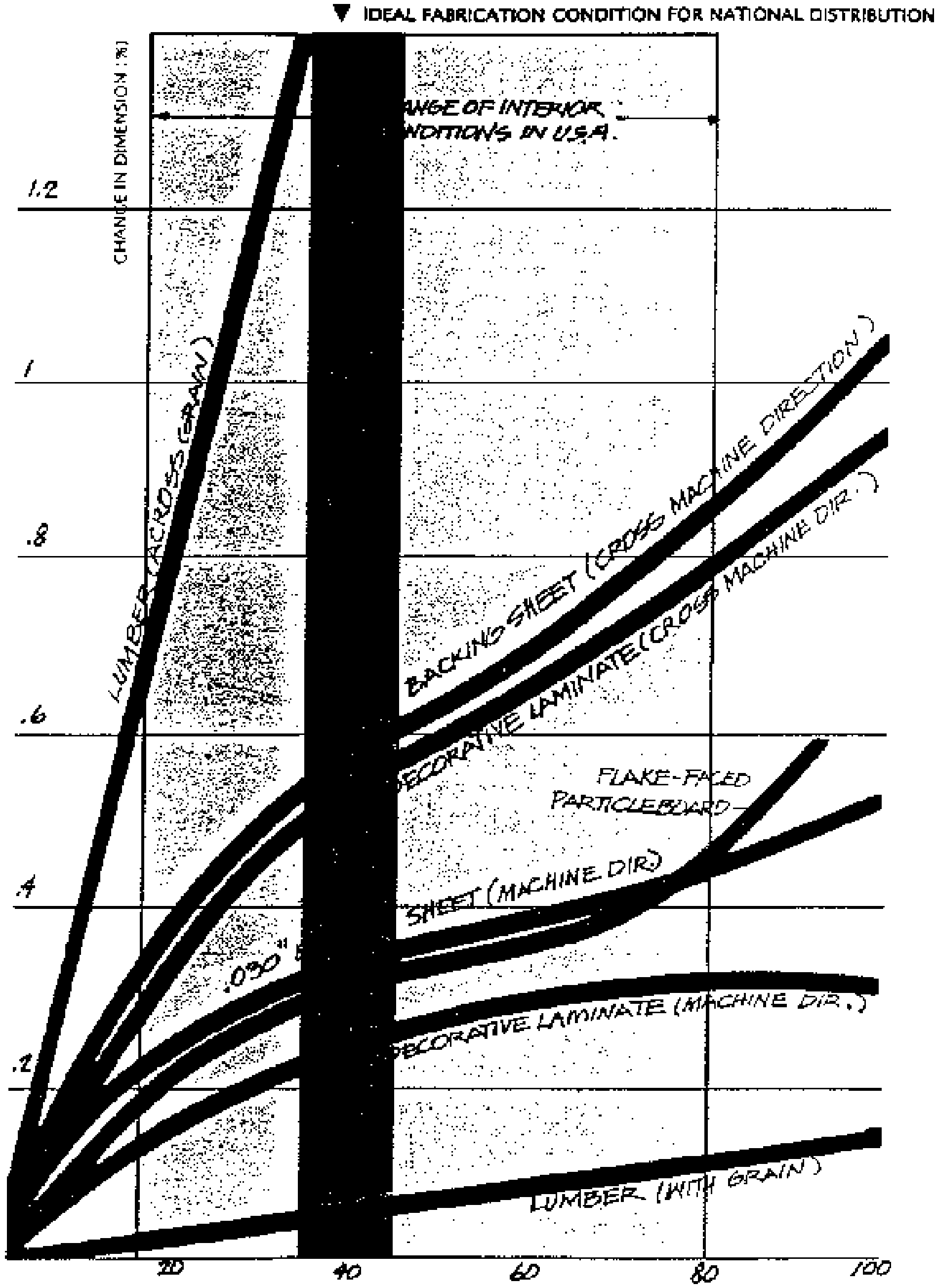
5.12.11 Ideal Fabrication Conditions Chart



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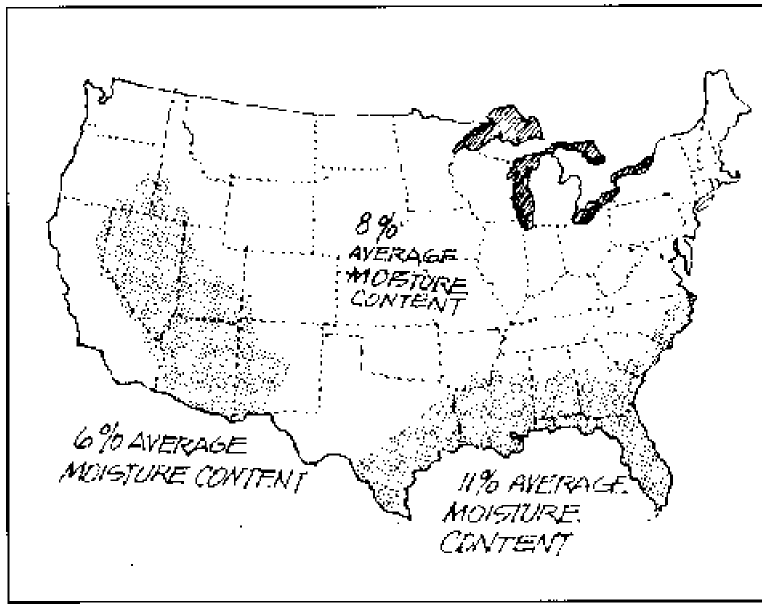
5.12.12 Selected Substrates—Handling and Storage Suggestions



Approximate equilibrium moisture content zones for wood-based products. Values may vary with local and seasonal conditions

Selecting the Substrate

Selection of PB/MDF for laminating applications should follow basic guidelines. Always select flat panels for substrates. Flatness indicates that the substrate is balanced and free of stress. Consider the substrate properties, including stiffness (MOE), thickness, linear expansion, and uniformity. These can be evaluated from the manufacturer's specifications or standards. The greater the MOE or thickness of the material, the better it will resist moisture related expansion stresses. Measure the panel moisture content and set guidelines of acceptability. Evaluate all of these properties with respect to laminates that will be applied.

Storage and Handling

Rules for substrate and laminate handling and storage are generally the same. Materials should be stored flat and kept dry. For best performance:

1. Do not store materials outside or in locations where they may be exposed to water or high humidity.

2. Keep material off the floor, use bolsters of the same thickness, and allow adequate space between units.

3. Avoid storage conditions where extremes of temperature and humidity can occur.

4. Before final assembly, allow materials a satisfactory conditioning period to equalize.

Laminates

High-pressure laminates, resin-saturated papers, vinyl films, heat transfer foils, decorative papers, and wood veneers comprise types of overlay materials commonly applied to PB/MDF substrates by the laminator.

High-Pressure Laminates (HPL)

High-pressure laminates consist of multiple layers of kraft paper saturated with phenolic resin, a decorative layer of paper saturated with melamine resin, and a very thin top sheet of paper heavily saturated with melamine resin. As does any wood-based product, HPLs expand and contract with changes in moisture content.

The HPL and the substrate materials should be brought to equilibrium at the same humidity and temperature.

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5.12.13 Use of Particleboard as Underlayment

Preparation of Subfloor

Particleboard underlayment should be applied over appropriate code approved subfloors. The subfloor must be of wood construction, dry, level, securely nailed, and free of foreign matter and projections. Ground level in crawl spaces should be at least 18 inches below the bottoms of floor joists and the ground within the crawl space should be covered with a minimum 6 mil polyethylene vapor retarder or equivalent. The crawl space should be well vented with uniformly distributed foundation vents. Do not apply particleboard underlayment over concrete or below grade.

When particleboard underlayment is to be applied with nails or staples, panel subfloors should be at least 19/32 inch thick with a minimum of 32/16 panel span rating. When particleboard underlayment is to be glue nailed, panel subfloors should be at least 15/32-inch thick (plywood) or 7/16-inch thick (OSB), with a minimum of 24/16 panel span rating.

Structural panel subfloors should be installed with the long panel axis perpendicular to the joist system. Board subfloors should be at least 1-inch nominal thickness and not more than 8-inches wide.

Floor areas over furnaces should be insulated and well ventilated. Hot air ducts should be insulated to prevent localized drying and shrinkage of floor components.

Installation of Underlayment

Install particleboard underlayment shortly before covering with finish floor materials. If the underlayment has been subjected to high humidity conditions prior to application, separate panels with sticks so air circulates and use furnace heat to dry them. If subjected to high humidity conditions after application, use furnace heat to dry before applying the floor covering.

Start laying the panels at a corner of the room. Leave a 3/8-inch gap between underlayment and walls. Arrange panels so that four panel corners do not meet at one point. Butt all panel edges and ends to a light contact.

With structural panel subfloor, offset underlayment panel joints and subfloor panel joints that are at right angles to the joists at least 2 inches. Offset underlayment panel joints and subfloor panel joints that are parallel to the joists at least one joist. When 1/4 inch or 5/16 inch particleboard underlayment is used the floor thickness (subfloor plus underlayment) should be one inch or greater.

With board or decking subfloors installed *perpendicular* to the joists, apply underlayment panels with edges over the joists, and with ends offset at least two inches from a subfloor joint. With board or decking subfloors applied *at an angle* to the joists, apply the underlayment panels perpendicular to the joists with end joints parallel to and over a joist. In both cases use a minimum particleboard thickness of 3/8 inch.

Sawing underlayment generates fine dust, and table saws should be connected to a vacuum system. A shop vacuum can be connected to small table saws with a sheet metal sleeve. Individuals working with wood products including particleboard, on the job or in the home shop, should wear at minimum the following safety equipment: a half-mask respirator (filter) that is NIOSH approved and has a HEPA filter rating printed on the package, side-shielded safety glasses, a long-sleeve shirt and gloves.

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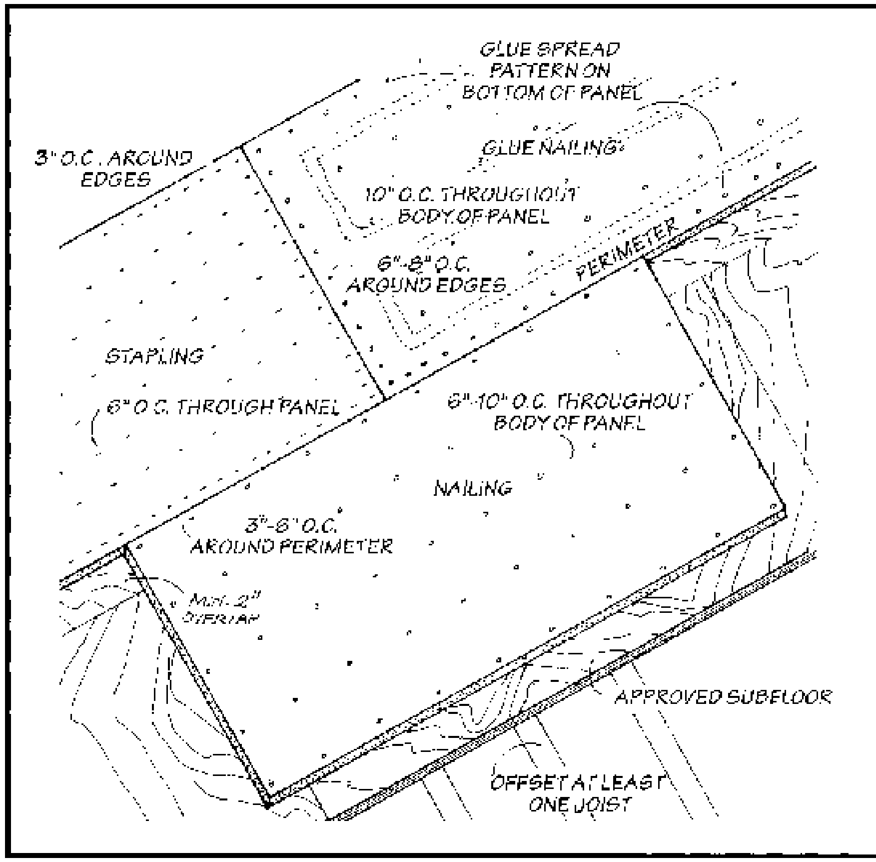


Fastening

Nailing

Use galvanized ring grooved underlayment nails to attach particleboard panels. Start nailing in the center of the panel and work toward the edges. Drive nails perpendicular to the surface and set flush. Drive nails no closer than 1/2-inch or further than 3/4-inch from the panel edges. Nail each panel completely before starting the next.

For panels up to and including 3/8-inch thick use 3d nails spaced 3 inches apart around the perimeter of the panel and 6 inches on centers each way throughout the body of the panel.

For panels 1/2-to 5/8-inches thick use 4d nails spaced 6 inches apart around the perimeter of the panel and 10 inches on centers each way throughout the body of the panel. Fastener lengths are designed to penetrate just through the subfloor and not substantially into the floor joists to minimize nail popping caused by shrinkage of the joists.

Stapling

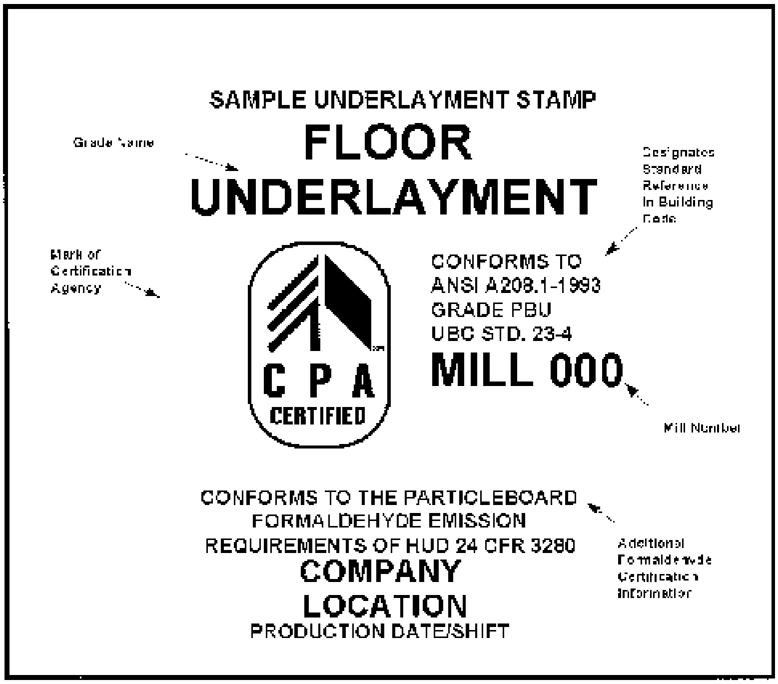
Galvanized divergent chisel-point power driven staples may be used to attach particleboard underlayment. They should be a minimum of 7/8-inch long, 18 gage and 3/16-inch crown for 1/4-inch thick underlayment; 1 1/8-inch long, 16 gage and 3/8-inch crown for 3/8-inch underlayment; 1 3/8-inch long, 16 gage and 3/8-inch crown for 1/2-inch and 5/8-inch underlayment. Staples should be spaced no further than 3 inches around the perimeter of the panel, 1/2 inch from the edge and 6 inches on centers each way throughout the body of the panel. Countersink staples no more than 1/16 inch.

Glue Nailing

For a superior floor system use the glue-nailing method of applying underlayment. Make sure the subfloor is free of all dust, dirt and debris before starting.

Apply a mastic adhesive formulated for these applications to the subfloor in a pattern providing a 12-inch wide strip along each underlayment panel end, a 3-inch wide strip along each panel edge, and a 6 inch wide strip down the center of the panel parallel to the edges. Follow adhesive manufacturer's instructions, and use a sufficient amount.

Continued


SAMPLE UNDERLAYMENT STAMP
Grade Name
FLOOR
UNDERLAYMENT
Designates Standard Reference In Building Code
Mark of Certification Agency
C P A
CERTIFIED
CONFORMS TO
ANSI A208.1-1993
GRADE PBU
UBC STD. 23-4
MILL 000
Mill Number
CONFORMS TO THE PARTICLEBOARD
FORMALDEHYDE EMISSION
REQUIREMENTS OF HUD 24 CFR 3280
Additional Formaldehyde Certification Information
COMPANY
LOCATION
PRODUCTION DATE/SHIFT

Continued

5.12.14 Placement of Various Types of Flooring Over Particleboard Underlayment

Do not use solvent based subfloor and construction adhesives which may cause subsequent staining of floor coverings.

Nailing should be done as described previously, except that the spacing should be 6 to 8 inches on centers around the perimeter of the panel and 10 inches on centers each way throughout the body of the panel. More nails should be used if needed to hold the panel in closer contact with the subfloor.

Filling and Sanding

Fill gouges, gaps and any chipped edges with a premium quality hardsetting, nonshrinking patching compound intended for this purpose following manufacturer's instructions. Allow filled areas to dry thoroughly and then sand flush with a wide belt sander. Sand any uneven joints between panels. Panel joints must be perfectly matched to prevent show-through.

Floor Coverings

Particleboard underlayment may be covered with carpeting, laminate flooring, resilient floorings, or seamless floor coverings. Do not apply ceramic tile over particleboard underlayment. Thoroughly vacuum the underlayment surface prior to installation of any floor covering.

Carpeting

Carpets should be installed as recommended by the manufacturer. The use of particleboard underlayment requires no special techniques.

Laminate Flooring

Laminate flooring should be installed following manufacturer's recommendations.

Resilient Flooring

Resilient flooring, tile or sheet goods should be 1/8-inch or greater in thickness. Floor coverings thinner than 1/16-inch should not be used.

If fully adhered resilient sheet or tile flooring is installed, choose a premium quality, high solids (typically 55-65% solids) flooring adhesive recommended for use by the flooring manufacturer with wood underlayments. Before applying adhesive, make sure the underlayment surface is free of all foreign materials and is dry.

When applying floor coverings, the temperature of the room and materials should be above 70° for a minimum of 24 hours before, during, and after application. Use a notched trowel to spread the adhesive, and apply enough adhesive to afford at least 50% transfer to the flooring. Allow the maximum "open assembly" time within the adhesive manufacturer's recommendations but apply the floor covering before the adhesive loses tack.

Use a lining felt if recommended. The seams of sheet goods should be tight and no closer than 2 inches to a parallel underlayment joint.

Roll the fully adhered sheet flooring in both directions with a heavy roller to assure good contact. Keep traffic off newly installed resilient flooring until a bond has been firmly established. For other types of finished flooring, follow the manufacturer's recommendations for installation.

Seamless Floorings

Seamless floorings should be high quality products and must be installed as recommended by the manufacturer.

Seamless floors are applied as several coats of liquid coating materials. They are comparatively thin flooring surfaces and require the utmost care in the preparation of the flooring structure and the underlayment surface prior to coating with the seamless flooring material.

The glue-nailed technique of underlayment application is recommended for all seamless flooring applications. Extra care should be taken to carefully fill and sand underlayment faces, and to build up the recommended thickness of seamless floorings.

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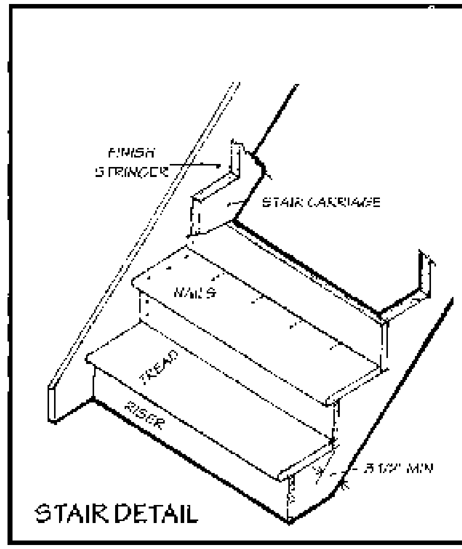
5.12.15 Particleboard as Stepping

Introduction

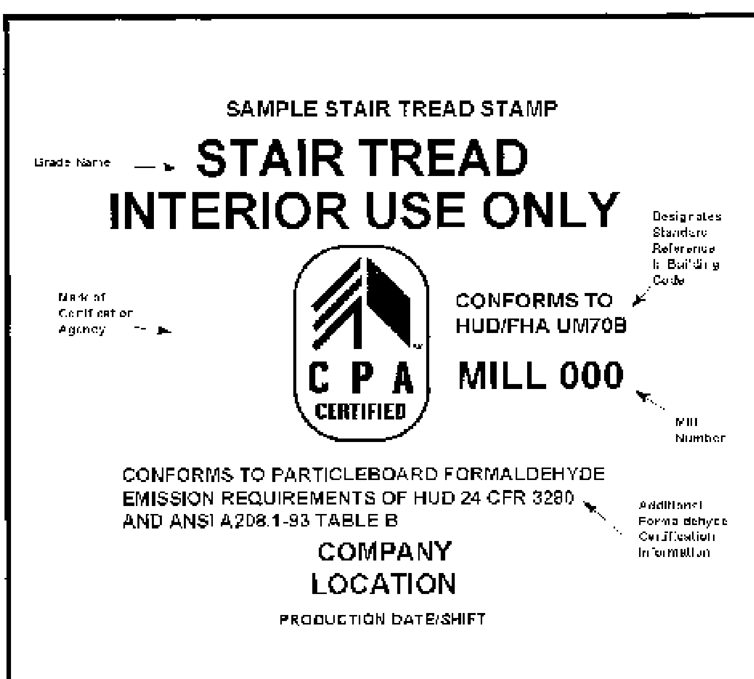
Particleboard has gained wide acceptance among builders as a stepping material when used in conformance with manufacturers' instructions. This bulletin reflects the general consensus among manufacturers about the recommended methods of installing particleboard stepping for interior stair treads. It includes references to the Use of Materials Bulletin 70B of the U.S. Department of Housing and Urban Development and the Federal Housing Administration.

FIGURE 1



Particleboard stepping should conform to the American National Standards Institute ANSI A208. 1-1993, Grade M-3, except that face screw holding capacity should be 225 lb minimum and edge screw holding capacity should be 200 lbs. minimum. Particleboard stepping has no knots or grain, comes with one edge bullnosed, and has been sanded to provide a smooth surface and close tolerances. It can be ordered in specific lengths from some manufacturers or cut on site from standard lengths.

FIGURE 3



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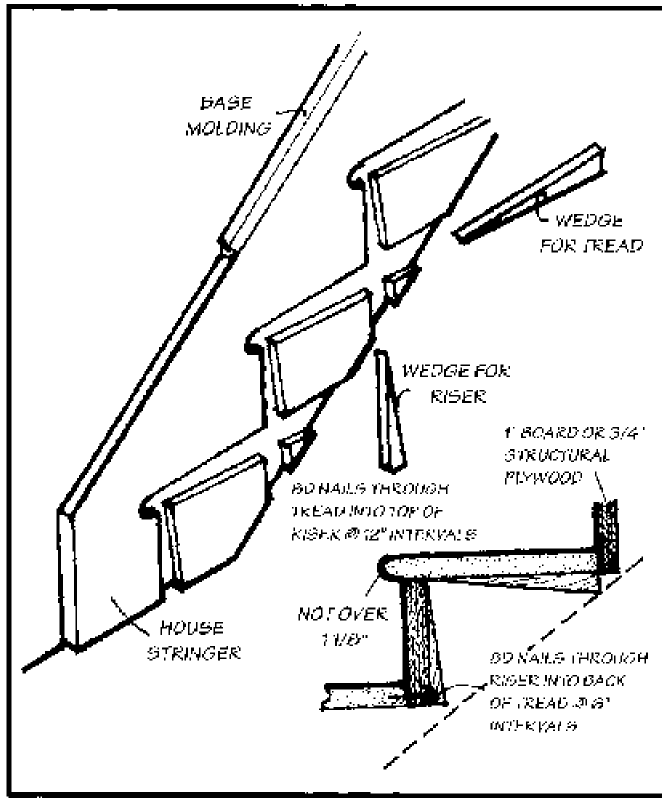
Medium Density Fiberboard (MDF) may also be used for stepping if the manufacturer has received a company specific "materials release" from HUD and the product is certified and grademarked by an independent inspection agency such as the Composite Panel Association.

Installation

Acclimate the stair treads to their surroundings for a minimum of 24 hours before installation of particleboard stepping. Particleboard stair treads can be installed using conventional framing and fastening practices. Structural adhesives should be used in combination with nailing. Each stair tread should be supported at both the front and back by a minimum 3/4" wood or structural grade plywood riser fastened with both nails and structural adhesives. Obtain back support by nailing through the back adjoining riser and into the center of the back edge of the particleboard tread.

FIGURE 2



Particleboard stepping should be covered with carpeting or resilient flooring. Stairs near entries subject to wet foot traffic should have the treads protected by a waterproof surface such as vinyl floor covering. When carpeting is used in these areas, the treads should be protected with a suitable moisture resistant coating before installation of the carpet.

Figure 1 is a cut-away view of an enclosed stairway. Figure 2 shows the detail of a staircase using housed stringers. Wedges are used for treads and risers, and nails go through risers into the back of treads at 6 inch intervals. When housed stringers are used, particleboard stair treads should not be routed out to form mortise and tenon joints with the risers. In each case, the front riser is set back 1 1/8" from the edge of the tread.

The HUD 70B UM Bulletin limits spans between stringers to 42 inches. It also requires that particleboard stepping be a minimum of 1 1/16" thick, with a 12 inch maximum width and one edge bullnosed. The builder can determine this by looking for the grademark which will note whether it conforms to HUD/FHA UM 70B.

Figure 3 shows the CPA grademark stamp. CPA is an approved independent testing and inspection agency whose program for testing and certification of particleboard interior stair treads has been accepted by HUD/FHA. Before the CPA grademark may be used, participating companies must comply with a rigid in-plant testing and quality control program. Compliance is verified by periodic unannounced inspections at the mill and by independent testing of samples.

The CPA stamp notes which mill made the stair tread and the standard to which it was manufactured.

Sawing stair treads generates fine dust, and tablesaws should be connected to a vacuum system. Individuals working with wood products on the job or in the home shop should wear at minimum the following safety equipment: a half mask respirator (filter) that is NIOSH approved and has a HEPA filter rating printed on the package, side shielded safety glasses, a long-sleeve shirt and gloves.

Continued

5.12.16 MDF Moldings and Millwork

MDF

Medium Density Fiberboard (MDF) is a composite panel product manufactured from wood fibers and synthetic resin binders bonded together under heat and pressure. The fibers and resin form a homogenous board with consistent properties in each direction.

MDF Mouldings and Millwork

MDF is an exceptional product for mouldings and millwork. The surface is flat, smooth, uniform and free of knots and grain. MDF is easily shaped into almost any form. High quality, clean, sharp contours and edges can be achieved in a wide range of profiles.

The homogeneous composition of MDF is compatible for high quality finishing techniques. MDF's uniform composition and smooth, tight surface, allows finishes to be applied directly to the surface. There are no finger joints so it is easy to create an even finish.

MDF mouldings and millwork are easy to work with at the job site. Mouldings are commonly available in lengths up to 16 feet (4.8 meters) and jambs are available in door height lengths.

MDF millwork is available as casing, crown, jambs, baseboard, chair rails and many other profiles.

Most MDF moulding comes preprimed. Factory prime coats permit the use of both water-base and solvent-base finish coat applications.

Before painting the surface should be cleaned to remove dust, dirt, finger prints and grease. Fill nail holes and any minor surface indentations before applying the top coat.

Top coats may be solvent based or water based. Acrylic and alkyd paints also work well. Use satin or semi-gloss finishes and follow the paint manufacturer's recommendations for temperature ranges at time of application. Use lacquer topcoats only with a coat of lacquer primer over the pre-primed moulding.

Avoid use of latex paints or lacquers at ambient temperatures of less than 55° F or relative humidity above 65%.

Also avoid the use of catalyzed lacquers and varnishes as they may not be compatible with the preprimed surface.

Moulding is generally delivered to the job site in cartons. MDF products must be stored inside and in a horizontal position.

Protect from Water

Protect the moulding from moisture during storage and construction. This would help avoid extra preparation or field sanding. In addition, water based primers used with MDF moulding are susceptible to "fiber raise" with any significant contact with water.

Allow MDF to Acclimate

Like solid wood, MDF changes dimensionally with changes in relative humidity. It is important to store MDF products on site for a minimum of 24 hours or longer in the heated environment in which they will be installed. This will help them become acclimatized to the moisture conditions at that location. To speed the process the cartons may be opened and the moulding removed and stickered.

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Most MDF moulding and millwork comes pre-primed. Veneer wrapped or prefinished MDF products are available when stain finishes are needed. MDF mouldings are intended for interior use only, unless otherwise recommended by the manufacturer.

Wrapped and Prefinished Mouldings

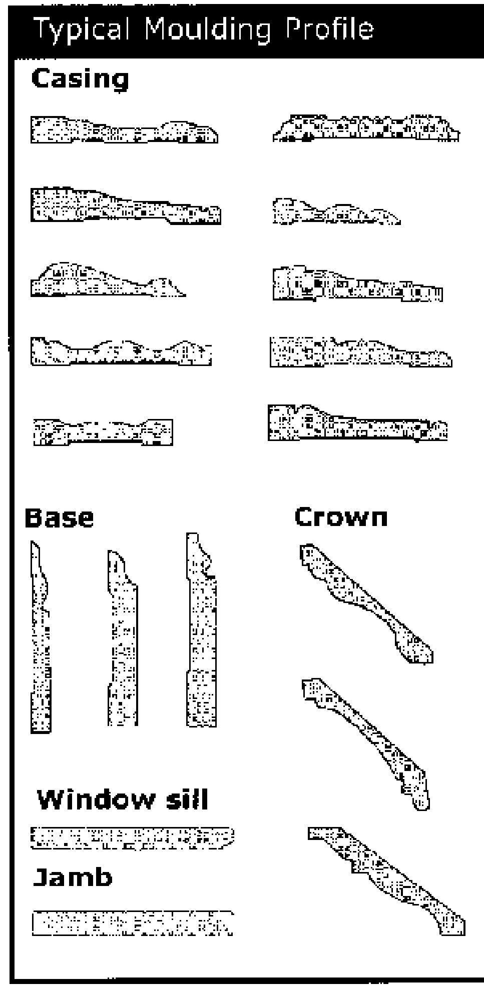
MDF mouldings are available with veneer, paper or other overlays. Special machines wrap the veneer or overlay over the profile. Grain printed and prefinished MDF mouldings are also available. Each provides the same ease of installation as standard MDF mouldings.

Moisture Resistance

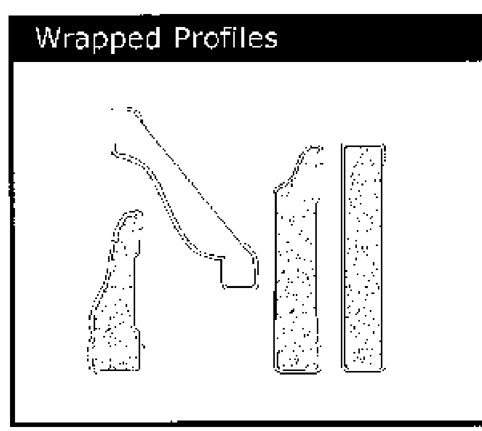
MDF mouldings with properties that enhance moisture resistance should be considered for use in bathrooms and for baseboards where the construction is slab-on-grade. While the most common adhesive for MDF is urea-formaldehyde, other adhesives or additives may be used to provide special properties such as reduced thickness swell or enhanced bond durability.

Exterior Use MDF

MDF can also be manufactured with special adhesives suitable for exterior applications. Uses include brick moulding, mouldings around doors and windows, exterior window sills, column facings, gable vents and louvers, soffit trim and other exterior trim.



Typical Moulding Profile


Wrapped Profiles

Continued

5.12.17 Saw/Cutting, Installing MDF Moldings, and Millwork

Sawing/Cutting

MDF is easily cut and installed at the job site using standard woodworking tools. These include a hand saw, miter box or small table saw, hammer or nail gun, nail set and tape measure.

When sawing MDF with power tools, use a carbide tipped combination blade for best results and keep the blades sharp.

Sawing MDF generates fine dust, so it is best to connect table saws to a vacuum system. For site use a shop vacuum can be connected to small table saws with a sheet metal sleeve. When working with wood products, including MDF, on the job or in the home shop, wear at minimum the following safety equipment: a half-mask respirator (filter) that is NIOSH approved and has a HEPA filter rating printed on the package, side-shielded safety glasses and a long-sleeve shirt and gloves.

Installing Doors and Millwork

Prehung door units are generally installed first. Before installation assure that all openings are plumb and square. Check to be sure the floor is level. If not, shim one side of the prehung unit.

Next install the door casing and then the base. Crown mouldings, window sills and casing may then be installed along with other trim.

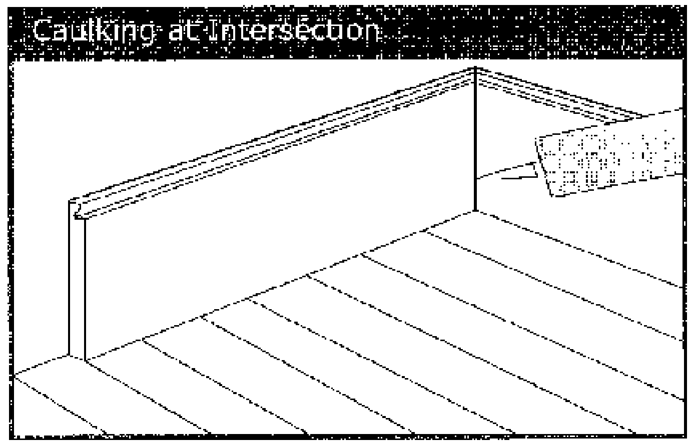
Joints

A long wall will generally require a joint in the moulding. The least noticeable way to join two pieces is with a 45 degree angle cut made with the miter box or power saw.

For inside corners, a coped joint will provide a smoother and more precise fit. A coped joint also can help hide wood movement due to humidity changes. For additional tips, consult a carpentry reference book.

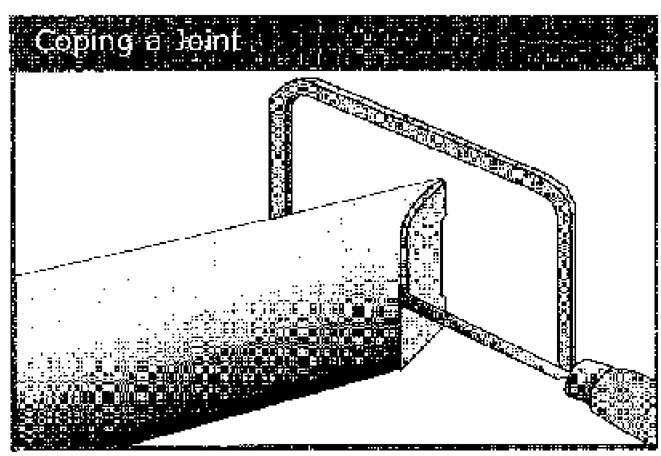
Fasten to Framing

Base and crown mouldings should be fastened at each framing member 16" or 24" on center. Do not cut the lengths to fit too tightly. Instead leave some room for caulking and minor expansion.



Floor Transitions

Differences in the height of flooring materials commonly requires accommodation during baseboard installation. For example, carpeted floors will be higher than hardwood floors or tile. Measure the height of the baseboard from the lower surface and trim back the baseboard height in the adjacent rooms to match the lower floor level. When practical, this problem can be avoided by installing moulding before carpet.



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5.13.0 Glulams

A glued laminated timber (glulam) is a stress-rated engineered wood product consisting of laminations of wood bonded together with an adhesive. The typical glulam is constructed of individual pieces of lumber generally having a nominal thickness of two inches (5.08 cm) or less. Individual pieces of lumber are end joined together to create long lengths referred to as laminations; the grain of all laminations run parallel with the length of the member. Glulams are available in a variety of stock sizes and can be ordered in custom lengths, widths, and depths. Glulams are available in four *appearance* groups—framing, industrial, architectural, and premium.

5.13.1 Camber in Glulam Beams

Camber

Glulam is the only glued engineered wood product that can be easily cambered to assure that the beam will not sag or be subject to structural problems caused by excessive deflection under gravity loads. Camber for glulam beams is specified as either "inches of camber" or as a radius of curvature that is to be used in the manufacturing process as shown in Figure 3.

Roof beams should be cambered for 1.5 times the calculated dead load deflection. For floor beams, the camber recommended is 1.0 times the calculated dead load deflection.

Since excessive camber can result in framing difficulties for residential applications, *APA EWS* trademarked stock beams are typically supplied with either a zero camber or a camber radius of 3500 ft.

Some stocking dealers also inventory glulam beams in what are commonly referred to as I-joist compatible (IJC) depths of 9-1/2, 11-7/8, 14 and 16 inches. With these depths, the I joists can be flush framed with the glulam beams in applications such as concealed floors.

Available sizes should be verified with local dealers and suppliers.

Table 3 provides approximate weights of Western species glulam beams in pounds per lineal foot.

FIGURE 3

BEAM CAMBER PARAMETERS

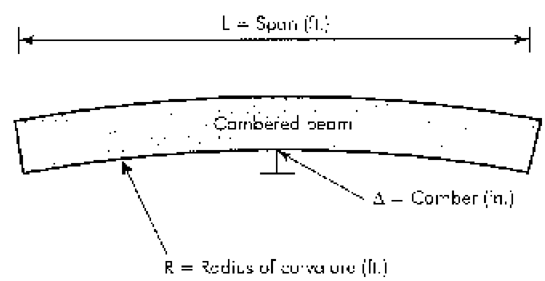


TABLE 2

STANDARD GLULAM BEAM WIDTHS (IN INCHES)

Nominal Width	3	4	6	8	10
Net width (Western species)	2-1/2	3-1/8(2)	5-1/8(2)	6-3/4	8-3/4
Net width (Southern pine)	2-1/2	3(1, 2)	5(1, 2)	6-3/4	8-1/2

(1) May also be available in 3-1/8 and 5-1/8 inches.

(2) May also be available in 3-1/2 and 5-1/2 inches framing classification for concealed applications

(By permission from APA—The Engineered Wood Association, Tacoma, Washington.)

5.13.2 Glulam Sizes and Weights

TABLE 3

GLULAM BEAM WEIGHTS (lbf/ft) (Western species)

	Width (in.)			
Depth (in.)	**3-1/8**	**5-1/8**	**6-3/4**	**8-3/4**
6	4.6	7.5	9.8	12.8
7-1/2	5.7	9.3	12.3	16.0
9	6.8	11.2	14.8	19.1
10-1/2	8.0	13.1	17.2	22.3
12	9.1	14.9	19.7	25.5
13-1/2	10.3	16.8	22.1	28.7
15	11.4	18.7	24.6	31.9
16-1/2	12.5	20.6	27.1	35.1
18	13.7	22.4	29.5	38.3
19-1/2	14.8	24.3	32.0	41.5
21	16.0	26.2	34.5	44.7
22-1/2	17.1	28.0	36.9	47.9
24	18.2	29.9	39.4	51.0
25-1/2	19.4	31.8	41.5	54.2
27	20.5	33.6	44.3	57.4
28-1/2	21.6	35.5	46.8	60.6
30	22.8	37.4	49.2	63.8
31-1/2	23.9	39.2	51.7	67.0
33	25.1	41.1	54.1	70.2
34-1/2	26.2	43.0	56.6	73.4
36	27.3	44.8	59.1	76.6
37-1/2	28.5	46.7	61.5	79.8
39	29.6	48.6	64.0	82.9
40-1/2	30.8	50.4	66.4	86.1
42	31.9	52.3	68.9	89.3

Notes:

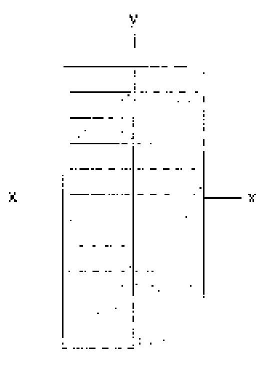
(1) Beam weight is based on 35 lbf/ft³.

(2) To figure total beam weight, multiply the tabulated weight per lineal foot by beam length. For example, the weight of a glued laminated beam 5-1/8" x 12" x 35' would be 14.9 lbf/ft x 35 ft = 521.5 lbf.

(3) As a "rule of thumb," approximate beam weight can be determined as follows. Beam weight (lbf/ft) = width (in.) x depth (in.) / 4
For example, the weight of a glued laminated beam 5-1/8" x 12" would be 5.125 x 12 / 4 = 15.4 lbf/ft.

FIGURE 2

BEAM CROSS SECTION



Beam Sizes

Glulam is available in a wide range of sizes to meet the requirements of typical construction applications. Stock widths for beams manufactured using Western species are 3-1/8, 3-1/2, 5-1/8, 5-1/2 and 6-3/4 inches and typically range from 6 inches to 27 inches in depth in multiples of 1-1/2 inches. Some distributors stock 8-3/4-inch beams. Southern pine glulam is typically supplied in depth multiples of 1-3/8 inches with widths of 3, 3-1/2, 5, 5-1/2, and 6-3/4 inches. Most Southern pine glulam manufacturers also supply stock beams in widths of 3-1/8 and 5-1/8 inches. Beams are cut to length when ordered. Custom beams are available in virtually any size and are generally required where long spans, unusually heavy loads or other special circumstances control design. Standard glulam widths are tabulated in Table 2.

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5.13.3 Equivalent Douglas Fir Glulam Sections as Substitutes for Sawn Lumber

EQUIVALENT DOUGLAS FIR GLULAM SECTIONS AS SUBSTITUTES FOR DOUGLAS-FIR SAWN LUMBER

Sawn Section (Nominal)	Equivalent Glulam Sections: Floor Beams (100%) No. 1	Roof Beams (115%) No. 1	Roof Beams (125%) No. 1
3 x 10	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9
3 x 12	3-1/8 x 10-1/2	3-1/8 x 9	3-1/8 x 10-1/2
3 x 14	3-1/8 x 12	3-1/8 x 10-1/2	3-1/8 x 10-1/2
4 x 10	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2
4 x 12	3-1/8 x 12	3-1/8 x 10-1/2	3-1/8 x 10-1/2
4 x 14	3-1/8 x 13-1/2	3-1/8 x 12	3-1/8 x 12
6 x 10	5-1/8 x 10-1/2	5-1/8 x 10-1/2	5-1/8 x 10-1/2
6 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12
6 x 14	5-1/8 x 13-1/2	5-1/8 x 13-1/2	5-1/8 x 13-1/2
6 x 16	5-1/8 x 15	5-1/8 x 13-1/2	5-1/8 x 15
2 – 2 x 8	3-1/8 x 7-1/2	3-1/8 x 7-1/2	3-1/8 x 7-1/2
2 – 2 x 10	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9
2 – 2 x 12	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2
2 – 2 x 14	3-1/8 x 12	3-1/8 x 10-1/2	3-1/8 x 10-1/2
3 – 2 x 8	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9
3 – 2 x 10	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2
3 – 2 x 12	3-1/8 x 13-1/2	3-1/8 x 12	3-1/8 x 12
3 – 2 x 14	3-1/8 x 13-1/2	3-1/8 x 13-1/2	3-1/8 x 13-1/2

Notes:

(1) Span = uniformly loaded simply supported beam with a span ranging from 6 ft up to 20 ft

(2) For roof beams, maximum deflection = L/180 under total load. Deflection under live load must be verified when live load/total load > 3/4.

(3) For floor beams, maximum deflection = L/360 under live load, based on live load/total load = 0.8. Where additional stiffness is desired or for other live load/total load ratios, design for deflection must be modified per requirements.

(4) Service condition = dry.

(5) Beam weights for solid-sawn and glulam members are assumed to be the same.

(6) Design properties at normal load duration and dry-use service conditions – No. 1: $F_b = C_F \times 1{,}000$ psi, $F_v = 95$ psi, $E = 1.7 \times 10^6$ psi, where C_F = size factor per 1991 NDS. Glulam: $F_{bx} = C_v \times 2{,}400$ psi, $F_v = 190$ psi, $E_x = 1.8 \times 10^6$ psi, where C_v = volume factor per 1991 NDS. Repetitive member factor is assumed to be 1.15 for the 3-member built-up lumber beams and 1.0 for 2-member built-up lumber beams and glulam beams.

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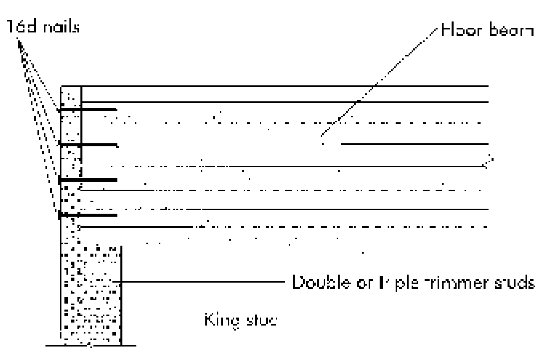
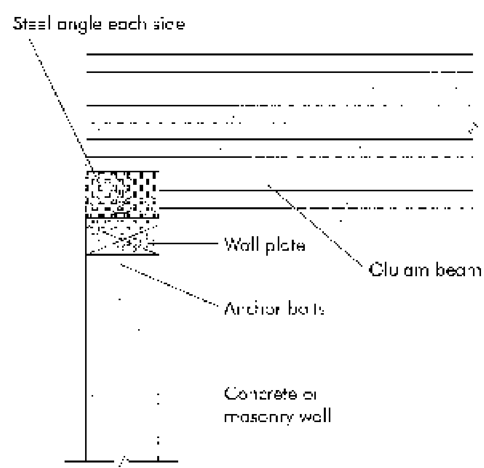
5.13.4 Glulam Beam Bearings—End Wall, Masonry Wall

BEAM AT END WALL BEARING



BEAM BEARING AT MASONRY WALL



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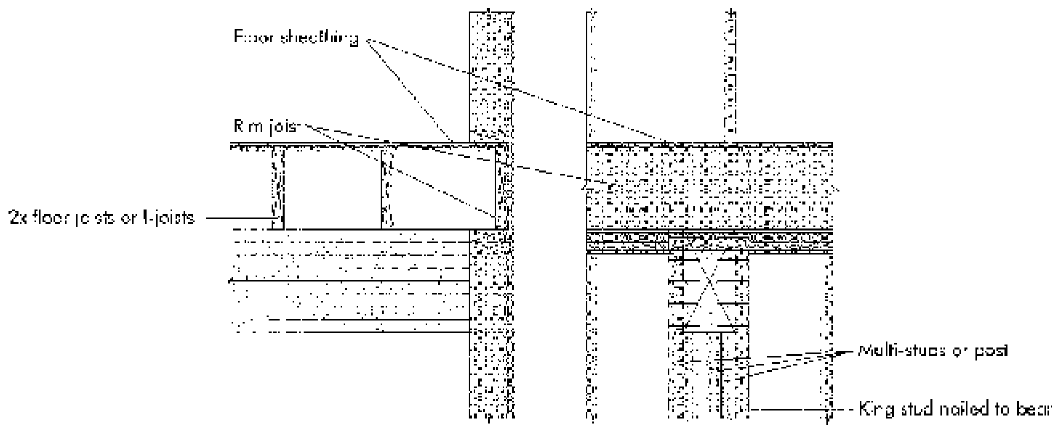
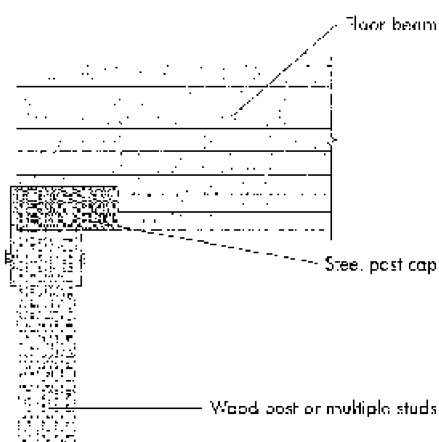
5.13.5 Glulam Bearings at End Walls with Steel Tie and Cap Plates

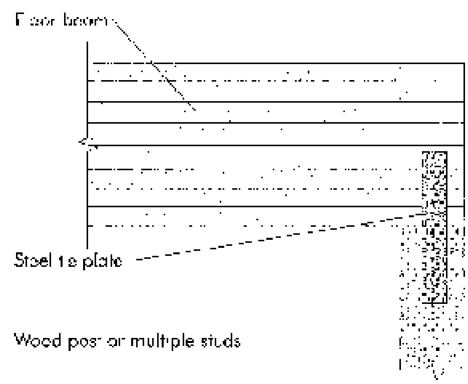
BEAM SUPPORT AT END WALL WITH FLOOR JOIST OVER BEAM



BEAM BEARING AT END WALL



BEAM BEARING AT END WALL



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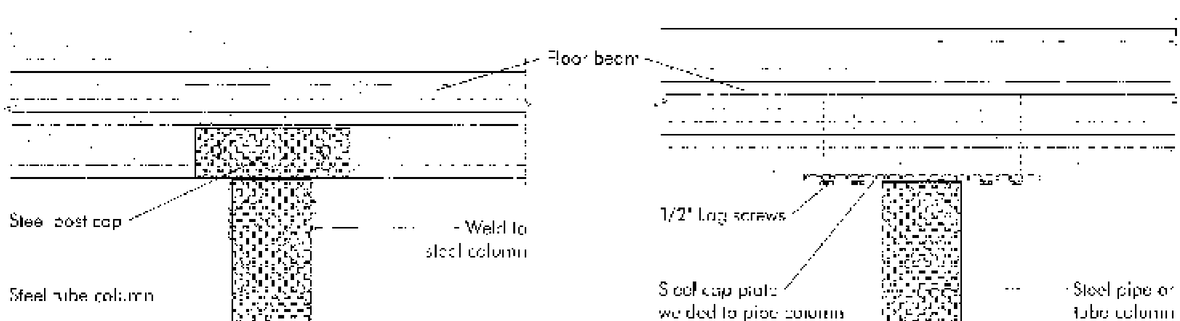
5.13.6 Continuous Glulam Beam Over Intermediate Steel Column

CONTINUOUS BEAM OVER INTERMEDIATE STEEL COLUMN



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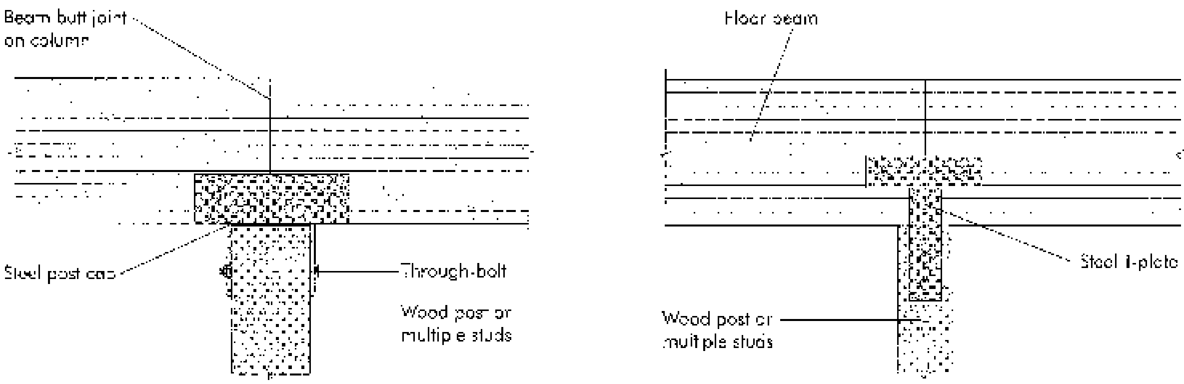
5.13.7 Glulam Beams Butting Over Intermediate Wood Supports

BEAMS BUTTING OVER INTERMEDIATE WOOD SUPPORT

BEAMS BUTTING OVER INTERMEDIATE WOOD SUPPORT



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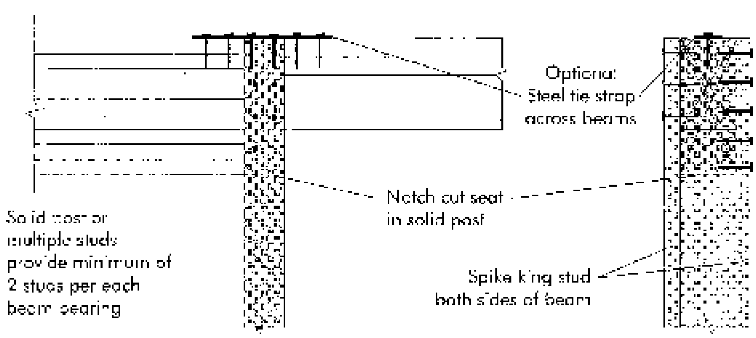
5.13.8 Beam Size Changes Over Intermediate Supports

BEAM SIZE CHANGE OVER INTERMEDIATE SUPPORT



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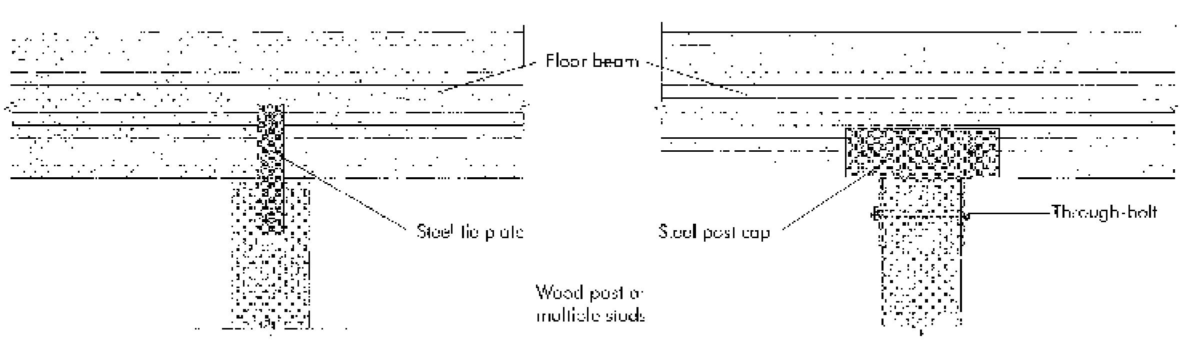
5.13.9 Glulam Continuous Floor Beam Over Intermediate Wood Supports

CONTINUOUS FLOOR BEAM OVER INTERMEDIATE WOOD SUPPORTS



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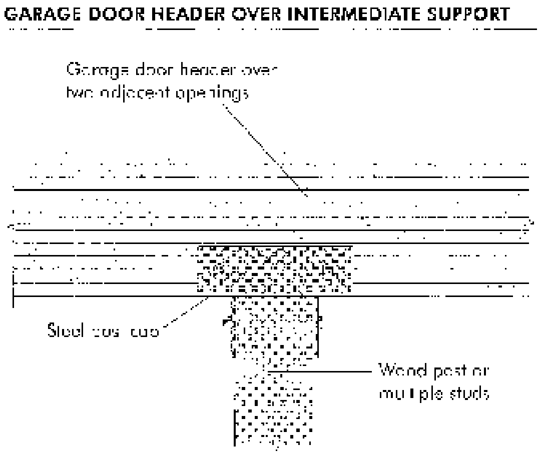
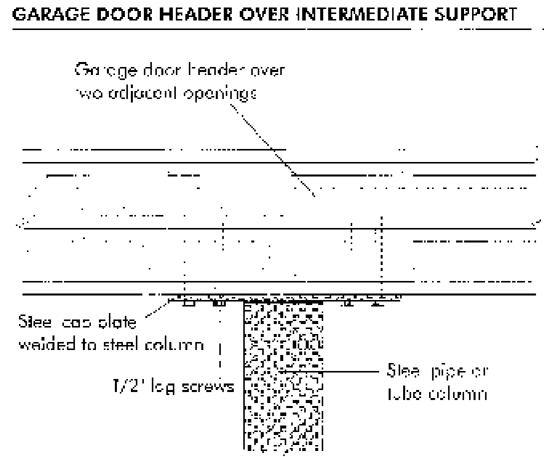
5.13.10 Glulams as Garage Door Headers





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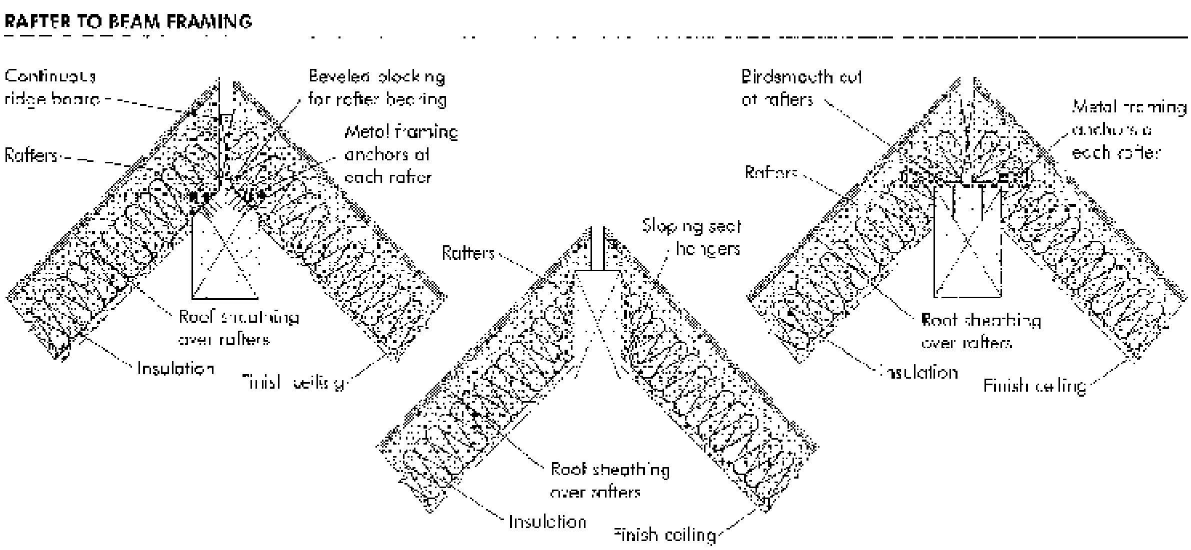
5.13.11 Rafter to Beam Framing



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5.13.12 I-Joist Series—Size, Depth, Flange Width

DIMENSIONS FOR APA PERFORMANCE RATED I-JOISTS

APA PRI Joist Series	Joist Designation	Nominal Depth	Net Depth	Flange Width
I x 10	C4 (PRI-15)	10"	9-1/2"	1-1/2"
I x 10	C6 (PRI-25)	10"	9-1/2"	1-3/4"
I x 12	C10 (PRI-15)	12	11-7/8"	1-1/2"
I x 12	C12 (PRI-25)	12	11-7/8"	1-3/4"
I x 14	C14 (PRI-25)	14	14"	1-3/4"
I x 14	C16 (PRI-35)	14	14"	2-5/16"
I x 16	C18 (PRI-25)	16	16"	1-3/4"
I x 16	C20 (PRI-35)	16	16"	2-5/16"
I x 10	S2 (PRI-30)	10"	9-1/2"	2-1/2"
I x 10	S4 (PRI-32)	10"	9-1/2"	2-1/2"
I x 12	S6 (PRI-30)	12"	11-7/8"	2-1/2"
I x 12	S8 (PRI-32)	12"	11-7/8"	2-1/2"
I x 12	S10 (PRI-42)	12"	11-7/8"	3-1/2"
I x 14	S12 (PRI-32)	14"	14"	2-1/2"
I x 14	S14 (PRI-42)	14"	14"	3-1/2"
I x 16	S16 (PRI-32)	16"	16"	2-1/2"
I x 16	S18 (PRI-42)	16"	16"	3-1/2"

Notes:
1. Tolerances permitted at time of manufacture:
   - flange width = +/- 1/32 inch
   - I-joist depth = + 0 inches, – 1/8 inch

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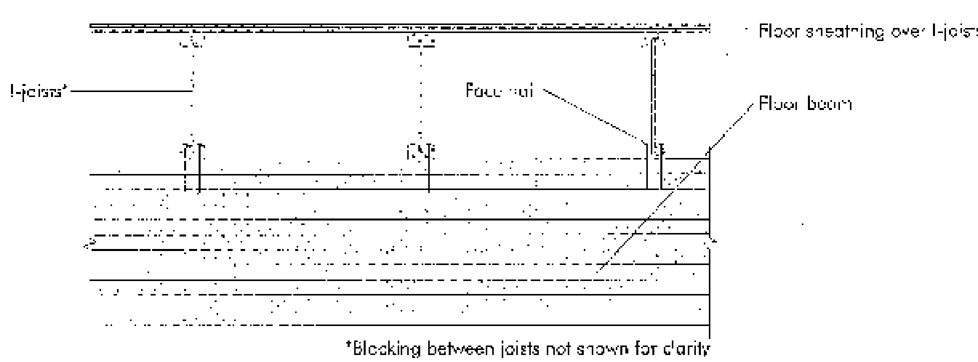
5.13.13 I-Joists Bearing on Floor Beams

I-JOISTS BEARING ON FLOOR BEAM



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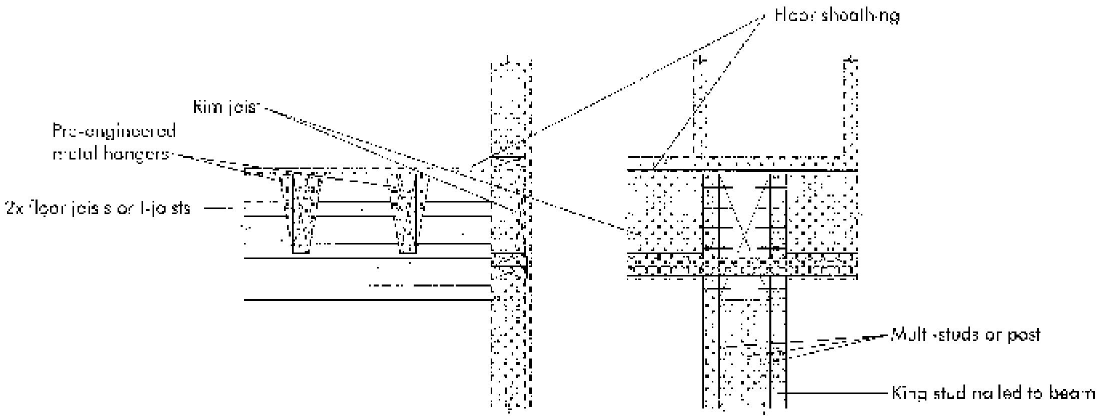
5.13.14 Beam Support at End Wall with Floor I-Joists

BEAM SUPPORT AT END WALL WITH FLOOR JOISTS FLUSH WITH BEAM



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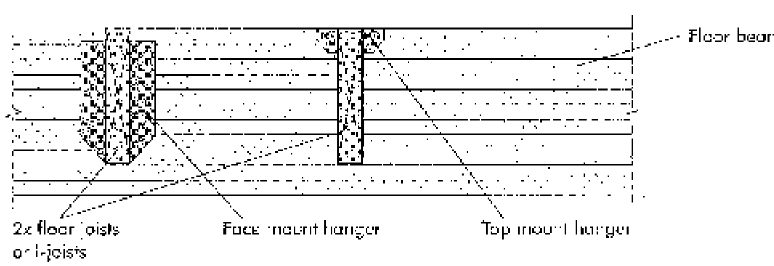
5.13.15 I-Joists Mounted Flush with Floor Beam

JOISTS MOUNTED FLUSH WITH FLOOR BEAM



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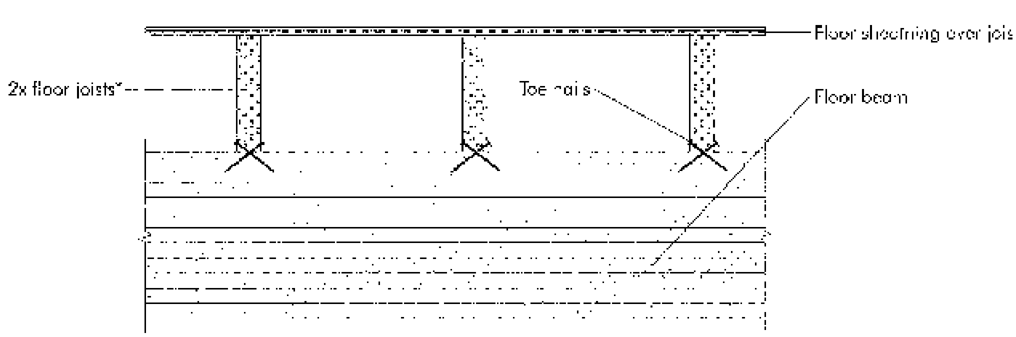
5.13.16 Lumber Joists Bearing on Floor Beam

LUMBER JOISTS BEARING ON FLOOR BEAM



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5.14.0 High-Pressure Laminate (HPL) Q&A

Q. What is HPL?

A. High pressure laminate is a thermoset paper/plastic composite, where decorative papers impregnated with melamine are consolidated over phenolic impregnated kraft papers at high temperature and pressure to form a homogeneous laminate.

Q. What is the difference between horizontal, vertical, and postforming grades of HPL?

A. Horizontal grade 10/HGS is thicker, .050," and not intended to be postformed to a tight radius. Horizontal surfaces include countertops, vanity tops, store fixtures, window sills, desks, table tops, convector covers, furniture and casework.
Vertical grade 55/VGS is thinner, .030," and does not have the impact resistance of a horizontal grade. Vertical surfaces include wall panels, elevator cabs, toilet compartments, etc.
Postforming is available in both horizontal grade 12/HGP, .042," and vertical grade 20/VGP, .030." Postforming is designed for tight inside and outside bends.

Q. What do the letters following the grade number mean?

A. Formica Corporation being a worldwide manufacturer utilizes the International Organization for Standardization (ISO) nomenclature. Examples are:

Grade 10/HGS ....Horizontal, General Purpose, Standard
Grade 12/HGP ....Horizontal, General Purpose, Postformable
Grade 20/VGP ....Vertical, General Purpose, Postformable
Grade 55/VGS ....Vertical, General Purpose, Standard
Grade 50/HGF ....Horizontal, General Purpose, Fire Rated
Grade 32/VGF ....Vertical, General Purpose, Fire Rated
Grade 72/CLS ....Cabinet Liner, Standard

Q. What causes expansion and contraction of laminates after fabrication? How can this be prevented?

A. High pressure laminate is a wood, paper product and like all wood products moves with changes in humidity. Laminates expand in high humidity and contract in low humidity. Laminate and core should be conditioned at 45% to 50% R.H. at least 48 hours prior to laminating. Pick a substrate that moves at the same dimensional change rate as HPL such as medium density fiberboard (MDF) or 45# industrial grade particleboard.

Q. What causes stress cracking? How can it be eliminated?

A. Excessive dimensional movement of the laminate can cause stress, especially on inside corners, which is relieved by the cracking. To eliminate cracking: acclimate the laminate and core, minimize cross directional dimensions, use the thickest laminate possible for the application, use the strongest adhesive possible for the application, and rout inside corners (⅛" minimum).

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5.14.0 High-Pressure Laminate (HPL) Q&A—Continued

Q. What causes laminated panels to warp?

A. Panel warpage is caused by a difference of movement between the laminate and the substrate. To minimize warpage, acclimate the laminate and core prior to bonding. Panels that require flatness should be balanced by bonding the same grade of laminate to both sides.

Q. Can HPL be used for exterior applications?

A. No.

Q. Can surface scratches be repaired?

A. No. Melamine is one of the hardest plastics known, but it can be scratched. Like glass, melamine scratches white, thus scratches are more apparent on dark solid colors. Because the finish is pressed into the laminate, it is impossible to repair. Superficial scratches can be hidden with the use of furniture polish.

Q. Do laminates fade?

A. Laminates will fade if exposed to direct sunlight. Bright chromatics fade easier than earthtones. All FORMICA brand laminate colors surpass industry fade requirements.

Q. Can you resurface laminate over laminate?

A. Yes, self edge or flat surfaces can be resurfaced. Follow the recommended procedures in our Fabrication Data Sheet titled "Resurfacing Laminated Assemblies With FORMICA brand products."

Q. Can laminates be painted?

A. Yes. However, the laminate surface has trace amounts of release agent which prevents paint adhesion. Lightly sanding the surface removes this agent and provides tooth for the paint. Epoxy paint adheres the best. Painted surfaces do not have the durability of laminate.

Q. What adhesives should be used to bond laminates?

A. FORMICA brand contact adhesives are available in brush, spray, flammable, and non-flammable formulations. Resorcinols, ureas, and PVAc (white glue) type adhesives yield stronger bonds.

Q. How should laminate be cleaned?

A. There is a thin layer of melamine resin on the surface of HPL, which is very hard and stain resistant, but there are many modern household reagents that will attack it. Do not use acids, alkalies, bleaches, or abrasive cleansers on laminate. Surfaces should be cleaned with a clean, soft cotton cloth and mild detergent such as Pine-Sol.

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PINE SOL is a registered trademark of American Cyanamid Company.

5.14.1 HPL Tips for Avoiding Panel Warpage

Causes of Panel Warpage

Laminate clad panels are susceptible to warpage if they are not physically restrained or balanced. Balanced panel construction equalizes the forces acting on both sides of the core material. If for any reason, these forces become unbalanced, warpage can result.

Warpage of wood product panel assemblies (e.g., laminate clad particleboard or MDF) is attributed to the differences in dimensional movement between the face and back laminates and the core or substrate material. This movement and its subsequent stresses are caused by the expansion or contraction of paper fibers in the laminate skins and wood fibers in wood composite cores as they respond to relative humidity changes. The stress and dimensional movement, generated within a laminate skin, is transmitted to the core through its glue line. The forces involved are tremendous and, if they are not properly considered in the panel design, warpage can result.

The use of laminates and substrates that have different strengths and/or dimensional movement potentials is not the only cause of warpage. Exposing one side of a panel assembly to different humidity conditions than the other side can also cause warpage. For example, a "balanced" panel will warp if one side is exposed to air conditioning and the other is against a damp, below grade wall (e.g., basement wall without a proper moisture barrier).

Tips for Avoiding Panel Warpage

1) All panel components should be acclimated to the same environment prior to assembly. This will ensure that one component will not be contracting while the other is expanding due to subsequent relative humidity changes. In addition, under extreme conditions, materials that have not been properly acclimated to the same condition prior to fabrication, can buckle or delaminate as well as warp. Proper preconditioning of materials can also help to minimize shrink-back or laminate growth problems on machined edges.

2) For critical applications requiring a well balanced assembly (doors, etc.), the same laminate or skin should be applied on both sides. Less critical applications may only require a cabinet liner or phenolic backer. Small components and mechanically restrained panels (countertops, etc.), on the other hand, may not need balancing sheets.

3) Thick panels warp less than thin panels due to increased rigidity and the geometry of the forces involved. For critical applications the thickest core material permissible should be selected to help minimize warpage.

4) Laminates expand and contract twice as much in their cross-grain direction as they do in their grain (parallel with the sanding lines) direction. Always align the sanding lines of the front and back laminates in the same direction and, wherever possible, align the grain direction of the laminate with the longest panel dimension. It is also advisable to align the grain and cross-grain directions of the laminates with that of the substrate.

Note: When multiple panels are viewed together, keep all laminate components aligned in the same direction to minimize visual changes in color or gloss due to the directionality of the underlying surface paper and laminate finish.

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5.14.2 HPL Stress Crack Avoidance

Causes of stress cracking

Stress cracking of high-pressure laminate is caused by the concentration or build-up of stresses in a particular area of a laminated assembly. When this stress becomes greater than that which the laminate can withstand, a stress crack will occur. If such stresses are allowed to concentrate around a cut-out or other such fabrication detail, one or more cracks can characteristically radiate from the sharper corners of the cut-out, where, for mechanical reasons, the laminate is weakest.

These stresses can be caused by external mechanical forces but are generally caused by the normal dimensional movements of the laminated assembly as it reacts to the surrounding environment. As with all wood-based products, high-pressure laminates and their substrates react to humidity changes. Under moist conditions laminated assemblies gain moisture and expand dimensionally. When this same assembly is subjected to dry conditions, however, this moisture is lost and shrinkage results. If the laminate shrinks more than the substrate, stress cracking of the laminate surface can occur in certain areas.

Techniques for controlling stress cracking

The occurrence of stress cracking can be greatly minimized by using fabrication techniques and practices which recognize and moderate the dimensional movement and associated stresses that can develop within a laminated assembly. These techniques and practices consist of: preconditioning, proper substrate selection, obtaining a good bond, proper inside corner fabrication, proper seam placement and good installation practices.

Preconditioning

Prior to the fabrication, allow the laminate and substrate to acclimate for at least 48 hours to the same ambient conditions. Optimum conditions are approximately 75°F and a relative humidity of 45 to 55%. Provision should be made for the circulation of air around the components.

Substrate selection

FORMICA brand laminate and COLORCORE brand surfacing material should be bonded to either a MDF (Medium Density Fiberboard) or a 45 lb. density industrial grade particleboard (CS 236-66: Type 1, Grade B, Class 2). The dimensional change properties of these substrates, being similar to that of high-pressure laminate, greatly reduces the potential for stress cracking when the assembly is subjected to low humidity conditions.

Plywood substrates should be avoided, whenever possible, for use with FORMICA brand laminate and should never be used as a substrate for COLORCORE brand surfacing materials. Because of its cross ply construction, plywood expands and shrinks less than either of these laminate grades. This results in greater stress built up within the laminate and thereby increases the chance of stress cracking.

Adhesive bond

The quality and nature of the bond between the laminate and the substrate is also an important factor to consider when trying to minimize stress cracking. Basically, the stronger and more rigid the bond, the less are the chances for stress cracking.

Contact adhesives, by their nature, are elastomeric and therefore transfer less of the stress to the substrate. Assemblies made with contact adhesives, therefore, are less crack resistant than those fabricated with rigid or semi-rigid adhesives. If contact adhesives are used they should be properly applied and fused to obtain the strongest possible bond.

Rigid and semi-rigid adhesives such as resorcinal, ureas and PVAc (white glues) transfer stresses directly to the substrate. Assemblies fabricated with these adhesives are more crack resistant.

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5.14.2 HPL Stress Crack Avoidance—Continued

The stress crack performance of assemblies using contact adhesive can be greatly improved if a PVAc (white glue) is used at all inside corners as illustrated below. Note: If the assembly is to be water resistant, a catalyzed PVAc glue should be used.

A. The cutout area of the laminate and substrate assembly is masked prior to applying the contact adhesive.
B. Once the contact adhesive has been applied and dried, the masking is removed and a PVAc glue is applied.
C. The laminate and substrate are then joined and nip rolled together to fuse the contact adhesive. The masked off area is then clamped until the adhesive sets. This usually takes about one hour.

(See attached figures)

Figure A

Figure B

Figure C

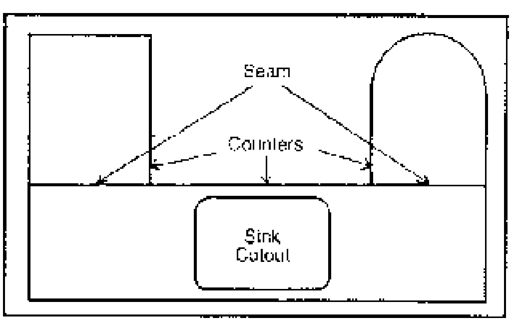
Inside corner fabrication

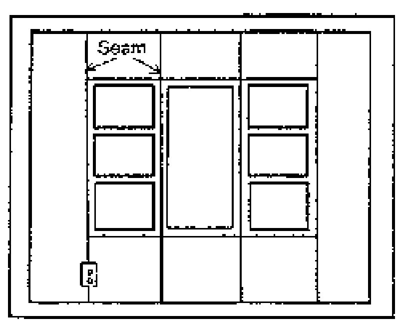
The inside corners of all cutouts must be radiused as large as possible (⅛" minimum) to minimize stress cracking. A radiused corner created by a ¼" diameter router bit is normally used. All edges and inside corners should be filed smooth and free of any chips or nicks.

Seam placement

Another effective means of minimizing the chances of stress cracking is to plan the placement of seams to reduce the number of inside corners. Examples of proper seam positions are shown in the following illustrations.

(See attached illustration)





Installation

Install the laminated assembly with sufficient clearance at pipes, electrical boxes, panel edges, etc., to allow for normal dimensional movement. Sinks, louvers, drop in ranges, etc., should fit easily into openings without binding. Do not install a panel or laminated assembly by force fitting. Panels should be installed in a flat plane by shimming, as necessary, to avoid mechanical stresses caused by bending or twisting.

Summary

1. Precondition laminate and substrate for a minimum of 48 hours prior to fabrication. Optimum conditions are approximately 75°F and 45 to 55% relative humidity.
2. Select the proper substrate...MDF or 45 lb density particleboard. Plywood should not be used with COLOR-CORE brand surfacing material.
3. Obtain a good bond. Assemblies bonded with rigid or semi-rigid adhesives are more crack resistant than those assembled with contact adhesives.
4. Radius inside corners as large as possible, ⅛" minimum.
5. Plan the placement of seams to minimize inside corners.
6. Provide sufficient clearance at sinks, electrical boxes, range cutouts, etc., to allow for dimensional movement. Do not force fit. Do not induce mechanical stresses.

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5.14.3 HPL Post-Forming Countertops

CONDITIONS AFFECTING POSTFORMING
Successful postforming is easily accomplished by using various techniques which recognize and moderate the common variables associated with postforming. These techniques incorporate: preconditioning, temperature control, elimination of drafts and proper equipment adjustment and maintenance.

PRECONDITIONING
Postforming grade laminate is slightly hygroscopic; that is, it is capable of losing or absorbing moisture from the atmosphere. Therefore, if it is exposed to dry air conditions, a loss of moisture can result that adversely affects its postforming properties. To assure proper postforming performance, FORMICA brand postforming grade laminate should be preconditioned prior to use for at least 48 hours at 70°F and 50% relative humidity. Small shop areas can be economically humidified with portable humidifier units. Larger areas may require specific recommendations from a HVAC equipment supplier.

Remember, when seasonal changes approach, preconditioning practices should be observed to maintain consistent postforming conditions inside the shop, regardless of the atmospheric conditions outside. This is especially important during the winter months when dry air conditions often exist.

TEMPERATURE CONTROL
The optimum postforming temperature for FORMICA brand laminate is at or near 325°F. Lower temperatures may cause cracking while higher temperatures may cause gloss changes, blistering and/or cracking. If either occurs, alter the surface temperature accordingly. On most equipment this can be accomplished by adjusting the power input to the heater, the heater height or the line speed.

To determine the surface temperature of laminated plastic there are two primary techniques which can facilitate equipment set-up.

One relatively simple technique involves the use of temperature indicators such as TEMPILAQ Temperature Indicating Liquid or TEMPILSTIK Temperature Indicating Crayons to facilitate equipment set-up. These are available from the Tempil Division of Big Three Industries, Inc., 2901 Hamilton Blvd., South Plainfield, NJ 07080 (phone: 201-757-8300).

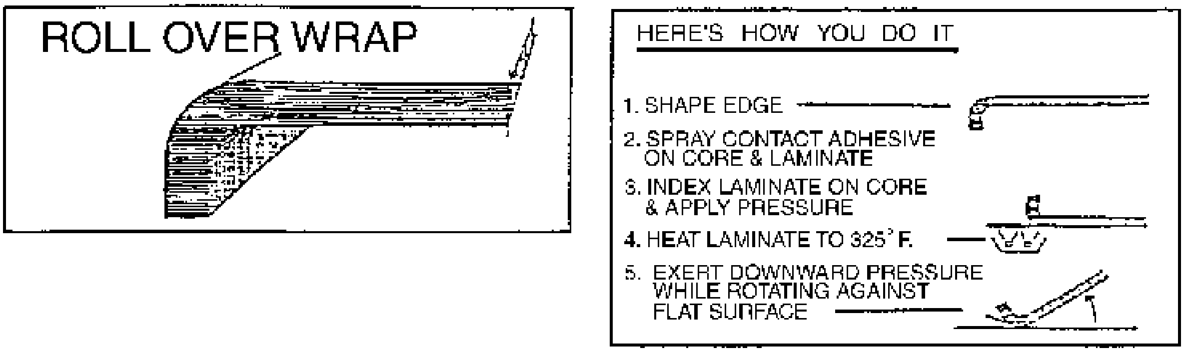
Another effective method of monitoring and measuring the laminate surface temperature is to use a noncontact infrared thermometer. One unit that we have found to be particularly useful is a Model D500-RS remote sensor Microscanner from Exergen Corp., 1 Bridge Street, Newton, MA 02158 (phone: 800-422-3006). A unit of this type is recommended for larger shops.

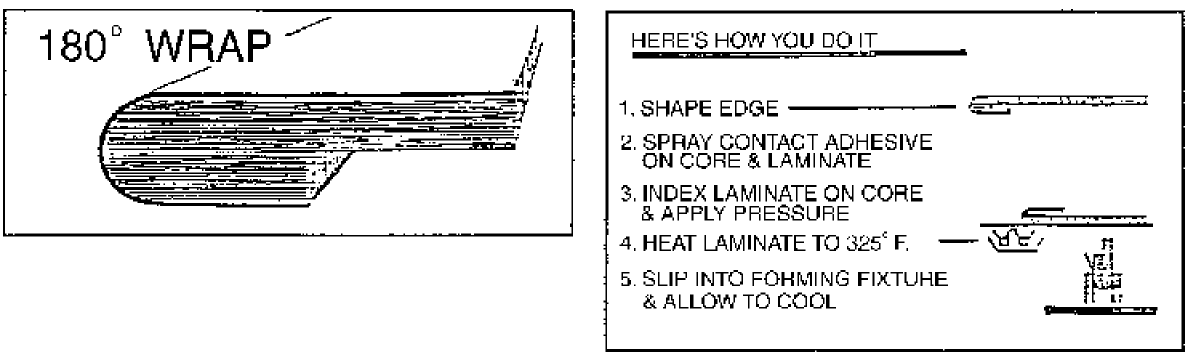
ELIMINATE DRAFTS
Avoid open windows or doors near the postforming operation. Sudden drafts over the heated laminate surface can drop its temperature below optimum conditions and cause cracking or crazing. This is especially important during cold weather when cold blasts from open doors, etc. can happen unexpectedly. The use of temporary or permanent partitions to eliminate drafts is often required.

EQUIPMENT INSPECTION
Commercial or custom built postforming equipment will perform efficiently and properly only if it is in good working condition. All equipment should, therefore, be inspected periodically. Automatic timers may malfunction. Heating elements may develop hot spots or fail to heat up. Guides or stops may loosen. Rollers may become misaligned or worn. Planned periodic inspection of all critical components will help avoid costly material damage and loss of valuable production time.

(By permission of Formica Corporation, Cincinnati, Ohio.)

5.14.4 HPL Post-Forming Countertops (Manual Techniques)





(By permission of Formica Corporation, Cincinnati, Ohio.)

5.14.5 Common Post-Forming Problems

SYMPTOM	PROBLEM	CAUSE	CORRECTION
Cracking, crazing	Heat source	Insufficient heat	Increase heat or rate of heat-up
		Improper heater position	Adjust heater to focus on bend area
	Cores	Irregular radius	Sand core
		Poor machining	Check cutter alignment
		Cold cores	Store at 65°F +
		Contaminated or dusty cores	Clean prior to forming
		Radius too tight	Increase radius
	Equipment	Poor alignment	Align equipment
		Dirty equipment	Clean equipment
	Laminate	Wrong grade	Use proper grade
		Dry conditions	Humidify storage area
Blisters	Heat source	Too much heat	Reduce heat
Glueline delamination	Heat source	Insufficient heat to soften laminate	Increase heat
		Too much heat	Reduce heat
	Core	Radius too tight	Increase radius
	Equipment	Poor alignment	Align equipment
	Adhesive	Insufficient adhesive	Increase spread rate
		Improper adhesive	Consult manufacturer
	Drying oven	Insufficient dry time	Increase drying time or oven temperature
Gloss change	Heat source	Too much heat	Reduce heat

IMPORTANT NOTICE

The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which Formica Corporation assumes legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purposes of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE.

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5.14.6 HPL Decorative Laminate Summary Table

High-pressure decorative laminate (HPDL) is used as a surfacing material on counters, desk tops, cabinets, as wall paneling, and on furniture. The physical characteristics of the materials should be considered in planning its design, fabrication and installation.

Like wood, HPDL has a grain direction, and its dimensional behavior is similar to that of wood. When humidity varies, the width of a laminate undergoes greater dimensional changes than the length by a ratio of nearly two to one.

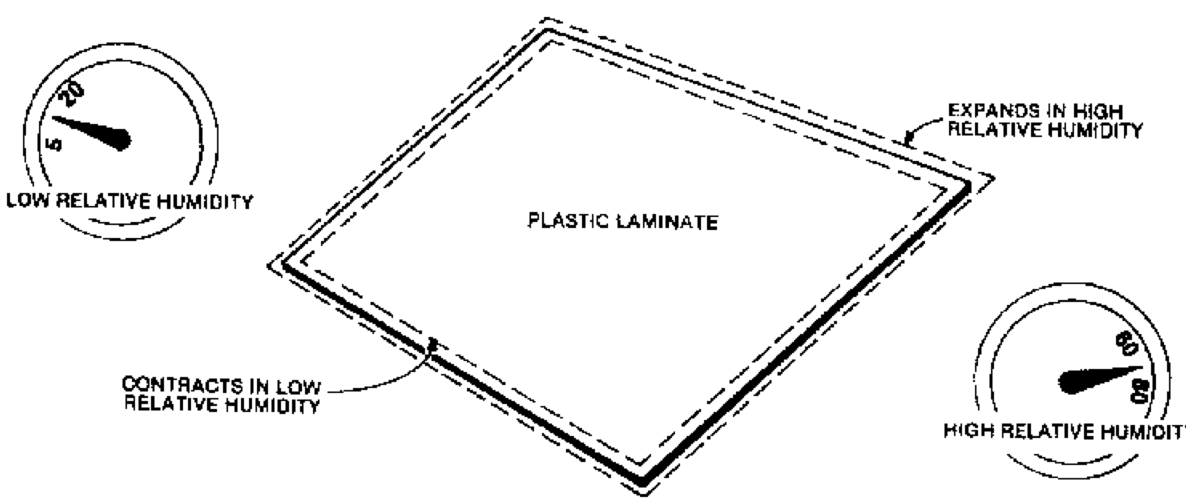
The following chart of performance properties (*) will serve as a guide to laminate selection. The laminate types are abbreviated as "GP" for General-purpose; "PF" for Post-forming; "CL" for Cabinet-liner; "BK" for Backer; and "FR" for Fire-rated, in accordance with NEMA usage. The number following the abbreviation is the nominal thickness in thousandths of an inch.

Tests for Resistance to: (**)	GP 50	GP 38	GP 28	GP 20	PF 42	PF 30	FR 50	CL 20	BK 20
Wear (cycles, max.)	400	400	200	200	400	300	400	50	--
Scuff	No Effect								--
Stain (variety of agents)	No Effect 1-23 Moderate Effect 24-29							Moderate Effect 1-29	---
Cleanability (cycles, max.)	25							50	---
Light (***)	Slight Effect							Moderate Effect	---
High Temperature	Slight Effect							Moderate Effect	---
Radiant Heat	125	100	80	60	100	80	75	---	---
Boiling Water	No Effect				Slight Effect		No Effect	Moderate Effect	--
Impact (inches, min.)	50	35	20	15	30	20	45	10	---

(*) These test procedures are those used by the National Electrical Manufacturers Association (NEMA) for testing high-pressure decorative laminates. The minimum requirements are excerpted from and comply with NEMA Standard LD3-1985 for high-pressure decorative laminates.

(**) This standard applies to decorative panel faces only.

(***) Environmental regulations have caused certain colors to be subject to fugitive changes in appearance and the manufacturer should be consulted.



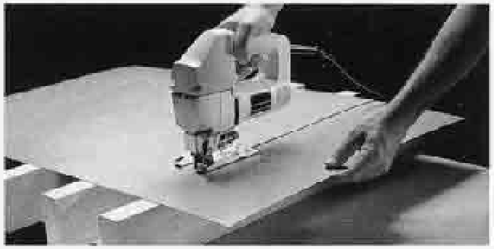
Movement in Relation to Humidity Changes - 200-34

(By permission of Formica Corporation, Cincinnati, Ohio.)

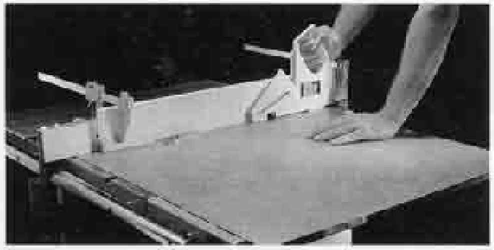
5.14.7 How to Laminate a Countertop

Cutting Formica Brand Laminate

Squaring. Although the laminate will normally be square, check corners with a carpenter's square to avoid problems later.
Blades. A fine-tooth blade, preferably carbide-tipped, and a slight set will give you the cleanest cut. There are some different methods you can use, however. Make sure to cut laminate surface area 3/8" to 1/2" over-sized for proper fitting later.



1. Sabre Saw. Cut laminate face down, using a metal cutting blade or fine-tooth wood cutting blade.



2. Table Saw. Cut laminate face up, using a carbide-tipped blade. Clamp hold-down strip to fence to avoid chatter.

3. Shears. Professional laminate shears take a good-sized bite each time. They are especially useful for irregular-shaped cuts.

How to Laminate a Countertop

A countertop can be one of the most satisfying projects you can do, since it enables you to give your kitchen a fresh, new look. It involves various cutting, bonding and installing techniques that require careful planning. You may want to try a smaller project first if you've never worked with laminate before.

Bonding laminates to a core or substrate is the same for any project. Use 45# density particleboard as your core, and follow these steps. We recommend grade -10/HGS or -12/HGP Formica® brand laminate. Always keep adhesive-coated pieces separated until you are ready to make permanent contact.

1. Start with the self-edge. Apply Formica brand #100 adhesive (or equivalent) to the laminate edge strip with small roller or brush.

2. Next, apply two coats of adhesive to core edge of countertop.

3. When adhesive is completely dry, bond the laminate edge strip to the core, using fingertips to keep surfaces apart. Position as you work. Note: contact cement cannot be repositioned after touching.

4. After strip is positioned, apply pressure immediately with J-roller. Be careful near the ends so you don't break the laminate.

5. Trim the excess laminate with a straight flush carbide cutter in a router or laminate trimmer.

6. File edge flush with smooth file. Keep file flat on the core. File only toward the core to prevent chipping.

7. Apply adhesive to the back of the laminate with a roller. Follow adhesive instructions.

8. Next, apply adhesive to the core (particleboard or old surface) with roller. Make sure both surfaces are free of dirt.

9. A surface is ready for bonding when adhesive does not transfer to your fingertip.

10. Position dowel rods approximately 6" apart to support laminate and keep it off the core as you align. Slide rods out after laminate is positioned over core material.

(By permission of Formica Corporation, 10155 Reading Rd., Cincinnati, Ohio.)

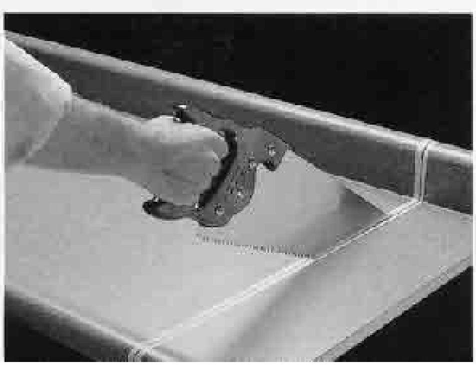
5.14.8 How to Install a Countertop

Step 1 Fitting to Length

Check for proper length. Allow desired overhang. End caps should be used on all exposed ends (end cap kits). End splashes should be used where top butts wall (end splash kit). Additional material should be allowed to scribe for a tight fit to an end wall.

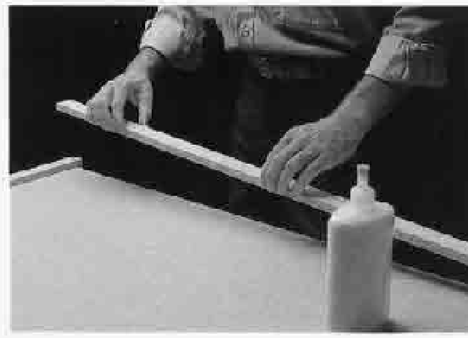
Step 2 Cutting

Cover the Formica brand laminate surface in the area to be sawed with a strip of masking tape and draw a pencil line on the tape to serve as your cutting guide. Use a fine-tooth handsaw (10 to 12 point) and always cut into the laminate surface to avoid chipping. Sand or file the cut to assure a smooth surface.



Step 3 Build Up

Place your countertop upside down on a flat surface. Choose strips of wood thick enough to allow the countertop surface to match the front build-up. Glue strips around perimeter of countertop.



Step 4 Applying End Caps

To apply end caps, set household iron at medium heat. Iron cap onto the end of the countertop with a back-and-forth motion. Let set for one minute, then tap the cap carefully with a rubber mallet. Finish trimming with a fine file, applying pressure only on the up strokes. Complete instructions are included in the end cap kit.

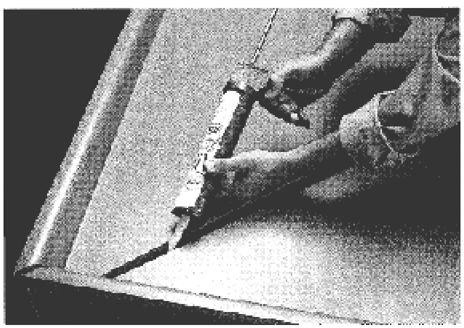
(By permission from Formica Corporation, 10155 Reading Rd., Cincinnati, Ohio.)

Step 5 Making Cutouts for Sinks or Rangetops

Always follow manufacturers' directions for installing appliances. Place the sink or rangetop rim on the back side of the countertop, where the appliance is to be located. Mark all the way around the edge of the rim. Use a sabre saw to cut the hole 1/4" to 3/8" smaller than the line. All cutout corners should have clean, chip-free radii. Apply two layers of heat-conductive aluminum tape around rangetop cutout.

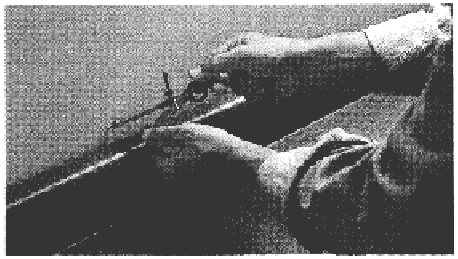
Step 6 Joining Miters

If your kitchen requires an L- or U-shaped top, precut miters should be joined at this point in the installation. Apply a bead of sealant to each mitered edge. Tighten fasteners only enough to hold them in place. Align front edges and tighten fasteners. Tap surfaces to align (use wood blocks to avoid damaging the surface). Then tighten fasteners securely.



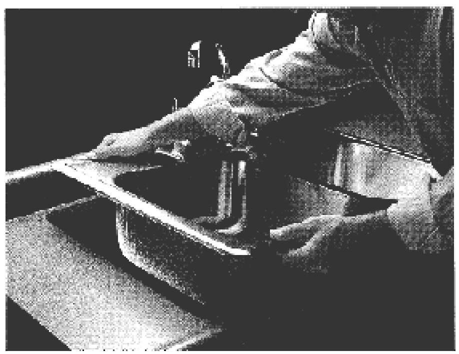
Step 7 Scribing

The countertop can be scribed to match the wall surface. The top is provided with a scribe edge on the backsplash for this purpose. Place the top on the cabinet. Use a scriber-compass to mark the top edge of the countertop, then belt sand or block-plane to the line. This will contour the countertop to the wall. Put top in place, check for level and stability, and then secure to cabinets with wood screws.



Step 8 Installing Sinks

You may find it more convenient to install the sink faucets, 3/8" supply tubing and basket drain now, before dropping the sink into place. This is important if space behind the installed bowl is too tight for easy connection of plumbing fittings. All sinks must be sealed with sealant to avoid water damage to base material.



Step 9 Finishing Installation and Care

Remove excess sealant from sink area or end splash. The Formica® brand laminate surface of your new countertop is highly resistant to staining, wear, and heat. It is not, however, completely impervious to chemicals, scratches and hot objects.

Cleaning. Formica brand laminate-clad countertops may be cleaned with a clean, non-abrasive, damp cotton cloth and a mild liquid detergent or household cleaner.

Heat Resistance. Avoid placing hot items on the countertop. Use a trivet or hot pad.

Surface Care. Use a cutting board to avoid damaging surface.

Use and Care Guidelines brochure is available by calling 1-800-FORMICA™.

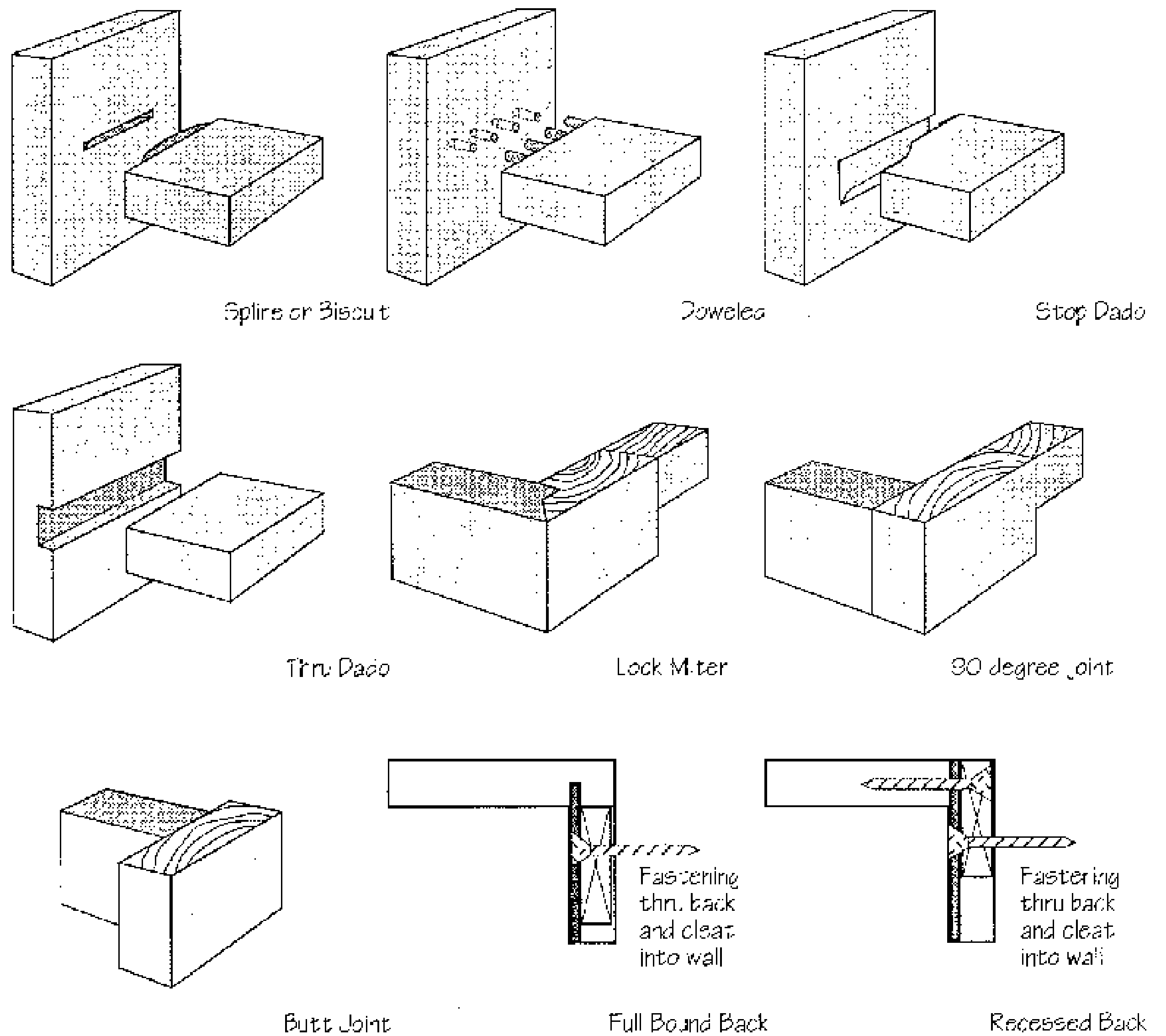
Continued

5.15.0 Low-Pressure Laminates (LPL)

Sometimes referred to as *saturated paper laminates*, these LPLs can take the form of solid-color decorative papers that have been saturated with either a melamine, a phenolic, or a polyester resin. These low-pressure laminates are wood based and will shrink and expand in the presence of moisture or the lack of moisture. Although the contractor will generally purchase these kinds of panel materials from a manufacturer, it is helpful to have knowledge of the factors involving successful assembly of these products.

- During assembly, the press should be loaded and closed as quickly as possible.
- Hot boards should be stacked flat and well supported while cooling. Rapid cooling is to be avoided.
- The volatile material in the papers should be retained and not dried out.
- The press platen temperature and conditions for the proper curing of both sides must be set when using different papers.
- When using phenolic papers with elevated temperatures and extended press times, degradation of the substrate must be avoided. Proper cooling of these panels is essential.

5.16.0 Cabinet Joinery Details

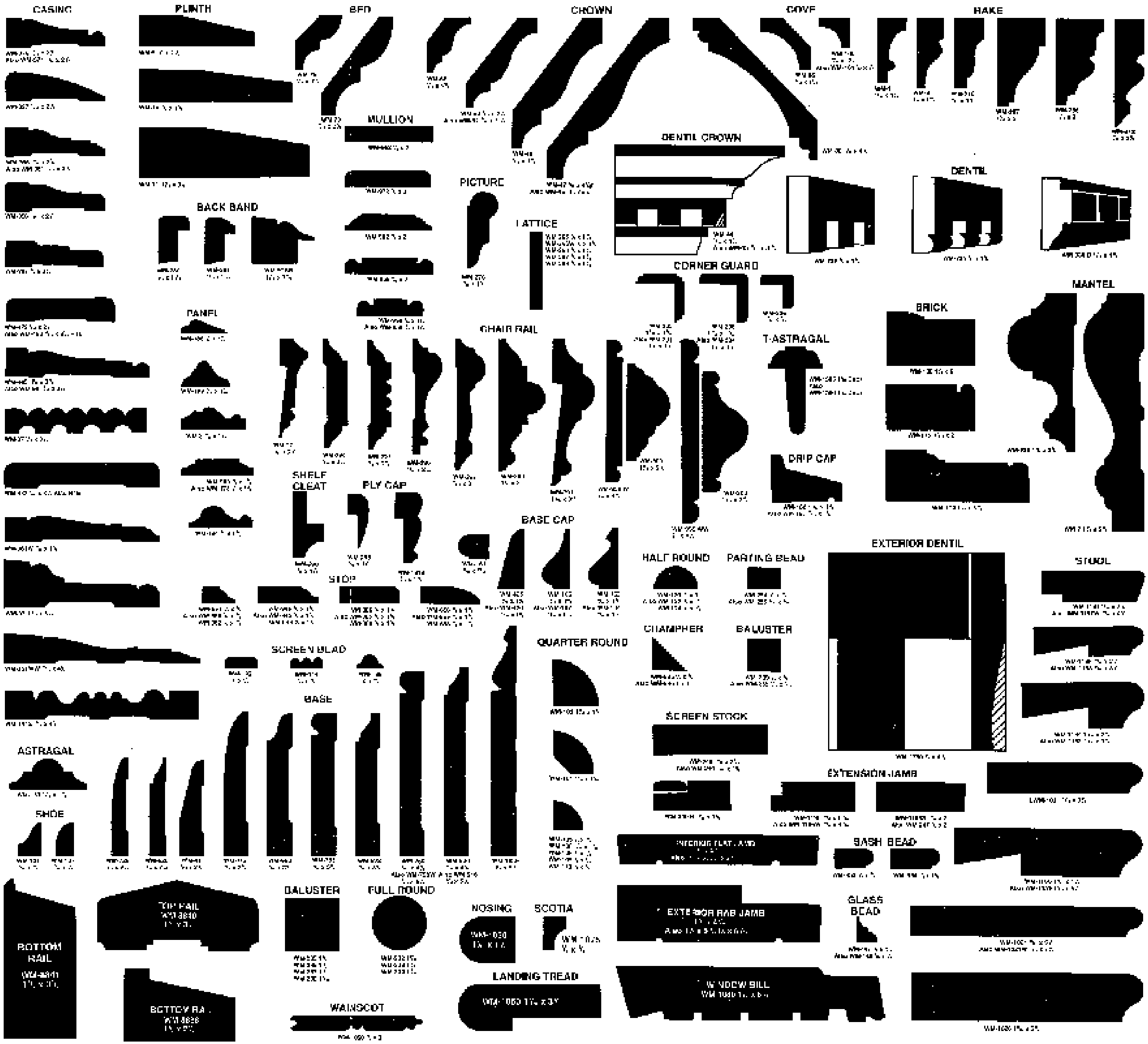


Case Joinery - Figure 400-16

Joinery of Face Frames to Cabinet Body Members

	Custom	Premium	Economy
Pressure glued (no nails or other visible fasteners)		√	
Glue and finish nail	√		
Nailed			√

5.17.0 Wood Trim and Molding Profiles



Section

6

Roofing and Sealants

Contents

6.0.0 Most Frequently Used Types of Roofing

6.0.0.1 Built-Up Membrane Roofing

All BURs share three basic components: felts, bitumens, and protective caps. The felts, asphalt-impregnated, fiberglass-reinforced membrane sheets are designed to act in concert with the bitumens (a semi-solid asphalt or coal tar pitch material) to create a moisture-resistant surface. The cap, weathering-grade asphalt embedded with mineral granules or gravel to protect the built-up roof from the elements is the third element in this assembly.

Built-up roofs can be subdivided into three categories:

1. *Smooth surface* BUR without any gravel topping. These roofs are lightweight, easy to inspect, and, if leaks occur, make it simple to determine the source of the leak.
2. *Gravel surface* BUR with a stone-aggregate spread over its entire surface after a flood coat of bitumen has been applied to protect the membrane from the elements. Gravel-surfaced BURs are limited to those roofs with slopes of 3 inches or less.
3. *Mineral surface* BUR with a top sheet of weathering-grade asphalt embedded with mineral granules to protect the surface from the elements.

6.0.0.2 Fluid-Applied Membrane Roofs

Fluid-applied roofs can be installed with either hot or cold materials. This type of roof installation requires a stable substrate, such as a cast-in-place concrete deck. When applied over concrete, which must meet certain moisture content standards, a prime coat is first sprayed or rolled on. This is generally followed by the installation of a nylon or fiberglass mat mopped directly onto the primed concrete surface after which top coat is applied by roller or spray. The fluid applied membrane makes it easy to spot leaks, which might occur if cracks appear in the substrate and the nylon/fiberglass mat cannot bridge the gap. The liquid-applied roof is often used where free-form roofs are constructed.

6.0.0.3 Single-Ply Membrane Roofs

The advent of man-made elastomeric materials, such polyvinyl chloride (PVC) and ethylene propylene diene monomer (EPDM), ushered in the era of single-ply membrane roofs. Elastic, flexible, easy to install, ozone and ultraviolet-ray resistant, these wide-width sheets (some as wide as 40 feet) provide a roof membrane with significantly fewer seams that is very cost-effective, long-lived, and relatively easy to repair if damaged.

A variation on the single-ply membrane roof is the IRMA roof (Inverted Roof Membrane Assembly), where the single-ply membrane is placed directly on the roof deck and rigid insulation, protection board, and aggregate ballast is placed on top. The membrane nestles protected from the elements and from roof traffic that could damage the membrane.

6.0.0.4 Metal Sheet and Metal Panel Roofs

Metals of various alloys (such as lead, terne, zinc, and copper) have been used for hundreds of years and are still popular today, primarily for aesthetic reasons or when historic restorations are being undertaken. Formed metal roofing should not be installed on sloped roofs with a pitch less than 1½ inches in one foot.

6.0.0.5 Shingles, Shakes, and Tile Roofs

These materials are actually watershedding materials, rather than waterproofing materials, and rely upon roof pitch to rapidly drain the water from the surface on the roof. Slopes of 3 to 4 inches per foot are recommended before selecting any of these materials. Wood shingles and wood shakes require installation where air can circulate behind them so that they can dry out after becoming wet. Slate shingles are expensive to purchase and install, but are extremely long lasting. This material is generally specified when restoration work is being undertaken. Porcelain enamel tiles or clay tiles are frequently used in certain parts of the country where mission or Spanish-style roofs are popular, such as the Southwest.

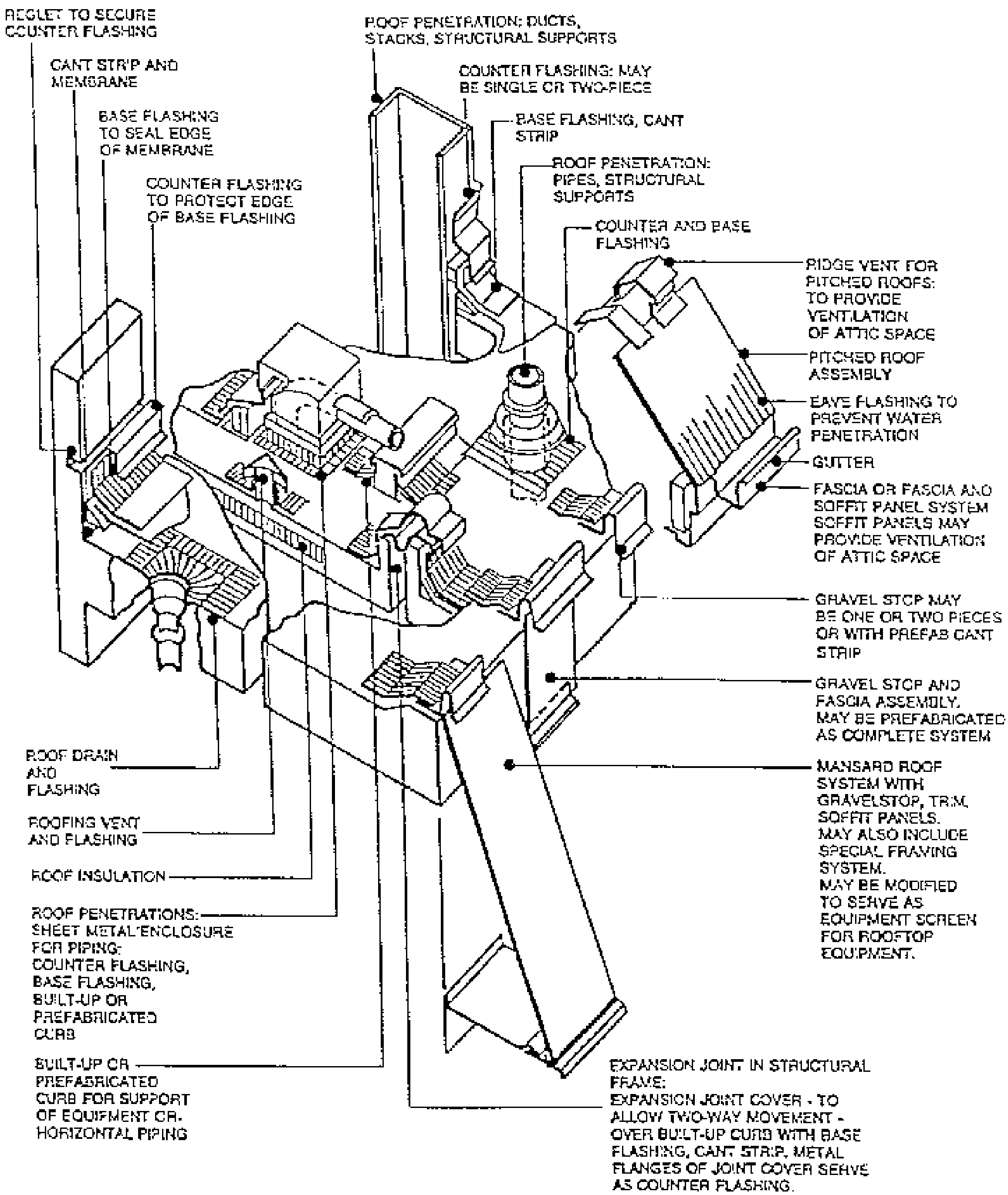
6.0.0.6 Defining Roof Slopes and other Types of Slopes

Percent Slope	Inch/Ft	Ratio	Degrees from Horizontal
1%	1/8	1 in 100	—
2%	1/4	1 in 50	—
3%	3/8	—	—
4%	1/2	1 in 25	—
5%	5/8	1 in 20	3
6%	3/4	—	—
7%	7/8	—	—
8%	approx. 1	approx. 1 in 12	—
9%	1 1/8	—	—
10%	1 1/4	1 in 10	6
11%	1 3/8	approx. 1 in 9	—
12%	1 1/2	—	—
13%	1 5/8	—	—
14%	1 3/4	—	—
15%			8.5
16%	1 7/8	—	—
17%	2	approx. 2 in 12	—
18%	2 1/8	—	—
19%	2 1/4	—	—
20%	2 3/8	1 in 5	11.5
25%	3	3 in 12	14
30%	3.6	1 in 3.3	17
35%	4.2	approx. 4 in 12	19.25
40%	4.8	approx. 5 in 12	21.5
45%	5.4	1 in 22	24
50%	6	6 in 12	26.5
55%	6 5/8	1 in 1.8	28.5
60%	7 1/4	approx. 7 in 12	31
65%	7 3/4	1 in 1 1/2	33
70%	8 1/8	1 in 1.4	35
75%	9	1 in 1.3	36.75
100%	12	1 in 1	45

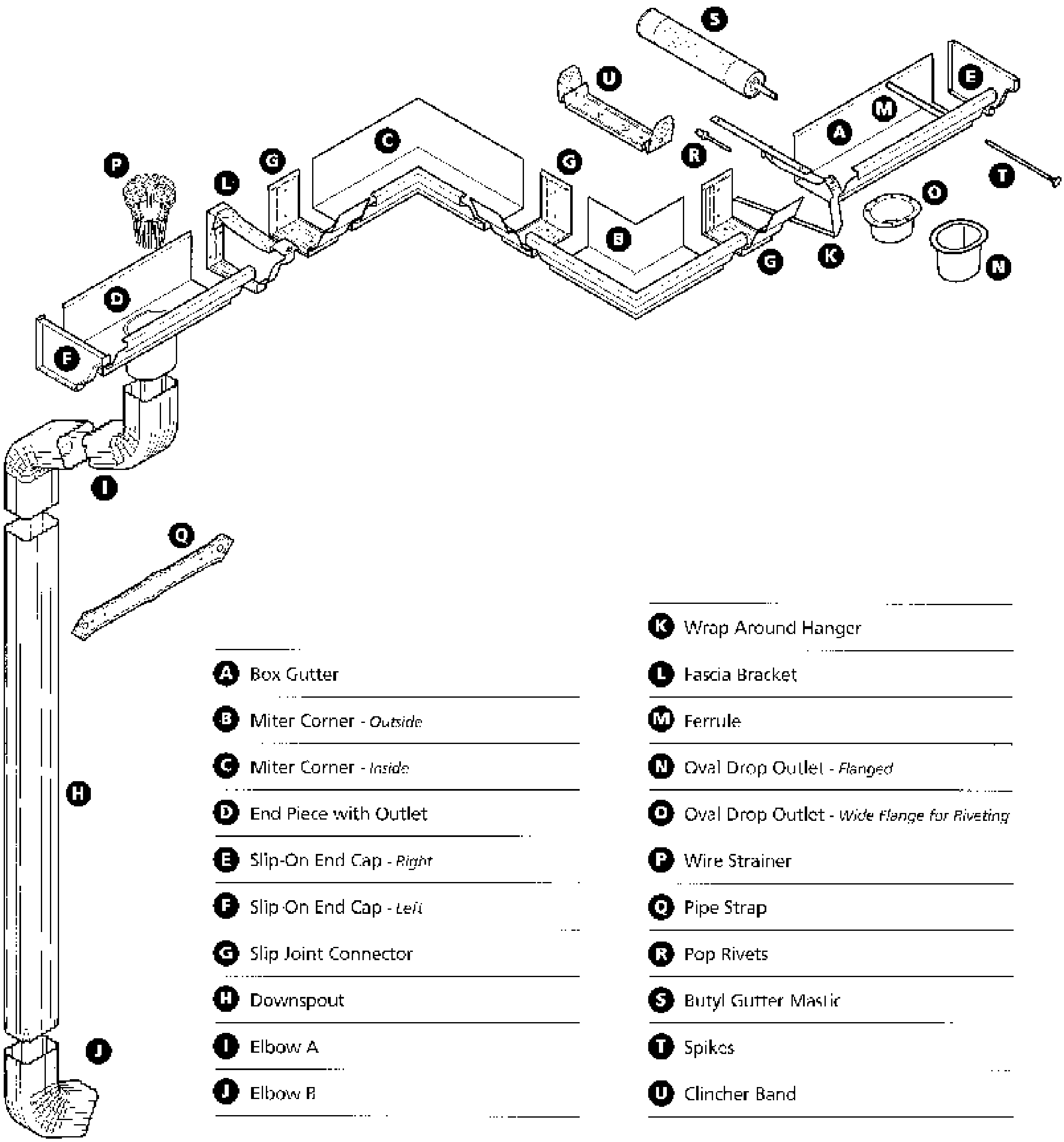
6.1.0 Roof Flashings

- *Gravel stops* Gravel stops are metal flashing attached to the edge of the roof to protect and secure the edge of the roof membrane. When gravel is placed on the roof, the profile of the gravel stop is such that it prevents the gravel from rolling or washing over the edge of the roof.
- *Copings* Similar in nature to gravel stops, except that they are placed on top of perimeter parapet walls to secure the roof's base flashing.
- *Base flashings* Generally flexible materials that provide watertight integrity between the horizontal roof membrane and some vertical surface. Base flashing can also be made of metal and require either a reglet or counterflashing on the vertical surface to ensure watertight conditions.
- *Counter flashings* Flashings that act as a shield to cover the seamed base flashing below. They are generally constructed of aluminum, copper, lead, or stainless steel.
- *Pipe and conduit flashings* Whenever a mechanical or electrical pipe or conduit penetrates the roof surface, some form of flashing must be installed to seal off this penetration. Factory-supplied "boots" or shop-fabricated "pitch pockets" are used to seal off these roof surfaces.
- *Roof drain flashings* When installed in a roof, generally at a low point in the roof surface where water tends to accumulate, special care is required where these flashings are installed. Usually installed by the plumbing contractor, roof drains can be purchased with flashings specially designed for that purpose.
- *Roof vent flashings* Roof vents installed through the roof surface require "boots" that can be purchased or fabricated for the purpose.
- *Pitch pockets* The "pocket" is usually formed of aluminum or copper and is fastened to the roof deck, which encloses a pipe or series of pipes that penetrate the roof surface. This pocket or dam is then filled with pitch, a black viscous tar that "cold" flows to seal the spaces around the penetrations. Pitch pockets require periodic inspections to ensure that the pitch levels are maintained.
- *Expansion joint covers* When a large expanse of roof is constructed, allowance must be made for expansion and subsequent contraction. Various types of bellow or slip-joint expansion joints can be installed, and (depending on the configuration) might require additional flashing to make them watertight.
- *Ridge flashings* Where the valley and eaves are created in a roof, flashings must be installed. Generally, this occurs when shingled roofs are installed, whether wood, tile, or slate.

6.1.1 Flashing Types and Locations



6.1.2 Gutter and Downspout Parts and Terminology



- **A** Box Gutter
- **B** Miter Corner - *Outside*
- **C** Miter Corner - *Inside*
- **D** End Piece with Outlet
- **E** Slip-On End Cap - *Right*
- **F** Slip-On End Cap - *Left*
- **G** Slip Joint Connector
- **H** Downspout
- **I** Elbow A
- **J** Elbow B
- **K** Wrap Around Hanger
- **L** Fascia Bracket
- **M** Ferrule
- **N** Oval Drop Outlet - *Flanged*
- **O** Oval Drop Outlet - *Wide Flange for Riveting*
- **P** Wire Strainer
- **Q** Pipe Strap
- **R** Pop Rivets
- **S** Butyl Gutter Mastic
- **T** Spikes
- **U** Clincher Band

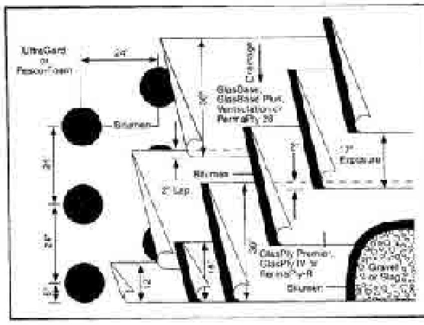
6.2.0 3-Ply Built-Up Roof on Approved Insulation

Specification 3GIG (Alternate)

Three Ply
Gravel Surfaced
Fiber Glass Built-Up Roof

For use over Schuller insulation, approved decks or other approved insulations, on inclines of up to 3" per foot (250 mm/m)

For Regions 1, 2 and 3
(Not acceptable in all locations, consult Schuller Technical Service Specialist)



Materials per 100 sq. ft. of Roof Area

Felts:
Ventsulation, GlasBase, PermaPly 28 or GlasBase Plus .... 1 ply
GlasPly Premier, PermaPly-R or GlasPly IV .... 2 plies

Bitumen (Interply):

Incline per foot	Bitumen	Nominal Weight
Up to ½"	170°F, Type II, Flat	53 lbs.
½" to 3"	190°F, Type III, Steep or 220°F, Type IV, Special Steep	53 lbs.
0 to 3"	PermaMop	53 lbs.

Surfacing:
Flood coat of bitumen .... 60 lbs.
Gravel .... 400 lbs.
or Slag .... 300 lbs.

Aggregate density, size and coverage will determine actual weight.
Approximate installed weight: 434 - 522 lbs.

General
This specification is for use over any type of approved structural deck which is not nailable and which offers a suitable surface to receive the roof. Poured and pre-cast concrete decks require priming with Schuller Concrete Primer prior to application of hot bitumen.

This specification is also for use over Schuller roof insulations or other approved rigid roof insulations, which are not nailable and which offer a suitable surface to install the roof. Specific written approval is required for any roof insulation not manufactured or supplied by Schuller. Insulation should be installed in accordance with the appropriate Schuller Insulation Specification detailed in the current Schuller Commercial/Industrial Roofing Systems Manual. This specification can also be used in certain reroofing situations. Refer to the "Reroofing" section of the Schuller Commercial/Industrial Roofing Systems Manual. This specification is not to be used directly over poured or pre-cast gypsum or lightweight, insulating concrete fills.

Design and installation of the deck and/or substrate must result in the roof draining freely and to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and are not eligible to receive a Schuller Roofing Systems Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual should be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
Note: On roof decks with slopes up to 1" per foot (83.3 mm/m), the roofing felts may be installed either perpendicular or parallel to the roof incline. On slopes over 1" per foot (83.3 mm/m), refer to **Paragraph 6.11** of this section for special requirements.

Using Ventsulation, GlasBase, GlasBase Plus or PermaPly 28, start with a 12" (305 mm) width (the use of a specific base sheet may be a condition of Guarantee). The following base sheet courses should be applied full width, lapping the side laps 2" (51 mm) and the end laps 4" (102 mm) over the preceding felts. Set each felt firmly into spot moppings of hot bitumen (within ±25°F [±14°C] of the EVT). The spot moppings should be applied by machine at the rate of approximately 7 lbs. per square (0.3 kg/m²). The spots should be approximately 12" (305 mm) in diameter and 24" (610 mm) o.c. Each row should be staggered from the previous one.

Using GlasPly Premier, PermaPly-R, or GlasPly IV, apply a piece 18" (457 mm) wide, then over that, a full width piece. The following felts are to be applied full width overlapping the preceding felts by 19" (483 mm) so that at least 2 plies of felt cover the base felt/substrate at all locations. Install each felt so that it is firmly and uniformly set, without voids, into the hot bitumen (within ±25°F [±14°C] of the EVT) applied just before the felt at a nominal rate of 23 lbs. per square (1.1 kg/m²) over the entire surface. Installation over porous substrates such as roof insulation may require up to 33 lbs. per square (1.6 kg/m²) of hot bitumen.

Surfacing
Flood the surface with the appropriate bitumen at an approximate rate of 60 lbs. per square (2.9 kg/m²). Into the hot bitumen, embed an acceptable gravel at a rate of 400 lbs. per square (19.5 kg/m²) or an acceptable slag at a rate of 300 lbs. per square (14.6 kg/m²). Aggregate must be installed so that there is complete coverage across the entire surface and at least 50% of the aggregate is solidly adhered in the hot bitumen. Aggregate should meet the requirements of ASTM D 1863.

Asphalt should meet the requirements of ASTM D 312. The contractor must provide a Schuller confirmation number for asphalt on jobs which require a Guarantee. Check with a Schuller Technical Service Specialist for special requirements in hot climates.

(By permission of Schuller Roofing Systems, Denver, Colorado.)

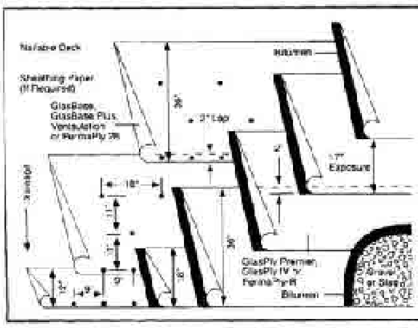
6.2.1 3-Ply Built-Up Roof on Nailable Deck

Specification 3GNG

Three Ply
Gravel Surfaced
Fiber Glass Built-Up Roof

For use over wood or other nailable decks on inclines of up to 3" per foot (250 mm/m)

For Regions 2 and 3



Materials per 100 sq. ft. of Roof Area

Sheathing Paper (Wood board decks only)........1 layer

Felts:
GlasBase, GlasBase Plus, PermaPly 28 or Ventsulation Felt........1 ply
GlasPly Premier, PermaPly-R or GlasPly IV........2 plies

Bitumen (Interply):

Incline per foot	Asphalt	Nominal Weight
Up to ½"	170°F, Type III, Flat	46 lbs.
½" to 3"	190°F, Type IV, Steep	46 lbs.
0 to 3"	PermaMop	46 lbs.

Surfacing:
Flood coat of bitumen........60 lbs.
Gravel........400 lbs.
or Slag........300 lbs.

Aggregate density, size and coverage will determine actual weight.
Approximate installed weight: 427 - 522 lbs.

General
This specification is for use over any type of approved structural deck (without insulation) which can receive and adequately retain nails or other types of mechanical fasteners that may be recommended by the deck manufacturer. Examples of such decks are wood and plywood. This specification is not for use directly over lightweight, insulating concrete decks.

Design and installation of the deck and/or substrate must result in the roof draining freely and to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and are not eligible to receive a Schuller Roofing Systems Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual should be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
Over wood board decks, one ply of sheathing paper must be used under the base felt and on top of the wood board deck.

Note: On roof decks with slopes up to 1" per foot (83.3 mm/m), the roofing felts may be installed either perpendicular or parallel to the roof incline. On slopes over 1" per foot (83.3 mm/m), refer to **Paragraph 6.11** of this section for special requirements.

Using GlasBase, GlasBase Plus, Ventsulation, or PermaPly 28 start with a 12" (305 mm) width (a specific base sheet may be a condition of Guarantee). The following base sheet courses are to be applied full width, lapping the preceding felt 2" (51 mm) on the side laps and 4" (102 mm) on the end laps. Nail the side laps 9" (229 mm) o.c. Down the longitudinal center of each felt, place two rows of nails spaced approximately 11" (279 mm) apart, with the nails staggered on approximately 18" (457 mm) centers. Use nails or fasteners appropriate to the type of deck with 1" (25 mm) minimum diameter caps. For additional fastener information, refer to the Fastener Data in the "Roof Deck" section of the current Schuller Commercial/Industrial Roofing Systems Manual.

Using GlasPly Premier, PermaPly R, or GlasPly IV, apply a piece 18" (457 mm) wide, then over that, a full width piece. The following felts are to be applied full width overlapping the preceding felts by 19" (483 mm) so that at least 2 plies of felt cover the base felt/substrate at all locations. Install each felt so that it is firmly and uniformly set, without voids, into the hot bitumen (within ±25°F (±14°C) of the EVT) applied just before the felt at a nominal rate of 23 lbs. per square (1.1 kg/m²) over the entire surface. Installation over porous substrates such as roof insulation may require up to 33 lbs. per square (1.6 kg/m²) of hot bitumen.

Surfacing
Flood the surface with the appropriate bitumen at an approximate rate of 60 lbs. per square (2.9 kg/m²). Into the hot bitumen, embed an acceptable gravel at a rate of 400 lbs. per square (19.5 kg/m²) or an acceptable slag at a rate of 300 lbs. per square (14.6 kg/m²). Aggregate must be installed so that there is complete coverage across the entire surface and at least 50% of the aggregate is solidly adhered in the hot bitumen. Aggregate should meet the requirements of ASTM D 1863.

Asphalt should meet the requirements of ASTM D 312. The contractor must provide a Schuller confirmation number for asphalt on jobs which require a Guarantee. Check with a Schuller Technical Service Specialist for special requirements in hot climates.

(By permission of Schuller Roofing Systems, Denver, Colorado.)

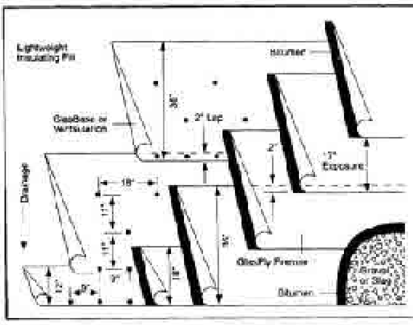
6.2.2 3-Ply Built-Up Roof on Lightweight Fill Insulated Deck

Specification 3GLG-CT

Three Ply
Gravel Surfaced
Fiber Glass Built-Up Roof

For use over approved, lightweight, insulating fill decks on inclines of up to ¼" per foot (20.8 mm/m)

For Regions 2 and 3



Materials per 100 sq. ft. of Roof Area

Felts:
GlasBase or Ventsulation Felt .... 1 ply
GlasPly Premier .... 2 plies

Bitumen (interply):

Incline per foot	Coal Tar Pitch	Nominal Weight
Up to ¼"	Type I	50 lbs.

Surfacing:
Flood coat of Bitumen .... 70 lbs.
Gravel .... 400 lbs.
or Slag .... 300 lbs.

Aggregate density, size and coverage will determine actual weight.
Approximate installed weight: 476 - 621 lbs.

General
This specification is for use over any type of approved, lightweight, insulating concrete fill deck (without insulation) which can receive and adequately retain nails or other types of mechanical fasteners as may be recommended by the deck manufacturer. Examples of such decks are Zonolite, Celcore and Elastizell. Schuller Ventsulation Felt is recommended over any wet fill deck and may be required as a condition of guarantee.

Design and installation of the deck and/or substrate must result in the roof draining freely and to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and are not eligible to receive a Schuller Roofing Systems Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual should be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
Over wood board decks, one ply of sheathing paper must be used under the base felt and on top of the wood board deck.

Note: On roof decks with slopes up to ¼" per foot (20.8 mm/m), the roofing felts may be installed either perpendicular or parallel to the roof incline.

DANGER: Coal tar is considered a hazard by inhalation, ingestion and skin contact. The International Agency for Research on Cancer (IARC) has classified coal tar as an agent which is carcinogenic to humans (Group 1). Schuller does not make or sell a coal tar pitch waterproofing agent, and does not recommend its use. Alternative materials, such as asphalt should be utilized.

Using GlasBase or Ventsulation, start with a 12" (305 mm) width (a specific base sheet may be a condition of Guarantee). The following base sheet courses are to be applied full width, lapping the preceding felt 2" (51 mm) on the side laps and 4" (102 mm) on the end laps. Nail the side laps 9" (229 mm) o.c. Down the longitudinal center of each felt, place two rows of nails spaced approximately 11" (279 mm) apart, with the nails staggered on approximately 18" (457 mm) centers. Use nails or fasteners appropriate to the type of deck with 1" (25 mm) minimum diameter caps. For additional fastener information, refer to the Fastener Data in the "Roof Deck" section of the current Schuller Commercial/Industrial Roofing Systems Manual.

Using GlasPly Premier, apply a piece 18" (457 mm) wide, then over that, a full width piece. The following felts are to be applied full width overlapping the preceding felts by 19" (483 mm) so that at least 2 plies of felt cover the base felt/substrate at all locations. Install each felt so that it is firmly and uniformly set, without voids, into the hot bitumen (within ±25°F [±14°C] of the EVT) applied just before the felt at a nominal rate of 25 lbs. per square (1.2 kg/m²) over the entire surface. Installation over porous substrates such as roof insulation may require up to 33 lbs. per square (1.6 kg/m²) of hot bitumen.

Surfacing
Flood the surface with the appropriate bitumen at an approximate rate of 70 lbs. per square (3.4 kg/m²). Into the hot bitumen, embed an acceptable gravel at a rate of 400 lbs. per square (19.5 kg/m²) or an acceptable slag at a rate of 300 lbs. per square (14.6 kg/m²). Aggregate must be installed so that there is complete coverage across the entire surface and at least 50% of the aggregate is solidly adhered in the hot bitumen. Aggregate should meet the requirements of ASTM D 1863.

Coal Tar Pitch must meet the requirements of ASTM D 450, Type I and be certified as such by the manufacturer, in writing.

(By permission of Schuller Roofing Systems, Denver, Colorado.)

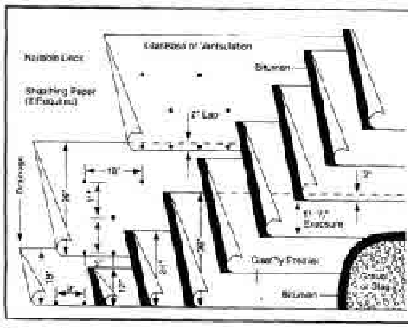
6.3.0 4-Ply Gravel Surface Built-Up Roof over Insulation, Inclines to 3" Per Foot

Specification 4GNG-CT

Four Ply
Gravel Surfaced
Fiber Glass Built-Up Roof

For use over wood or other nailable decks on inclines of up to ¼" per foot (20.8 mm/m)

For Regions 1, 2 and 3



Materials per 100 sq. ft. of Roof Area

Sheathing Paper:		
Any wood decks		1 layer
Felts:		
GlasBase or Ventsulation Felt		1 ply
GlasPly Premier		3 plies
Bitumen (Interply):		
Incline per foot	Coal Tar Pitch	Nominal Weight
Up to ¼"	Type I	75 lbs.
Surfacing:		
Flood coat of bitumen		70 lbs.
Gravel		400 lbs.
or Slag		300 lbs.

Aggregate density, size and coverage will determine actual weight.
Approximate installed weight: 446 - 452 lbs.

General
This specification is for use over any type of approved structural deck (without insulation) which can receive and adequately retain nails or other types of mechanical fasteners that may be recommended by the deck manufacturer. Examples of such decks are wood and plywood. This specification is not for use directly over lightweight, insulating concrete decks.

Design and installation of the deck and/or substrate must result in the roof draining freely and to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and are not eligible to receive a Schuller Roofing Systems Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual should be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
Over wood board decks, one ply of sheathing paper must be used under the base felt and on top of the wood board deck.

Note: On roof decks with slopes up to ¼" per foot (20.8 mm/m), the roofing felts may be installed either perpendicular or parallel to the roof incline.

DANGER: Coal tar is considered a hazard by inhalation, ingestion and skin contact. The International Agency for Research on Cancer (IARC) has classified coal tar as an agent which is carcinogenic to humans (Group 1). Schuller does not make or sell a coal tar pitch waterproofing agent, and does not recommend its use. Alternative materials, such as asphalt should be utilized.

Using Ventsulation or GlasBase, start with an 18" (457 mm) width (the use of a specific base sheet may be a condition of Guarantee). The following base sheet courses are to be applied full width, lapping the preceding felt 2" (51 mm) on the side laps and 4" (102 mm) on the end laps. Nail the side laps 9" (229 mm) o.c. Down the longitudinal center of each felt, place two rows of nails spaced approximately 11" (279 mm) apart, with the nails staggered on approximately 18" (457 mm) centers. Use nails or fasteners appropriate to the type of deck with 1" (25 mm) minimum diameter caps. For additional fastener information, refer to the Fastener Data in the "Roof Deck" section of the current Schuller Commercial/Industrial Roofing Systems Manual.

Using GlasPly Premier, PermaPly-R, or GlasPly IV, apply a piece 12" (305 mm) wide, then over that, one 24" (610 mm) wide, then over both, a full width piece. The following felts are to be applied full width, overlapping the preceding felts by 24⅔" (627 mm) so that at least 3 plies of felt cover the base felt/substrate at all locations. Install each felt so that it is firmly and uniformly set, without voids, into the hot bitumen (within ±25°F [±14°C] of the EVT) applied just before the felt at a nominal rate of 25 lbs. per square (1.2 kg/m²) over the entire surface. Installation over porous substrates such as roof insulation may require up to 30 lbs. per square (1.5 kg/m²) of hot bitumen.

Surfacing
Flood the surface with the appropriate bitumen at an approximate rate of 70 lbs. per square (3.4 kg/m²). Into the hot bitumen, embed an acceptable gravel at a rate of 400 lbs. per square (19.5 kg/m²) or an acceptable slag at a rate of 300 lbs. per square (14.6 kg/m²). Aggregate must be installed so that there is complete coverage across the entire surface and at least 50% of the aggregate is solidly adhered in the hot bitumen. Aggregate should meet the requirements of ASTM D 1863.

Coal Tar Pitch must meet the requirements of ASTM D 450, Type I and be certified as such by the manufacturer, in writing.

(By permission of Schuller Roofing Systems, Denver, Colorado.)

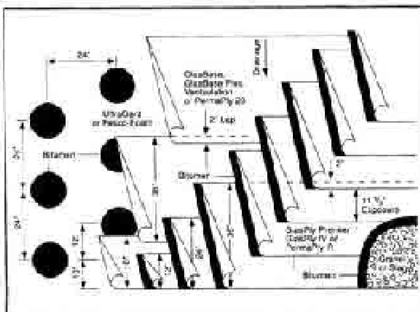
6.3.1 4-Ply Smooth Surface Built-Up Roof Over Insulation, Inclines to 3" Per Foot

Specification 4GIG (Alternate)

Four Ply
Gravel Surfaced
Fiber Glass Built-Up Roof

For use over Schuller insulation, approved decks or other approved insulations, on inclines of up to 3" per foot (250 mm/m)

For Regions 1, 2 and 3
(Not acceptable in all locations, consult Schuller Technical Service Specialist)



Materials per 100 sq. ft. of Roof Area

Felts:
GlasBase, GlasBase Plus, PermaPly 28 or Ventsulation Felt .... 1 ply
GlasPly Premier, PermaPly-R or GlasPly IV .... 3 plies

Bitumen (Interply):

Incline per foot	Bitumen	Nominal Weight
Up to ½"	170°F, Type II, Flat	75 lbs.
½" to 3"	190°F, Type II, Steep or 220°F, Type IV, Special Steep	75 lbs.
0 to 3"	PermaMop	75 lbs.

Surfacing:
Flood coat of bitumen .... 60 lbs.
Gravel .... 400 lbs.
or Slag .... 300 lbs.

Aggregate density, size and coverage will determine actual weight.
Approximate installed weight: 460 - 665 lbs.

General
This specification is for use over any type of approved structural deck which is not nailable and which offers a suitable surface to receive the roof. Poured and pre-cast concrete decks require priming with Schuller Concrete Primer prior to application of hot bitumen.

This specification is also for use over Schuller roof insulations or other approved rigid roof insulations, which are not nailable and which offer a suitable surface to install the roof. Specific written approval is required for any roof insulation not manufactured or supplied by Schuller. Insulation should be installed in accordance with the appropriate Schuller Insulation Specification detailed in the current Schuller Commercial/Industrial Roofing Systems Manual. This specification can also be used in certain reroofing situations. Refer to the "Reroofing" section of the Schuller Commercial/Industrial Roofing Systems Manual. This specification is not to be used directly over poured or pre-cast gypsum or lightweight, insulating concrete fills.

Design and installation of the deck and/or substrate must result in the roof draining freely and to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and are not eligible to receive a Schuller Roofing Systems Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual should be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
Note: On roof decks with slopes up to 1" per foot (83.3 mm/m), the roofing felts may be installed either perpendicular or parallel to the roof incline. On slopes over 1" per foot (83.3 mm/m), refer to **Paragraph 6.11** of this section for special requirements.

Using Ventsulation, GlasBase, GlasBase Plus or PermaPly 28, start with an 18" (457 mm) width (the use of a specific base sheet may be a condition of Guarantee). The following base sheet courses should be applied full width, lapping the side laps 2" (51 mm) and the end laps 4" (102 mm) over the preceding felts. Set each felt firmly into spot moppings of hot bitumen (within ±25°F [±14°C] of the EVT). The spot moppings should be applied by machine at the rate of approximately 7 lbs. per square (0.3 kg/m²). The spots should be approximately 12" (305 mm) in diameter and 24" (610 mm) o.c. Each row should be staggered from the previous one.

Using GlasPly Premier, PermaPly-R, or GlasPly IV, apply a piece 12" (305 mm) wide, then over that, one 24" (610 mm) wide, then over both, a full width piece. The following felts are to be applied full width, overlapping the preceding felts by 24 2/3" (627 mm) so that at least 3 plies of felt cover the base felt/substrate at all locations. Install each felt so that it is firmly and uniformly set, without voids, into the hot bitumen (within ±25°F (±14°C) of the EVT) applied just before the felt at a nominal rate of 23 lbs. per square (1.1 kg/m²) over the entire surface. Installation over porous substrates such as roof insulation may require up to 33 lbs. per square (1.6 kg/m²) of hot bitumen.

Surfacing
Flood the surface with the appropriate bitumen at an approximate rate of 60 lbs. per square (2.9 kg/m²). Into the hot bitumen, embed an acceptable gravel at a rate of 400 lbs. per square (19.5 kg/m²) or an acceptable slag at a rate of 300 lbs. per square (14.6 kg/m²). Aggregate must be installed so that there is complete coverage across the entire surface and at least 50% of the aggregate is solidly adhered in the hot bitumen. Aggregate should meet the requirements of ASTM D 1863.

Asphalt should meet the requirements of ASTM D 312. The contractor must provide a Schuller confirmation number for asphalt on jobs which require a Guarantee. Check with a Schuller Technical Service Specialist for special requirements in hot climates.

(By permission of Schuller Roofing Systems, Denver, Colorado.)

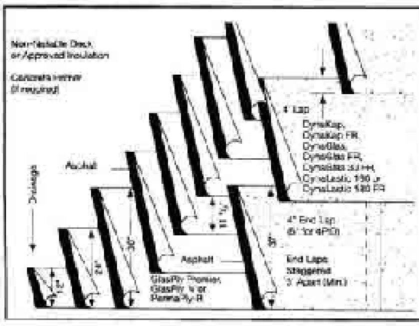
6.4.0 3- and 4-Ply Hot-Mopped Modified Bitumen Roofs

Specification 4CID/4FID/4PID

Four Ply Hot Mopped
Modified Bitumen
Mineral Surfaced Roofing System

For use over Schuller insulation, approved decks, or other approved insulations on inclines up to 3" per foot (250 mm/m)

For Regions 1, 2 and 3



Materials per 100 sq. ft. of Roof Area

Primer (if required):
Schuller Concrete Primer .... 1 gallon

Intermediate Felts:
GlasPly Premier, GlasPly IV or PermaPly R .... 3 layers

Cap:
4CID—DynaKap or DynaKap FR
4FID—DynaGlas, DynaGlas FR or DynaGlas 30 FR
4PID—DynaLastic 180 or DynaLastic 180 FR .... 1 layer

Bitumen (Refer to Paragraph 7.8):

Incline per foot	Bitumen	Total Weight
Up to ½"	190°F, Type III, Steep	92 lbs.
½" to 3"	220°F, Type IV, Special Steep	92 lbs.

Approximate installed weight: 175 - 205 lbs.

General
This specification is for use over any type of approved structural deck which is not nailable and which provides a suitable surface to receive the roof. Poured and pre-cast concrete decks require priming with Schuller Concrete Primer prior to application of hot bitumen.

This specification is also for use over Schuller roof insulations, or other approved roof insulations which are not nailable and which provide a suitable surface to receive the roof. Specific written approval is required for any roof insulation that is not supplied by Schuller. Insulation should be installed in accordance with the appropriate Schuller Insulation Specification detailed in the Schuller Commercial/Industrial Roofing Systems Manual. This specification can also be used in certain reroofing situations. Refer to the "Reroofing" section of the Schuller Commercial/Industrial Roofing Systems Manual. This specification is not to be used directly over gypsum, either poured or precast, or lightweight, insulating concrete decks or fills.

Design and installation of the deck and/or roof substrate must result in the roof draining freely, to outlets numerous enough and so located as to remove water promptly and completely. Areas where water ponds for more than 24 hours are unacceptable and will not be eligible for a Schuller Roofing System Guarantee.

Note: All general instructions contained in the current Schuller Commercial/Industrial Roofing Systems Manual shall be considered part of this specification.

Flashings
Flashing details can be found in the "Bituminous Flashings" section of the Schuller Commercial/Industrial Roofing Systems Manual.

Application
On roof decks with slopes up to ½" per foot (41.6 mm/m), the roofing felts and modified bitumen sheets may be installed either perpendicular or parallel to the roof incline.

Roll a 12" (305 mm) wide piece of one of the intermediate felts listed into a full mopping of bitumen. Over that, apply one 24" (610 mm) wide. Over both, apply a full width piece. The remaining felts are to be applied full width, overlapping the preceding felts by 24⅔" (627 mm), so that at least 3 plies of felt cover the substrate at all locations.

Apply a full width piece of one of the cap sheets listed into a full mopping of bitumen. Subsequent sheets are to be applied in the same manner, with 4" (102 mm) side and end laps over the preceding sheets (6" [152 mm] end laps for DynaLastic products).

Apply all felts so that they are firmly and uniformly set, without voids, into the hot bitumen. Bitumen temperature should be at the Equiviscous Temperature (EVT), ±25°F (±14°C), at the point of application. All felt edges shall be well sealed. The bitumen shall be applied just before the felt, at a nominal rate of 23 lbs. per square (1.1 kg/m²). When applying over insulations, more than 23 lbs. per square (1.1 kg/m²) of bitumen may be needed due to the absorbency of the insulation. For modified bitumen sheets, the bitumen temperature shall be at a minimum of 400°F (204°C), or at the EVT, whichever is higher, when the sheet is set into it. This higher temperature maximizes the bonding of the modified bitumen sheet.

For cold weather application techniques, refer to **Paragraph 7.31.**

Steep Slope Requirements
Special procedures are required on inclines over ½" per foot (41.6 mm/m). Refer to **Paragraph 7.29.**

Surfacing
No additional surfacing is required.

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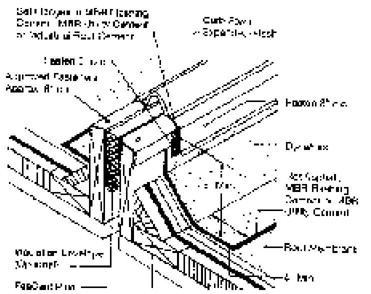
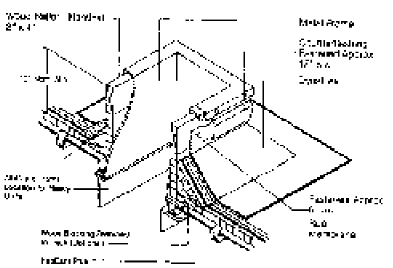
6.5.0 Built-Up Roof Flashing Details



Specification DFE-7

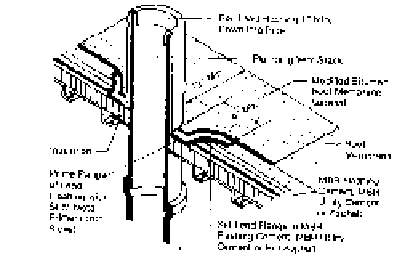
Expansion Joint Cover: Application of the base flashing is outlined in Specification DFE-1 (NLB). Install and splice Expand-O-Flash in accordance with the installation instructions provided with the product.

Prefabricated intersections, as well as horizontal-to-vertical transitions, are available to complete the Expand-O-Flash installation. Refer to Section 12 on "Roofing Accessories" in the current Schuller Commercial/Industrial Roofing Systems Manual.



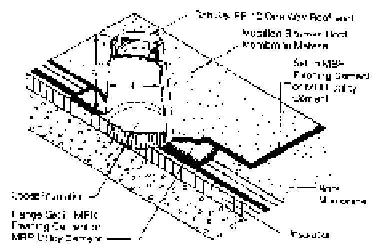
Specification DFE-8

Prefabricated Curbs: Refer to Flashing Specification DFE-1 (NLB) for detailed instructions on application of the base flashing. Base flashing tails should extend as far up the prefabricated curb as practicable, but not less than 8" (203 mm). Install the flashing receiver and metal counterflashing in accordance with the prefabricated curb manufacturer's specifications and details, or in accordance with the DFE-8 detail.



Specification DFE-9

Plumbing Vent Flashing: Prime both sides of the flange of the lead boot with SPM Metal Primer. Set the flange into a bed of MBR Flashing Cement, MBR Utility Cement, or a mopping of hot bitumen. Cover the flange with a layer of modified bitumen membrane sheet, set in MBR Flashing Cement, MBR Utility Cement, or hot bitumen. Roll the top edge of the lead boot down into the pipe a minimum of 1" (25 mm). Minimum weight of lead sheet: 2½ lbs. per square foot (12.2 kg/m²).

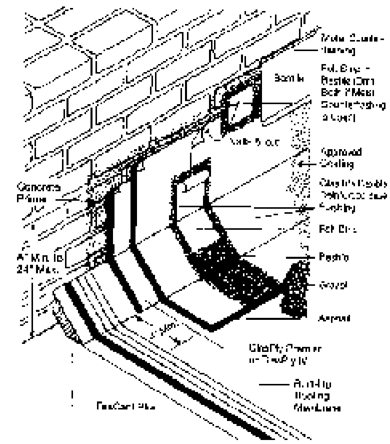


Specification DFE-10

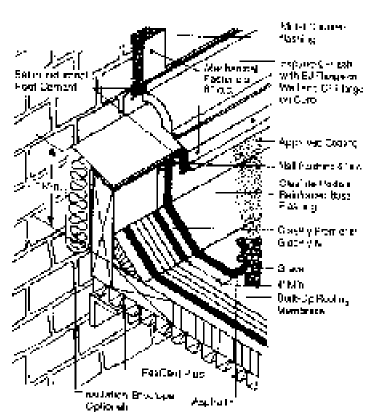
FP-10 One Way Roof Vent: Cut a 5" (127 mm) diameter hole in membrane. Remove all or part of the insulation, as necessary to facilitate venting; replace with loose insulation to prevent possible condensation. Apply a layer of MBR Flashing Cement or MBR Utility Cement around the 5" (127 mm) hole and press the vent flange into place. Flash in the vent with a layer of modified bitumen membrane sheet, set in MBR Flashing Cement or MBR Utility Cement.

Note: Hot asphalt may be used in lieu of the MBR Flashing or Utility Cements to set and flash in the vent, however, do not mix the two methods of application.

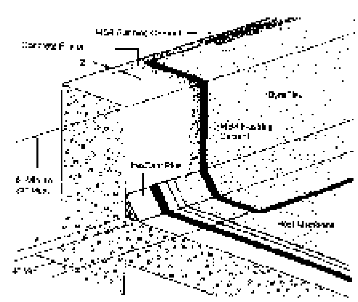
For load-bearing masonry parapet construction with nailing facilities



For non load-bearing construction, using roof-to-wall expansion joint cover



For load-bearing masonry parapet construction with no nailing facilities



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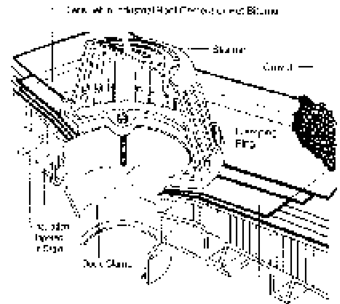
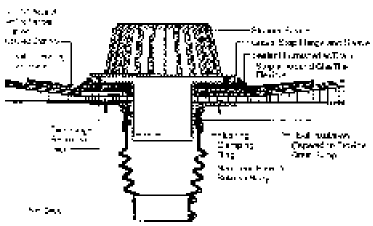
6.5.1 Built-Up Roof Flashing Details—Continued

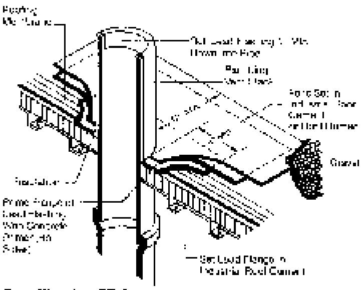


Specification FE-11

Flashing to Metal Drain: Run membrane plies to edge of drain opening. Prime both sides of a 30" (762 mm) square (minimum) piece of lead flashing (minimum 2.5 lb./sq. ft. [12.2 kg/m²]) with Schuller Concrete Primer and apply to the roof surface in Industrial Roof Cement. Cover the lead flashing with 2 plies of GlasPly Premier, GlasPly IV, or PermaPly R, set in Industrial Roof Cement or hot bitumen. Flashing felts should extend 4" and 6" (102 mm and 152 mm) beyond the edge of the lead flashing, in all directions. The membrane plies, lead flashing, and flashing felts should all extend under the clamping ring. Attach the clamping ring and tighten uniformly.

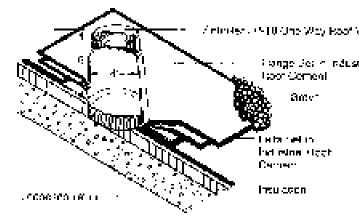


Specification FE-12



Specification FE-9

Plumbing Vent Flashing: Prime both sides of the flange of the lead boot with Schuller Concrete Primer and set into a bed of Industrial Roof Cement. Cover with 2 layers of GlasPly Premier, GlasPly IV, or PermaPly R, set in Industrial Roof Cement or hot bitumen. Roll top edge of lead boot down into pipe. Minimum weight of lead sheet: 2.5 lbs. per square foot (12.2 kg/m²).

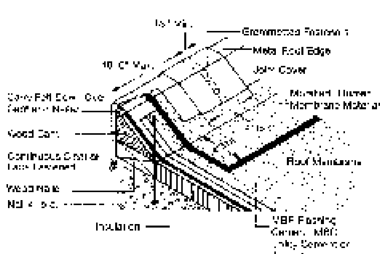


Specification FE-10

FP-10 One-Way Roof Vent: Cut a 5" (127 mm) diameter hole in the membrane. Remove all or part of the insulation, as necessary to facilitate venting; replace with loose insulation to prevent possible condensation. Apply a layer of Industrial Roof Cement around the 5" (127 mm) hole and press the vent flange into place. Flash in the vent with 2 plies of GlasPly Premier, GlasPly IV, or PermaPly R, set in Industrial Roof Cement. One FP-10 Vent should be used per 10 squares of roof area.

Note: Hot asphalt may be used in lieu of Industrial Roof Cement to set and strip in the vent, however, do not mix the two methods of application.

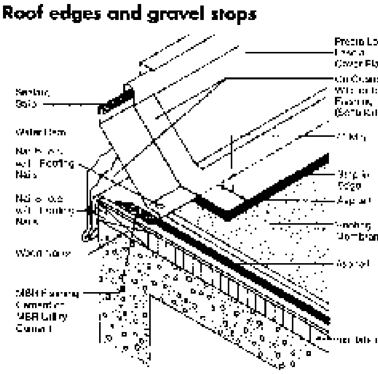
Roof Edge Details



FE-4 Roof Edge

Roof Edge

Roof edges and gravel stops



FE-4 Presto Lock

Presto Lock Fascia and Flashing System

(By permission of Schuller Roofing Systems, Denver, Colorado.)

6.6.0 Single-Ply Membrane Securement Data

A. The following charts indicate the required number of perimeter membrane sheets, width of field membrane sheets and required fastening density for Carlisle's Sure-Seal/Brite-Ply Mechanically Fastened Roofing System. The chart is categorized by deck type and includes four different wind zones which are identified on the "Basic Wind Speed Map" at the end of this section.

B. To determine appropriate securement requirements, identify project wind zone from the map and select the chart based on project deck type. The building height is then used to determine membrane securement requirements for the project.

Wind Zone	Deck Type (1)	Building Height	# of Perimeter Sheets	Field Membrane Width	Fastening Density (Field & Perimeter Sheets)
Zone 1 79 MPH or Less (126 km/h)	Steel and Lightweight Concrete over Steel	0' - 75' (23 m)	1	10' (3 m)	12" (31 cm) O.C.
		76' - 150' (23.2 - 46 m)	1	10'	6" (15.5 cm) O.C.
			1	7' (2.1 m)	12" O.C.
	Structural Concrete	0' - 75' (23 m)	1	10'	12" O.C.
		76' - 150' (23.2 - 46 m)	2	10'	12" O.C.
	Plywood, Wood Planks (2) or Oriented Strand Board	0' - 50' (15.2 m)	1	10'	12" O.C.
		51' - 150' (15.5 - 46 m)	2	10'	6" O.C.
	Gypsum and Fibrous Cement	0' - 75' (23 m)	2	10'	6" O.C.
			2	7'	12" O.C.
Zone 2 80 - 89 MPH (128-142 km/h)	Steel and Lightweight Concrete over Steel	0' - 75' (23 m)	1	10'	6" O.C.
			1	7'	12" O.C.
		76' - 100' (23.2 - 30.5 m)	2	10'	6" O.C.
			2	7'	12" O.C.
		101' - 150' (30.8 - 46 m)	2	10'	6" O.C.
	Structural Concrete	0' - 75' (23 m)	2	10'	12" O.C.
		76' - 150' (23.2 - 46 m)	2	10'	6" O.C.
			2	7'	12" O.C.
	Plywood, Wood Planks (2) or Oriented Strand Board	0' - 50' (15.2 cm)	2	10'	6" O.C.
			2	7'	12" O.C.
		51' - 150' (15.5 - 46 m)	4	10'	6" O.C.
	Gypsum and Fibrous Cement	0' - 50' (15.2 m)	2	10'	6" O.C.
			2	7'	12" O.C.

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6.6.0 Single-Ply Membrane Securement Data—Continued

Wind Zone	Deck Type (1)	Building Height	# of Perimeter Sheets	Field Membrane Width	Fastening Density (Field & Perimeter Sheets)
Zone 3 90-99 MPH (3) (144-158 km/h)	Steel and Lightweight Concrete over Steel	0' - 40' (12.2 m)	2	10' (3 m)	6" (15.5 cm) O.C.
			2	7' (2.1 m)	12" (31 cm) O.C.
		41' - 75' (12.5 - 30.5 m)	2	10'	6" (15.5 cm) O.C.
		76' - 100' (23.2 - 30.5 m)	2	7' (2.1 m)	6" O.C.
	Structural Concrete	0' - 75' (23 m)	2	10'	6" O.C.
			2	7'	12" O.C.
		76' - 150' (23.2 - 46 m)	3	7'	12" O.C.
			2	10'	6" O.C.
	Plywood, Wood Planks (2) or Oriented Strand Board	0' - 100' (30.5 m)	2	7'	6" O.C.
	Gypsum and Fibrous Cement	0' - 75' (23 m)	2	7'	6" O.C.
Zone 4 100 MPH (160 km/h) or Greater	Steel and Lightweight Concrete over Steel	0' - 100' (30.5 m)	2	7'	6" O.C.
	Structural Concrete	0' - 150' (46 m)	1	7'	6" O.C.
	Plywood, Wood Planks (2) or Oriented Strand Board	NOT ACCEPTABLE			
	Gypsum and Fibrous Cement	NOT ACCEPTABLE			

Notes:

(1) Refer to "Attachment I", Pullout Values/Withdrawal Resistance Criteria, for roof deck/pullout requirements and the required Carlisle Fastener.

(2) On plywood or wood plank decks, if pullout tests exceed 425 pounds (192 kg) per fastener, the membrane securement requirements for steel decks may be followed providing the pullout tests are submitted to Carlisle for approval.

(3) These areas located between wind zone contours of 90-100 MPH (144 - 160 km/h) that are within 20 miles (32 km) of the coastline shall be considered as a Zone 4 Wind Zone.

C. The fastening criteria shown above does not necessarily reflect Factory Mutual approvals. For specific requirements when a Factory Mutual rating is required, refer to the Carlisle *Code Approval Guide* which is published separately

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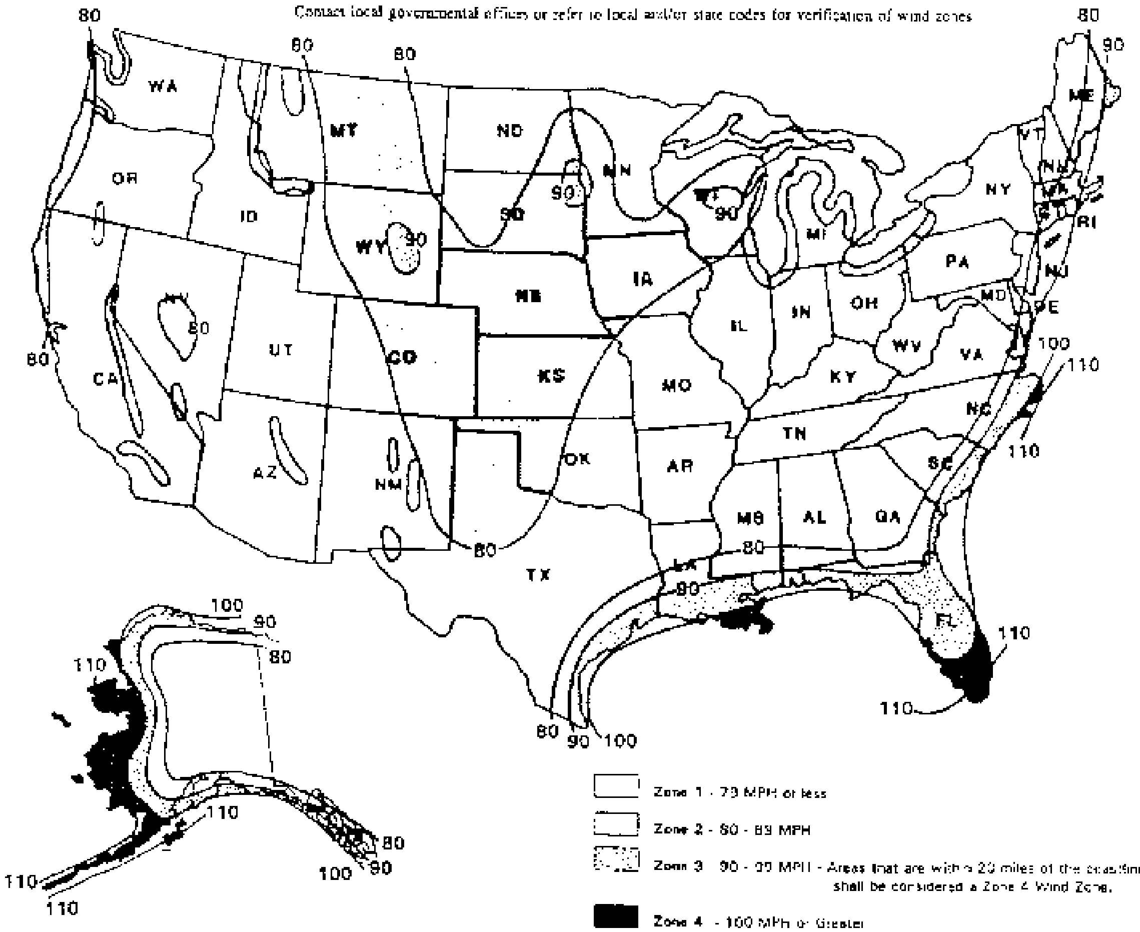
6.6.1 Basic Wind-Speed Map

This map is based on ASCE 7-99, formerly ANSI A 58.1–1982.



(By permission of The Carlisle Corporation, Carlisle, Pennsylvania.)

6.6.2 Single-Ply Membrane Ballasted Roof Stone Specifications

Rounded Water-Worn Gravel must be applied over the EPDM membrane at the minimum rate of 1000 pounds (488 kg/10 m²) per square and must be evenly distributed to maintain an average of 10 pounds per square foot (approximately 48.8 kg/m²).

ASTM D 448 SIZE NUMBER	MINIMUM COVERAGE RATE (pounds per square) (kg/10 m²)	AVERAGE COVERAGE RATE (pounds per square foot continuously distributed)	Average kg/m² (continuously distributed)
4 (1-1/2 inch; 3.8 cm) nominal diameter)	1000 (488)	10	48.8
3 (2 inch; 5 cm) nominal diameter)	1000 (488)	10	48.8
24 (2-1/2 inch; 6.4 cm) nominal diameter)	1000 (488)	10	48.8
2 (2-1/2 inch; 6.4 cm) nominal diameter)	1300 (634)	13	63.4
1 (3-1/2 inch; 8.9 cm) nominal diameter)	1300 (634)	13	63.4

Standard sizes of coarse aggregate - Based on ASTM D448

Size Number	1	2	24	3	4
Nominal Size Square Openings	3-1/2" (8.9 cm) to 1-1/2" (3.8 cm)	2-1/2" (6.4 cm) to 1-1/2" (3.8 cm)	2-1/2" (6.4 cm) to 3/4" (1.9 cm)	2" (5 cm) to 1" (2.5 cm)	1-1/2" (3.8 cm) to 3/4" (1.9 cm)
Amounts Passing Each Lab Sieve (Square Opening), Percent (%)					
4" (10 cm)	100				
3-1/2" (8.9 cm)	90 to 100				
3" (8 cm)		100	100		
2-1/2" (6.4 cm)	25 to 60	90 to 100	90 to 100	100	
2" (5 cm)		35 to 70		90 to 100	100
1-1/2" (3.8 cm)	0 to 15	0 to 15	25 to 60	35 to 70	90 to 100
1" (2.5 cm)				0 to 15	20 to 55
3/4" (1.9 cm)	0 to 5	0 to 5	0 to 10		0 to 15
1/2" (1.3 cm)			0 to 5	0 to 5	
3/8" (1 cm)					0 to 5

(By permission of The Carlisle Corporation, Carlisle, Pennsylvania.)

6.6.3 Single-Ply Membrane Splicing Cement Guide

One gallon of Splicing Cement, applied in a medium, relatively even coat, will achieve the approximate coverage rates as listed:

Linear Feet	Splice Width
150 feet	3 inches
120 feet	4 inches
100 feet	5 inches
85 feet	6 inches
75 feet	7 inches

Note: The above coverage rates have been calculated to include the application of Splicing Cement 1 inch beyond the splice width on both mating surfaces of the membrane.

FOR CURED-TO-CURED MEMBRANE SPLICES ONLY:

a. While the Splicing Cement is drying, apply a bead of In-Seam Sealant™ no less than 1/8 inch and no more than 1/4 inch wide within 1/2 inch of the inside edge of the bottom membrane sheet.

Note: When minimum 6-inch wide membrane splices incorporate Sure-Seal HP Purlin Fasteners and HP Locking Seam Plates, the In-Seam Sealant shall be applied along the center line used to locate fastening plates (approximately 3 inches from the edge of the membrane sheet). At the Fastening Plates, apply the In-Seam Sealant around the edge of the plate which is nearest the outside edge of the top membrane sheet. Refer to Detail MR-2-B.

Approximately 75 linear feet of coverage per tube can be achieved when a 5/32 inch diameter bead of In-Seam Sealant is applied.

b. Maintain a continuous bead of In-Seam Sealant on all membrane splices.

c. During splice cleaning procedures, Sure-Seal HP Splice Wipes contaminated with In-Seam Sealant cannot be reused for the application of Splice Cleaner.

Allow the cement to dry until it is tacky but will not string or stick to a dry finger touch and will not move when pushed with a dry finger.

Roll the top membrane sheet onto the mating surface. Take care not to stretch or wrinkle the membrane sheet to avoid a fishmouth in the field splice.

Assemble the seam with hand pressure by wiping toward the splice edge.

Immediately roll the splice with a 2-inch wide steel roller, using positive pressure, toward the outer edge of the splice. DO NOT ROLL PARALLEL TO THE SPLICE EDGE. On a completed splice, the In-Seam Sealant must remain evident and must be sensitive to the touch.

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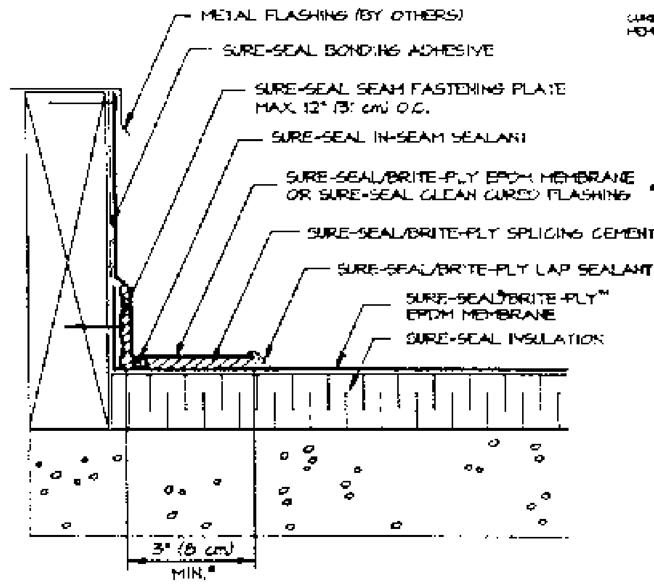
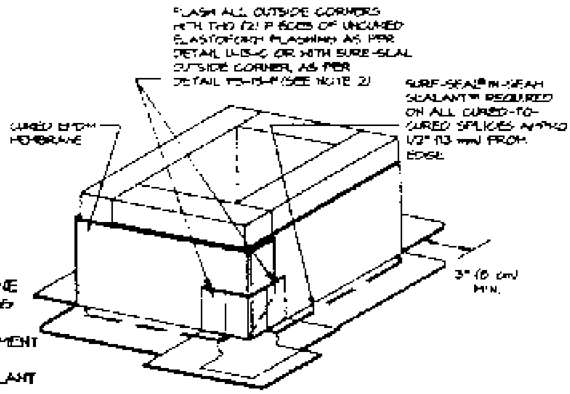
6.7.0 Single-Ply Membrane Curb Flashing Details

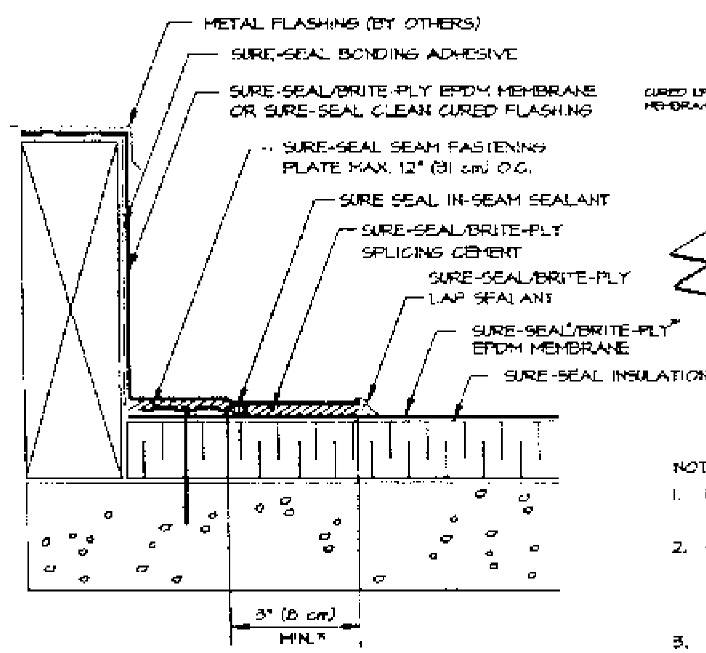


* FOR PROPER IN-SEAM SEALANT PLACEMENT REFER TO DETAIL U-2

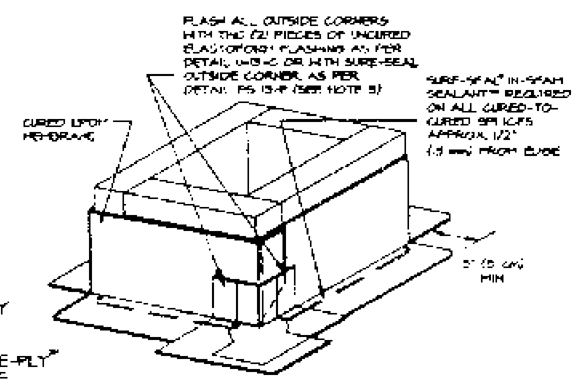


NOTES:

1. FASTEN MEMBRANE FLASHING 12 IN. (31 cm) ON CENTER. IF FASTENER PENETRATES METAL COUNTERFLASHING, USE EPDM WASHER OR APPLY WATER CUT-OFF MASTIC OR CAULK FASTENER HEAD.
2. IF VERTICAL SPLICE NOT LOCATED AT CORNER, 6 IN. (15.5 cm) WIDE UNCURED ELASTOFORM FLASHING OR PRESSURE-SENSITIVE FLASHING MUST BE CENTERED OVER FIELD SPLICE AT ANGLE CHANGE.



* FOR PROPER IN-SEAM SEALANT PLACEMENT REFER TO DETAIL U-2



NOTES:

1. FOR ALTERNATE CURB FLASHING REFER TO DETAIL U-12-C OR U-12-D.
2. HP LOCKING SEAM PLATES OR POLYMER SEAM PLATES ARE REQUIRED IN LIEU OF SEAM FASTENING PLATES FOR MECHANICALLY FASTENED ROOFING SYSTEMS OVER STEEL DECKS.
3. IF VERTICAL SPLICE NOT LOCATED AT CORNER, 6 IN. (15.5 cm) WIDE UNCURED ELASTOFORM FLASHING OR PRESSURE SENSITIVE FLASHING MUST BE CENTERED OVER FIELD SPLICE AT ANGLE CHANGE.

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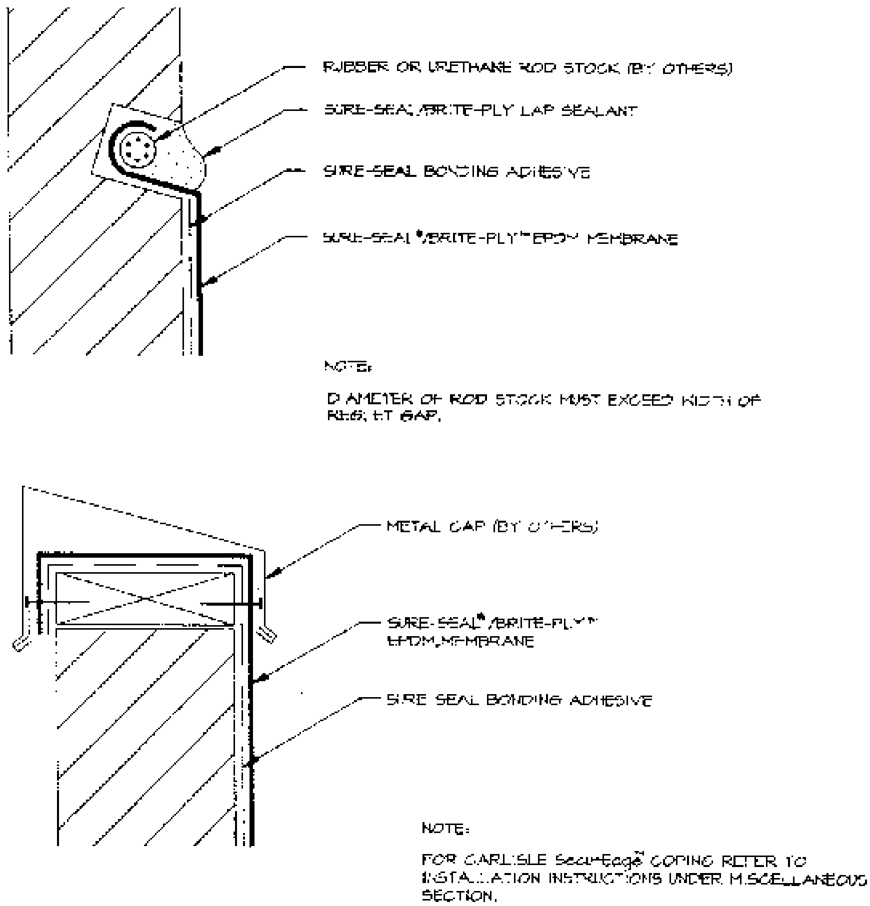
6.7.1 Single-Ply Membrane Reglet and Cap Flashing Details



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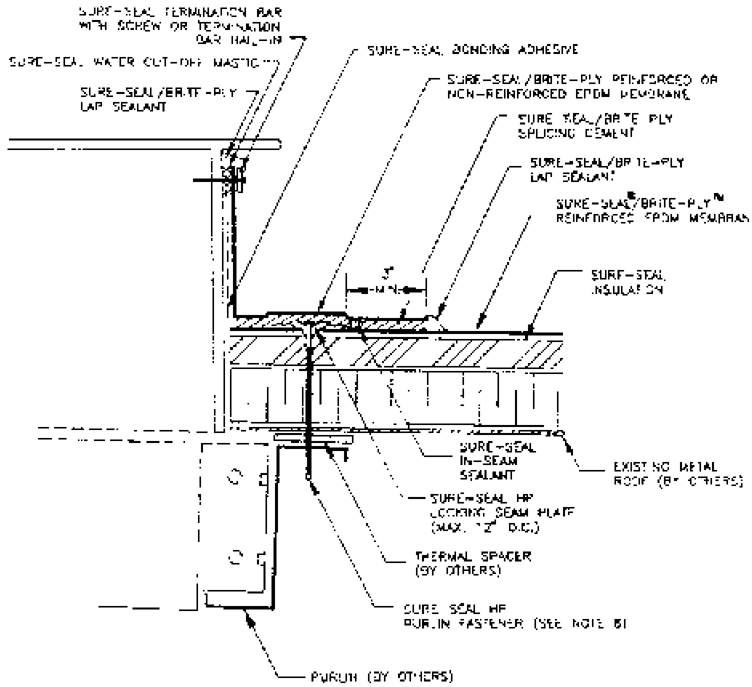
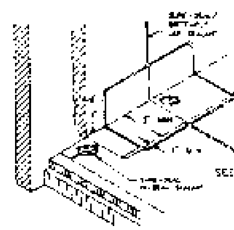
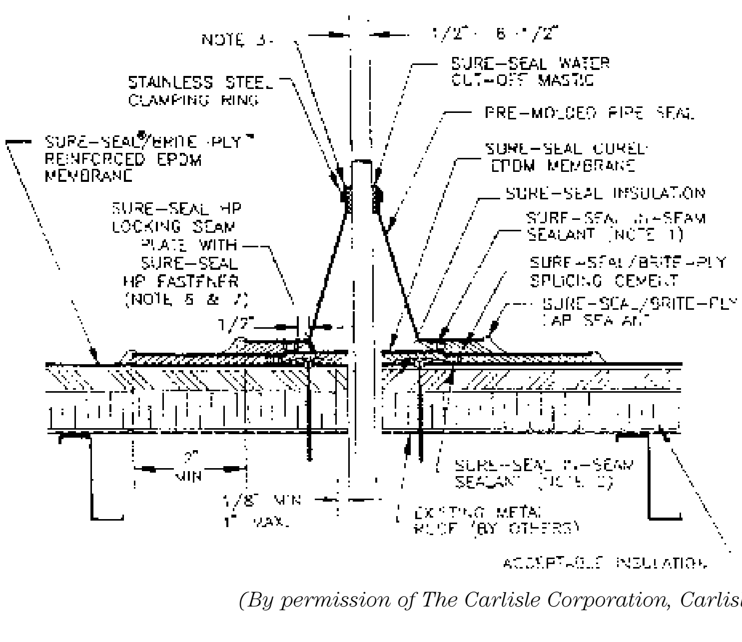
6.7.2 Single-Ply Membrane Curb and Vertical Pipe Flashing Details





NOTES:

1. SEE DETAIL MR-2-C FOR PROPER MEMBRANE SPLICE BETWEEN CURED EPDM MEMBRANE SECTIONS.
2. LOCATE TERMINATION ABOVE ANTICIPATED WATER LEVEL.
3. MAINTAIN A CONTINUOUS BEAD OF IN-SEAM SEALANT AT ALL MEMBRANE SPLICES; ESPECIALLY AT SPLICE INTERSECTIONS. REFER TO MR-2-C DETAIL.
4. IN-SEAM SEALANT IS REQUIRED ON ALL VERTICAL SPLICES BETWEEN ADJOINING SECTIONS OF CURED EPDM MEMBRANE.
5. IF A CONTINUATION OF THE DECK MEMBRANE IS TO BE USED AS WALL FLASHING, REFER TO DETAIL MR-12-D.
6. 6 INCH WIDE UNCURED ELASTOFORM FLASHING MUST BE CENTERED OVER FIELD SPLICE.
7. MEMBRANE MAY BE SECURED VERTICALLY WITH AN APPROPRIATE CARLISLE FASTENER AND STANDARD SEAM FASTENING PLATE.
8. HP PURLIN FASTENERS MUST PENETRATE THE PURLIN A MINIMUM OF 1 INCH.



NOTES.

1. APPLY IN SEAM SEALANT 1/2 INCH FROM THE INSIDE EDGE OF THE PIPE SEAL FLANGE.
2. IN-SEAM SEALANT MUST BE LOCATED A MAXIMUM OF 1/2 INCH AWAY FROM THE HP LOCKING SEAM PLATE AND SHALL BE CONTINUOUS AROUND THE PIPE.
3. PRE MOLDED PIPE SEAL MUST HAVE INTACT RIB AT THE TOP EDGE REGARDLESS OF PIPE DIAMETER.
4. HP LOCKING SEAM PLATES ARE ALSO REQUIRED AROUND FIELD FABRICATED PIPE SEALS (U-14 DETAILS).
5. SEE SPECIFICATION FOR OTHER DETAILS REQUIRING HP LOCKING SEAM PLATES.
6. SPACING SHALL BE A MAXIMUM OF 6 INCHES ON CENTER INTO 26 AND 28 GAUGE METAL ROOFING. SPACING CAN BE A MAXIMUM OF 12 INCHES ON CENTER INTO 24 GAUGE METAL ROOFING PROVIDING THE PULLOUT VALUES IDENTIFIED IN THIS SPECIFICATION ARE ACHIEVED.
A MINIMUM OF 3 HP FASTENERS AND SURE-SEAL HP LOCKING SEAM PLATES ARE REQUIRED.
7. HP FASTENER MUST PENETRATE THE EXISTING ROOF A MINIMUM OF 3/4 INCH.

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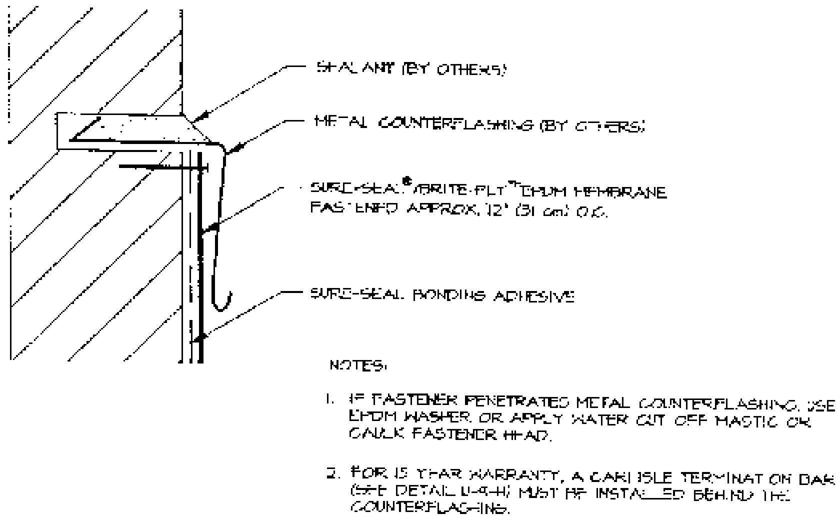
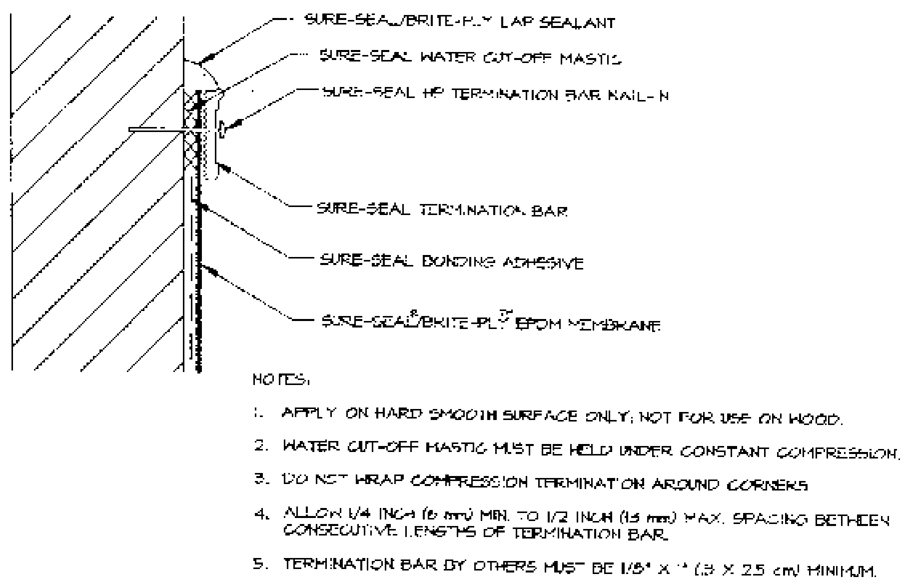
6.7.3 Single-Ply Membrane Counterflashing/Vertical Termination Flashing Details





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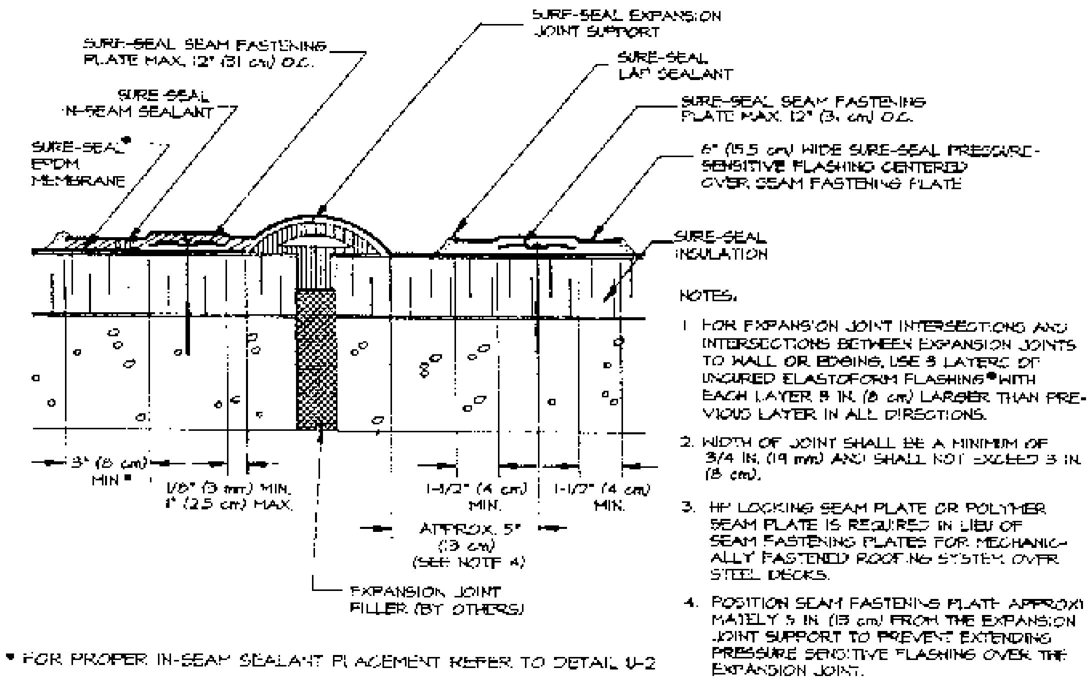
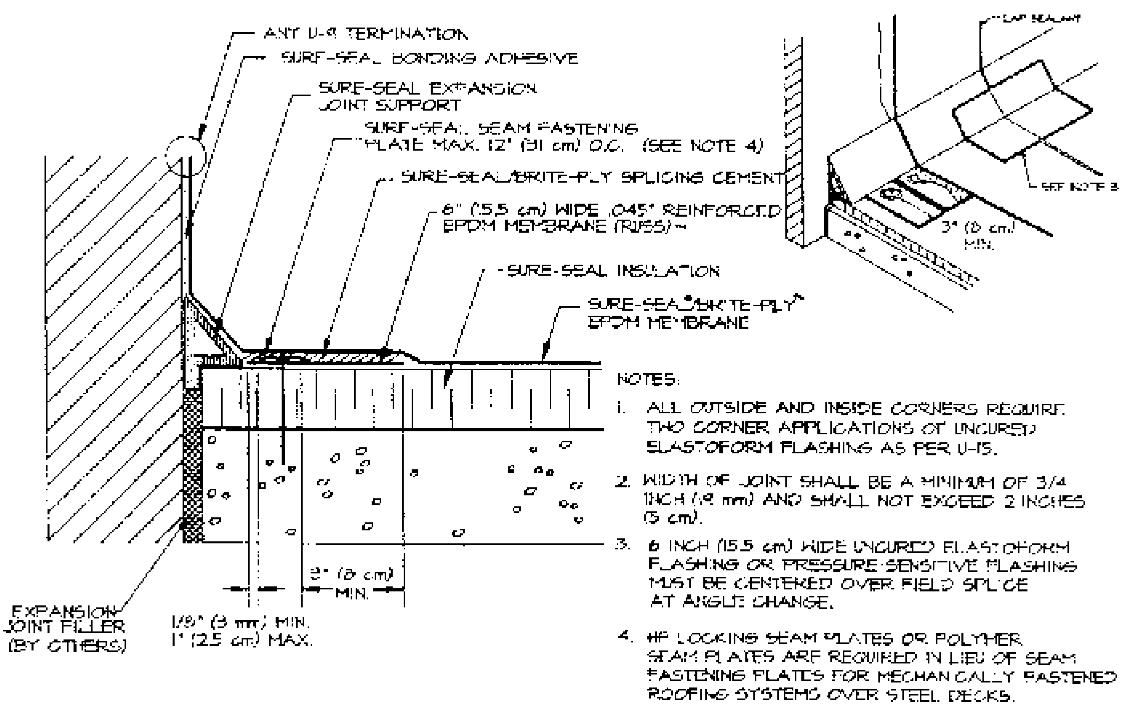
6.7.4 Single-Ply Membrane Expansion-Joint Details





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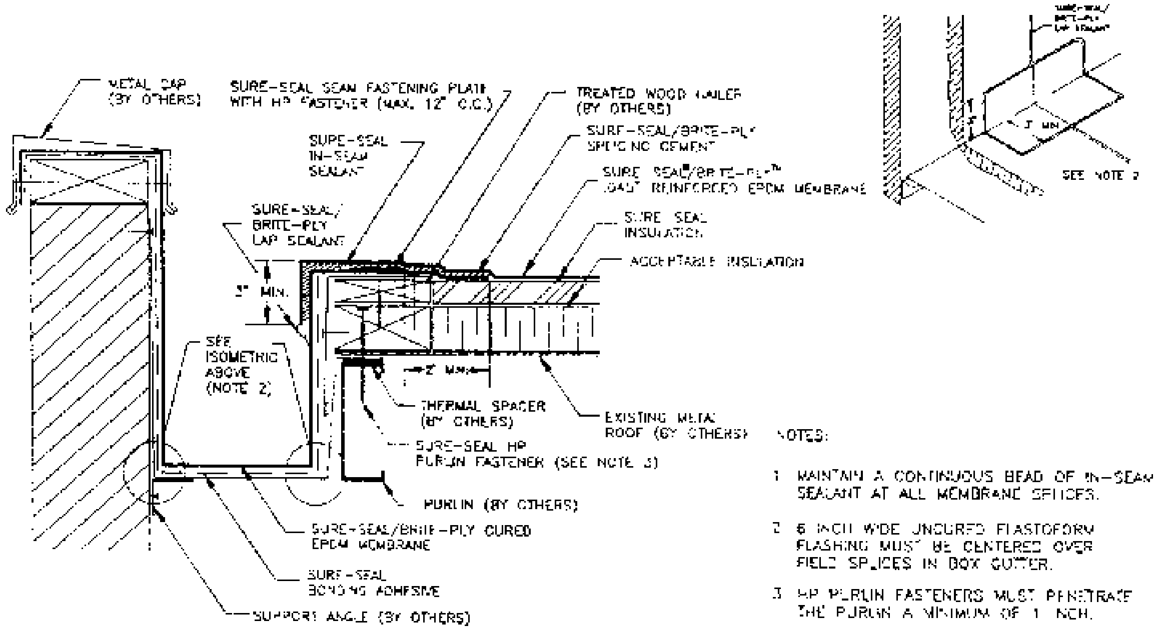
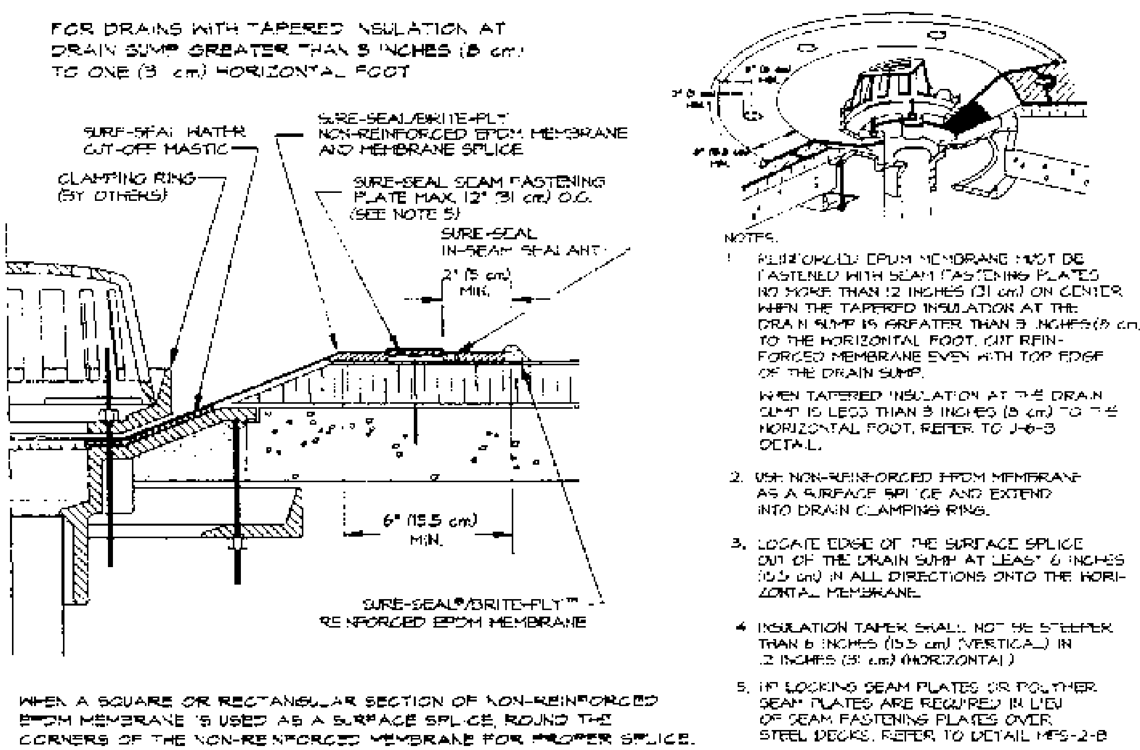
6.7.5 Single-Ply Membrane Box Gutter/Roof Drain Flashing Details





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6.7.6 Single-Ply Membrane Acceptable Roof Deck Chart

1. Proper decking shall be provided by the building owner. The building owner or its designated representative must have a registered engineer investigate the building structure to ensure its ability to withstand the total weight of this roofing system, as well as construction loads and live loads, in accordance with all applicable codes. The specifier must also designate the maximum allowable weight and location for material loading and storage on the roof.
2. Acceptable decks, minimum pullouts, and approved Carlisle Fasteners:

Deck Type	Minimum Pullout	Approved Fastener	Minimum Penetration
Steel, 22 gauge or heavier	425 pounds	HP Fastener	3/4 Inch
Lightweight Insulating Concrete over Steel	360 pounds	HP Fastener	3/4 Inch
Structural Concrete, rated 3,000 psi or greater	800 pounds	HP Concrete Spike or HP Fastener (1)	1-1/4 Inches
Wood Planks and Plywood (minimum 15/32 inch thick APA Grade CDX)	360 pounds	HP Fastener (2)	1 Inch (Maximum 1 1/2-inches on wood planks)
Oriented Strand Board (OSB) (minimum 7/16 inch thick APA Rated non-veneer)	360 pounds	HP Woodie Fastener (3)	1-1/2 Inches
Cementitious Wood Fiber and Gypsum	300 pounds	HP Lightweight Deck Fastener	1-1/2 Inches

Notes:
1. HP Fasteners over 6 inches in length are not recommended for use on concrete decks.
2. If the minimum pullout into plywood decks cannot be achieved, a trial test should be conducted with the HP Woodie Fastener to determine acceptability (refer to Note 3 below).
3. A maximum of 1 1/2-inch thick insulation can be specified in conjunction with HP Woodie Fasteners.

If toggle bolts are specified for membrane securement, contact Carlisle for requirements.

3. Withdrawal resistance tests are strongly suggested to determine the suitability of a roof deck. Cementitious wood fiber, gypsum, lightweight insulating concrete over steel and oriented strand board (regardless of thickness), or plywood (less than ⅝ inch in thickness) must be tested. If the minimum pullout requirements cannot be achieved, Carlisle may be contacted for options concerning an appropriate roofing system.

6.8.0 Single-Ply Membrane Underwriters Laboratories Specifications

The following information highlights the Underwriters Laboratories (UL) and Factory Mutual (FM) code ratings achieved with Carlisle's Sure-Weld Mechanically Fastened Roofing System:

UL Class "A"

Deck Type	Insulation	Thickness	Maximum Slope
Non-Combustible and Combustible (For combustible decks, gypsum wallboard must be installed beneath the insulations listed) (1) (2)	Carlisle HP Recovery Board	1/2"-3"	1"
	Carlisle HP Recovery Board/Polyisocyanurate	1/2" Min./Any	1"
	Carlisle HP Recovery Board/Polystyrene	1/2" Min./Any	1"
	Carlisle Polyisocyanurate HP, HP-N or HP-W	Any	1/2"
Combustible	Gypsum Board Gypsum Board/Polyisocyanurate Gypsum Board/Polystyrene	1/2" 1/2"/Any 1/2"/Any	2" 2" 2"

UL Class "B"

Deck Type	Insulation (3)	Thickness	Maximum Slope
Combustible	Carlisle Polyisocyanurate HP, HP-N, HP-W	2" Min.	1/2"
	Carlisle Polyisocyanurate/G2 Base Sheet (4)	1-1/2" Min./ G2 Base	1/2"
	HP Recovery Board Board/Polyisocyanurate	1/2" Min./ 1-1/2" Min.	1"
	HP Recovery Board/Polyisocyanurate/G2 Base Sheet (4)	1/2" Min./1" Min./G2 Base	1"
	HP Recovery Board/G2 Base Sheet (4)	1" Min./G2 Base	1"

Notes:

(1) Minimum 1/2 inch thick gypsum wallboard can be a classified or unclassified material with a minimum weight of 1.84 pounds per square foot. 1/4 inch thick Georgia Pacific Dens-Deck or Sound Deadening Board with a minimum weight of 1.09 pounds per square foot may be substituted for 1/2 inch thick gypsum wallboard.

(2) On Retrofit/No Tearoff projects, where the existing roof is Class A rated, the gypsum board can be eliminated. Existing roofs which are Class B or C rated will require the use of gypsum board to achieve a Class A rating, otherwise, the new roofing system will retain the existing UL rating.

(3) Insulation joints (bottom layer) are to be staggered a minimum of 6 inches from joints in wood deck.

(4) Acceptable G2 base sheets can be one of the following: Celotex Type G2 Vaporbar GB, GAF Gafglas No. 75 Base Sheet, Manville Glasbase, Owens Corning Perma Ply No. 28 or Tamko Glass Base.

(By permission of The Carlisle Corporation, Carlisle, Pennsylvania.)

6.9.0 Single-Ply Membrane Roofing Preventative Maintenance Guidelines

Periodic maintenance to the roofing system will help to address those locations where moisture could infiltrate and cause damage. It is imperative that the building owner recognizes the importance of preventative maintenance in an effort to increase the life expectancy of the roofing system beyond the warranty period.

Preventative Maintenance

The following is a list of general care and maintenance requirements for Carlisle Roofing Systems. These maintenance items will help attain maximum performance from the roofing system.

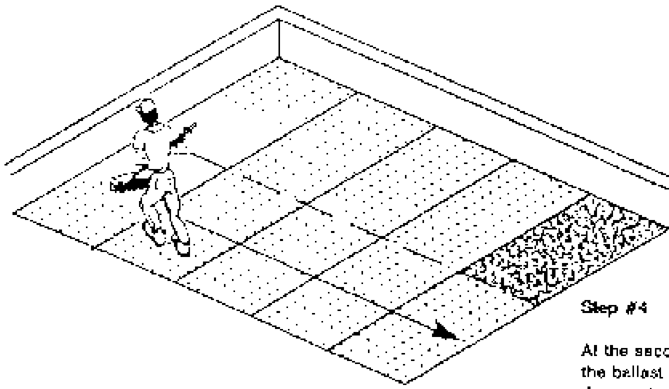
- *Provide proper drainage* Keep the roof surface clean of leaves, twigs, paper or accumulated dirt at drain areas to avoid clogged drains. Excessive ponding of water on the surface of the membrane will increase the probability of moisture entering the structure in the event of a puncture or cut in the membrane.
- *Avoid degrading the membrane*.

Do not expose the membrane to the following materials because of possible degradation of the membrane:

- Liquids that contain petroleum products
- Solvents
- Grease used for lubricating roof top units
- Oils (new or old) used for air conditioning or compressor units
- Kitchen wastes or other animal fats
- Chemicals

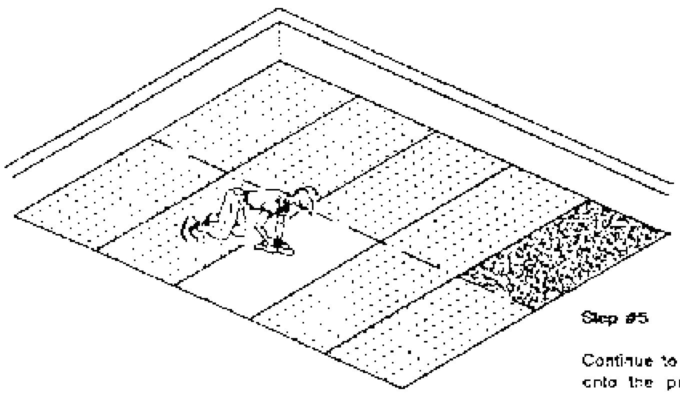
Catch pans and proper drainage of the pans or other means of containment can be used for membrane protection. Prolonged exposure to these materials will cause swelling and possible degradation of the membrane if the spills are not removed.

6.9.1 Investigation of Leaks on a Ballasted Single-Ply Membrane Roof



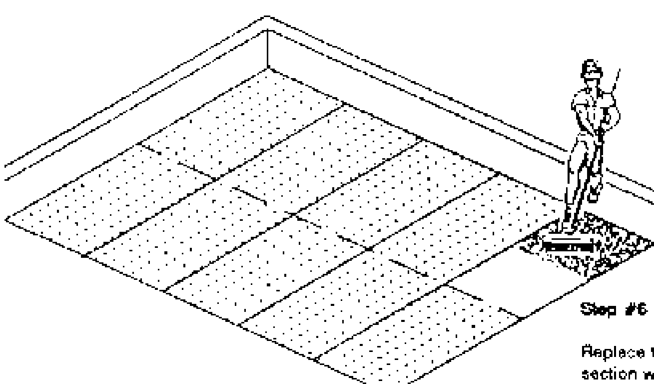
Step #4

At the second half of the area to be investigated, continue to remove the ballast from the section between factory splices by pushing it onto the previously exposed membrane at the end of the first half of the area being investigated.



Step #5

Continue to remove ballast from consecutive sections by pushing it onto the previously exposed membrane at the adjoining section already investigated. Continue removing and replacing ballast along the second half of the area being investigated until the last section is exposed.



Step #6

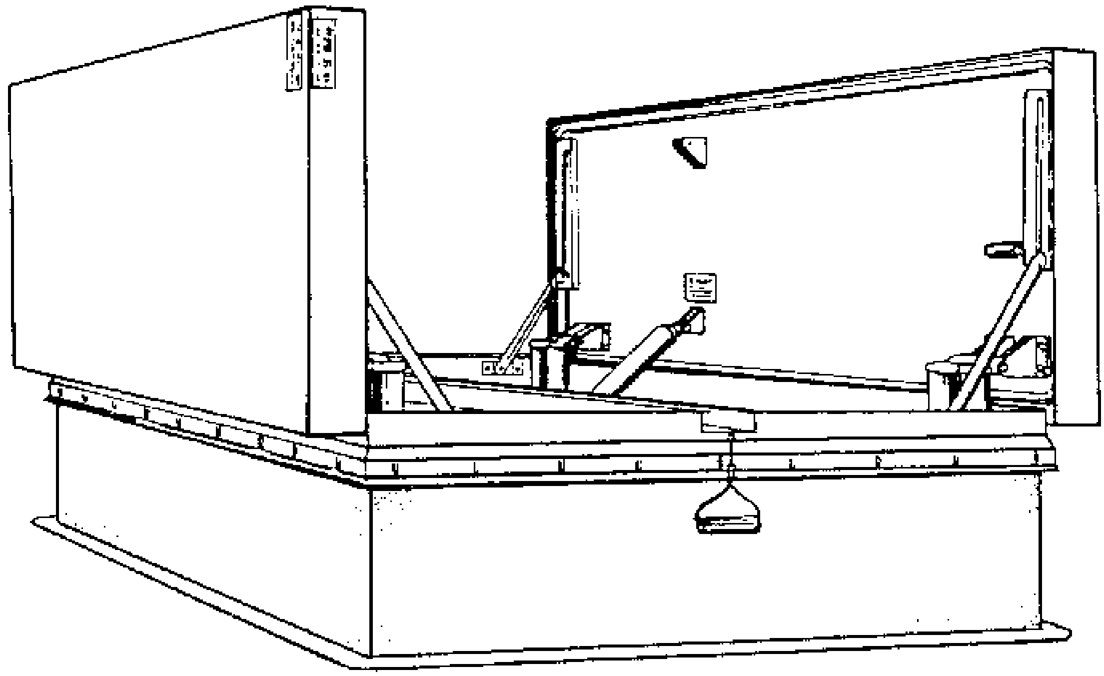
Replace the ballast at the last section with half the ballast from the first section where ballast removal initially began to expose the final factory splice section. After investigating the final section, replace the ballast

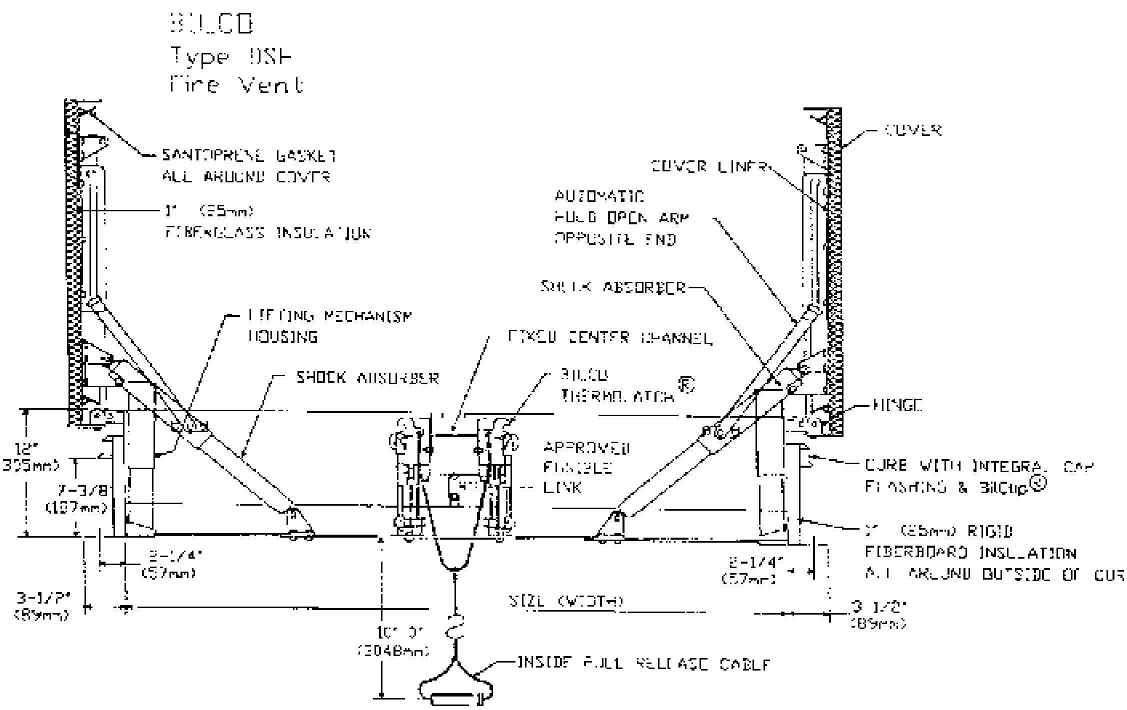
Continue the procedure across all sections of the roof (maximum 30 feet wide) until the leak has been found.

Use of the ballast removal steps, outlined above, avoids the double movement of ballast except at the first section.

(By permission of The Carlisle Corporation, Carlisle, Pennsylvania.)

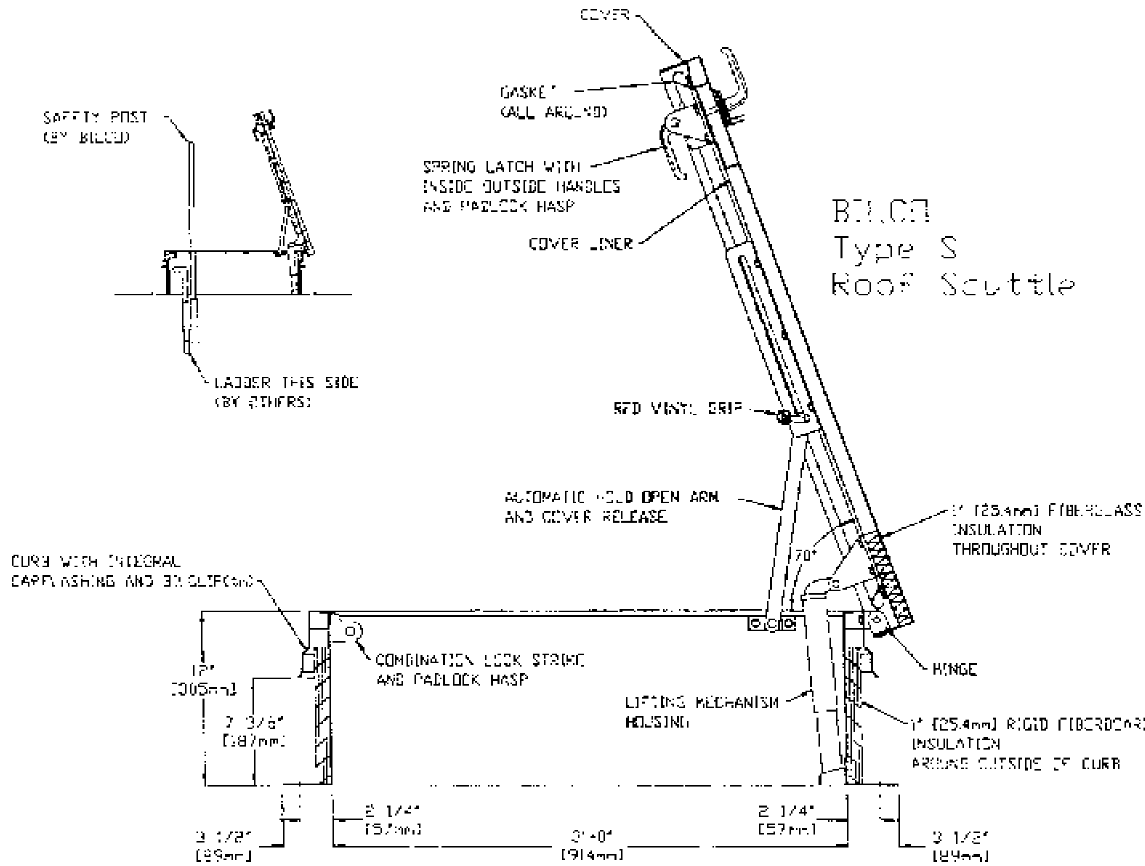
6.10.0 A Typical Fire Vent for BUR and SPM roofs

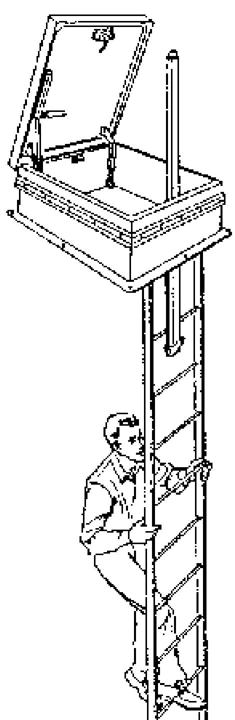




(By permission of the Bilco Company, New Haven, Connecticut.)

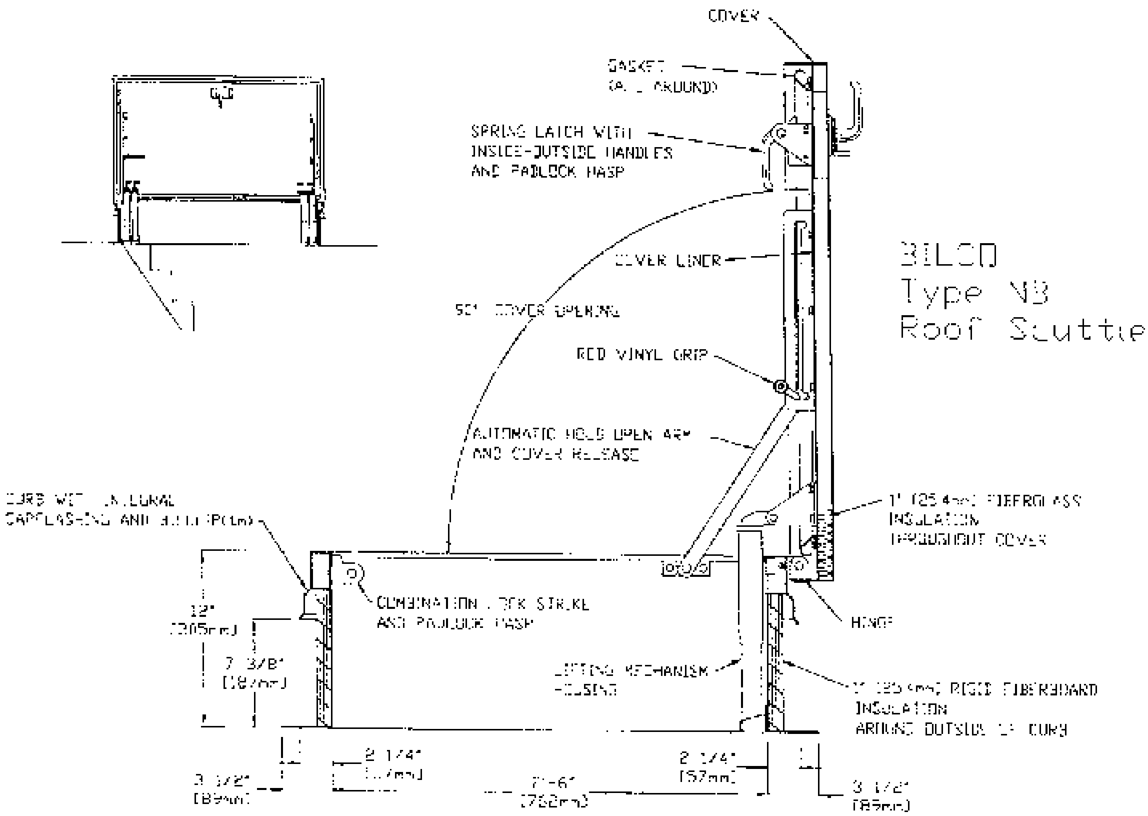
6.10.1 A Typical Roof Hatch Where a Ladder Is Used for Access

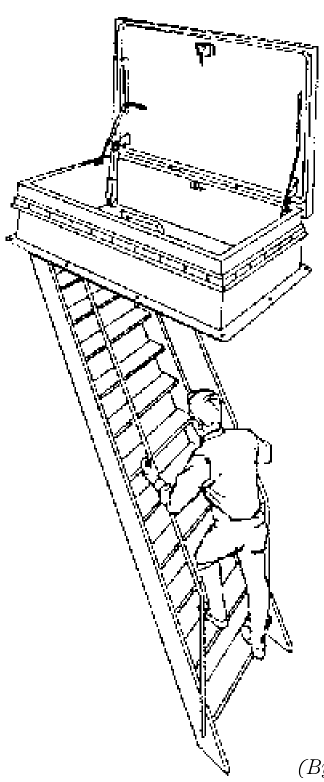




(By permission of the Bilco Company, New Haven, Connecticut.)

6.10.2 Typical Roof Hatch Where a Ships Ladder Is Used for Access





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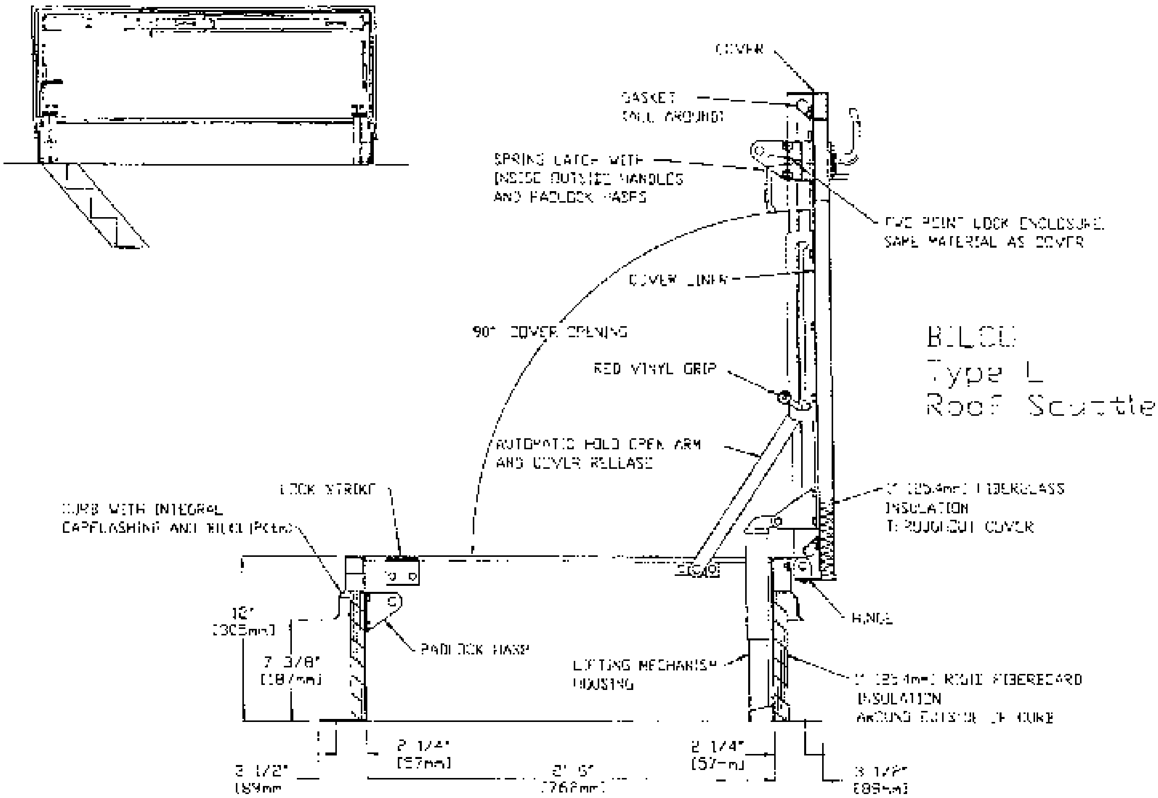
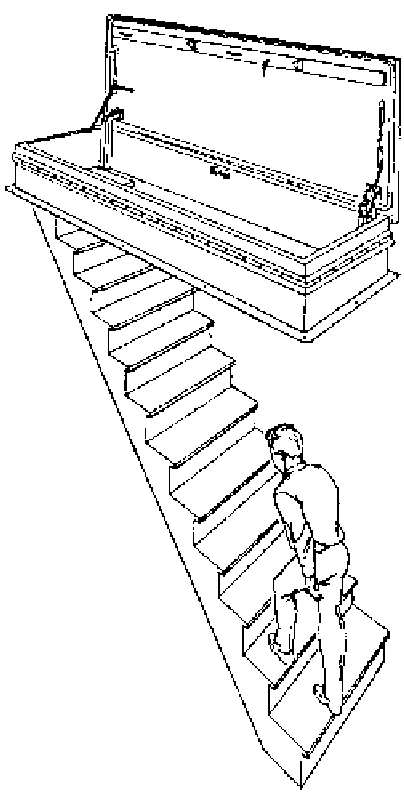
6.10.3 Typical Roof Hatch Installation Where Stairs Are Used for Access





(By permission of the Bilco Company, New Haven, Connecticut.)

6.11.0 Copper and Lead-Coated Copper Roofing Material Sizes and Weights

Manufactured in accordance with ASTM B 370

COLD ROLLED COPPER SHEET							
SIZES			COLD ROLLED			LEAD COATED	
			POUNDS PER SHEET	POUNDS PER CASE	SHEETS PER CASE	POUNDS PER CASE	SHEETS PER CASE
* 12 oz.	(.0162)	36 x 96	17.8	1068	60		
12 oz	(.0162)	36 x 120	22.3	1070	48		
16 oz.	(.0216)	24 x 96	15.8	1027	65	1027	65
16 oz	(.0216)	24 x 120	19.8	990	50	990	50
16 oz.	(.0216)	30 x 96	19.8	990	50	990	50
16 oz.	(.0216)	30 x 120	24.7	988	40		
16 oz.	(.0216)	36 x 96	23.7	1042	44	1042	44
16 oz	(.0216)	36 x 120	29.7	1069	36	1069	36
20 oz.	(.0270)	24 x 96	19.9	1054	53		
20 oz.	(.0270)	24 x 120	24.9	1070	43		
20 oz	(.0270)	30 x 96	24.9	1070	43		
20 oz.	(.0270)	30 x 120	31.1	1088	35		
20 oz	(.0270)	36 x 96	29.9	1046	35	1046	35
20 oz.	(.0270)	36 x 120	37.3	1044	28	1044	28
24 oz.	(.0323)	36 x 96	35.6	1068	30		
24 oz.	(.0323)	36 x 120	44.5	1112	25		
32 oz	(.0431)	36 x 96	47.3	1040	22		
32 oz.	(.0431)	36 x 120	59.1	1063	18		
48 oz.	(.0646)	36 x 96	70.9	1063	15		
48 oz.	(.0646)	36 x 120	88.7	1064	12		

COLD ROLLED COPPER COILS				
GAUGE		WIDTH	COIL ID	COIL WT.
16 oz.	(.0216)	9 15/16"	16"	1500/2000#
16 oz.	(.0216)	9 7/8"	16"	1500/2000#
16 oz.	(.0216)	10 1/2"	16"	1500/2000#
16 oz.	(.0216)	11 5/8"	16"	1500/2000#
16 oz.	(.0216)	11 3/4"	16"	1500/2000#
16 oz	(.0216)	11 7/8"	16"	1500/2000#
16 oz.	(.0216)	13 1/8"	16"	1500/2000#
16 oz.	(.0216)	13 3/4"	16"	1500/2000#
16 oz.	(.0216)	15"	16"	1500/2000#
16 oz.	(.0216)	18"	20"	1000/1200#
16 oz.	(.0216)	20"	20"	1000/1200#
16 oz.	(.0216)	24"	20"	1000/1200#

SOFT COPPER ROLLS		
SIZE AND GAUGE	NO. OF ROLLS PER BOX	NET WEIGHT PER BOX
6" x 16 oz. (.0216)	5	500
7" x 16 oz. (.0216)	5	500
8" x 16 oz. (.0216)	5	500
10" x 16 oz (.0216)	5	500
12" x 16 oz. (.0216)	5	500
14" x 16 oz. (.0216)	5	500
16" x 16 oz. (.0216)	5	500
18" x 16 oz. (.0216)	5	500
20" x 16 oz. (.0216)	5	500
24" x 16 oz (.0216)	5	500

* Weight of a square foot of material is equal to the above identified ounces.

6.12.0 Standard Sizes and Exposure to Weather for Slate Roof Tiles

SCHEDULE OF STANDARD ROOFING SIZES

Standard thickness 3/16 inch; Other thicknesses available.

Sizes of slate, in.	No. in each sq.	Exposed when laid 3 in. lap	Approximate nails needed per square	
			LBS.	OZS.
24x16	86	10-1/2 in.	1	0
24x14	98	10-1/2 in.	1	2
24x13	106	10-1/2 in.	1	3
24x11	125	10-1/2 in.	1	7
24x12	114	10-1/2 in.	1	5
22x14	108	9-1/2 in.	1	4
22x13	117	9-1/2 in.	1	5
22x12	126	9-1/2 in.	1	7
22x11	138	9-1/2 in.	1	9
22x10	152	9-1/2 in.	1	12
20x14	121	8-1/2 in.	1	6
20x13	132	8-1/2 in.	1	8
20x12	141	8-1/2 in.	1	10
20x11	154	8-1/2 in.	1	12
20x10	170	8-1/2 in.	1	15
20x 9	189	8-1/2 in.	2	3
18x14	137	7-1/2 in.	1	9
18x13	148	7-1/2 in.	1	11
18x12	160	7-1/2 in.	1	13
18x11	175	7-1/2 in.	2	0
18x10	192	7-1/2 in.	2	3
18x 9	213	7-1/2 in.	2	7
16x14	160	6-1/2 in.	1	13
16x12	184	6-1/2 in.	2	2
16x11	201	6-1/2 in.	2	5
16x10	222	6-1/2 in.	2	8
16x 9	246	6-1/2 in.	2	13
16x 8	277	6-1/2 in.	3	2
14x12	218	5-1/2 in.	2	8
14x11	238	5-1/2 in.	2	11
14x10	261	5-1/2 in.	3	3
14x 9	291	5-1/2 in.	3	5
14x 8	327	5-1/2 in.	3	12
14x 7	374	5-1/2 in.	4	4
12x10	320	4-1/2 in.	3	10
12x 9	355	4-1/2 in.	4	1
12x 8	400	4-1/2 in.	4	9
12x 7	457	4-1/2 in.	5	3
12x 6	533	4-1/2 in.	6	1
10x 8	515	3-1/2 in.	5	14
10x 7	588	3-1/2 in.	7	4
10x 6	686	3-1/2 in.	7	13

(By permission from Buckingham Slate, Arvonia, Virginia.)

6.12.1 Slate Roof Installation Procedures

SLATE

(A) Slate shall be Genuine Unfading BUCKINGHAM-VIRGINIA SLATE as furnished by the Buckingham-Virginia Slate Corporation, 1 Main Street, P.O. Box 8, Arvonia, Virginia 23004, of the following sizes and thicknesses:
(B) All slate shall be hard, dense, sound rock, punched for two nails each. No cracked slate shall be used. All exposed corners shall be practically full. No broken corners on covered ends which sacrifice nailing strength or the laying of a water-tight roof will be allowed.

SLATING

(A) The entire surface of all roofs, unless otherwise specified, and all other surfaces so indicated on the drawings, shall be covered with slate as herein specified, in a proper and watertight manner.
(B) The slate shall project 2" at the eaves and from 1/2" to 1" as directed at all gable ends, and shall be laid in horizontal courses with 3" headlap, and each course shall break joints with the preceding one by at least 3". Slates at the eaves or cornice line shall be doubled using same thickness slate for under-eaves at first exposed course. Under eave slate to be approximately 3" longer than exposure of first course.
(C) Wood cant strip at eaves to be furnished by others.
(D) Slates overlapping sheet metal work shall have the nails so placed as to avoid puncturing the sheet metal. Exposed nails shall be permissible only in top courses where unavoidable.
(E) Neatly fit slate around all pipes, ventilators, and other vertical surfaces.
(F) Nails shall not be driven so far as to produce a strain on the slate.
(G) Cover all exposed nail heads with elastic cement. Hip slates and ridge slates shall be laid in elastic cement spread thickly over unexposed surface of under courses of slate, nailed securely in place and carefully pointed with elastic cement.
(H) Build in and place all flashing pieces, snow-guards, etc., furnished by the sheet metal contractor and cooperate with him in doing the work of flashing. (If roofing contractor has the flashing and sheet metal work under his contract, change this paragraph to suit.)
(I) Upon completion, all slate must be sound, whole, clean, and the roof shall be left watertight and neat in every respect, and subject to the architect's approval.

ROOFING FELT

(A) On all surfaces to be covered with slate, furnish and lay genuine asphalt saturated rag felt of an approved equal, not less in weight than that commercially known as "30 pound" felt or equal.
(B) Felt shall be laid in horizontal layers with joints lapped towards the eaves at least 2", and well secured along laps and at ends as necessary to properly hold the felt in place and protect the structure until covered with the slate. All felt shall be preserved unbroken, tight, and whole.
(C) Felt shall lap all hips and ridges at least 12" to form double thickness and shall be lapped 2" over the metal of any valleys or built-in gutters.

NAILS

(A) All slate shall be fastened with two large head slaters' hard copper wire nails, cut copper, cut brass or cut yellow metal slating nails to be inserted as desired of sufficient length to adequately penetrate the roof boarding. (Gauge or weight of nails should be inserted.)
(B) (In event the nailing base is other than wood, change the above paragraph to suit material used.)

HIPS

(A) All hips shall be laid to form "Fantail," "Saddle," "Mitred," "Boston." (to be inserted as desired.)

RIDGES

(A) All ridges to be laid to form "Comb," "Saddle," "Strip Saddle" (to be inserted as desired.) The nails of the combing slate shall pass through the joints of the slate below.
(B) The combing slate shall be laid with the same exposure as the next course down. (If desired, the combing slate sloping away from the direction of prevailing storms may project 1" above the combing slate on opposite side of ridge.)

VALLEYS

(A) All valleys shall be laid to form "Closed," "Open," "Round" (to be inserted as desired.)

FLASH & SHEET METAL WORK

(Specifications for flashing and sheet metal work to be inserted here if included under this specification.

(By permission from Buckingham Slate, Arvonia, Virginia.)

6.12.2 Slate Roof Installation Procedures

In the laying of any roofing material workmanship is as essential as the proper selection of the material. The more enduring the material the more important this factor becomes. Slate, the most lasting roofing material known, should be laid by roofers of experience and training. It is a mistake to assume that those without such experience are qualified to properly lay slate. For

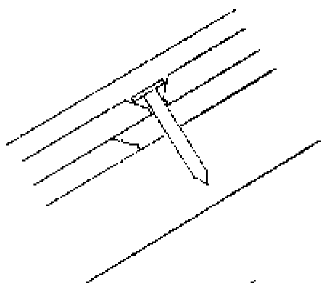


Figure 9.
Properly Nailed

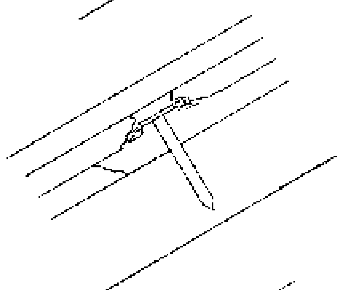


Figure 10.
Nail Driven Too Far

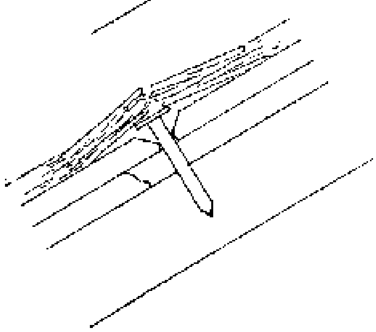


Figure 11.
Nail Not Driven Far Enough

instance the nailing of wooden shingles and slates are entirely different. The heads of slating nails should just touch the slate and should not be driven "home" or draw the slate, but left with the heads just clearing the slate so that the slate hangs on the nail. The opposite is true of wooden shingles and a man used to laying this material will invariably handle slate in the same way. As a consequence the slate, held too rigidly in place, is shattered around the nail hole or the head of the nail crushed and eventually the slate may "ride" up over the nail and be blown off in a heavy wind. The blame is

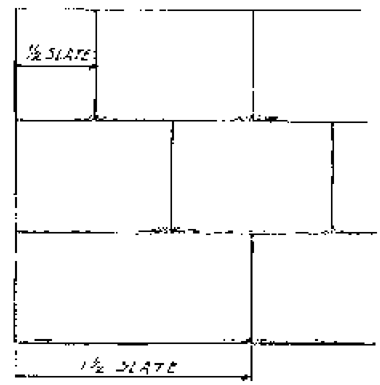


Figure 12. Starting Slate

placed on the material whereas the real reason can be traced to the method of nailing. All nails should penetrate the sheathing and not the joints between boards. This is especially important near the ridge of the roof.

It would seem almost unnecessary to mention the fact that there should be no through joints from the roof surface to the felt. The joints in each course should be well broken with those below. Where this simple precaution is neglected it is possible that water may find its way through the joints, eventually cause the felt to disin-

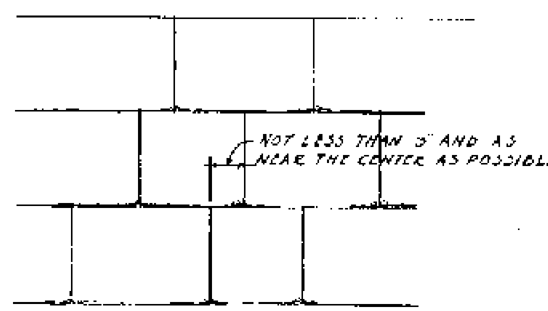


Figure 13. Proper Jointing

tegrate and leaks to develop. Where random widths are used the overlapping slate should be jointed as near the center of the under slate as possible and not less than

(By permission from Buckingham—Virginia Slate, Arvonia, Virginia.)

3" from any under joint. Where all slates are of one width, this is automatically taken care of by starting every other course with a half slate or, where available and practicable, a slate one and one-half times the width of the others.

With but few exceptions, the standard 3" lap should be insisted upon. The "standard 3" lap" or "3" headlap" means the lap of the slate over the *second* course below, see Figure 15. The small saving in slate through reducing the lap will not compensate for the risk entailed of leakage due to the lessened amount of material over which water might be blown.

A practice prevalent among many roofers is that of driving the slater's stake into the roof boards. To avoid damaging the roofing felt, a plank should be used for this purpose or the stake driven into the scaffold only. Slaters occasionally use a metal strap as a support for the scaffold brackets. This practice should be discouraged when these are cut off and a part left on the roof. They will rust in time and stain the slate in a most unsightly manner.

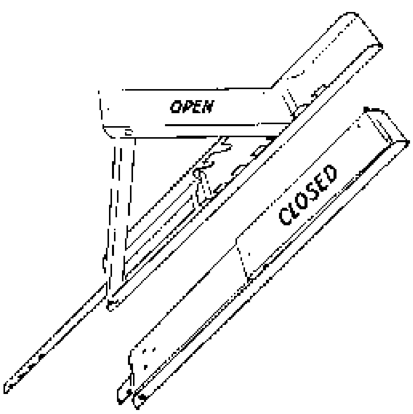


Figure 14. A Satisfactory Scaffold Bracket

The foregoing applies to slating in general. The forming of slate hips, ridges, valleys, eaves and gables require a description peculiar to themselves.

Exposure

The "exposure" of a slate is the portion not covered by the next course of slate above and is thus the length of the unit exposed to the weather. The standard lap of the alternate courses used on sloping roofs is 3" and is the basis upon which all roofing slate is sold and the quantity computed. The proper exposure to use is then obtained by deducting 3" from the length of the slate used and dividing by two. For instance, the exposure for a 24" slate is 24" minus 3" = 21" ÷ 2 = 10½" exposure.

The following table will be found of use in readily obtaining the proper exposure.

Exposure in Inches for Sloping Roofs

Length of Slate in Inches	Slope 8" to 20" per foot, 3" lap
24	10½
22	9½
20	8½
18	7½
16	6½
14	5½
12	4½
10	3½

Sloping roofs having a rise of 8" to 20" per foot of horizontal run should be laid with the 3" lap. Buildings located in the southernmost parts of the country or on the Pacific slope may however be safely roofed with a lap of 2" providing a high standard of workmanship is otherwise maintained. For steeper roofs, such as the Mansard and others nearly vertical in plane a 2" lap will usually be found sufficient. In some sections of the country it is customary to increase the lap to 4" when the slope is from 4" to 8" per foot, while in other parts the 3" lap is considered entirely adequate. Flat roof construction should be used for slopes less than 4" per foot. For vertical walls or siding use 2" lap.

Ridges

There are two common methods of finishing the ridge of the roof. These are usually known as the "Saddle Ridge" and "Comb Ridge" but each may have other names and certain variations in laying according to local practice. In Figure 16.12.3 are illustrated two types of saddle ridge which are known respectively as the "Saddle Ridge" and the "Strip Saddle Ridge." In the first of these, the "Saddle Ridge," the regular roofing slates are extended to the ridge so that pieces of slate on the opposite sides of the roof butt flush. On top of the last regular course of roofing slate at the ridge is laid another course of slate called the "Combing Slate" and the pieces on the opposite sides of roof butted flush.

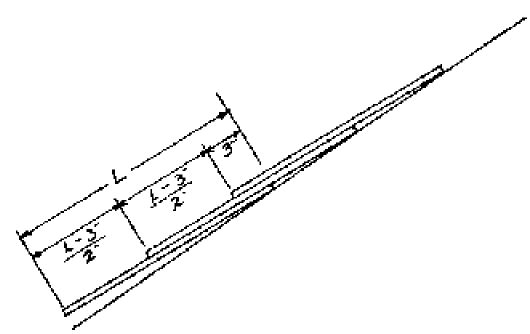


Figure 15. Lap and Exposure

Continued

Nails

Slate, being a permanent material, is worthy of care and thought in the proper selection of the various materials used in connection with it, and especially as to the method of securing the slate to the roof construction.

Like any other construction unit, a slate roof can only be as strong and enduring as its weakest part, and the majority of slate roof failures over a period of years may be attributed to the punching of the nail holes, the nailing of the slates, or the nails themselves. As has previously been stated, the art of properly laying and nailing slate is not to be discounted and belongs to men trained especially in the work. The punching and nailing of the slate have been described under the heading, "Laying Slate," on page 13.

Before nails came into extensive use, the slate were held in place by means of wooden pegs driven through the slate and hooked over the roof lath. It is the practice in some localities today to hang the slate to the laths or battens by means of heavy wire hooked through the slate and over the laths. This method is in general use where the slate is laid directly on steel construction. Copper nails of sufficient length to be securely hooked and clinched over the structural angles may also be used. These should have large heads and the shafts be of No. 10 or 11 gauge metal.

Nailing is more extensively used today than other methods for securing the slate, and careful attention should be given the characteristics of nails selected for this purpose. The important considerations involved are shape, size and material.

For all practical purposes, the ordinary diamond point and smooth shaft are sufficient for a slating nail and the needle point is seldom, if ever, necessary or of advantage. The shaft, since it supports a greater weight and must resist a small shearing stress, should be larger than that of the shingle nail. To prevent the slate from being lifted up over the nail after being laid, the diameter of the head should be greater than that of shingle nails.

The temptation to use shingle nails instead of slating nails should be discouraged, for the slight saving in cost on the entire roof cannot approach the cost of repairs which may develop as a result of this practice. Architects and owners should insist that the roofer use nails of proper size and kind of non-ferrous metals.

The much-mooted question of the material of which the nails should be made must remain a matter of opinion and judgment until an impartial investigation shall throw further light upon the subject.

It is hoped that research in this field may be undertaken in the near future and definite results furnished those interested. It is a generally accepted fact that copper is one of the most enduring of metals and that iron and steel, adequately protected from corrosion by a heavy coating of zinc applied by the hot-dipped process, will give reasonable service. Plain or ordinary galvanized nails should not be used for laying slate. Nails having a copper content, such as "yellow metal," or "Muntz Metal" and cut zinc nails are sometimes used. Nails should be carefully selected and be the best grade of a reputable manufacturer. Recently "Cimet," "Everdur" and similar chrome-iron alloy nails and other types particularly suited to resist atmospheric corrosion, have been put on the market. Their cost is higher than copper, yet for certain buildings with excessive or unusual acid fumes under and surrounding the slate roofs, it may prove economical to use such nails. Time and wider use of these newer types will prove whether they are or are not superior to copper. When cost is an item, the "Copperweld" nail, being less expensive than solid copper, is often used and may prove to be the satisfactory method of protecting the steel shaft.

Under ordinary conditions, it will be found satisfactory to use 3d nails for commercial standard slates up to 18 inches in length. Use 4d nails for the longer slates and 6d on the hips and ridges. Thicker slates require longer and heavier gauge nails. The proper size may be determined by adding 1 inch to twice the thickness of the slate.

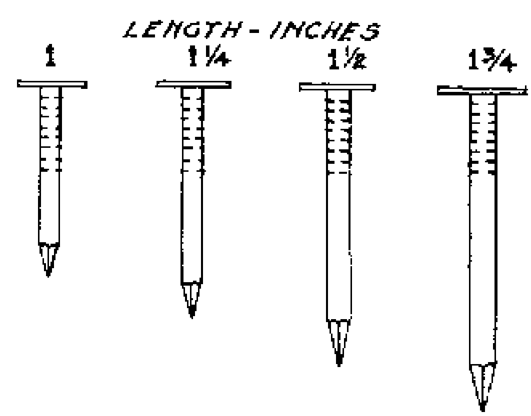
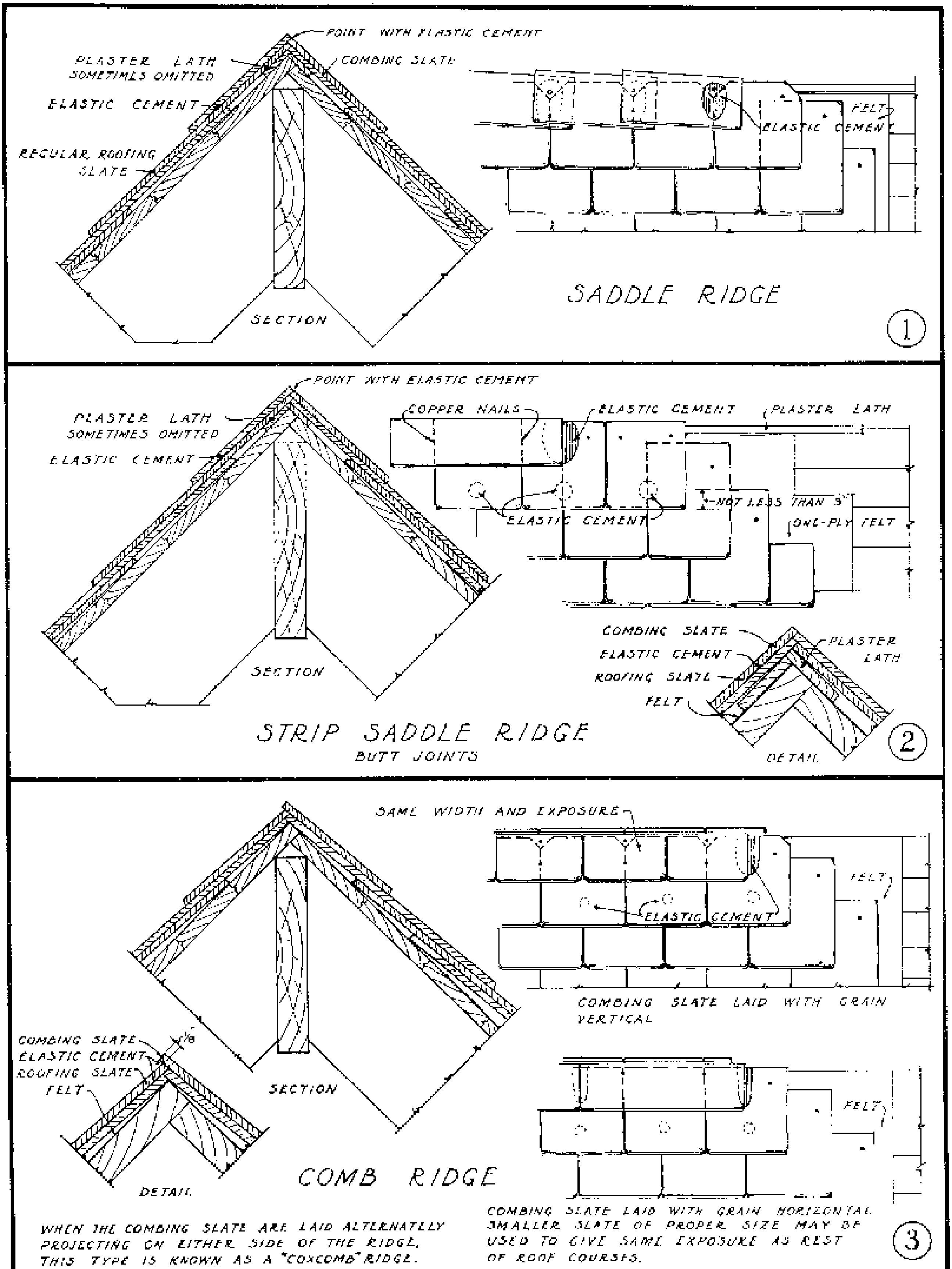


Figure 33. Full Size Nails

Continued

6.12.3 Slate Roof—Eave Joining Details

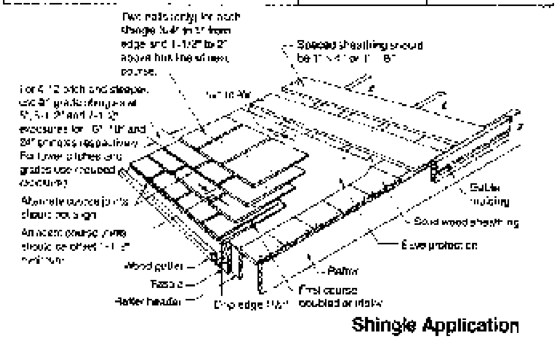


(By permission from Buckingham—Virginia Slate, Arvonia, Virginia.)

6.13.0 Cedar Shingle/Shake Installation Diagrams

Shingle Exposure

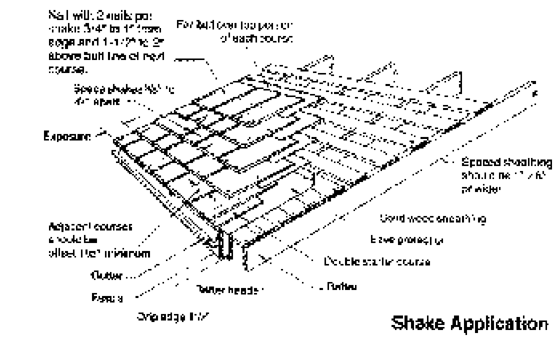
PITCH	Maximum exposure recommended for roofs								
	Length								
	No. 1 Blue Label			No. 2 Red Label			No. 3 Black Label		
	16"	18"	24"	16"	18"	24"	16"	18"	24"
3/12 to 4/12	3¾"	4¼"	5¾"	3½"	4"	5½"	3"	3½"	5"
4/12 and steeper	5"	5½"	7½"	4"	4½"	6½"	3½"	4"	5½"



Shake Exposure

PITCH	Maximum exposure recommended for roofs	
	Length	
	18"	24"
4/12 and steeper	7½"	10"(a)

(a) 24" x 3/8" handsplit shakes limited to 7-1/2" maximum weather exposure (5' per UBC)



6.13.1 Cedar Shingle-Grade Label Facsimiles

(By permission of Cedar Shake and Shingle Bureau, Bellevue, Washington.)

6.13.2 Cedar Shingle and Shake Installation and Maintenance Tips

SOME BASIC MAINTENANCE TIPS TO FOLLOW

Using a CEDAR SHAKE AND SHINGLE BUREAU "APPROVED MAINTENANCE TECHNICIAN" will help to ensure your safety and professional workmanship

If you're doing it yourself BE CAREFUL! Use extreme caution on the roof, on slippery surfaces, around power lines, ladders and equipment.

SHOES

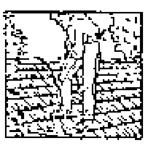
Wear suitable footwear. Tennis shoes will provide traction and will minimize damage to the shakes or shingles

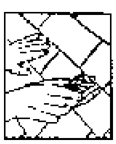
TRIM OVERHANGING BRANCHES

This will prevent debris and moss from clogging the valleys and gutters and from keeping the roof wet or damp. It will also eliminate roof damage in wind storms

RUN LEADERS TO THE GROUND

Run downspouts (leaders) to the ground onto splashblocks slanting away from the foundation, or directly to another gutter below, never onto a lower roof surface





CLEAN GUTTERS AND DOWNSPOUTS

Spring and Fall

NEVER BLOCK OFF ROOF VENTILATION

Such as louvers, ridge vents or soffit vents, even in winter. One of the most critical factors in roof durability is proper ventilation. Without it, heat and moisture build-up in the attic area and can cause rafters and sheathing to rot, roofing to buckle, and insulation to lose its effectiveness. Also ice dams frequently occur when attics are not properly ventilated.

STEP RIGHT

Avoid walking on a cedar roof that is not from the sun.

Never walk or stand on the lower end (butt end) of the shake or shingle to avoid cracking or weakening. Shingles and tapersawn shakes lay flat and therefore will not crack as easily. Carefully place your feet directly against the butt end of the row above.

SWEEP CLEAN

Remove debris (branches, pine needles, leaves, etc.). Leaving them on the roof retains moisture and encourages decay. This accumulation could also impede the run-off rain water which then could result in leaks. Being careful not to damage the shakes or shingles, clean them by using a stiff broom or brush. Remove foreign matter from the spaces (keyways) between the individual shake or shingle

MOLD AND MILDEW

Mold and mildew can be killed and cleared temporarily from wood roofs with the following solution:

MOLD AND MILDEW CONTROL FORMULA

3 ounces trisodium phosphate (TSP)
1 ounce detergent (e.g., Tide)
1 quart 5% sodium hypochlorite (Clorox)
3 quarts of warm water

This solution should be applied undiluted, and the surface scrubbed with a soft brush. When the surface is clean, it should be rinsed thoroughly with fresh water.

Care should be taken not to spray vegetation. If it does happen, rinse the plants thoroughly with fresh water.

MOSS CONTROL

In dry weather, control of moss can be accomplished by spraying or brushing the roof with a 10% solution of zinc sulfate. The moss absorbs the zinc oxide and eventually can be swept off the roof.

A solution of household bleach (sodium hypochlorite) mixed in a ratio of one part bleach to four parts water should prove to be equally effective.

Caution should be exercised in the use of all chemicals because of their high toxicity. Generally there is no hazard to plants provided that the chemicals do not contact the surrounding soil. If this should happen, either by direct contact or by the chemicals running through a septic tank and into the soil, no vegetation may grow for some time, since the soil may be sterilized.

ZINC OR COPPER STRIPS FOR MOSS CONTROL

The use of these strips nailed at the ridge cap can be effective for moss control. These strips should run the full length of the roof and have a portion exposed to the weather. The reaction between the rain water and the zinc or copper forms a mild chemical solution that is carried down over the roof and retards formation of moss, fungus and mildew.

REPLACE AND BLEND

Replace all broken or missing shakes, shingles and ridge capping. New replacements can be made to blend in with the rest of the roof by dipping or spraying them with a 50% solution of baking soda and water.

(1 lb of baking soda dissolved in 1/2 gallon of water)

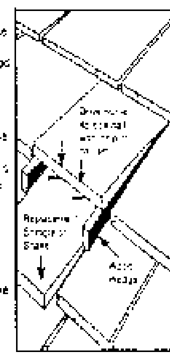
The shakes and shingles will turn a weathered gray color after 4 or 5 hours in sunlight. This is a chemical reaction and is permanent.

REPLACING A MISSING OR DAMAGED SHAKE OR SHINGLE

Lift up the shingle or shake in the course above with wood wedges

Push the replacement shingle or shake up, then drive two 4d box nails into the shingle or shake at an angle

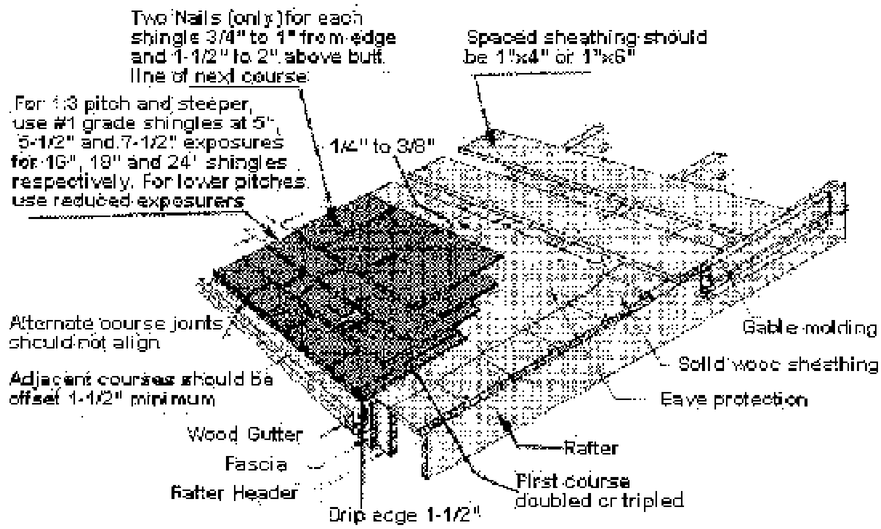
Finally, drive the butt of the replacement shingle or shake up flush with the rest of the course



(By permission of Cedar Shake and Shingle Bureau, Bellevue, Washington.)

6.3.3 General Application Instructions for Shingles

Regardless of style, the following basic application details must be observed.



1. Shingles must be doubled or tripled at all eaves.
2. Butts of first course shingles should project 1-1/2" beyond the fascia.
3. Spacing between adjacent shingles (joints) should be a minimum of 1/4" and a maximum of 3/8."
4. Joints in any one course should be separated not less than 1-1/2" from joints in adjacent courses; and in any three courses, no two joints should be in direct alignment.
5. In lesser grade shingles containing both flat and vertical grain, joints should not be aligned with centerline of heart.
6. Flat grain shingles wider than 8" should be split in two before nailing. Knots and similar defects should be treated as the edge of the shingle and the joint in the course above placed 1-1/2" from the edge of the defect.

Roof Fastener Guidelines

Nails

Each shingle or shake should be applied with two corrosion-resistant fasteners, such as stainless steel (type 304 or 316), hot-dipped zinc coated, or aluminum nails. If preservative treated shingles or shakes are installed the treating company's recommendations regarding the compatibility of the preservative chemicals with the fastener should be followed. Minimum nail lengths are shown below.

Nails: Type of Shingle or Shake	**Nail Type and Minimum Length**	
Shingles-New Roof	**Type**	**(in.)**
16" and 18" Shingles	3d Box	1-1/4"

(By permission from the Cedar Shake & Shingle Bureau, Sumas, Washington.)

24" Shingles	4d Box 1-1/2"
Shakes-New Roof	**Type (in.)**
18" Straight-Split	5d Box 1-3/4"
18" and 24" Handsplit--and-Resawn	6d Box 2"
24" Tapersplit	5d Box 1-3/4"
18" and 24" Taper-sawn	6d Box 2"

Staples

Staples should be aluminum or stainless steel (type 304 or 316) 16 gauge. Two staples should be driven per shingle or shake with the staple crowns (7/16" min.) horizontal to the shingle or shake butt and driven in the same location as nails relative to the sides and overlapping butt line. Staples should be long enough to penetrate the sheathing at least 3/4" and driven flush with the surface of the shingle or shake.

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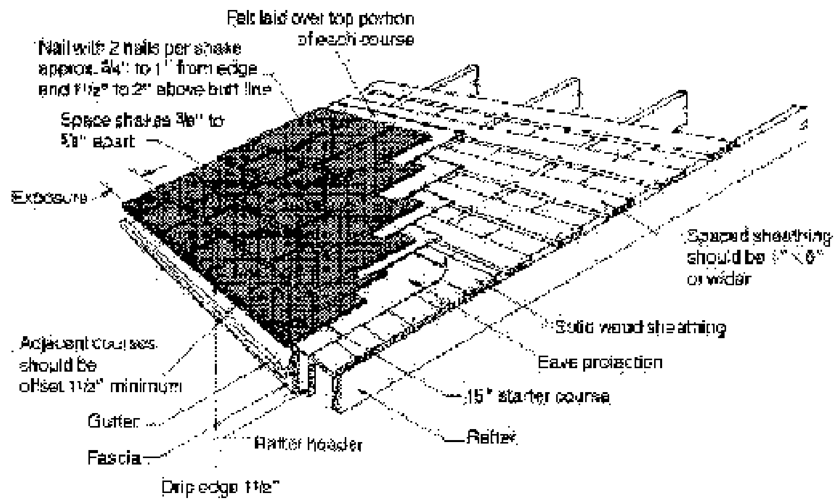
6.13.4 General Application Instructions for Shakes

Shakes, like shingles, are normally applied in straight, single courses. The following application details must be observed.



1. The starter course may be two or three layers of shingles or shakes overlaid with desired shake. A 15" shake is made expressly of starter and finish courses.
2. Butts of first course shakes should project 1-1/2" beyond the fascia.
3. An 18" wide strip of No. 30 roofing felt (or No. 15 felt depending upon code requirements) should be laid over the top portion of the shakes and extend on to the sheathing. The bottom edge of the felt should be positioned above the butt of the shakes at a distance equal to twice the weather exposure. For example, 24" shakes laid with 10" exposure would have felt applied 20" above the butt. Thus the felt will cover the top 4" of the shakes and extend up 14" onto the sheathing. Note that the top edge of the felt must rest on the spaced sheathing.
4. Spacing between adjacent shakes should be a minimum of 3/8" and a maximum of 5/8".
5. Joints between shakes should be offset 1-1/2" over adjacent courses.
6. Straight-split shakes should be laid with the froe-end (the end from which the shake has been split and which is smoother) toward the ridge.

Roof Fastener Guidelines

Nails

Each shingle or shake should be applied with two corrosion-resistant fasteners, such as stainless steel (type 304 or 316), hot-dipped zinc coated, or aluminum nails. If preservative treated shingles or shakes are installed the treating company's recommendations regarding the compatibility of the preservative chemicals with the fastener should be followed. Minimum nail lengths are shown below.

Nails: Type of Shingle or Shake	**Nail Type and Minimum Length**
Shingles-New Roof	**Type (in.)**

(By permission from the Cedar Shake & Shingle Bureau, Sumas, Washington.)

16" and 18" Shingles	3d Box 1-1/4"
24" Shingles	4d Box 1-1/2"
Shakes-New Roof	**Type (in.)**
18" Straight-Split	5d Box 1-3/4"
18" and 24" Handsplit--and-Resawn	6d Box 2"
24" Tapersplit	5d Box 1-3/4"
18" and 24" Taper-sawn	6d Box 2"

Staples

Staples should be aluminum or stainless steel (type 304 or 316) 16 gauge. Two staples should be driven per shingle or shake with the staple crowns (7/16" min.) horizontal to the shingle or shake butt and driven in the same location as nails relative to the sides and overlapping butt line. Staples should be long enough to penetrate the sheathing at least 3/4" and driven flush with the surface of the shingle or shake.

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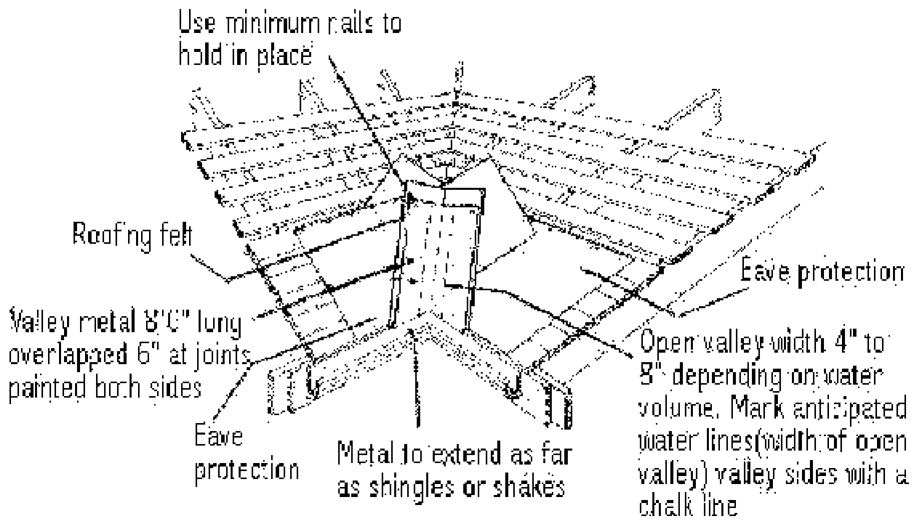
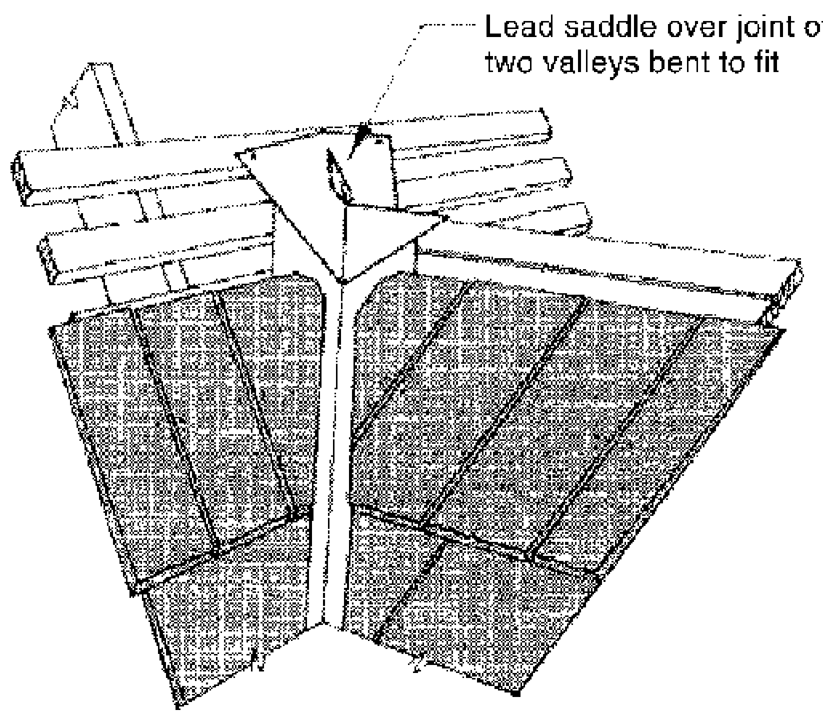
6.13.5 Wood Roof Valley Flashing Details

Most roof leaks can occur where water is channeled off the roof or where the roof abuts a vertical wall or chimney. At these points, metal valleys and flashings are used to assist the shingles or shakes in keeping the structure sound and dry. Structural members that protrude through a roof should be flashed at all intersecting angles to prevent leakage. Step flashing should extend under the shingles or shakes and up the vertical surface and should be covered by a second layer of flashing (counter flashing).





Typical saddle flashing

(By permission from the Cedar Shake & Shingle Bureau, Sumas, Washington.)

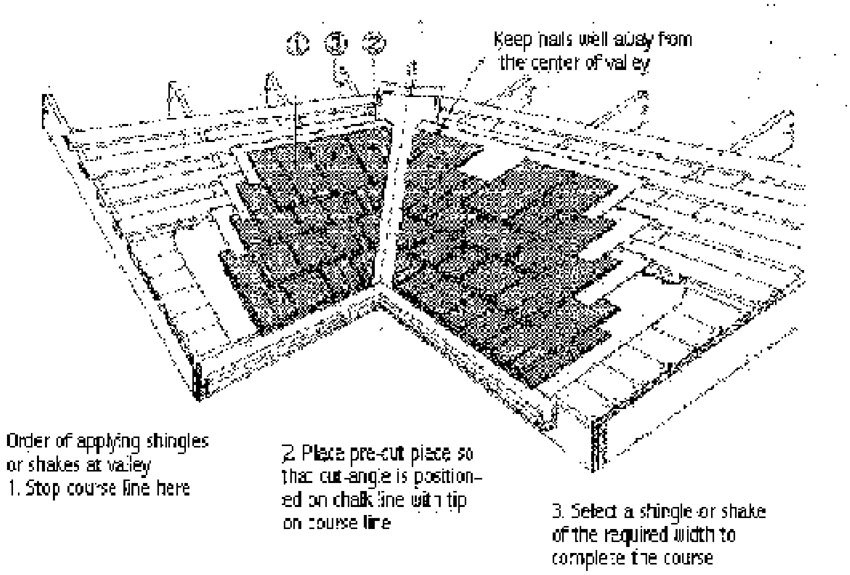
Flashing should be prepainted on both sides using a good metal or bituminous paint. Flashing strips which must be bent to sharp angles should be painted after bending. Metal flashing with baked-on enamel coating is available in some areas. Different flashing metals are available in different areas depending on climatic variations. It is good practice to use metals that have proven their reliability under the specific conditions to be encountered. It is important that metal flashing have the same longevity as Western Red Cedar.

Valleys-Shingles

For roofs with slopes of 1:1 or greater, valley flashing should extend not less than 7" on each side of the valley centerline. For roof slopes less than 1:1, flashing should extend not less than 10" on each side. Valley flashing should be center crimped, painted, galvanized steel or aluminum. Valley metal should be underlayed with No. 15 roofing felt (minimum). Shingles should not be applied with their grain parallel to the valley centerline and those extending into the valley should be cut at the correct angle (Figure 12). Joints between shingles must not break into the valley.

Valleys-Shakes

On shake roofs it is recommended that a strip of No. 15 (minimum) roofing felt be installed over the sheathing and under the metal valley. Metal valleys should be center-crimped, painted, galvanized steel or aluminum and have a minimum total width of 20". In some areas, however, flashing width requirements may differ and local building codes should be consulted. Shakes should not be applied with their grain parallel to the valley centerline and those extending into the valley should be cut at the correct angle (Figure 12). Joints between shakes must not break into the valley.



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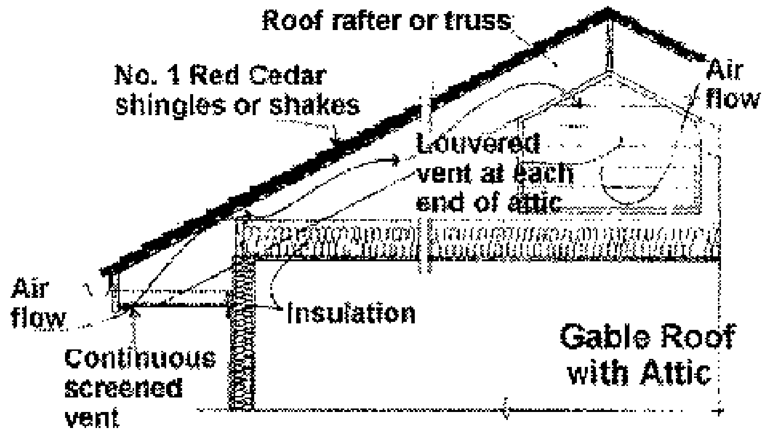
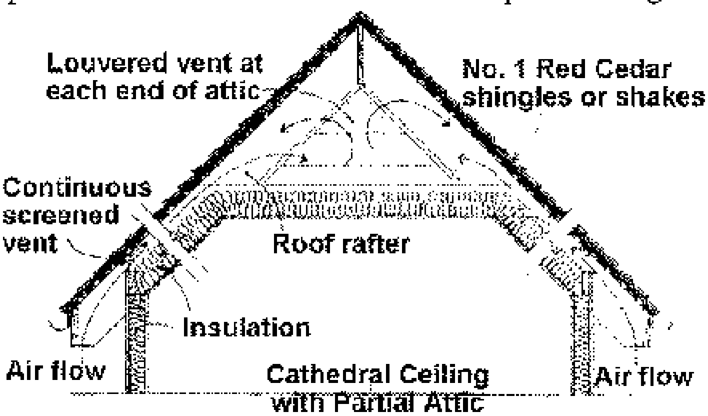
6.13.6 Wood Roof Ventilation Details

The importance of good attic ventilation beneath the root cannot be overemphasized. Such movement of air will prevent or inhibit condensation of moisture on the undersurface of the shingles or shakes, or on the roof decks. Vents should be provided at the soffits (eaves) as well as at gable ends (screened to prevent ingress of insects) or preferably the ridge lines with cross-ventilation desirable. A rule of thumb for adequate ventilation is that the ratio of total net free ventilation area to the area of the attic should be not less than 1:150, with compensation made for screens over vent apertures. Attic fans may be beneficial, these supplying additional movement of air in attic spaces. Several examples of construction techniques which provide roof ventilation are shown in "Cold Weather Roof System Details."

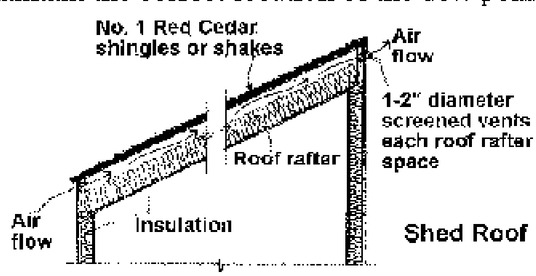


VAPOR BARRIER GUIDELINES

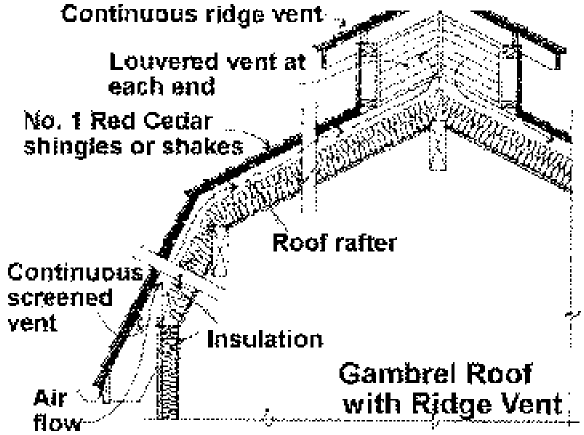
The decision on whether to use a separate vapor barrier must be made by the designer, based on the type of building, its end use, and its geographic location. A separate vapor barrier is sometimes omitted on a sandwich-type roof deck when the weather-shedding skin is not a membrane-type impervious to the transmission of water vapor. Although some types of rigid insulation have the properties of a vapor barrier, a layer of roofing felt is often placed between the deck and the insulation as an air check. Many specifiers still prefer to use a separate vapor barrier because it prevents vapor from condensing in the insulation, which reduces the overall efficiency. Where a vapor barrier is used, care must be taken to ensure that the dew point is well to the outside of the vapor barrier in order to prevent condensation on the deck. Ideally the vapor barrier should be as close as possible to the warm side of the roof, and the thickness of the insulation should be increased as the deck thickness increases to maintain the correct location of the dew point.



In unevenly heated buildings such as churches and halls, or buildings such as swimming pools where an unusually high level of moisture is generated, the excess humidity may have to be removed by mechanical means to prevent condensation on the deck. In air-conditioned buildings, use of the cold weather roof system allows a constant flow of air between the insulation and the roofing, helping to reduce the energy required for cooling. Full details on the cold weather roof system are given on page 14.



(By permission from the Cedar Shake & Shingle Bureau, Sumas, Washington.)



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For additional information contact the Cedar Shake & Shingle Bureau for an application manual.

Cedar Shake & Shingle Bureau
P.O. Box 1178
Sumas, WA 98295
604-462-8961
Fax: 604-462-9386
E-Mail: Technical Information

Continued

6.14.0 A Checklist to Detect or Avoid Roof Leaks for All Types of Roofs

The source of a leak is not necessarily directly above the appearance of water penetration on the inside of a building. Water has a tendency to travel by the forces of gravity or to be forced into a certain path by high winds. Careful inspection of the roof and all flashings is sometimes necessary to detect a leak; planned inspections by the owner might uncover a potential problem so that repairs can be effected.

1. Most leaks occur at the perimeter of the building because this is where more movement occurs, except at structural expansion joints. This area requires frequent inspection or "first look" if a leak has been reported.
2. Roof penetrations, those at roof drains or roof curbs or around roof accessories or pipe/conduit flashings, would be the next best place to inspect.
3. Parapet walls, exposed in two sides, might experience greater temperature variations and subsequent expansion and contraction activity, giving rise to tears in the flashing and leaks.
4. Equipment supports are frequently sources of roof leaks. Roof insulation attached to the outside surface of structural steel supports could act as a thermal bridge and increase the potential for condensation build-up.
5. Tears or splits in the membrane itself, caused by workers working on the roof and abusing the surface, is another area of investigation. Servicing of roof-top equipment where oils and lubricants are used can also result in leaks because of the oils or lubricants being carelessly spilled on the roof membrane and dissolving a portion of the membrane.

6.15.0 Albedo—Measuring Energy Efficiency of Roof Membranes

Resistance to heat flow has been quantified by the use of "R" values—a means of measuring how well a substance or material resists the transmission of heat into a building in hot weather and how well it keeps heat in a building during cold weather. But when it comes to energy gained or lost through a roof assembly, another form of measurement is often used, and that measure is referred to as "albedo"—solar reflectance. Albedo measures how much of the solar energy striking a roof membrane surface is reflected.

Energy efficient roofing systems exhibit three qualities:

1. Good reflectance—albedo.
2. Sufficient insulation to resist the flow of heat into the structure.
3. Good emissivity—the ability of the roof surface to radiate the absorbed energy away from the structure rather than retaining it.

The following chart lists albedo and emissivity factors for selected surfaces:

Material	Albedo	Emissivity
Concrete	0.3	0.94
Red brick	0.3	0.90
Tar paper	0.05	0.93
White plaster	0.93	0.91
Bright galvanized iron	0.35	0.13
Bright aluminum foil	0.85	0.04
White pigment	0.85	0.96
White single-ply roofing	0.78	0.90

6.16.0 Roof Insulation—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Roof Insulation

No.
07200

Date

1. Approved shop drawings, product data, and samples as required are on site.
2. Materials are of type required (surfaces, treatment, ratings, sizes, thickness, etc.)
3. Materials are stored to prevent moisture infiltration and are installed dry.

RIGID INSULATION

4. Wood nailers/stops are provided at perimeters, etc., as required.
5. Vapor barrier is provided if required. Observe installation, nailing, requirements. Check that vapor barrier seals insulation at gravel stops, walls, and openings.
6. Method of installing over decking, under topping, vapor barrier, etc., is as required.
7. Fasteners, when specified, are of proper type and spaced as required.
8. Observe fastener penetration through decking if required.
9. Joints are staggered, except when joints are to be taped. When two layers are being installed, vertical joints should be offset. Do not allow joints over flute openings in steel deck.
10. Insulation is installed in conjunction with roofing membrane when required. Water cut-offs, if required, are installed at end of each day's work. Insure insulation is covered by roofing each day.
11. Fire-resistant adhesives are provided where required.
12. Expansion provisions are observed.
13. Insulation remains dry until covered by roofing.
14. Insulation at roof drains should permit proper drainage. Insulation may require routing or back cutting.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________

6.17.0 Flashing and Sheet Metal—Quality Control Checklist

Quality Control Checklist

Project no.

Section	No.
Flashing and Sheet Metal	07600

Date

1. Approved shop drawings, product data, and samples are on site.
2. Delivered material is of approved type, shape, gauge, metal, fabrication, priming, etc., as required, and all accessories are provided.
3. Isolation provisions are made for dissimilar metals. Do not allow copper and aluminum flashings to be in contact with each other or with ferrous metal. Copper or aluminum flashings are to be fastened with nonferrous nails or screws. Ferrous equipment bases are not to be set on copper flashings.
4. Expansion joints are provided and installed as required or as specified. Note location of joints with respect to drains, downspouts, scuppers, corners, and other outlets.
5. Observe methods of installation — nailing and cleating types for spacing and location; also soldering, welding, bolting, and riveting.
6. Flashing does not interfere with structural requirements.
7. Generally see the edge metal is lapped a minimum of 4" with 12" staggered nailing or fastening through the back flange unless otherwise required.
8. All edge metal laps are coated with plastic cement or manufacturer's approved material on horizontal flange and vertical rise. Coating covers entire lap and is sandwiched between.
9. Lengths are as long as practicable. (Not over 20' for GSM.)
10. Installation is coordinated with roofing installation.
11. Nailer or cant strip is provided for fastening flashing to roof deck; is of proper material, well secured, and allows venting if required or specified.
12. Inner flange is applied over felt, lapped, set with polyisobutylene tape, and properly nailed, or as required.
13. Flashing is embedded in the roof membrane assembly and additional strip plies of membrane are provided as may be required by the roof system.
14. Method of anchoring lower edge of fascia is as required. Observe alignment, stiffness, etc.
15. Gravel stops are to be flush with deck unless otherwise required.
16. Expansion joints, concealed or standing, are provided midway between outlets and/or as required.
17. Scuppers are installed low enough not to dam water on roof.
18. Overflow drains and scuppers if indicated or required by code are provided, located properly, i.e., low point of roof.
19. Accessories are provided if required — basket strainer, bird screens, covers, etc.

BASE & CAP FLASHINGS

20. Flashing is provided to suit conditions: cant, size, gauge, and fabrication.
21. Base flashing extends up sufficiently; flange is embedded at least 4" in roofing membrane and is installed similarly to gravel stops. Method of embedment is as per manufacturer's approved product data. It is good practice to cover as much metal as practical to avoid movement from temperature variations.
22. Seams are lapped, locked, and soldered as required.
23. Secure anchorage is provided for size, spacing, and fixing of cleats or other equipment mountings.
24. Cap flashings are of shapes, sizes, and gauges required and are installed to provide secure anchorage, allow movement, and have sufficient laps and spacing.
25. Counter flashing is extended sufficiently into masonry walls or into reglet and is securely anchored and caulked, if necessary.

OTHER ROOF FLASHING

26. Reglets are provided at required areas; observe the setting in concrete or masonry to assure firm anchorage. Reglets are protected to prevent deformation or filling during installation.
27. Observe installation of sheet metal into reglets for tightness, weatherproofness, caulking, and lap.
28. Plastic flashing is of type required and is installed in accordance with requirements.

continued on next page

Flashing and Sheetmetal continued

WALL AND THROUGH WALL FLASHING

29. Verify contractor understands locations for flashing fabrication and design.

30. Lap, turn up, location in wall, depth in masonry, length, etc., are as required.

31. Sill flashing and pans extend full depth, are turned up, extend beyond horns or 4", and are installed for drainage.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________________

Continued

6.18.0 Membrane Roofing—Quality Control Checklist

Quality Control Checklist

Project no.

Section: Membrane Roofing

No.: 07500

Date

1. All shop drawings, product data and samples as required are approved and on site.
2. Attend roofing preconstruction meeting (if one is held). Review construction sequence, any deviations from approved submittals, field problems, and requirements to obtain Owner's desired warrantee.
3. Before roofing contractor commences his work, observe the following:
   a. Surfaces are clean and free from foreign material;
   b. Excess mortar or concrete is removed; all holes, joints and crack are pointed and rough, or high spots are ground smooth on concrete decks;
   c. Wood nailers or other attachment conditions are adequate;
   d. Surfaces are dry as required by manufacturer. Surfaces are tested for dampness if necessary.
   e. Slope is as required. If roof surfaces do not have sufficient slope, notify proper personnel.
   f. Pipes, conduits and other items penetrating the membrance are in place and ready to receive flashings.
   g. All sheet metal and roof accessories are in place or on hand to be installed in conjunction with roofing as required.
4. Materials of types required are provided. Materials are identifiable and comply with ASTM or FS standards. Stand roll roofing on end and keep free of contact with earth or moisture. Protective coverings of stored roll roofing should be vented so condensation will not occur.
5. Nails and fasteners are of length, shank, head, and coating required.
6. Surface to receive roofing is primed, if required.
7. Roofing materials should not be applied unless correct application conditions can be maintained.
8. Observe lap, nailing, and quantity of adhesive applied. In no case should membrane touch membrane; no bare spots.
9. See that membrane is laid so that it is free of air pockets, wrinkles, and buckles. Rolling may be required.
10. All surfaces are kept moisture-free. Under no condition allow exposure of insulation or incompletely installed membrane overnight without protection. Protect stored material from moisture.
11. Observe installation of roofing at cant strips, vertical surfaces, reglets, and penetration. Observe sealing of roofing membrane envelopes where use of envelope is required.
12. All concrete walls to receive roofing are primed. All wall membranes are properly prepared and attached or fastened as specified.
13. Observe welds, do not allow any skips or unwelded joints.
14. Operations are performed in a manner to avoid plugging of drains, weeps, etc., and do not damage or mess adjoining surfaces.
15. Observe that roof drains are set to permit proper drainage.
16. Roofing membrane is fully set into clamping ring. Lead collar flashing is installed and stripped in, if required.
17. Roofing is protected from damage by other trades or by general contractor during installation and following completion. If subject to heavy traffic, movement of equipment, storage of materials, or use as a work surface, runways, plywood sheets or other protection should be provided.
18. Observe cut samples if required. Observe that patching is properly performed where samples are cut.
19. Clean-up provided after installation, drains cleared, and debris is removed from site.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________________

The category "sealants" spans a wide range of construction activities and applications—from preventing water and moisture from infiltrating into below-grade structures to maintaining the watertight integrity of the entire superstructure.

This section deals primarily with caulking and sealant compounds: selection and application, and, secondarily, curtain wall and masonry sealants.

6.19.0 Sealants as Joint-Filling Compounds

These materials generally fall into one of three categories:

- *Dynamic joints* Joints that exhibit changes due to movement from expansion, contraction, isolation and loadings.
- *Static joints* Joints that exhibit little or no movement, such as masonry mortar joints. However, no joint in a building is truly static because all materials exhibit some movement from temperature changes and load factors.
- *Butt joints* Joints that have opposing faces that contract and expand and place a sealant in compression, tension, and can also exhibit shear from extreme loading forces or seismic events.

6.20.0 Proper Application of Sealants

The key to proper application of any sealant begins with proper surface preparation, which can vary considerably from one material to another. Most manufacturers go to great lengths to provide detailed surface preparation and application procedures, which are often ignored by the applicator, resulting in either poor performance or outright failure.

The following general guidelines are to be augmented by the manufacturer's instructions for the sealant and surface selected:

- *Concrete and masonry* Concrete can have the most variable surface conditions of any product because of variations in curing conditions, moisture content, finishing techniques, additives, hardeners, curing compounds, and form-release agents. Concrete and masonry surfaces can exhibit weak surface layers because of laitance present in concrete and the potential for spalling in masonry structures. Surfaces contaminated by laitance, hardeners, curing compounds and form-release materials can be sandblasted or wire brushed to remove these contaminants.

  Newly placed concrete or masonry must be allowed to cure before applying sealants. If these surfaces, once cured, become wet from rain, they should be allowed to dry at least 24 hours in good drying weather before sealant or primer application. Because most sealant manufacturers do not recommend applying their products in temperatures below 40 degrees F, frost is a problem. Under these conditions, an application of isopropyl alcohol or methyl ethyl ketone will cause surface moisture to evaporate and a sealant can be quickly applied before frost forms again.
- *Stone* These surfaces generally provide good sealant adhesion. However, some material (such as granite, limestone, and marble) should be primed before a sealant is applied. If the surface area of the stone appears to be flaking or dusty, it must be cleaned by either water blasting, sandblasting, or wire brushing before primer and sealant application.
- *Glass and porcelain surfaces* These surfaces are excellent substrates for sealants once their surfaces are cleaned of contaminants and oils. Methyl ethyl ketone or alcohol is an ideal cleaner.
- *Painted and lacquered surfaces* Depending on where these surfaces are located and their exposure to the weather, sealants should not be applied to flaking painted or lacquered surfaces. Sound painted/lacquered surfaces should first be cleaned by wiping with a solvent to remove oil and dust. It is preferable to do a test section to ensure that the solvent does not "lift" the painted surface.
- *Rigid plastic materials* Solvents will clean these surfaces adequately. However, the manufacturer of the fiberglass, acrylic, or other plastic compound should be consulted to determine which solvents will not permanently damage the plastic surface.
- *Flexible plastics and elastomers* These materials are difficult for sealants to adhere to. Test applications of a solvent, such as VM&P naptha, should be applied to determine if it is harmful to the plastic or elastomer.

- *Aluminum with a mill finish* A good degreasing solvent, such as trichloroethane or xylene, will clean these surfaces properly. A rub down with fine steel wool or fine emery cloth might permit better adhesion.
- *Aluminum with an anodized finish* This surface generally provides an excellent surface for sealant application. However, it should be wiped down with methyl ethyl ketone or xylene to remove any surface contaminants.
- *Copper* Copper can oxidize and this patina must be removed by either sanding or rubbing with steel wool. Copper is not compatible with many sealants; the sealant manufacturer or distributor should be contacted for the proper selection.
- *Lead* Though not used extensively as a new material, lead is often encountered in restoration work. It is difficult to obtain adhesion to a lead surface—even after cleaning with xylene or methyl ethyl ketone. Seek the manufacturer's recommendation.
- *Steel* Most steel surfaces to be caulked will have been painted, and procedures for any painted surface will apply. For unpainted steel surfaces, the steel must be free from rust, oil, and other surface contaminants. Abrade the surface by sandblasting or wire brushing down to a sound surface, clean with a solvent, and then apply the caulking.

  Stainless steel This is another difficult surface for adhesion purposes. Primers are often recommended along with solvent cleaning of the surface.

  Galvanized steel New galvanized surfaces present more difficult surfaces for adhesion than weathered galvanized surfaces. Once again, consultation with the sealant manufacturer is recommended.

6.21.0 Typical Properties of Noncementitious vs Cementitious Repair Materials

Property	Epoxy	Polyester	MMA	Cement	Latex-Cement
Compressive strength	High	High	Moderate	Moderate	Moderate
Adhesion:					
Dry surfaces	Excellent	Variable	Very good	Fair-good	Good-VG
Wet surfaces	Excellent *(some)*	Poor	Poor	Good	Very good
Shrinkage	Minimal (<1%)	High (8%)	Moderate	Moderate	Low-Moderate
Thermal coefficient of expansion	High (14×10^{-6}/°F)	----------	Very high (40×10^{-6}/°F)	Moderate (6×10^{-6}/°F)	Moderate (6×10^{-6}/°F)
Modulus of elasticity	Variable (low mod used for masonry)	Low to medium (variable)	Medium	Medium	Low-medium
Permeability	*Permeability controlled by proper aggregate:binder ratios*			Good	Good
Appearance: Color	Yellows in sun	Yellows in sun	Non-yellowing	May fade	Resists fading
wet/dry	*Do not develop same wet/dry appearances as natural stone*			Good w/d	Good w/d
Common uses	Welding cracks Consolidation Rebonding Terra cotta repair	Marble analogs Consolidation Concrete repair	Impregnation Consolidation Civil engineering	Patching Grouting Coating	Patching Coating Rebonding
Safety/handling	Sensitizer Corrosive hardeners	Irritating odor Mod. toxicity	Irritating odor Flammable	Dust (silica) Alkaline (cement)	Dust (silica) Alkaline

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6.22.0 Advantages/Disadvantages of Various Sealants

Sealant Type (Typical Cost)*	Key Attributes	Disadvantages
ORGANICS Butyl, Acrylic, & Solvent Acrylic [6-8 ¢/ft]	paintability	very low movement high shrinkage poor weatherability
POLYSULFIDES [10-12 ¢/ft]	chemical resistance abrasion resistance paintability below grade applications	modulus changes with temperature compression set potential new formulations unproven old formulations contained PCBs
POLYURETHANES [10-15 ¢/ft]	color flexibility limited life "self cleaning" paintability	reversion with heat, humidity, UV modulus changes with temperatures poor application in cold temperatures
SILICONES Acetoxy (vinegar smell) [9-12¢/ft]	optically clear available field proven history long shelf-life Antifungal formulations	incompatible with reflective glass, concrete, some metals adhesion to fluoropolymer paint abrasion resistance
NEUTRAL [11-20¢/ft]	20+ year lifetime largest range of modules the only sealant for structural adhesion modulus stability at various temperatures field proven history	abrasion resistance overplasticized formulations and stain adjacent surfaces

*Average Pacific Northwest contractor cost per foot based on a 1/4" x 1/4" joint

6.23.0 Properties of Various Sealant Materials

Properties of Interest	General Purpose Epoxy	Novolac Epoxy	Polymer Alloys	Polyester	Vinyl Ester	Acrylic	Poly-urethane	Water-based Urethane
Alkali Resistance	Excellent	Excellent	Excellent	Poor to Fair	Good to Very Good	Very Good	Very Good	Very Good
Acid Resistance	Good	Excellent 98% H_2SO_4	Excellent 99% H_2SO_4	Good	Very Good to Excellent	Good	Good	Good to Very Good
Solvent Resistance	Fair to Good	Good to Very Good	Excellent	Fair to Good	Excellent	Poor to Good	Fair to Good	Excellent 200
Physical Properties	Hard, Tough & Rigid	Hard, Tough & Rigid	Hard, Tough & Rigid	Hard, Tough & Rigid	Hard, Tough & Rigid	Hard Scratch-Resistant, Tough	Durable Scratch-Resistant, Tough	Hard, Tough & Rigid
Flexibility	Good	Good	Good	Good	Good	Very Good to Excellent	Excellent	Good
Impact Resistance	Good	Good	Good	Good	Good	Very Good to Excellent	Excellent	Good
Abrasion Resistance	Good	Good	Good	Good	Good	Very Good	Excellent	Good
UV Resistance	Fair	Fair	Fair	Good	Fair	Excellent	Fair to Excellent	Very Good
Preferred Application Temperatures	40°-110°F	50°-110°F	50°-110°F	50°-110°F	50°-110°F	-20°-90°F	40°-110°F	50°-110°F
Moisture Tolerance (During Application)	Very Good	Very Good	Very Good	Poor	Poor	Poor	Poor	Good to Very Good
V.O.C's (Volatile Organic Compounds)	Very Low to None	None	None	—	—	High (MMA)	Very Low to None	Very Low

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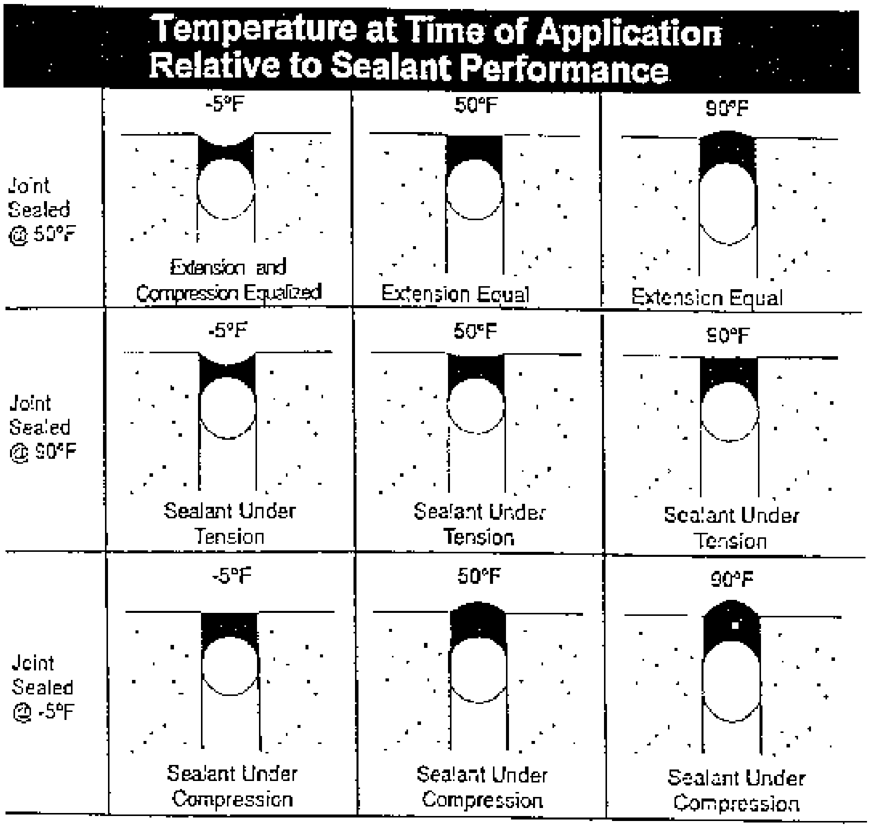
6.24.0 Temperatures vs Sealant Performance



	Canada and Northern USA		Southern USA	
	°F	°C	°F	°C
A. Estimated highest building surface temperature	155	68	180	82
B. Estimated lowest building surface temperature	-45	-43	-20	-29
Maximum temperature differential controlling joint movement (A-B)	200	111	200	111

6.25.0 Dow Corning Silicone-Sealant Designs, UL Ratings, Estimating Requirements

FIGURE 1: RECOMMENDED JOINT DESIGN

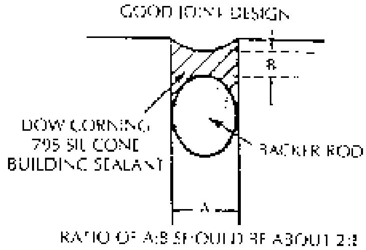


TABLE I: UL FIRE RESISTANCE RATING FOR JOINTS USING DOW CORNING 795 SILICONE BUILDING SEALANT

Maximum Joint Width, inches	Exterior Joint Sealant Thickness, inches	Forming Material	Forming Material Thickness (Item 2), inches	Rating, hours
1	½	Mineral Wool	3	2
1	1½[1]	Backer Rod	-	2

[illegible]
This is not a recommended design for a joint requiring ±50 percent movement.

FIGURE 2: BOND BREAKER TAPE

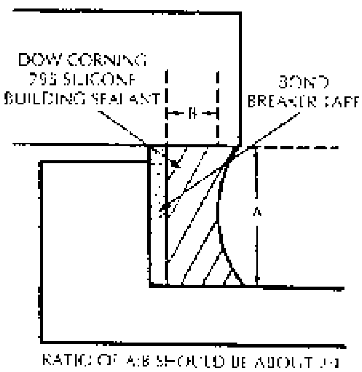


TABLE II: ESTIMATING REQUIREMENTS

Linear Feet per Gallon of DOW CORNING 795 Silicone Building Sealant for Various Joint Sizes								
	WIDTH, Inches							
DEPTH, Inches	1/4	3/8	1/2	5/8	3/4	1	2	3
1/8	616	411	307	—	—	—		—
3/16	411	275	205	164	—	..	—	—
1/4	307	205	154	123	103	—	—	—
3/8	—	137	103	82	68	51	25	17
1/2	—	—	77	62	51	39	19	12

FIGURE 3: EXTERIOR JOINT SEALING CONFIGURATIONS AND FIRE RATINGS

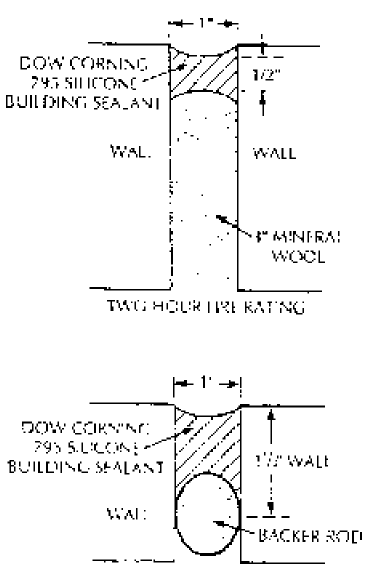
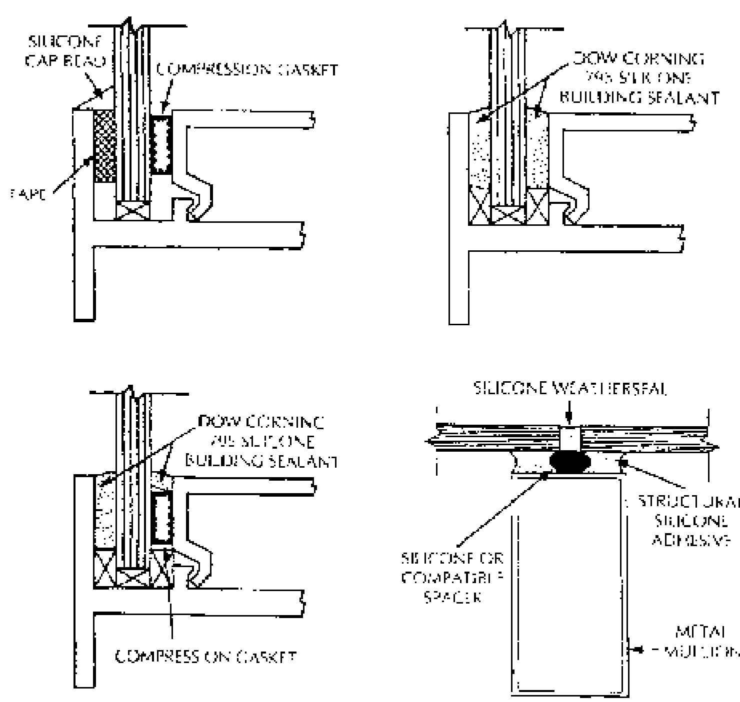


FIGURE 4: EXAMPLES OF TYPICAL GLAZING DETAILS



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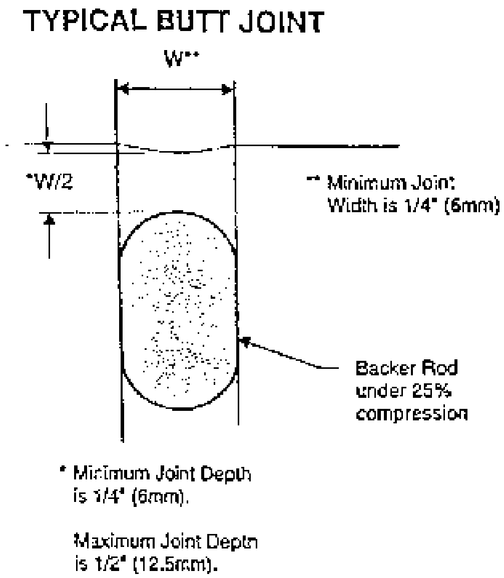
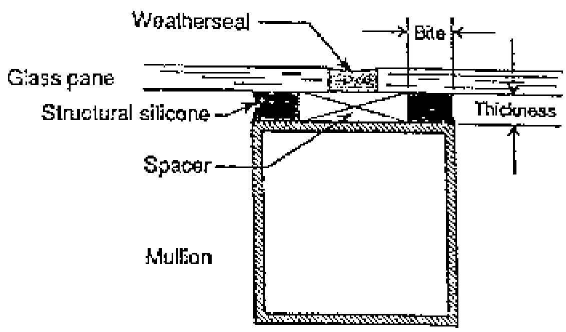
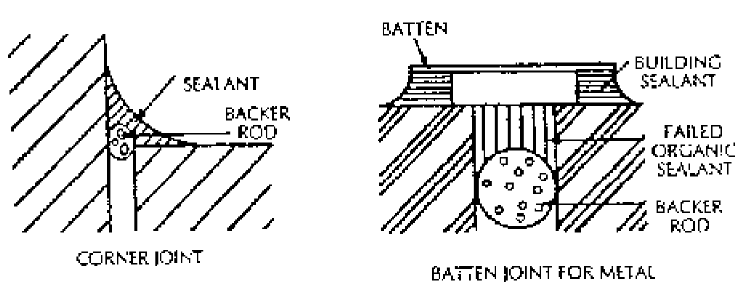
6.26.0 Typical Butt Joints and Other Joint Details

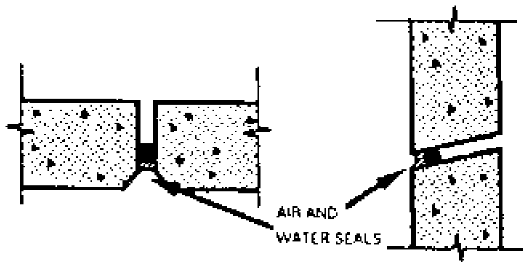




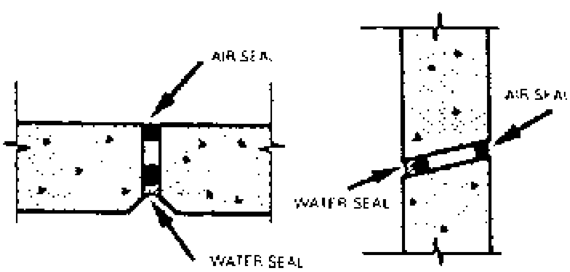
Structural glazing joints sealed with silicone sealant.



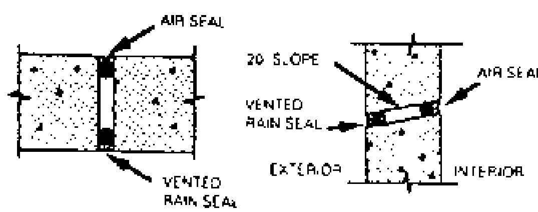
6.27.0 Typical Exterior Wall Air-Seal Applications



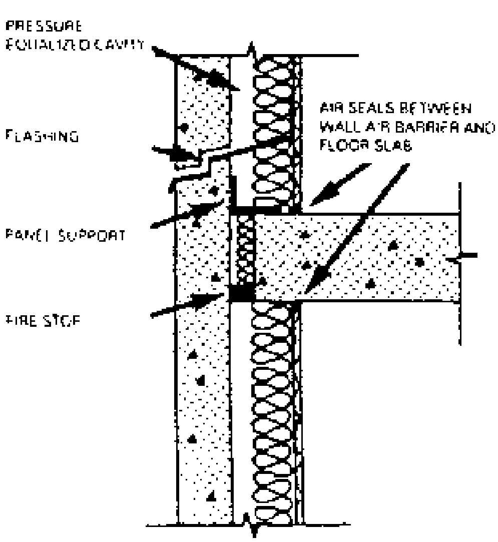
PRECAST WALL PANEL WITH ONE-STAGE JOINTS



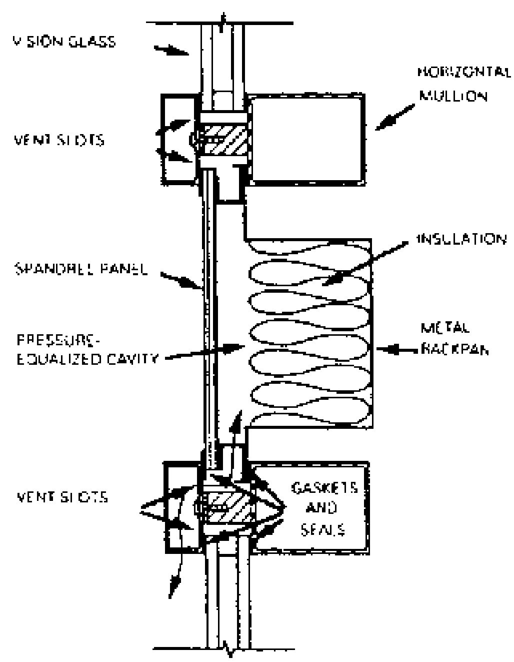
PRECAST WALL PANEL WITH TWO-STAGE JOINTS



TWO-STAGE PRESSURE-EQUALIZED JOINTS

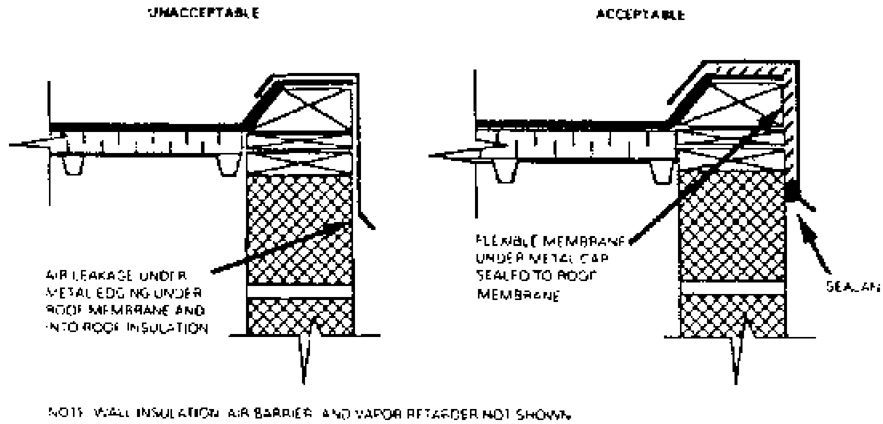


PRECAST CONCRETE PRESSURE-EQUALIZED RAIN SCREEN

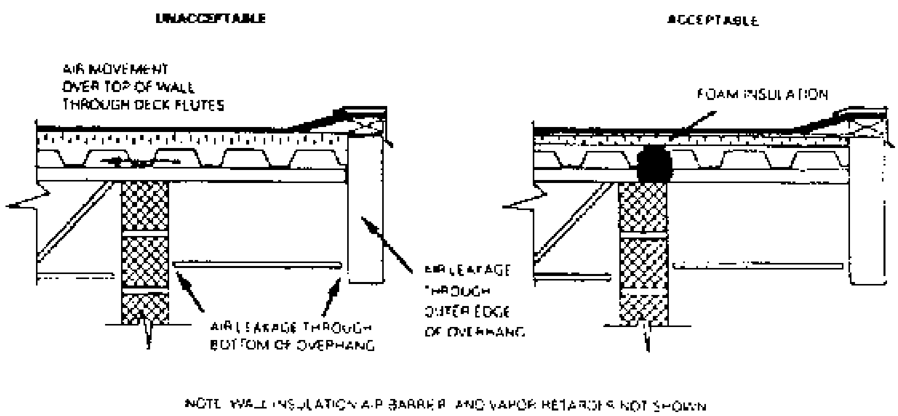


PRESSURE-EQUALIZED CURTAIN WALL MULLIONS

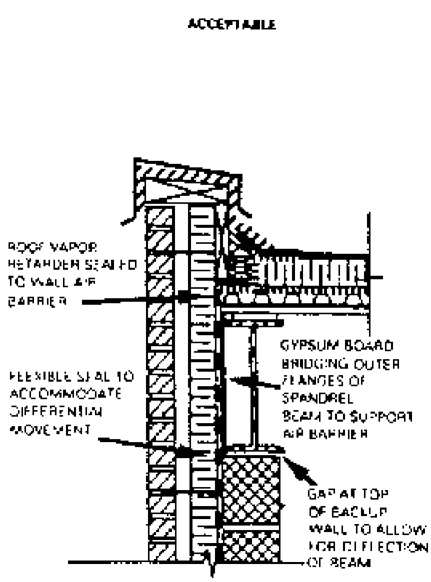
6.28.0 Acceptable/Unacceptable Air-Seal Applications



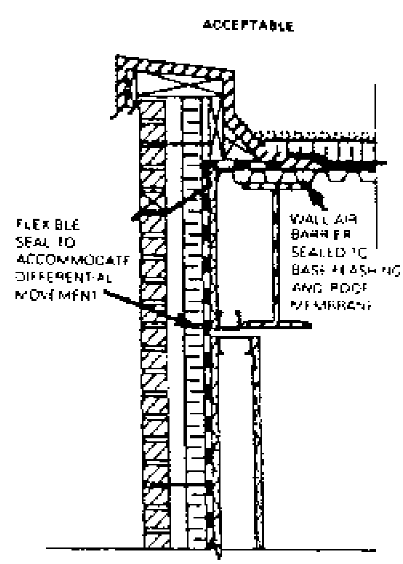
AIR LEAKAGE AT ROOF EDGE



AIR LEAKAGE AT ROOF OVERHANG



MASONRY WALL/ROOF EDGE WITH STEEL FRAME



METAL STUD WALL/ROOF EDGE WITH STEEL FRAME

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6.29.0 Adhesion Test Procedures

Recently, Bill Walter needed a field test for adhesion. He had a substrate with limited surface integrity and wanted to know if his surface preparation would be adequate.

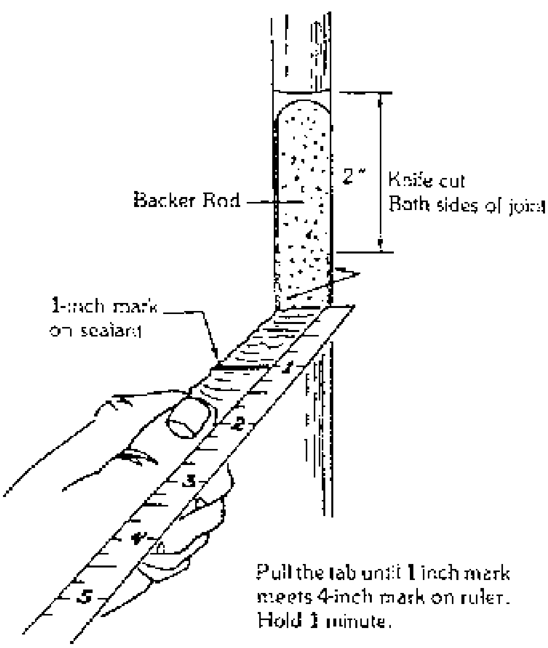
My answer was that he should prepare the surface on a test piece, then follow the procedure outlined below for either low or high modulus sealants (depending on his choice)

Bill thought the test was handy and of probable value to many applicators and contractors, so I am passing it on through the APPLICATOR.

As a check for adhesion, a hand pull test may be run on the job site after the sealant is fully cured. (Usually within 14 to 21 days).

The hand pull test procedure is as follows:

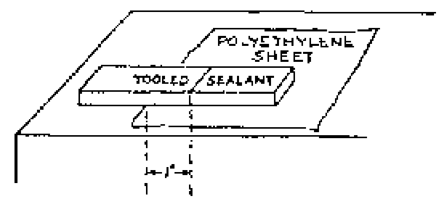
1. Make a knife cut horizontally from one side of the joint to the other
2. Make two vertical cuts approximately 2-inches long at the sides of the joint, meeting the horizontal cut at the top of the 2-inch cuts.
3. Place a 1-inch mark on the sealant tab as shown in the picture below.



4. Grasp the 2-inch piece of sealant firmly between the finger just above the 1-inch mark and pull at a 90° angle Hold a ruler along side the extending sealant
5. If the 1-inch mark on the sealant can be pulled 3 inches to the 4-inch mark on the ruler (300% elongation) and held with no failure of sealant (the sealant is not pulling away from the walls of the joint), the sealant will perform in 50% joint expansion.
6. Sealant may be replaced in test area easily, merely by applying more sealant in the same manner it was originally installed (assuming good adhesion was obtained). Care should be taken to assure that the new sealant is in contact with the original and that the original sealant surfaces are clean, so that a good bond between the new and old sealant will be obtained.

NOTE: Adhesion may be adversely affected by:
1. Moisture in or on the substrate during sealant application and cure.
2. Contaminated or weak surfaces.
3. Poor application technique.

NOTE: If the test is done on a flat surface, a test piece like that below is recommended.



¼-inch deep, 1-inch wide, approximately 4 inches long
Pull at 90° holding at 1 inch mark.
No under cutting is needed since the sealants generally do not adhere well to polyethylene.
After cure, proceed starting at step #3 above.

NOTE: It is often desirable to submerge the test piece in water for one day or seven days and repeat the test starting at step #4. Whether one day or seven days is chosen depends on the climate or environment where the sealant is expected to be used

As a check for adhesion, a hand pull test may be run on the job site after the sealant is fully cured (usually within fourteen to 21 days).

The hand pull test procedure is as follows:

1. Make a knife cut horizontally from one side of the joint to the other.
2. Make two vertical cuts approximately 2-inches long, at the sides of the joint, meeting the horizontal cut at the top of the 2-inch cuts.
3. Grasp the 2 inch piece of sealant firmly between the fingers and pull down at a 90° angle or more, and try to pull the uncut sealant out of the joint.
4. If adhesion is acceptable, the sealant should tear cohesively in itself before releasing adhesively from the substrate.
5. Sealant may be replaced in test area easily merely by applying more sealant in the same manner it was originally installed (assuming good adhesion was obtained). Care should be taken to assure that the new sealant is in contact with both surfaces.

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6.30.0 Proper Parapet Wall-Sealants Diagrams

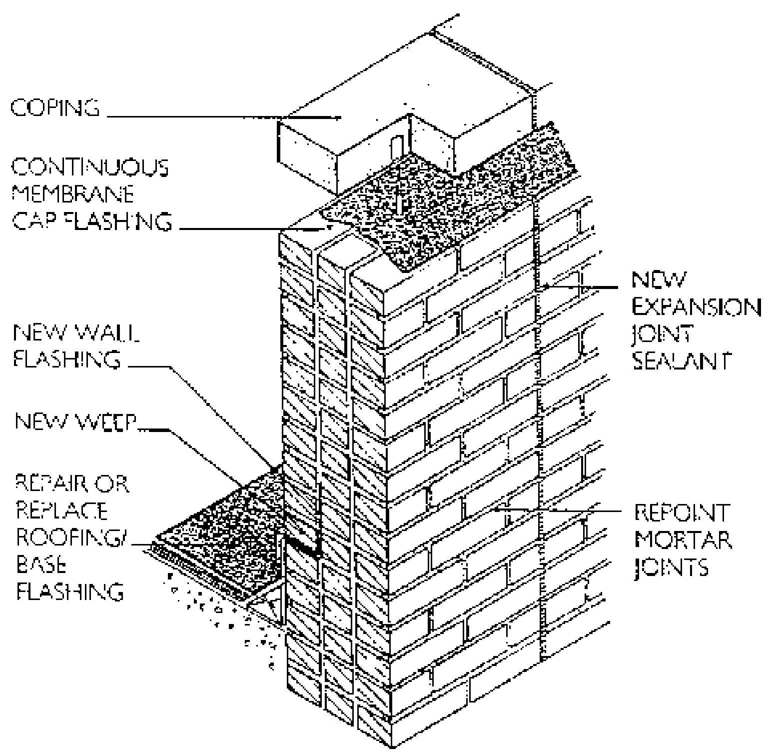
The Best Moisture Escape Routes

1. Ventilate the cavity for walls to breathe.
2. Install weep holes and/or clean existing weep holes that might have become clogged.
3. Correct improperly installed flashing and/or install additional flashing at problem areas.

The Best Barriers to Water Entry

1. Create water infiltration barriers, such as cap flushing.
2. Install adequate expansion and control joints to accommodate expansion due to thermal movement, moisture absorption, and freeze-thaw cycles.
3. Replace spalled brick.
4. Repoint deteriorating joints.

A word of caution: When replacing glazed brick, do not use corner brick in any location other than corners. With its two glazed sides, corner brick will fail to provide a proper bond on one side.



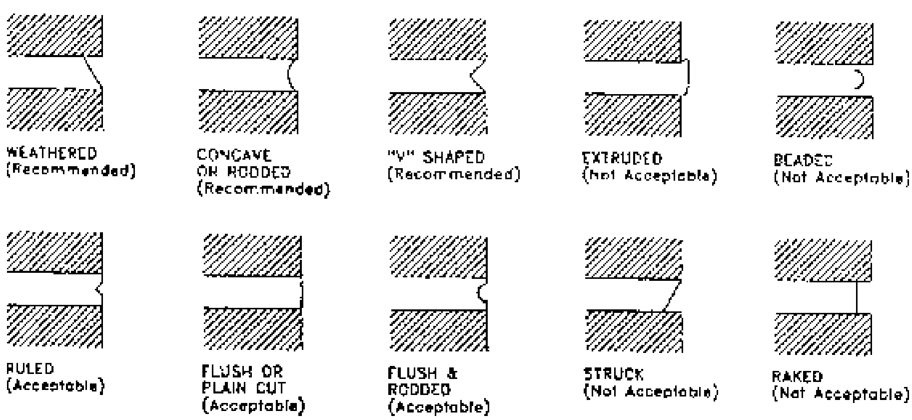
6.31.0 When Is It Time to Repoint? Mortar Joint Details

You know it's time to repoint when:

- Mortar has eroded to expose the brick behind the glazed face.
- Mortar has crumbled from the joint.
- Hairline cracks have appeared in the mortar.
- The bond between the mortar and the glazed brick is broken.

Strategies for maintaining mortar joints include the following:

1. Remove the old mortar by cutting out to a depth of at least ⅝"; remove more if necessary to eliminate unsound mortar.
2. Clean joints of old mortar, dust, and dirt prior to repointing.
3. Avoiding damaging brick edges when removing old mortar.
4. Use a mix ratio of 1 part Portland cement to 1 to 1½ parts hydrated lime to 6 parts sand for a flexible, but durable mortar.
5. Day and evening temperatures should be above 40°F during repointing; the area of work should be protected from the weather when not being worked on.
6. All excess mortar, smears, and droppings should be cleaned up before the mortar sets.
7. Joint configuration must be designed so that the mortar meets the top edge of the glaze and the joint easily sheds water.



6.32.0 Inspection of Mortar Joints to Determine Water-Resistant Integrity

- Has the mortar eroded to the point where a large portion of the underside of the brick above and below is visible? If so, it is time to repoint.
- Has the mortar begun to crumble from the joint? If so, it is time to repoint.
- Have hairline cracks formed in the mortar? If so, it is time to repoint.
- Is the bond between the mortar and brick broken? If so, it is time to repoint.

6.33.0 Steps Taken to Repoint Properly

1. Cut out old mortar to a depth of at least ⅝ inch. Remove more if a sound surface has not been found at that depth.
2. Avoid damaging the edges of the bricks while cleaning out the old mortar joint.
3. Clean out dust and dirt from the old joint.
4. Mix up a batch of mortar with the following proportions:
   1 part Portland cement
   1 to 1½ parts hydrated lime
   6 parts sand
5. Repointing should not take place when both day and night temperatures are below 40 degrees F.
6. Clean off excess mortar, drips, etc., before the mortar sets up.
7. The proper selection mortar-joint configuration will help to prevent a recurrence of premature failure.

6.34.0 Guidelines for Waterproof Back-Up of Wythes in Masonry Cavity Walls

* Don't neglect the need for properly installed flashing and adequately spaced weep holes. Waterproofing on the outer surface of a backup wythe is not intended to work by itself, but must work integrally with other details to prevent water leakage.

* The surface on which the waterproofing is to be applied should be clean and smooth, with all mortar projections cut flush.

* Most waterproofing must be applied within a specific temperature range. For example, some coatings should not be applied below 50 degrees F or above 95 degrees F. Always check manufacturers' recommendations.

* Use adequate safety protection, as needed: a face shield or protective goggles, an approved respirator, gloves, etc. Check product labels for safety information, proper application technique, and cautionary advice.

* Always request and read the manufacturer-supplied Material Safety Data Sheet (MSDS) for all products. It also is a good idea to make sure that products comply with all Volatile Organic Compound (VOC) regulations.

* Dispose of all empty containers in accordance with federal, state, and local regulations.

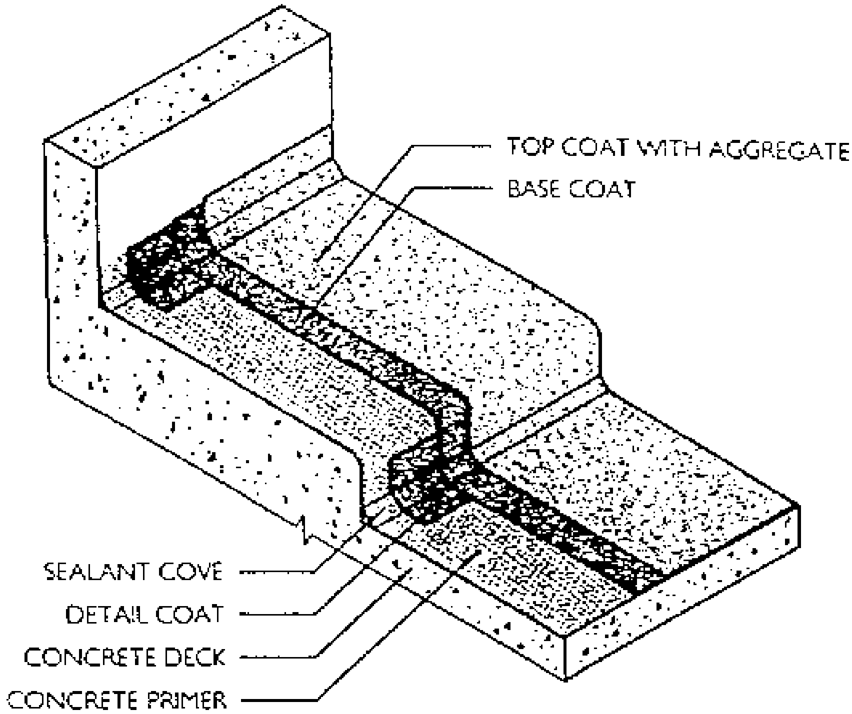
* When spray-applying a waterproof coating, be aware that high winds may make it difficult to get a consistent application and may even blow the spray to neighboring areas where it can damage exposed surfaces and foliage.

* Protect vegetation and painted areas from spills or overspray.

* For sealers or coatings that must be mixed with water, use only clean water free of any contaminants; make sure the mixing container also is clean.

(Reprinted by permission from the Sealant, Waterproofing, and Restoration Institute, Kansas City, Missouri.)

6.35.0 Diagram of a Typical Composite Waterproofing System



(Reprinted by permission from the Sealant, Waterproofing, and Restoration Institute, Kansas City, Missouri.)

6.36.0 Parking Garage Inspection Checklist

Level

	Problems: major	Problems: minor	Problems: none	Locations	Comments
I. Concrete Slab					
A. Floor (Top of Slab)					
Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Potholes					
Leaching					
Water Stains					
Unevenness of deck					
Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
Slab Protection					
Membrane					
Sealer					
B. Ceiling (Underside of Slab)					
Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					
Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
II. Expansion Joints/Control Joints					
A. Freeze/Thaw Damage					
B. Damage from Traffic or Snow Plows					
C. Joint Failure					
D. Bearing Pads					
III. Drainage					
A. Floor Drains					
B. Ponding					
IV. Beams and Girders					
A. Concrete					
Cracking					
Horizontal					
Vertical					
Diagonal					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					

6.37.0 Sealant/Caulking—Quality Control Checklist

Quality Control Checklist

Project no.

Section

Sealants and Caulking

No.

07921

Date

1. Approved submittals: shop drawings, samples, product data, certificates as required, are on site.
2. Materials are properly stored on site and protected.
3. Manufacturer's field supervision and pre-installation conference is conducted if required by sealant manufacturers.
4. Environmental, climatic and temperature conditions are suitable.
5. Joint width/depth conditions are as required.
6. Joint substrate conditions are as required.
7. Application of joint cleaners as required.
8. Application of joint primers as required.
9. Masking of adjoining surfaces as required.
10. Installation of joint backing materials as required.
11. Installation of bond breakers as required.
12. Appropriate sealant types installed in proper locations and adjacent to proper materials.
13. Observe application of sealant as required.
14. Joints tooled to provide smooth, uniform, concave surface as required.
15. No sealants out of plumb, cracking.
16. No backing materials out of plumb, displaced.
17. Debris is removed periodically, not piled.
18. Joint sealers protected during and after curing period.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

7

Fireproofing

Contents

7.0.0 Fireproofing or Fire Resisting?

Fireproofing, in many cases, might better be referred to as fire resistance because the materials applied, mainly to structural steel systems, are meant to protect these systems from collapsing when exposed to the presence of fire for specific periods of time (one, two, three, or four hours). In other cases, the term *fire retardant* is more applicable, particularly when applied to flammable or combustible materials, like wood. In this case, fire retardancy provides a limit to the flame spread, fuel contribution, and smoke development that would have occurred if the combustible surface had not been treated with a fire-resistive coating.

7.1.0 Four Accepted Methods to Fireproof Steel

1. Spray or trowel on materials of a cementitious or mineral-fiber nature.
2. Concrete encase structural steel columns or beams, or increase the thickness of concrete-suspended slabs on metal deck.
3. Apply specific numbers of layers of gypsum drywall onto the structural steel members.
4. Spray, brush, or roll on a water- or solvent-based intumescent material or mastic.

7.1.1 Spray-on or Trowel-On “Dry” or “Wet” Systems

Spray- or trowel-on “dry” or “wet” cementitious or mineral-fiber materials are the most prevalent forms of structural-steel fireproofing and are generally divided into two groupings (Type I and Type II).

- *Type I* A factory-mixed cementitious materials with a minimum density of 15/14 pounds per cubic foot (240 kg/cubic meter).
- *Type II* A factory-mixed, asbestos-free, mineral-fiber material with inorganic binders, having a minimum applied dry density of 15 pounds per cubic foot (240 kg/cubic meter). If this system is used, it is generally followed by a water overspray to press any loose fibers and allow the binders to migrate and product a firm surface.

7.2.0 Fireproofing Terminology

- *Air erosion* Resistance of spray fireproofing to dusting, flaking, sifting, and delamination because of air movement across its surface. ASTM E-859-82/GSA sets the performance quality for air erosion; it is to be 0.025 gm/ft^2 maximum.
- *Bond strength* The ability of the spray fireproofing to resist pulling away from the steel substrate. The higher the bond strength, the lower the chance for cohesive or adhesive failure. ASMT E-736-80 refers to bond strength and sets 200 lbs/ft^2 as the minimum bond strength.
- *Damageability* The resistance to physical abuse from abrasion, impact penetration, and compression. Two tests conducted by the City of San Francisco developed two standards and one test by ASTM provides the third:

  Impact penetration Six cubic centimeters maximum (City of San Francisco).

  Abrasion resistance 22 cubic centimeters maximum (City of San Francisco).

  Compression 500 pounds per square foot minimum (ASTM E-761-80).
- *Dry mix* It has no requirement to pre-mix with water or other additives. It can be applied in its original state by air under pressure. Water is introduced at the spray nozzle prior to application. The dry mix is quick and easy to apply.
- *Wet mix* The product is mixed with water to provide a slurry that is applied under high pressure through a nozzle. Although it is frequently referred to as *cementitious,* many manufacturer’s products do not contain cement. This type of application provides cost-effective, fire-resistant performance per unit thickness.

7.3.0 Typical Spray Fireproofing Specifications

Physical Performance Characteristics: Fireproofing material shall meet the following physical performance standards:

1. Dry Density: The field density shall be measured in accordance with ASTM Standard E 605. Minimum average density shall be that listed in the UL Fire Resistance Directory *for each rating indicated*, ICBO Evaluation Report as required by the authority having jurisdiction, or minimum average 240 kg/cubic meter (15 pcf), whichever is greater.
2. Deflection: Material shall not crack or delaminate from the surface to which it is applied when tested in accordance with ASTM E 759.
3. Bond Impact: Material subject to impact tests in accordance with ASTM E 760 shall not crack or delaminate from the surface to which it is applied.
4. Bond Strength: Fireproofing, when tested in accordance with ASTM E 736, shall have a minimum average bond strength of 9.6 KPa (200 psf) and a minimum individual bond strength of 7.2 KPa (150 psf).
5. Air Erosion: Maximum allowable total weight loss of the fireproofing material shall be .05 gms/square meter (.005 grams/ft²) when tested in accordance with ASTM E 859. Sample surface shall be "as applied" (not pre-purged) and the total reported weight loss shall be the total weight loss over a 24 hour period from the beginning of the test.
6. High Speed Air Erosion: Materials to be used in plenums or ducts shall exhibit no continued erosion after 4 hours at an air speed of 12.7 m/s (47 km/h) [2500 ft/min (29 mph)] when tested in accordance with UMC Standard 6-1 and ASTM E 859.
7. Compressive Strength: The fireproofing shall not deform more than 10% when subjected to compressive forces of 57 KPa (1200 psf) when tested in accordance with ASTM E 761.
8. Corrosion Resistance: Fireproofing applied to steel shall be tested in accordance with ASTM E 937 and shall not promote corrosion of steel.
9. Abrasion Resistance: No more than 15 cm³ shall be abraded or removed from the fireproofing substrate when tested in accordance with the test methods developed by the City of San Francisco, Bureau of Building Inspection.
10. Impact Penetration: The fireproofing material shall not show a loss of more than 6 cm³ when subjected to impact penetration tests in accordance with the test methods developed by the City of San Francisco, Bureau of Building Inspection.
11. Surface Burning Characteristics: Material shall exhibit the following surface burning characteristics when tested in accordance with ASTM E 84:
    Flame Spread 0
    Smoke Development 0
12. Resistance to Mold: The fireproofing material shall be formulated at the time of manufacturing with a mold inhibitor. Fireproofing material shall be tested in accordance with ASTM G 21 and shall show resistance to mold growth for a period of 21 days for general use and 60 days for materials to be installed in plenums.
13. Combustibility: Material shall have a maximum total heat release of 20 MJ/m² and a maximum 125 kw/m² peak rate of heat release 600 seconds after insertion when tested in accordance with ASTM E 1354 at a radiant heat flux of 75kw/m² with the use of electric spark ignition. The sample shall be tested in the horizontal orientations.

Primed/Painted Substrates and Metal Decking.

Cross Reference Sec. 05100 Structural Steel and Section 05300 Metal Decking.

Primed/Painted Substrates: Fireproofing obtains its maximum bond when applied to unprimed/unpainted structural steel. Priming of interior structural steel is generally unnecessary and is not recommended by the steel industry. Primers add to the cost of the structure and may adversely affect the fire-resistance rating and the bond of the fireproofing to the substrate. Grace recommends that the structural steel specification include the following: "Interior structural steel to receive application of spray-applied fireproofing shall be free of primer and paint."

Currently, no primer/paint is specifically listed by Underwriters Laboratories Inc. for use with interior structural steel. According to the UL's Fire Resistance Directory, primer/paint removal, bond strength tests, mechanical attachment, bonding agents, or combination thereof may be required to maintain a fire resistive rating. Contact your Grace Representative for more information. Please note that there are limited UL approvals for primed/painted metal decks and joist element.

Metal Decking: Rolling compounds or lubricants are commonly used in the manufacture of steel decking. These compounds may impair proper adhesion of fireproofing to the substrate. Lubricants are available which, when used in appropriate quantities, will not adversely affect the bond of fireproofing to steel deck surfaces. Grace recommends that Section 05300 Metal Decking states: "Steel Deck manufacturer shall supply decking free of amounts of lubricants or oils which would impair the adhesion of spray-applied fireproofing."

7.4.0 Spray Fireproofing Guide for Dry Mix Applications

This is an abbreviated guide and is not intended as a substitute for the CAFCO Application and Installation Manual. All applicators should thoroughly review the Application and Installation Manual prior to applying this product.

PREFERRED NOZZLE:	2-1/2" (65 mm) I.D. High output Air/Water nozzle, made by Hydra-Cone. The use of an expander sleeve is recommended to provide an even spray pattern. A 10 to 20 cfm (280 to 570 liters/min) AIR COMPRESSOR providing 60 psi (4.1 kg/cm²) air pressure at the nozzle is required.
ACCEPTABLE NOZZLES:	2-1/2" (65 mm) I.D. RA-9 Airless or 2" (50 mm) I.D. RA-6 Airless nozzles, made by Hydra-Cone. The use of an expander sleeve is recommended to provide an even spray pattern. 2-1/2" (65 mm) I.D. Boss 8 and 6 jet Airless nozzles, made by Contractors Consulting Service.
UNACCEPTABLE NOZZLE:	2" or 2-1/2" (50 or 65 mm) I.D. Hydra-Cone (Center Stem Jet), made by Hydra-Cone.
RECOMMENDED EQUIPMENT:	Unisul - All Pneumatic Fireproofing Machines Contractors Consulting Service - All BOSS Machines
MACHINE SETTINGS:	Unisul - Carding boxes or slide gates should be set at 6 to 8. BOSS - discs should be set at position 8. When feeding material, empty only one bag of material into machine hopper at a time. When the hopper is 1/4 full, empty next bag into the hopper.
WATER RATIO:	1.2 to 1 water to material ratio, by weight. Water pressure should be a minimum of 60 psi (4.1 kg/cm²) as measured at the nozzle. Refer to the CAFCO Application and Installation Manual for methods to determine water flow rate and material feed rate.
WATER BOOSTER PUMP:	IT IS MANDATORY THAT A WATER BOOSTER PUMP WITH A 55 GAL.(200 LITER) MINIMUM RESERVOIR TANK BE USED TO INSURE PROPER WATER PRESSURE AND VOLUME.
HOSE SET-UP:	*TRANSFER HOSE* must be smooth interior, rubber or plastic with a 2-1/2" (65 mm) or 3" (75 mm) Inside Diameter (I.D.). It must be reinforced to resist kinking or cracking and must resist static build-up. The maximum transfer hose length, not including standpipe, is 250 ft (75 m). *LIGHTWEIGHT FLEX HOSE (WHIP HOSE)* must be rubber or plastic with a 2" (50 mm) or 2-1/2" (65 mm) Inside Diameter. It must be lightweight and flexible to allow mobility at the nozzle and must resist static build-up. The maximum whip hose length is 25 ft (8 m).

(By permission of Isolatex International, Stanhope, New Jersey.)

7.4.0 Spray Fireproofing Guide for Dry Mix Applications—Continued

NOZZLE DISTANCE:	18" to 24" (450 to 600 mm) from the substrate.
SURFACE PREPARATION:	Ensure surfaces are clean and free of dirt, oil, grease, loose mill scale, paints/primers (other than those approved) and any other materials that may impair adhesion. For applications to primed steel, contact the Isolatek International Technical Department. Note: See CAFCO Application and Installation Manual for use of CAFCO BOND-SEAL on various substrates.
APPLICATION TEMPERATURE:	Maintain a minimum substrate and ambient temperature of 40°F (4°C) prior to, during, and a minimum of 24 hours after application.
VENTILATION:	Provide a minimum of 3 complete air exchanges per hour until the material is dry.
WATER OVERSPRAY:	IT IS MANDATORY THAT THE BLAZE-SHIELD II BE OVERSPRAYED WITH WATER BEFORE THE END OF THE WORK DAY.

NOTE: Only the listed equipment, nozzles and procedures are approved for applying CAFCO BLAZE-SHIELD II Deviations from any of these recommendations will result in product not meeting claims as published in Isolatek's literature. For complete details, refer to the CAFCO Application and Installation Manual. This guide is not a substitute for the CAFCO Application and Installation Manual.

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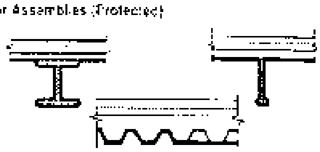
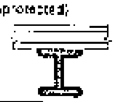
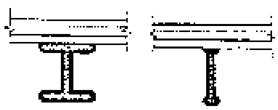
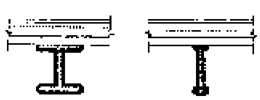
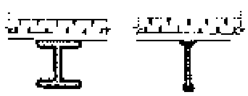
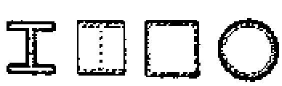
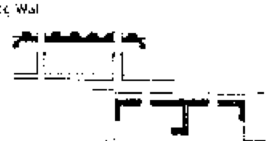
7.5.0 UL/ULC Fire-Resistance Ratings Chart (Dry and Wet Mixes)

Dry Mix Fire Protection

Assembly	BLAZE-SHIELD® DC/F, II Rating (Hr) 1	1½	2	3	4	UL, ULC Design	BLAZE-SHIELD® HP Rating (Hr) 1	1½	2	3	4	UL, ULC Design
Floor Assemblies (Protected) 	●	●	●	●		D832	●	●	●	●		D832
	●	●	●	●	●	D858	●	●	●	●		G851
	●	●	●	●		D859	●	●	●	●		F816 ▲
	●	●	●	●	●	D860						
	●	●	●	●		G801						
					●	F801 ▲						
	●	●	●	●		F816 ▲						
	●	●	●	●		F819 ▲						
Floor Assemblies (Unprotected) 	●	●	●	●		D902	●	●	●	●		D902
	●	●	●			F904 ▲	●	●	●			F904 ▲
Beam Only Floors 	●	●	●	●		N815	●	●	●	●	●	N816
	●	●	●	●	●	N816	●	●	●	●		N826
	●	●	●	●	●	N823	●	●	●	●	●	O804 ▲
	●	●	●	●		N826						
	●	●	●			N830						
	●		●			N802 ▲						
	●	●	●	●	●	C364 ▲						
Roof Assemblies Protected (with board insulation) 	●	●	●			P801	●	●	●			P801
	●	●	●			P814	●	●	●			P814
	●	●	●			P819	●	●	●			P819
	●	●	●			P825	●					R805 ▲
	●					R805 ▲						
Roof Assemblies Unprotected (with insulating concrete) 	●	●	●			P908	●	●	●			P907
	●	●	●			P922	●	●	●			P922
Beam Only Roofs 	●	●	●	●		S801	●	●	●	●		S801
	●	●	●			S802 *	●	●	●			S802 *
	●	●	●	●	●	S805 *	●	●	●	●	●	S805 *
	●	●	●			S806	●	●	●			S806
Columns, Wide Flange, Pipe and Tube 	●	●	●	●	●	X829	●	●	●	●	●	X829
	●	●	●	●	●	X827	●	●	●	●	●	X827
	●	●	●	●		Z808 ▲						
	●	●	●			Z802 ▲						
	●	●	●	●		Z805 ▲						
Nonbearing Wall 	●	●	●	●	●	U804	●	●	●	●		U804
	●	●	●	●	●	W801 ▲	●	●	●	●	●	W801 ▲

Wet Mix Fire Protection

Assembly	Calco® 300, 400 Rating (Hr) 1	1½	2	3	4	UL, ULC Design	Calco® 800 Rating (Hr) 1	1½	2	3	4	UL, ULC Design
Floor Assemblies (Protected)	●	●	●	●		D759	●	●	●	●	●	D744
	●	●	●	●		G705						
	●	●	●	●		D860						
Floor Assemblies (Unprotected)	●	●	●	●		D902	●	●	●	●		D902
Beam Only Floors	●	●	●	●	●	N759	●	●	●	●	●	N742
	●	●	●	●		N761	●	●	●	●		N760
	●	●	●	●	●	C708 ▲	●	●	●	●	●	D707 ▲
Roof Assemblies Protected (with board insulation)	●	●	●	●		P719						
	●	●	●			P720						
Roof Assemblies Unprotected (with insulating concrete)	●	●	●			P906						
	●	●	●			P922						
Beam Only Roofs	●	●	●	●	●	S721	●	●	●	●		S720
	●	●	●	●	●	S729						
Columns, Wide Flange, Pipe and Tube	●	●	●	●	●	X790	●	●	●	●	●	X764
	●	●	●	●	●	Z715 ▲	●	●	●	●		X767
					●	Z716 *	●	●	●	●	●	X768
							●	●	●	●	●	XR703
Nonbearing Wall												

* ULC designs listed are for Calco 300 only

* Requires material on underside of deck.

▲ ULC design

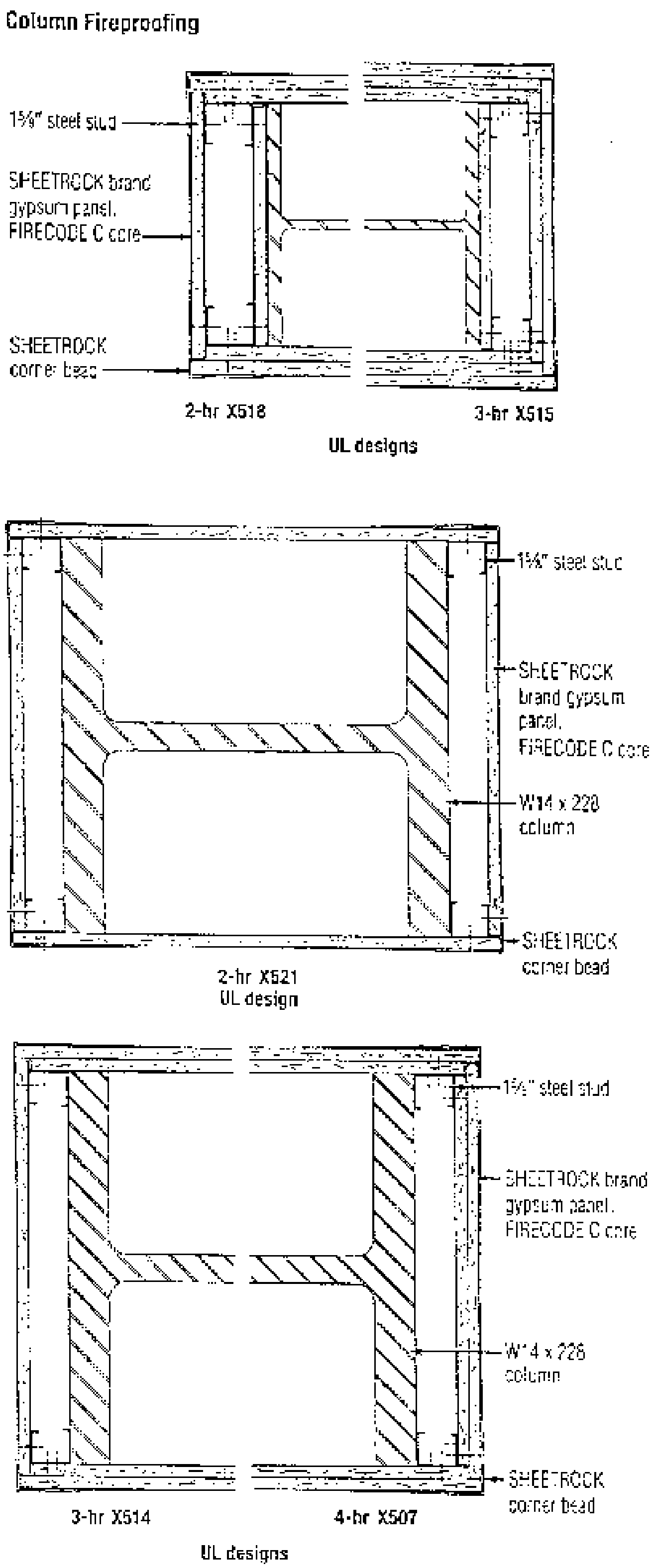
(By permission of Isolatex International, Stanhope, New Jersey.)

7.6.0 Standard Physical-Performance Properties for Spray-Applied Materials

CHARACTERISTIC	ASTM STANDARD	LOW DENSITY	MEDIUM DENSITY	HIGH DENSITY
Surface Burning Characteristics	E84	Flame.......0 Smoke......0	Flame.......0 Smoke......0	Flame.......0 Smoke......0
Density	E605	15 lb/ft^3 (240 kg/m^3)	22 lb/ft^3 (352 kg/m^3)	40 lb/ft^3 (640 kg/m^3)
Cohesion / Adhesion (Bond Strength)	E736	150 lb/ft^2 (7.2 kPa)	434 lb/ft^2 (20.8 kPa)	1,000 lb/ft^2 (48.1 kPa)
Deflection	E759	No cracks or delaminations	No cracks or delaminations	No cracks or delaminations
Bond Impact	E760	No cracks or delaminations	No cracks or delaminations	No cracks or delaminations
Compressive Strength	E761	750 lb/ft^2 (35.9 kPa)	7340 lb/ft^2 (351 kPa)	43,200 lb/ft^2 (2068 kPa)
Air Erosion Resistance	E859	< 0.025 g/ft^2	< 0.025 g/ft^2	< 0.025 g/ft^2
Corrosion Resistance	E937, Mil Std 810	Does not promote corrosion of steel	Does not promote corrosion of steel	Does not promote corrosion of steel
Combustibility	E136, E1354	Noncombustible	Noncombustible	Noncombustible

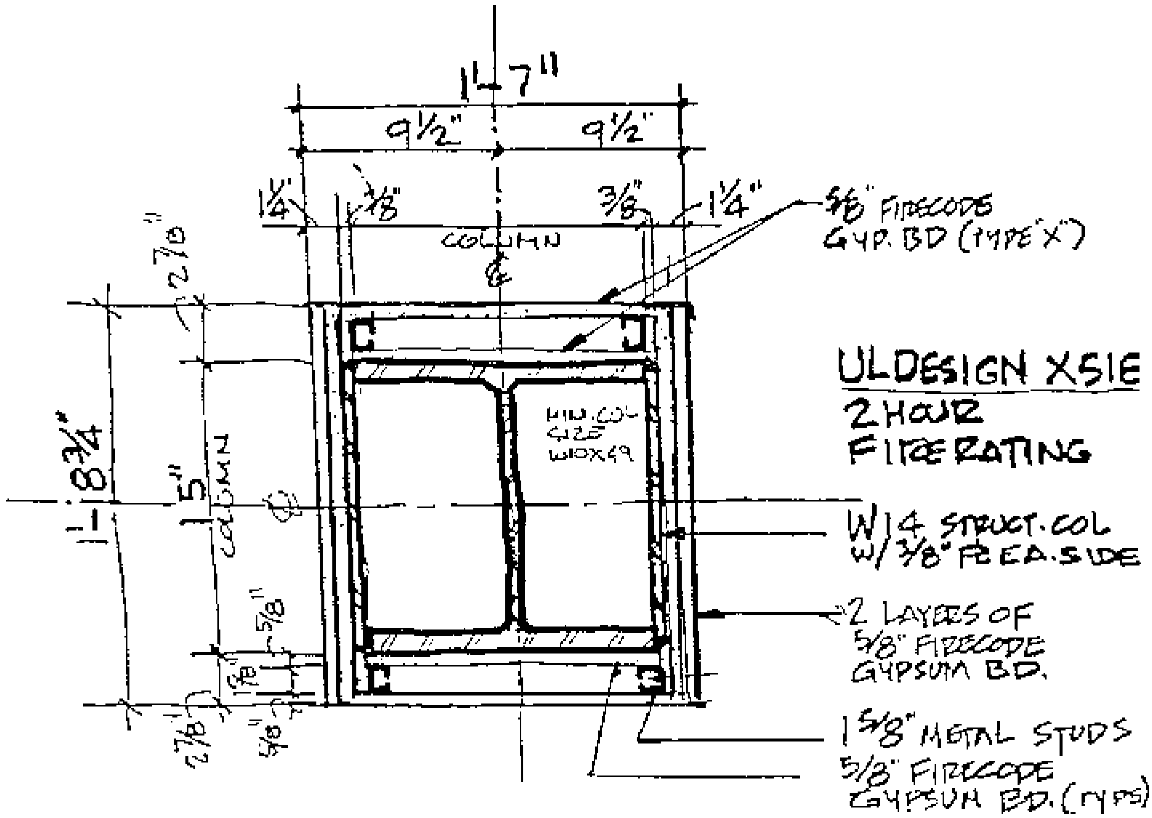
(By permission of Isolatex International, Stanhope, New Jersey.)

7.7.0 Column Fireproofing Utilizing Gypsum Drywall (Two- and Three-Hour Ratings)

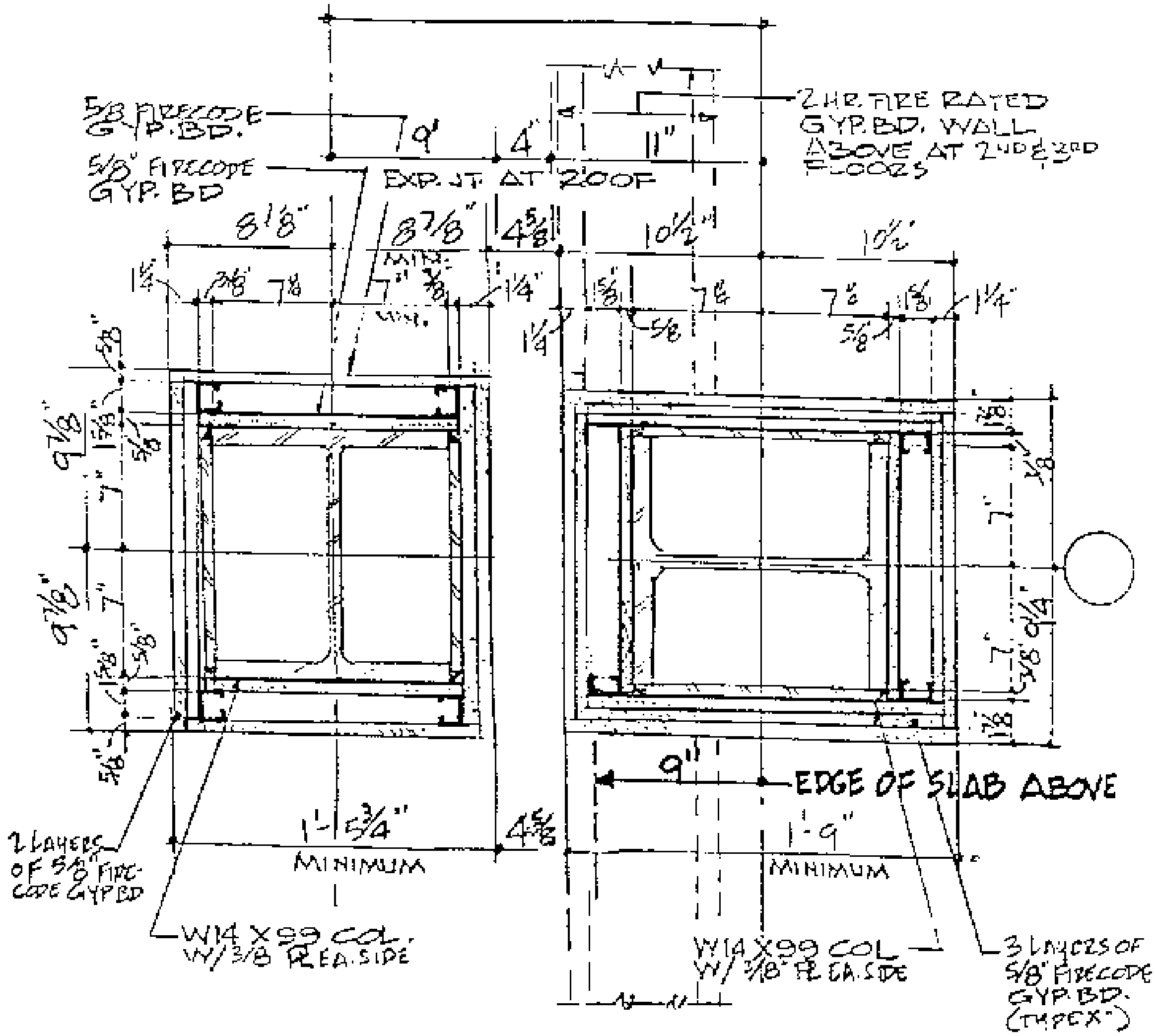


(By permission from United States Gypsum Corp., Chicago, Illinois.)

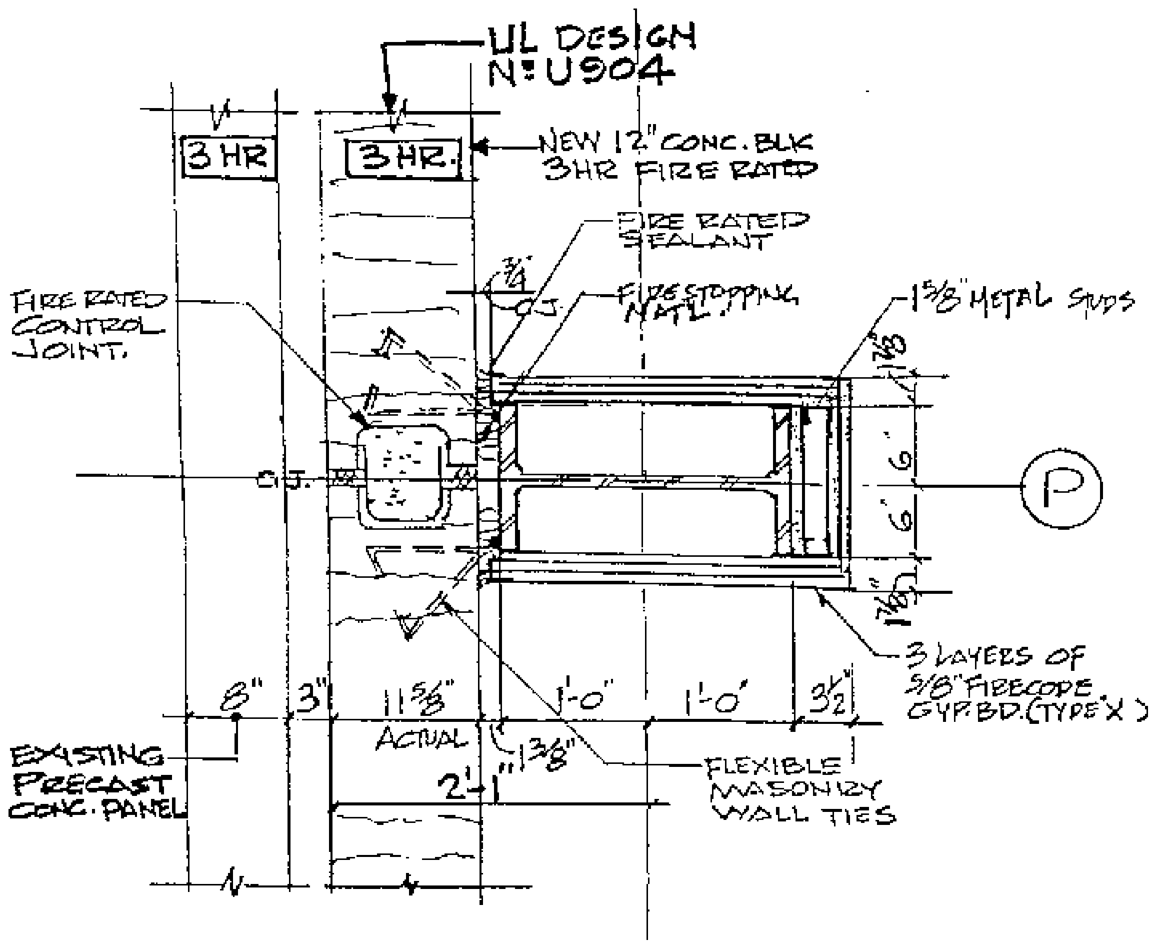
7.8.0 Two-Hour Fire-Rated Drywall Column Enclosure (UL Design X518)



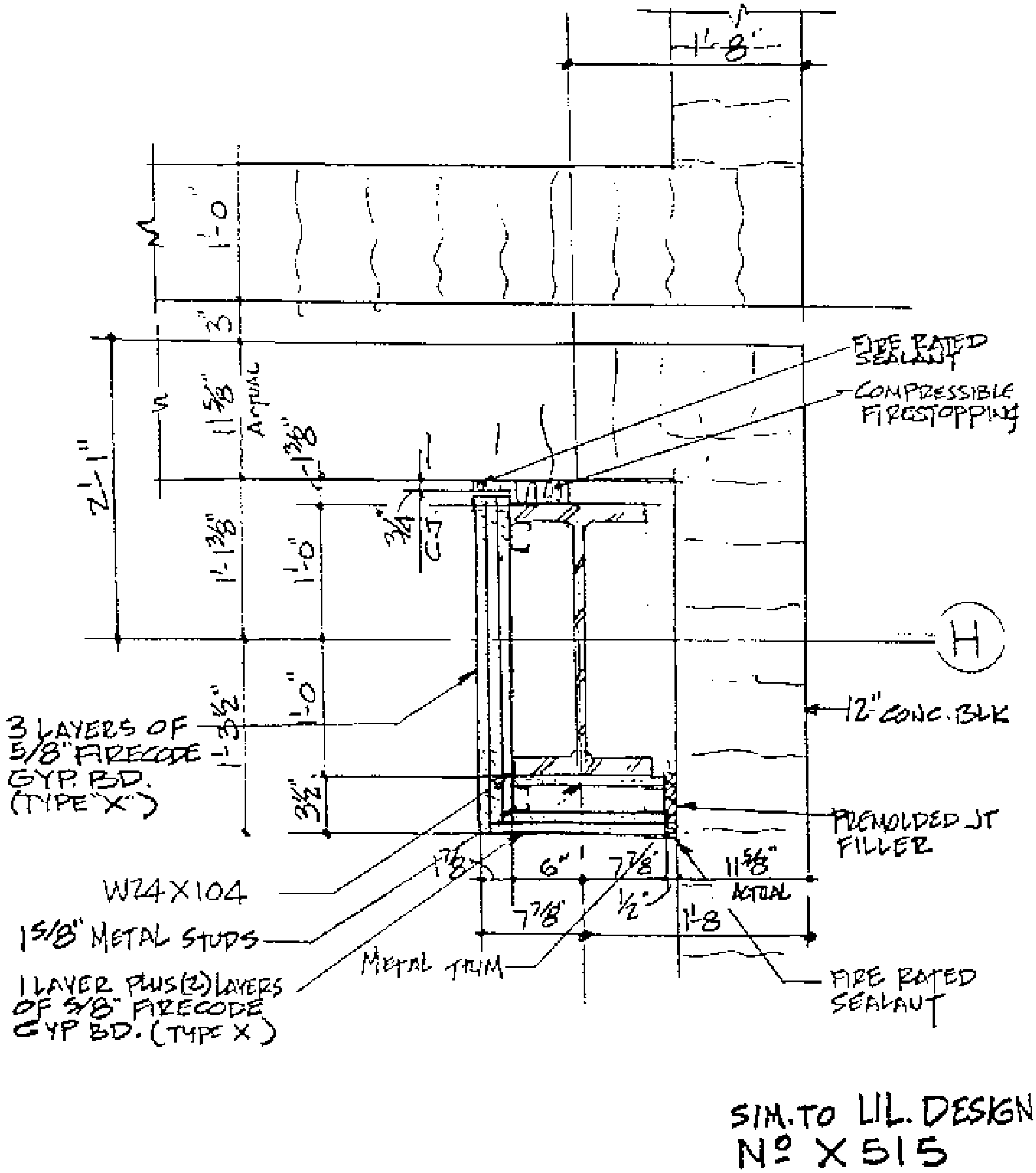
7.9.0 Two Three-Hour Drywall Column Enclosure Design (UL Design X518, X515)



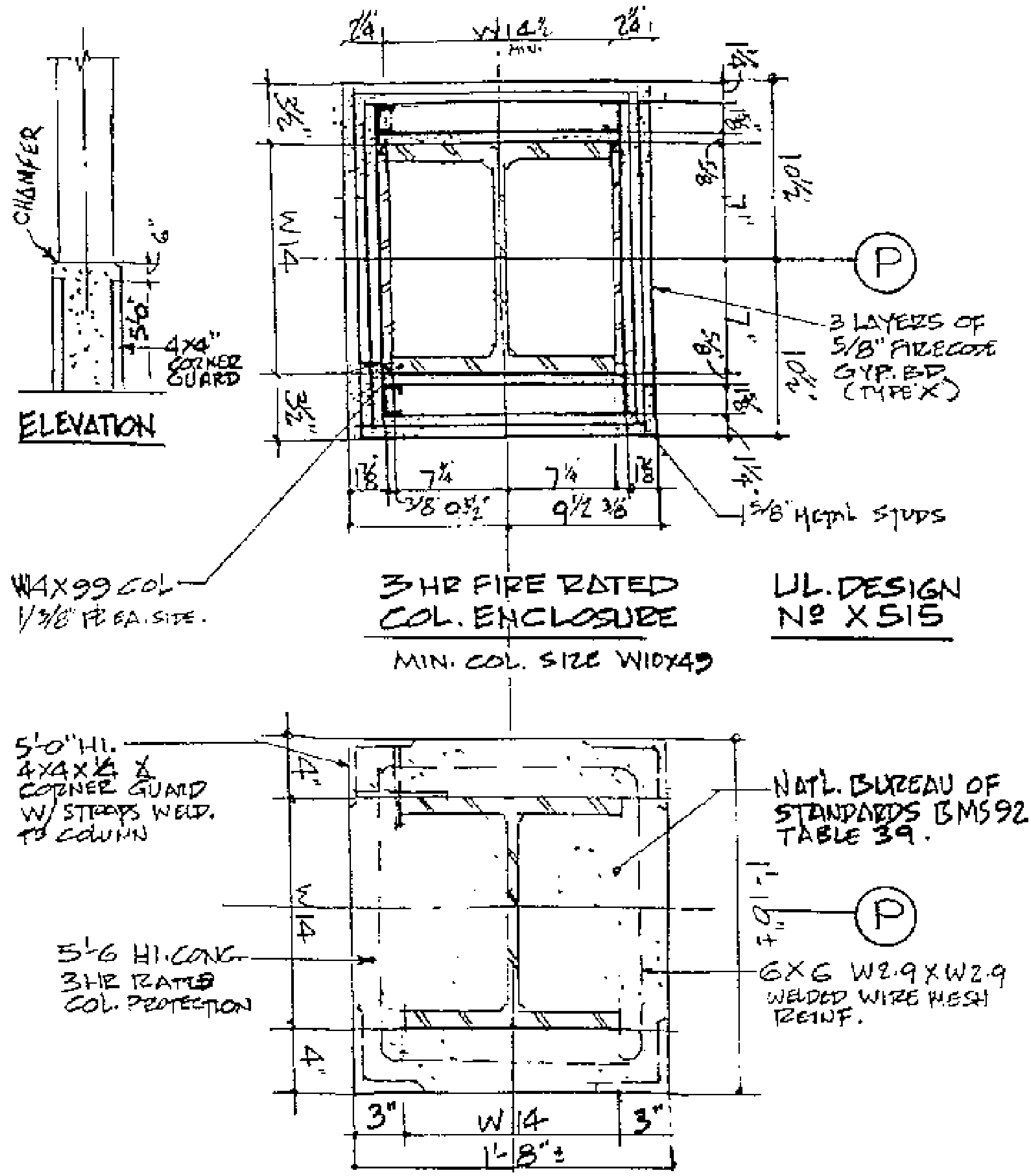
7.10.0 Three-Hour Drywall Column Enclosure to Precast Concrete Panel (UL Design U904)



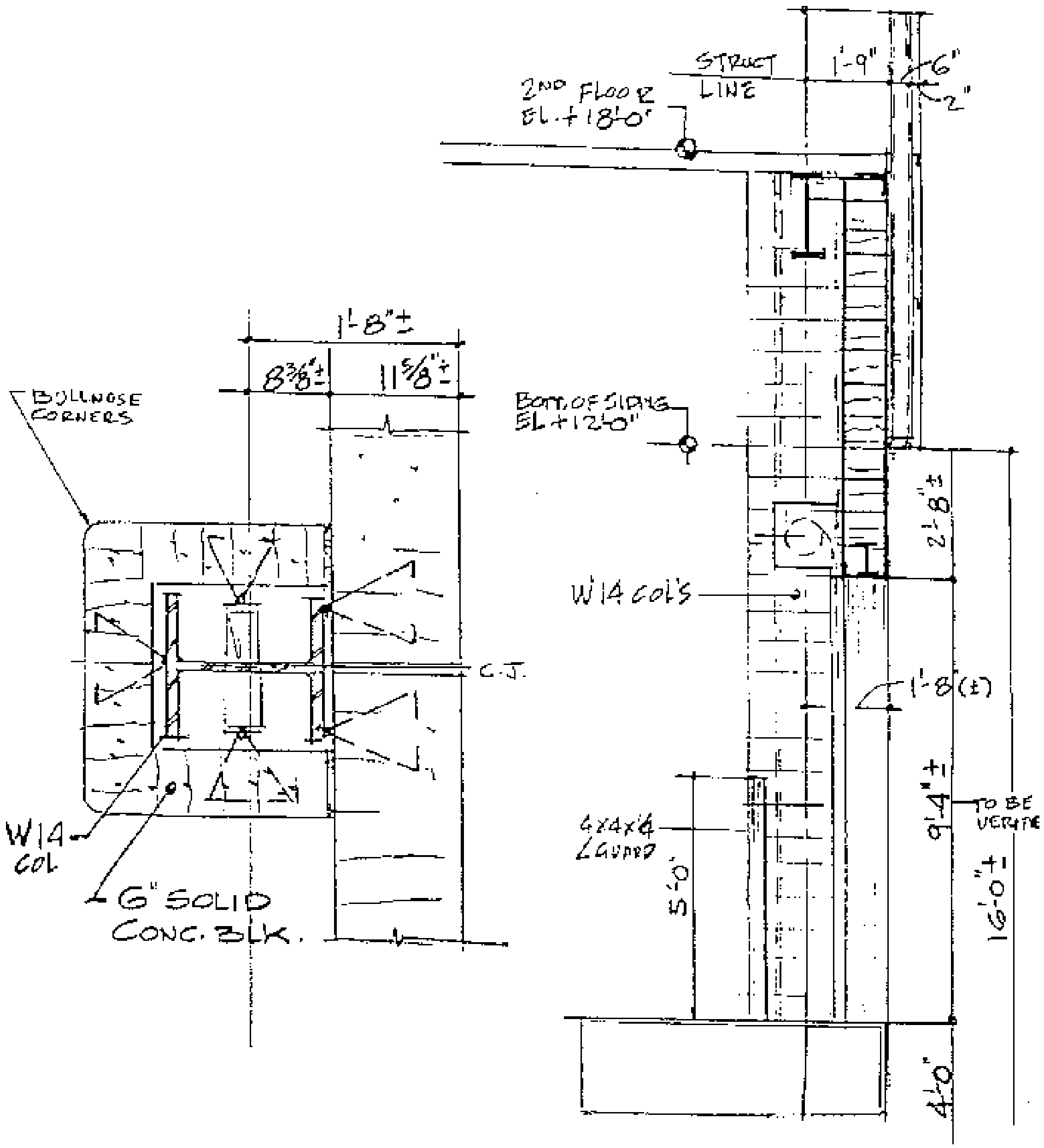
7.11.0 Three-Hour Drywall Column Enclosure at 12" Block Wall Corner (UL Design X515)



7.12.0 Three-Hour Concrete Column Enclosure (Traffic Area)



7.13.0 Three-Hour Masonry Column Enclosure



7.14.0 Fire Resistant Materials and Construction per Uniform Building Code

SECTION 701 — SCOPE

This chapter applies to materials and systems used in the design and construction of a building to safeguard against the spread of fire and smoke within a building and the spread of fire to or from buildings.

SECTION 702 — DEFINITIONS

For the purposes of this chapter, the terms, phrases and words listed in this section and their derivatives shall have the indicated meanings.

ANNULAR SPACE is the opening around the penetrating item.

CONCRETE, CARBONATE AGGREGATE, is concrete made with aggregates consisting mainly of calcium or magnesium carbonate, e.g., limestone or dolomite, and containing 40 percent or less quartz, chert or flint.

CONCRETE, LIGHTWEIGHT AGGREGATE, is concrete made with aggregates of expanded clay, shale, slag or slate or sintered fly ash or any natural lightweight aggregate meeting ASTM C 330 and possessing equivalent fire-resistive properties and weighing 85 to 115 pounds per cubic foot (pcf) (1360 to 1840 kg/m^3).

CONCRETE, SAND-LIGHTWEIGHT, is concrete made with a combination of expanded clay, shale, slag or slate or sintered fly ash or any natural lightweight aggregate meeting ASTM C 330 and possessing equivalent fire-resistive properties and natural sand. Its unit weight is generally between 105 and 120 pcf (1680 and 1920 kg/m^3).

CONCRETE, SILICEOUS AGGREGATE, is concrete made with normal-weight aggregates consisting mainly of silica or compounds other than calcium or magnesium carbonate, and may contain more than 40 percent quartz, chert or flint.

F RATING is the time period the penetration firestop system limits the passage of fire through the penetration when tested in accordance with UBC Standard 7-5.

FIREBLOCKING is building material installed to resist the free passage of flame and gases to other areas of the building through small concealed spaces.

FIRE-RESISTIVE JOINT SYSTEM is an assemblage of specific materials or products that are designed, tested and fire resistive in accordance with UBC Standard 7-1 to resist, for a prescribed period of time, the passage of fire through joints.

JOINT is the linear opening between adjacent fire-resistive assemblies. A joint is a division of a building that allows independent movement of the building, in any plane, which may be caused by thermal, seismic, wind loading or any other loading.

MEMBRANE PENETRATION is an opening made through one side (wall, floor or ceiling membrane) of an assembly.

PENETRATION is an opening created in a membrane or assembly to accommodate penetrating items for electrical, mechanical, plumbing, environmental and communication systems.

EXCEPTION: Ducts.

PENETRATION FIRESTOP SYSTEM is an assemblage of specific materials or products that are designed, tested and fire resistive in accordance with UBC Standard 7-5 to resist, for a prescribed period of time, the passage of fire through penetrations.

SPLICE is the result of a factory or field method of joining or connecting two or more lengths of a fire-resistive joint system into a continuous entity.

T RATING is the time period that the penetration firestop system including the penetrating item, limits the maximum temperature rise to 325°F (163°C) above its initial temperature through the penetration on the nonfire side, when tested in accordance with UBC Standard 7-5.

THROUGH-PENETRATION is an opening that passes through both sides of an assembly.

SECTION 703 — FIRE-RESISTIVE MATERIALS AND SYSTEMS

703.1 General. Materials and systems used for fire resistive purposes shall be limited to those specified in this chapter, unless accepted under the procedure given in Section 703.2 or 703.3.

The materials and details of construction for the fire-resistive systems described in this chapter shall be in accordance with all other provisions of this code except as modified herein.

For the purpose of determining the degree of fire resistance afforded, the materials of construction listed in this chapter shall be assumed to have the fire-resistance rating indicated in Table 7-A, 7-B or 7-C.

As an alternate to Table 7-A, 7-B or 7-C, fire-resistive construction may be approved by the building official on the basis of evidence submitted showing that the construction meets the required fire-resistive classification.

703.2 Qualification by Testing. Material or assembly of materials of construction tested in accordance with the requirements set forth in UBC Standard 7-1 shall be rated for fire resistance in accordance with the results and conditions of such tests.

> **EXCEPTION:** The acceptance criteria of UBC Standard 7-1 for exterior-bearing walls shall not be required to be greater with respect to heat transmission and passage of flame or hot gases than would be required of a nonbearing wall in the same building with the same distance to the property line. The fire exposure time period, water pressure and duration of application for the hose stream test shall be based on the fire-resistive rating determined by this exception.

Fire-resistive assemblies tested under UBC Standard 7-1 shall not be considered to be restrained unless evidence satisfactory to the building official is furnished by the person responsible for the structural design showing that the construction qualifies for a restrained classification in accordance with UBC Standard 7-1. Restrained construction shall be identified on the plans.

703.3 Calculating Fire Resistance. The fire-resistive rating of a material or assembly may be established by calculations. The procedures used for such calculations shall be in accordance with UBC Standard 7-7.

703.4 Standards of Quality. In addition to all the other requirements of this code, fire-resistive materials shall meet the requirements for fire-resistive construction given in this chapter.

The standards listed below labeled a "UBC standard" are also listed in Chapter 35, Part II, and are part of this code. The standards listed below labeled an "Adopted Standard" are also listed in Chapter 35, Part III, and are part of this code. The other standards

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listed below are recognized standards. (See Sections 3503 and 3504.)

1. UBC Standard 7-1, Fire Tests of Building Construction and Materials

2. UBC Standard 7-2, Fire Tests of Door Assemblies

3. UBC Standard 7-3, Tinclad Fire Doors

4. UBC Standard 7-4, Fire Tests of Window Assemblies

5. UBC Standard 7-5, Fire Tests of Through-penetration Fire Stops

6. UBC Standard 7-6, Thickness, Density Determination and Cohesion/Adhesion for Spray-applied Fire-resistive Fireproofing

7. UBC Standard 7-7, Methods for Calculating Fire Resistance of Steel, Concrete, Wood, Concrete Masonry and Clay Masonry Construction

8. ASTM C 516, Vermiculite Loose-fill Insulation

9. ASTM C 549, Perlite Loose-fill Insulation

10. ANSI/NFPA 80, Standard for Fire Doors and Fire Windows

11. ASTM C 587 and C 588, Gypsum Base for Veneer Plaster and Gypsum Veneer

12. ASTM C 332, Lightweight Aggregates for Insulating Concrete

13. ASTM C 331, Lightweight Aggregates for Concrete Masonry Units

14. UL 555, Fire Dampers

15. UL 555C, Ceiling Dampers

16. UL 555S, Leakage Rated Dampers for Use in Smoke Control Systems

17. UL 33, Heat Response Links for Fire Protection Service

18. UL 353, Limit Controls

19. ASTM E 1399, Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems

20. Adopted standard—Fire-Resistance Design Manual, Fourteenth Edition

21. Adopted standard—ASTM C 330, Lightweight Aggregates for Structural Concrete

22. Adopted standard—CPSC 16 CFR, Part 1209 Interim Safety Standard for Cellulose Insulation and Part 1404 Cellulose Insulation

SECTION 704 — PROTECTION OF STRUCTURAL MEMBERS

704.1 General. Structural members having the fire-resistive protection set forth in Table 7-A shall be assumed to have the fire-resistance ratings set forth therein.

704.2 Protective Coverings.

704.2.1 Thickness of protection. The thickness of fire-resistive materials required for protection of structural members shall be not less than set forth in Table 7-A, except as modified in this section. The figures shown shall be the net thickness of the protecting materials and shall not include any hollow space back of the protection.

704.2.2 Unit masonry protection. Where required, metal ties shall be embedded in transverse joints of unit masonry for protection of steel columns. Such ties shall be as set forth in Table 7-A or be equivalent thereto.

704.2.3 Reinforcement for cast-in-place concrete column protection. Cast-in-place concrete protection for steel columns shall be reinforced at the edges of such members with wire ties of not less than 0.18 inch (4.6 mm) in diameter wound spirally around the columns on a pitch of not more than 8 inches (203 mm) or by equivalent reinforcement.

704.2.4 Embedment of pipes. Conduits and pipes shall not be embedded in required fire protection of structural members.

704.2.5 Column jacketing. Where the fire-resistive covering on columns is exposed to injury from moving vehicles, the handling of merchandise or other means, it shall be protected in an approved manner.

704.2.6 Ceiling membrane protection. When a ceiling forms the protective membrane for fire-resistive assemblies, the assemblies and their supporting horizontal structural members need not be individually fire protected except where such members support directly applied loads from a floor and roof or more than one floor. The required fire resistance shall not be less than that required for individual protection of members.

704.2.7 Plaster application. Plaster protective coatings may be applied with the finish coat omitted when they comply with the design mix and thickness requirements of Tables 7-A, 7-B and 7-C.

704.2.8 Truss protection. Where trusses are used as all or part of the structural frame and protection is required by Table 6-A, such protection may be provided by fire-resistive materials enclosing the entire truss assembly on all sides for its entire length and height. The required thickness and construction of fire-resistive assemblies enclosing trusses shall be based on the results of full-scale tests or combinations of tests on truss components or on approved calculations based on such tests that satisfactorily demonstrate that the assembly has the required fire resistance.

704.3 Protected Members.

704.3.1 Attached metal members. The edges of lugs, brackets, rivets and bolt heads attached to structural members may extend to within 1 inch (25 mm) of the surface of the fire protection.

704.3.2 Reinforcing. Thickness of protection for concrete or masonry reinforcement shall be measured to the outside of the reinforcement except that stirrups and spiral reinforcement ties may project not more than $^1/_2$ inch (12.7 mm) into the protection.

704.3.3 Bonded prestressed concrete tendons. For members having a single tendon or more than one tendon installed with equal concrete cover measured from the nearest surface, the cover shall not be less than that set forth in Table 7-A.

For members having multiple tendons installed with variable concrete cover, the average tendon cover shall not be less than that set forth in Table 7-A, provided:

1. The clearance from each tendon to the nearest exposed surface is used to determine the average cover.

2. In no case can the clear cover for individual tendons be less than one half of that set forth in Table 7-A. A minimum cover of $^3/_4$ inch (19.1 mm) for slabs and 1 inch (25.4 mm) for beams is required for any aggregate concrete.

3. For the purpose of establishing a fire-resistive rating, tendons having a clear covering less than that set forth in Table 7-A shall not contribute more than 50 percent of the required ultimate moment capacity for members less than 350 square inches (0.226 m^2) in cross-sectional area and 65 percent for larger members. For structural design purposes, however, tendons having a reduced cover are assumed to be fully effective.

704.4 Members Carrying Masonry or Concrete. All members carrying masonry or concrete walls in buildings over one

Continued

story in height shall be fire protected with one-hour fire protection or the fire-resistive requirement of the wall, whichever is greater.

704.5 Fire-resistive Material Omitted. Fire-resistive material may be omitted from the bottom flange of lintels spanning not over 6 feet (1829 mm), shelf angles or plates that are not a part of the structural frame.

704.6 Spray-applied Fire-resistive Materials. The density and thickness of spray-applied fire-resistive materials shall be determined following the procedures set forth in UBC Standard 7-6.

SECTION 705 — PROJECTIONS

Cornices, eave overhangs, exterior balconies and similar architectural appendages extending beyond the floor area as defined in Section 207 shall conform to the requirements of this section. (See Section 1006 for additional requirements applicable to exterior exit balconies and stairways.)

Projections from walls of Type I or II construction shall be of noncombustible materials.

Projections from walls of Type III, IV or V construction may be of noncombustible or combustible materials.

Combustible projections located where openings are not permitted or where protection of openings is required shall be of one-hour fire resistive or heavy timber construction conforming to Section 605.6.

For projections extending over public property, see Chapter 32.

For combustible ornamentation, see Section 601.5.4.

For limitations on projection distances, see Sections 503.2 and 1204.

SECTION 706 — FIRE-RESISTIVE JOINT SYSTEMS

706.1 General. Joints installed in or between fire-resistive walls, fire-resistive floor or floor-ceiling assemblies and fire-resistive roof or roof-ceiling assemblies shall be protected by an approved fire-resistive joint system designed to resist the passage of fire for a time period not less than the required fire-resistance rating of the floor, roof or wall in or between which it is installed. Fire-resistive joint systems shall be tested in accordance with Section 706.2.

> **EXCEPTION:** Fire resistive joint systems are not required for joints in the following locations.
>
> 1. Floors within a single dwelling unit.
> 2. Floors where the joint is protected by a shaft enclosure in accordance with Section 711.
> 3. Floors with atriums where the space adjacent to the atrium is included in the volume of the atrium for smoke-control purposes.
> 4. Floors within malls.
> 5. Floors within open parking structures.
> 6. Mezzanine floors.
> 7. Walls that are permitted to have unprotected openings.
> 8. Roofs where openings are permitted.

Such material or construction assembly shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to accommodate expected building movements and to resist the passage of fire and hot gases.

706.2 Fire-resistive Joint Systems. Fire-resistive joint systems shall be tested in accordance with UBC Standard 7-1 under the following conditions:

1. Joint systems shall be installed full height in wall assemblies and full length in floor and roof assemblies.

2. Floor and roof assemblies shall be tested with a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa).

3. Wall assemblies shall be tested with a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) measured at the mid-height of the wall assembly.

4. Joint systems shall contain a splice. For wall assemblies, the splice shall be located above the mid-height of the wall assembly.

5. Joint systems shall be tested at the maximum joint width for which they are designed. Joint systems designed to accommodate movement shall be expanded to the maximum joint opening width for which they are intended to function.

6. Joint systems designed to be load-bearing shall be loaded to the maximum design load in accordance with their intended application.

7. Joint systems designed to accommodate movement shall be preconditioned by cycling between the minimum and the maximum joint opening width for which they are intended to function for the number of cycles specified in Table 7-D.

8. Nonsymmetrical wall joint systems shall be tested in accordance with Sections 706 and 709.5.

SECTION 707 — INSULATION

707.1 General. Thermal and acoustical insulation located on or within floor-ceiling and roof-ceiling assemblies, crawl spaces, walls, partitions and insulation on pipes and tubing shall comply with this section. Duct insulation and insulation in plenums shall conform to the requirements of the Mechanical Code.

> **EXCEPTION:** Roof insulation shall comply with Section 1510.

707.2 Insulation and Covering on Pipe and Tubing. Insulation and covering on pipe and tubing shall have a flame-spread rating not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with UBC Standard 8-1.

> **EXCEPTION:** Foam plastic insulation shall comply with Section 2602.

707.3 Insulation. Cellulose loose-fill insulation shall comply with CPSC 16 CFR, Parts 1209 and 1404. All other insulation materials, including facings, such as vapor barriers or breather papers installed within floor-ceiling assemblies, roof-ceiling assemblies, walls, crawl spaces or attics, shall have a flame-spread rating not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with UBC Standard 8-1.

> **EXCEPTIONS:** 1. Foam plastic insulation shall comply with Section 2602.
>
> 2. When such materials are installed in concealed spaces of Types III, IV and V construction, the flame spread and smoke developed limitations do not apply to facings, provided that the facing is installed in substantial contact with the unexposed surface of the ceiling, floor or wall finish.

SECTION 708 — FIRE BLOCKS AND DRAFT STOPS

708.1 General. In combustible construction, fireblocking and draftstopping shall be installed to cut off all concealed draft openings (both vertical and horizontal) and shall form an effective barrier between floors, between a top story and a roof or attic space, and shall subdivide attic spaces, concealed roof spaces and floor ceiling assemblies. The integrity of all fire blocks and draft stops shall be maintained.

708.2 Fire Blocks.

708.2.1 Where required. Fireblocking shall be provided in the following locations:

Continued

1. In concealed spaces of stud walls and partitions, including furred spaces, at the ceiling and floor levels and at 10-foot (3048 mm) intervals both vertical and horizontal. See also Section 803, Item 1.

EXCEPTION: Fire blocks may be omitted at floor and ceiling levels when approved smoke-actuated fire dampers are installed at these levels.

2. At all interconnections between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings and cove ceilings.

3. In concealed spaces between stair stringers at the top and bottom of the run and between studs along and in line with the run of stairs if the walls under the stairs are unfinished.

4. In openings around vents, pipes, ducts, chimneys, fireplaces and similar openings that afford a passage for fire at ceiling and floor levels, with noncombustible materials.

5. At openings between attic spaces and chimney chases for factory-built chimneys.

6. Where wood sleepers are used for laying wood flooring on masonry or concrete fire-resistive floors, the space between the floor slab and the underside of the wood flooring shall be filled with noncombustible material or fire blocked in such a manner that there will be no open spaces under the flooring that will exceed 100 square feet (9.3 m^2) in area and such space shall be filled solidly under all permanent partitions so that there is no communication under the flooring between adjoining rooms.

EXCEPTIONS: 1. Fire blocking need not be provided in such floors when at or below grade level in gymnasiums.

2. Fire blocking need be provided only at the juncture of each alternate lane and at the ends of each lane in a bowling facility.

708.2.2 Fire block construction. Except as provided in Item 4 above, fireblocking shall consist of 2 inches (51 mm) nominal lumber or two thicknesses of 1-inch (25 mm) nominal lumber with broken lap joints or one thickness of $^{23}/_{32}$ inch (18.3 mm) wood structural panel with joints backed by $^{23}/_{32}$-inch (18.3 mm) wood structural panel or one thickness of $^{3}/_{4}$-inch (19.1 mm) Type 2-M particleboard with joints backed by $^{3}/_{4}$-inch (19.1 mm) Type 2-M particleboard.

Fire blocks may also be of gypsum board, cement fiber board, batts or blankets of mineral or glass fiber, or other approved materials installed in such a manner as to be securely retained in place. Loose-fill insulation material shall not be used as a fire block unless specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and to retard the spread of fire and hot gases.

Walls having parallel or staggered studs for sound-transmission control shall have fire blocks of batts or blankets of mineral or glass fiber or other approved flexible materials.

708.3 Draft Stops.

708.3.1 Where required. Draftstopping shall be provided in the locations set forth in this section.

708.3.1.1 Floor-ceiling assemblies.

708.3.1.1.1 Single-family dwellings. When there is usable space above and below the concealed space of a floor-ceiling assembly in a single-family dwelling, draft stops shall be installed so that the area of the concealed space does not exceed 1,000 square feet (93 m^2). Draftstopping shall divide the concealed space into approximately equal areas.

708.3.1.1.2 Two or more dwelling units and hotels. Draft stops shall be installed in floor-ceiling assemblies of buildings having more than one dwelling unit and in hotels. Such draft stops shall be in line with walls separating individual dwelling units and guest rooms from each other and from other areas.

708.3.1.1.3 Other uses. Draft stops shall be installed in floor-ceiling assemblies of buildings or portions of buildings used for other than dwelling or hotel occupancies so that the area of the concealed space does not exceed 1,000 square feet (93 m^2) and so that the horizontal dimension between stops does not exceed 60 feet (18 288 mm).

EXCEPTION: Where approved automatic sprinklers are installed within the concealed space, the area between draft stops may be 3,000 square feet (279 m^2) and the horizontal dimension may be 100 feet (30 480 mm).

708.3.1.2 Attics.

708.3.1.2.1 Two or more dwelling units and hotels. Draft stops shall be installed in the attics, mansards, overhangs, false fronts set out from walls and similar concealed spaces of buildings containing more than one dwelling unit and in hotels. Such draft stops shall be above and in line with the walls separating individual dwelling units and guest rooms from each other and from other uses.

EXCEPTIONS: 1. Draft stops may be omitted along one of the corridor walls, provided draft stops at walls separating individual dwelling units and guest rooms from each other and from other uses, extend to the remaining corridor draft stop.

2. Where approved sprinklers are installed, draftstopping may be as specified in the exception to Section 708.3.1.2.2.

708.3.1.2.2 Other uses. Draft stops shall be installed in attics, mansards, overhangs, false fronts set out from walls and similar concealed spaces of buildings having uses other than dwellings or hotels so that the area between draft stops does not exceed 3,000 square feet (279 m^2) and the greatest horizontal dimension does not exceed 60 feet (18 288 mm).

EXCEPTION: Where approved automatic sprinklers are installed, the area between draft stops may be 9,000 square feet (836 m^2) and the greatest horizontal dimension may be 100 feet (30 480 mm).

708.3.1.3 Draft stop construction. Draftstopping materials shall not be less than $^{1}/_{2}$ inch (12.7 mm) gypsum board, $^{3}/_{8}$-inch (9.5 mm) wood structural panel, $^{3}/_{8}$-inch (9.5 mm) Type 2-M particleboard or other approved materials adequately supported.

Openings in the partitions shall be protected by self-closing doors with automatic latches constructed as required for the partitions.

Ventilation of concealed roof spaces shall be maintained in accordance with Section 1505.

708.4 Draft Stops or Fire Blocks in Other Locations. Fireblocking of veneer on noncombustible walls shall be in accordance with Section 708.2.1, Item 1.

For fireblocking ceilings applied against noncombustible construction, see Section 803, Item 1.

SECTION 709 — WALLS AND PARTITIONS

709.1 General. Fire-resistive walls and partitions shall be assumed to have the fire-resistance ratings set forth in Table 7-B.

Where materials, systems or devices are incorporated into the assembly that have not been tested as part of the assembly, sufficient data shall be made available to the building official to show that the required fire-resistive rating is not reduced. Materials and methods of construction used to protect joints and penetrations in fire-resistive, fire-rated building assemblies shall not reduce the required fire-resistive rating.

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709.2 Combustible Members. Combustible members framed into a wall shall be protected at their ends by not less than one half the required fire-resistive thickness of such wall.

709.3 Exterior Walls.

709.3.1 Extension through attics and concealed spaces. In fire-resistive exterior wall construction, the fire-resistive rating shall be maintained for such walls passing through attic areas or other areas containing concealed spaces.

709.3.2 Vertical fire spread at exterior walls.

709.3.2.1 General. The provisions of this section are intended to restrict the passage of smoke, flame and hot gases from one floor to another at exterior walls. See Section 710 for floor penetrations.

709.3.2.2 Interior. When fire-resistive floor or floor-ceiling assemblies are required, voids created at the intersection of the exterior wall assemblies and such floor assemblies shall be sealed with an approved material. Such material shall be securely installed and capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to UBC Standard 7-1 time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) for the time period at least equal to the fire-resistance rating of the floor assembly.

709.3.2.3 Exterior. When openings in an exterior wall are above and within 5 feet (1524 mm) laterally of an opening in the story below, such openings shall be separated by an approved flame barrier extending 30 inches (762 mm) beyond the exterior wall in the plane of the floor or by approved vertical flame barriers not less than 3 feet (914 mm) high measured vertically above the top of the lower opening. Flame barriers shall have a fire resistance of not less than three-fourths hour.

> **EXCEPTIONS:** 1. Flame barriers are not required in buildings equipped with an approved automatic sprinkler system throughout.
>
> 2. This section shall not apply to buildings of three stories or less in height.
>
> 3. Flame barriers are not required on Group S, Division 4 Occupancies.

709.4 Parapets.

709.4.1 General. Parapets shall be provided on all exterior walls of buildings.

> **EXCEPTION:** A parapet need not be provided on an exterior wall when any of the following conditions exist:
>
> 1. The wall is not required to be of fire-resistive construction.
>
> 2. The wall, due to location on property line, may have unprotected openings.
>
> 3. The building has an area of not more than 1,000 square feet (93 m^2) on any floor.
>
> 4. Walls that terminate at roofs of not less than two-hour fire-resistive construction or roofs constructed entirely of noncombustible materials.
>
> 5. One-hour fire-resistive exterior walls may terminate at the underside of the roof sheathing, deck or slab, provided:
>
> 5.1 Where the roof-ceiling framing elements are parallel to the walls, such framing and elements supporting such framing shall not be of less than one-hour fire-resistive construction for a width of 5 feet (1524 mm) measured from the interior side of the wall for Groups R and U Occupancies and 10 feet (3048 mm) for all other occupancies.
>
> 5.2 Where roof-ceiling framing elements are not parallel to the wall, the entire span of such framing and elements supporting such framing shall not be of less than one-hour fire-resistive construction.
>
> 5.3 Openings in the roof shall not be located within 5 feet (1524 mm) of the one-hour fire-resistive exterior wall for Groups R and U Occupancies and 10 feet (3048 mm) for all other occupancies.
>
> 5.4 The entire building shall be provided with not less than a Class B roofing assembly.

709.4.2 Construction. Parapets shall have the same degree of fire resistance required for the wall upon which they are erected, and on any side adjacent to a roof surface, shall have noncombustible faces for the uppermost 18 inches (457 mm), including counterflashing and coping materials. The height of the parapet shall not be less than 30 inches (762 mm) above the point where the roof surface and the wall intersect. Where the roof slopes toward a parapet at slopes greater than 2 units vertical in 12 units horizontal (16.7% slope), the parapet shall extend to the same height as any portion of the roof that is within the distance where protection of wall openings would be required, but in no case shall the height be less than 30 inches (762 mm).

709.5 Nonsymmetrical Wall Construction. Walls and partitions of nonsymmetrical construction shall be tested with both faces exposed to the furnace, and the assigned fire-resistive rating will be the shortest duration obtained from the two tests conducted in conformance with UBC Standard 7-1. When evidence is furnished to show that the wall was tested with the least fire-resistive side exposed to the furnace, subject to acceptance of the building official, the wall need not be subjected to tests from the opposite side.

709.6 Through Penetrations.

709.6.1 General. Through penetrations of the fire-resistive walls shall comply with Section 709.6.2 or 709.6.3.

> **EXCEPTION:** Where the penetrating items are steel, ferrous or copper pipes or steel conduits, the annular space shall be permitted to be protected as follows:
>
> 1. In concrete or masonry walls where the penetrating items are a maximum 6-inch (152 mm) nominal diameter and the opening is a maximum 144 square inches (92 903 mm^2) concrete, grout or mortar shall be permitted when installed the full thickness of the wall or the thickness required to maintain the fire rating, or
>
> 2. The material used to fill the annular space shall prevent the passage of flame and hot gases sufficient to ignite cotton waste when subjected to UBC Standard 7-1 time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) at the location of the penetration for the time period equivalent to the fire rating of the construction penetrated.

709.6.2 Fire-rated assembly. Penetrations shall be installed as tested in the approved UBC Standard 7-1 rated assembly.

709.6.3 Penetration firestop system. Penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with UBC Standard 7-5 and shall have an F rating of not less than the required rating of the wall penetrated.

709.7 Membrane Penetrations. Membrane penetrations of the fire-resistive walls shall comply with Section 709.6.

> **EXCEPTIONS:** 1. Steel electrical boxes that do not exceed 16 square inches (10 323 mm^2) in area, provided that the area of such openings does not exceed 100 square inches for any 100 square feet (694 mm^2/m^2) of wall area. Outlet boxes on opposite sides of the wall shall be separated by a horizontal distance of not less than 24 inches (610 mm). Membrane penetrations for electrical outlet boxes of any material are permitted, provided that such boxes are tested for use in fire-resistive assemblies and installed in accordance with the tested assembly.
>
> 2. The annular space created by the penetration of a fire sprinkler shall be permitted to be unprotected, provided such space is covered by a metal escutcheon plate.

Noncombustible penetrating items shall not be connected to combustible materials on both sides of the membrane unless it can

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be confirmed that the fire-resistive integrity of the wall is maintained in accordance with UBC Standard 7-1.

709.8 Joints. The protection of joints shall comply with the requirements of Section 706.

SECTION 710 — FLOOR CEILINGS OR ROOF CEILINGS

710.1 General. Fire-resistive floors, floor-ceiling or roof-ceiling assemblies shall be assumed to have the fire-resistance ratings set forth in Table 7-C. When materials are incorporated into an otherwise fire-resistive assembly that may change the capacity for heat dissipation, fire test results or other substantiating data shall be made available to the building official to show that the required fire-resistive time period is not reduced.

Where the weight of lay-in ceiling panels used as part of fire-resistive floor-ceiling or roof-ceiling assemblies is not adequate to resist an upward force of 1 pound per square foot (0.048 kN/m^2), wire holdowns or other approved devices shall be installed above the panels to prevent vertical displacement under such upward force.

710.2 Through Penetrations.

710.2.1 General. Through penetrations of fire-resistive horizontal assemblies shall be enclosed in fire-resistive shaft enclosures in accordance with Section 711.1 or shall comply with Section 710.2.2 or 710.2.3.

EXCEPTIONS: 1. Steel, ferrous or copper conduits, pipes, tubes, vents, concrete or masonry penetrating items that penetrate a single fire-rated floor assembly where the annular space is protected with materials that prevent the passage of flame and hot gases sufficient to ignite cotton waste when subjected to UBC Standard 7-1 time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) at the location of the penetration for the time period equivalent to the fire-resistive rating of the construction penetrated. Penetrating items with a maximum 6-inch (152 mm) nominal diameter shall not be limited to the penetration of a single-fire-resistive floor assembly, provided that the area of the penetration does not exceed 144 square inches in any 100 square feet (100 000 mm^2 in 10 m^2) of floor area.

2. Penetrations in a single concrete floor by steel, ferrous or copper conduits, pipes, tubes and vents with a maximum 6-inch (152 mm) nominal diameter provided concrete, grout or mortar is installed the full thickness of the floor or the thickness required to maintain the fire-resistive rating. The penetrating items with a maximum 6-inch (152 mm) nominal diameter shall not be limited to the penetration of a single concrete floor, provided that the area of the penetration does not exceed 144 square inches (92 903 mm^2).

3. Electrical outlet boxes of any material are permitted provided that such boxes are tested for use in fire-resistive assemblies and installed in accordance with the tested assembly.

710.2.2 Fire-rated assemblies. Penetrations shall be installed as tested in the approved UBC Standard 7-1.

710.2.3 Penetration firestop system. Penetration shall be protected by an approved penetration firestop system installed as tested in accordance with UBC Standard 7-5. The system shall have an F rating and a T rating of not less than one hour but not less than the required rating of the floor penetrated.

EXCEPTION: Floor penetrations contained and located within the cavity of a wall do not require a T rating.

710.3 Membrane Penetrations. Penetrations of membranes that are part of a fire-resistive horizontal assembly shall comply with Section 710.2.

EXCEPTIONS: 1. Membrane penetrations of steel, ferrous or copper conduits, electrical outlet boxes, pipes, tubes, vents, concrete, or masonry penetrating items where the annular space is protected in accordance with Section 709.6 or 710.2 or is protected to prevent the free passage of flame and the products of combustion. Such penetrations shall not exceed an aggregate area of 100 square inches in any 100 square feet (694 mm^2/m^2) of ceiling area in assemblies tested without penetrations.

2. Membrane penetrations for electrical outlet boxes of any material are permitted, provided that such boxes are tested for use in fire-resistive assemblies and installed in accordance with the tested assembly.

3. The annular space created by the penetration of a fire sprinkler shall be permitted to be unprotected, provided such space is covered by a metal escutcheon plate.

710.4 Roofs. Fire-resistive roofs may have unprotected openings. See Chapter 24 for skylight construction.

710.5 Wiring in Plenums. Wiring in plenums shall comply with the Mechanical Code.

710.6 Joints. The protection of joints in fire-resistive floors and roofs shall comply with the requirements of Section 706.

SECTION 711 — SHAFT ENCLOSURES

711.1 General. Openings through floors shall be enclosed in a shaft enclosure of fire-resistive construction having the time period set forth in Table 6-A for "shaft enclosures" except as permitted in Sections 711.3, 711.5 and 711.6. See also Section 304.6 for shafts in Group B Occupancies, Section 306.6 for shafts in Group F Occupancies, Sections 307.6 and 307.11.2.3 for shafts in Group H Occupancies, Section 309.6 for shafts in Group M Occupancies and Section 311.6 for shafts in Group S Occupancies.

711.2 Extent of Enclosures. Shaft enclosures shall extend from the lowest floor opening through successive floor openings and shall be enclosed at the top and bottom.

EXCEPTIONS: 1. Shafts extending through or to the underside of the roof sheathing, deck or slab need not be enclosed at the top.

2. Shafts need not be enclosed at the bottom when protected by fire dampers conforming to approved recognized standards, installed at the lowest floor level within the shaft enclosure.

Shaft enclosures shall be constructed to continuously maintain the required fire-resistive integrity.

711.3 Special Provision. In other than Group I Occupancies, openings that penetrate only one floor and are not connected with openings communicating with other stories or basements and that are not concealed within building construction assemblies need not be enclosed.

Exit enclosures shall conform to the applicable provisions of Section 1005.3.3.

In one- and two-story buildings other than Group I Occupancies, gas vents, ducts, piping and factory-built chimneys that extend through not more than two floors need not be enclosed, provided the openings around the penetrations are firestopped at each floor.

EXCEPTION: BW gas vents installed in accordance with their listing.

Gas vents and factory-built chimneys shall be protected as required by the Mechanical Code.

Walls containing gas vents or noncombustible piping that pass through three floors or less need not provide the fire-resistance rating specified in Table 6-A for "shaft enclosures," provided the annular space around the vents or piping is filled at each floor or ceiling with noncombustible materials.

EXCEPTION: BW gas vents installed in accordance with their listing.

Openings made through a floor for penetrations such as cables, cable trays, conduit, pipes or tubing that are protected with approved through penetration fire stops to provide the same degree

Continued

of fire resistance as the floor construction need not be enclosed. For floor-ceiling assemblies, see Section 710.

711.4 Protection of Openings. Openings into a shaft enclosure shall be protected by a self-closing or an automatic-closing fire assembly conforming to Section 713 and having a fire-protection rating of one hour for openings through one-hour fire-resistive walls and one and one-half hours for openings through two-hour fire resistive walls.

> EXCEPTIONS: 1. Openings to the exterior may be unprotected when permitted by Table 5-A.
>
> 2. Openings protected by through-penetration fire stops to provide the same degree of fire resistance as the shaft enclosure. See Sections 709 and 710.
>
> 3. Noncombustible ducts, vents or chimneys used to convey vapors, dusts or combustion products may penetrate the enclosure at the bottom.

Openings in shaft enclosures penetrating smoke barriers shall be further protected by smoke dampers conforming with approved recognized standards. See Chapter 35, Part IV.

> EXCEPTIONS: 1. Exhaust-only openings serving continuously operating fans and protected using the provisions of Chapter 9.
>
> 2. Smoke dampers are not required when their operation would interfere with the function of a smoke-control system.

711.5 Rubbish and Linen Chute Termination Rooms. In other than Group R, Division 3 Occupancies, rubbish and linen chutes shall terminate in rooms separated from the remainder of the building by an occupancy separation having the same fire resistance as required for the shaft enclosure, but not less than one hour. Openings into chutes and chute termination rooms shall not be located in corridors or stairways. For sprinklers, see Section 904.2.2.

711.6 Chute and Dumbwaiter Shafts. In buildings of Type V construction, chutes and dumbwaiter shafts with a cross-sectional area of not more than 9 square feet (0.84 m^2) may be either of approved fire-resistive wall construction or may have the inside layers of the approved fire-resistive assembly replaced by a lining of not less than 0.019-inch (0.48 mm) No. 26 galvanized sheet gage metal with all joints locklapped. The outside layers of the wall shall be as required for the approved construction. All openings into any such enclosure shall be protected by not less than a self-closing solid-wood door $1^3/_8$ inches (35 mm) thick or equivalent.

SECTION 712 — USABLE SPACE UNDER FLOORS

Usable space under the first story shall be enclosed, and such enclosure, when constructed of metal or wood, shall be protected on the side of the usable space as required for one-hour fire-resistive construction. Doors shall be self-closing, tightfitting of solid-wood construction $1^3/_8$ inches (35 mm) in thickness or self-closing, tightfitting doors acceptable as a part of an assembly having a fire-protection rating of not less than 20 minutes when tested in accordance with Part II of UBC Standard 7-2.

> EXCEPTIONS: 1. Group R, Division 3 and Group U Occupancies.
>
> 2. Basements in single-story Group S, Division 3 repair garages where 10 percent or more of the area of the floor-ceiling is open to the first floor.
>
> 3. Underfloor spaces protected by an automatic sprinkler system.

SECTION 713 — FIRE-RESISTIVE ASSEMBLIES FOR PROTECTION OF OPENINGS

713.1 General. Where required by this code for the fire protection of openings, fire assemblies shall meet the requirements of this section.

713.2 Definitions.

FIRE ASSEMBLY is the assembly of a fire door, fire window or fire damper, including all required hardware, anchorage, frames and sills.

FIRE ASSEMBLY, AUTOMATIC-CLOSING, is a fire assembly that may remain in an open position and that will close automatically when subjected to one or the other of the following:

1. An increase in temperature.

Unless otherwise specified, the closing device shall be one rated at a maximum temperature of 165°F (74°C).

2. Actuation of a smoke detector.

The closing device shall operate by the activation of an approved listed smoke detector. Smoke detectors shall be installed and maintained as set forth in approved nationally recognized standards.

FIRE ASSEMBLY, SELF-CLOSING, is a fire assembly that is kept in a normally closed position and is equipped with an approved device to ensure closing and latching after having been opened for use.

713.3 Identification of Fire Doors, Fire Windows and Fire Dampers. Fire doors, fire windows and fire dampers shall have an approved label or listing mark, indicating the fire-protection rating, which is permanently affixed at the factory where fabrication and assembly are done. Periodic inspections shall be made by an approved inspection agency during fabrication and assembly.

Labels for fire doors used to protect openings into exit enclosures shall indicate that the temperature rise on the unexposed surface does not exceed 450°F (232°C) above ambient at the end of 30 minutes of the fire exposure specified in UBC Standard 7-2 to show compliance with Section 1005.3.

Oversized fire doors may be installed when approved by the building official. The doors shall be labeled or be furnished with a certificate of inspection from an approved agency.

713.4 Installation of Fire Doors, Hardware and Frames, and Fire Dampers. Approved fire door hardware and fire door frames including the anchorage thereof shall be installed in accordance with their listing. Fire dampers shall be fabricated and installed in an approved manner.

713.5 Fire-resistive Tests. The fire-protection rating of all types of required fire assemblies shall be determined in accordance with the requirements specified in UBC Standards 7-2, 7-3 and 7-4. The fire-protection rating of fire dampers shall be determined in accordance with the requirements specified within approved recognized standards.

713.6 Hardware.

713.6.1 Closing devices. Every fire assembly shall be provided with a closing device as follows:

1. Fire assemblies required to have a three-hour fire-protection rating shall be automatic closing fire assemblies. Automatic-closing fire assemblies to be activated by an increase in temperature shall have one heat-actuating device installed on each side of the wall at the top of the opening and one on each side of the wall at the ceiling height where the ceiling is more than 3 feet (914 mm) above the top of the opening.

Continued

2. Fire assemblies required to have a one- and one-half-hour, one-hour or three-fourths-hour fire-protection rating shall be either automatic- or self-closing fire assemblies. Automatic-closing fire assemblies to be activated by an increase in temperature shall have heat-actuating devices located as required in Item 1 or by a single fusible link in the opening incorporated in the closing device.

3. Fire door assemblies required to have fire-protection rating, which are installed across a corridor, shall be automatic-closing fire assemblies. Such fire assemblies shall be activated by a smoke detector. All hold-open devices shall be listed for the purpose and shall release or close the door in the event of a power failure at the device.

4. Fire assemblies required by provisions of Chapter 10 shall have closing devices as specified in Chapter 10.

5. Doors that are a part of an automobile ramp enclosure shall be equipped with automatic-closing devices.

Fire doors that are automatic closing by smoke detection shall not have a closing or reclosing delay of more than 10 seconds.

713.6.2 Hinges. Swinging fire doors shall not have less than two hinges, and when such door exceeds 60 inches (1524 mm) in height, an additional hinge shall be installed for each additional 30 inches (762 mm) of height or fraction thereof. Hinges, except for spring hinges, shall be of the ball-bearing or antifriction type. When spring hinges are used for door-closing purposes, not less than one half of the hinges shall be spring hinges.

713.6.3 Latch. Unless otherwise specifically permitted, all single doors and both leaves of pairs of side-hinged swinging doors shall be provided with an automatic latch that will secure the door when it is closed.

713.7 Glazed Openings in Fire Doors. Glazed openings in fire doors shall not be permitted in a fire assembly required to have a three-hour fire-resistive rating.

The area of glazed openings in a fire door required to have one-and one-half hour or one-hour fire-resistive rating shall be limited to 100 square inches (64 500 mm^2) with a minimum dimension of 4 inches (102 mm). When both leaves of a pair of doors have observation panels, the total area of the glazed openings shall not exceed 100 square inches (64 500 mm^2) for each leaf.

Glazed openings shall be limited to 1,296 square inches (0.84 m^2) in wood and plastic-faced composite or hollow metal doors, per light, when fire-resistive assemblies are required to have a three-fourths-hour fire-resistive rating.

713.8 Fire Window Size. Fire windows required to have a three-fourths-hour fire-protection rating for protection of openings in exterior walls shall have an area not greater than 84 square feet (7.8 m^2) with neither width nor height exceeding 12 feet (3658 mm) and for protection of openings in interior walls shall be limited in area and size to that tested.

713.9 Glazing. Glazing materials and glass block assemblies shall be qualified by tests in accordance with UBC Standard 7-2 (for fire doors) or UBC Standard 7-4 (for fire windows) as appropriate for the use, and they shall be labeled for the required fire-protection rating and installed in accordance with their listing. Glazing in fire door assemblies and in fire window assemblies subject to human impact in hazardous locations as indicated in Section 2406.4 shall comply with Section 2406.3.

713.10 Smoke Dampers. Not less than Class II, 250°F (121°C) smoke dampers complying with approved recognized standards (see Chapter 35, Part IV) shall be installed and be accessible for inspection and servicing in the following ducted or unducted air openings at:

1. Penetrations of area or occupancy separation walls.

2. Penetrations of the fire-resistive construction of horizontal exit walls or corridors serving as a means of egress.

> **EXCEPTION:** Openings for steel ducts penetrating the required fire-resistive construction of corridors are not required to have smoke dampers when such ducts are of not less than 0.019-inch (0.48 mm) thickness (No. 26 galvanized sheet steel gage) and have no openings serving the corridor.

3. Penetrations of shaft enclosures.

> **EXCEPTION:** Exhaust-only openings serving continuously operating fans and protected using the provisions of Chapter 9.

4. Penetrations of smoke barriers.

5. Penetrations of elevator lobbies required by Section 403.7 or 1004.3.4.5.

6. Penetrations of areas of refuge.

> **EXCEPTION:** Ventilation systems specifically designed and protected to supply outside air to these areas during an emergency.

A smoke damper need not be provided when it can be demonstrated that the smoke damper is not essential to limit the passage of smoke under passive conditions and the proper function of a smoke control system complying with Chapter 9 does not depend on the operation of the damper. Smoke dampers may be omitted at openings that must be maintained open for proper operation of a mechanical smoke-control system, provided that adequate protection against smoke migration, in the event of system failure, has been provided.

Smoke dampers shall be closed by actuation of a smoke detector installed in accordance with the Fire Code and one of the following applicable methods:

1. Where a damper is installed within a duct, a smoke detector shall be installed in the duct within 5 feet (1524 mm) of the damper with no air outlets or inlets between the detector and the damper. The detector shall be listed for the air velocity, temperature and humidity anticipated at the point where it is installed.

2. Where a damper is installed within an unducted opening in a wall, a spot-type detector listed for releasing service shall be installed within 5 feet (1524 mm) horizontally of the damper.

3. Where a damper is installed in a ceiling, a spot-type detector listed for releasing service shall be installed on the ceiling within 5 feet (1524 mm) of the damper.

4. Where a damper is installed in a corridor wall or ceiling, the damper may be controlled by a smoke-detection system installed in the corridor.

5. When a total-coverage smoke-detection system is provided within all areas served by an HVAC system, dampers may be controlled by the smoke-detection system.

713.11 Fire Dampers. Fire dampers complying with the requirements of approved recognized standards (see Chapter 35, Part IV) shall be installed and be accessible for inspection and servicing in the following ducted and unducted air openings at:

1. Penetrations through area separation walls or occupancy separations.

2. Penetrations of the fire-resistive construction of horizontal exit walls or corridors serving as a means of egress.

> **EXCEPTION:** Openings for steel ducts penetrating the required fire-resistive construction of corridors are not required to have dampers when such ducts are of not less than 0.019-inch (0.48 mm) thickness (No. 26 galvanized sheet steel gage) and have no openings serving the corridor.

3. Penetrations of shaft enclosures.

Continued

7.15.0 Interior Finish Criteria

INTERIOR FINISHES

SECTION 801 — GENERAL

801.1 Scope. Interior wall and ceiling finish shall mean the exposed interior surfaces of buildings including, but not limited to, fixed or movable walls and partitions, interior wainscoting, paneling or other finish applied structurally or for decoration, acoustical correction, surface insulation, sanitation, structural fire resistance or similar purposes. Requirements for finishes in this chapter shall not apply to trim defined as picture molds, chair rails, baseboards and handrails; or to doors and windows or their frames; or to materials that are less than $^1/_{28}$ inch (0.9 mm) in thickness applied directly to the surface of walls or ceilings.

Foam plastics shall not be used as interior finish except as provided in Section 2602. For foam plastic trim, see Section 601.5.5.

See Section 1403 for veneer.

801.2 Standards of Quality. The standards listed below labeled a "UBC standard" are also listed in Chapter 35, Part II, and are part of this code.

1. UBC Standard 8-1, Test Method for Surface-burning Characteristics of Building Materials

2. UBC Standard 8-2, Standard Test Method for Evaluating Room Fire Growth Contribution of Textile Wall Covering

801.3 Veneer. Veneers shall comply with Section 1403.

SECTION 802 — TESTING AND CLASSIFICATION OF MATERIALS

802.1 Testing. Tests shall be made by an approved testing agency to establish surface-burning characteristics and to show that materials when cemented or otherwise fastened in place will not readily become detached when subjected to room temperatures of 300°F (149°C) for 25 minutes. Surface-burning characteristics shall be determined by one of the following methods:

1. The surface-burning characteristics as set forth in UBC Standard 8-1.

2. Any other recognized method of test procedure for determining the surface-burning characteristics of finish materials that will give comparable results to those specified in method Item 1.

3. The room fire growth contribution for textile wall coverings as set forth in UBC Standard 8-2.

802.2 Classification. The classes of materials based on their flame-spread index shall be as set forth in Table 8-A. The smoke density shall be no greater than 450 when tested in accordance with UBC Standard 8-1 in the way intended for use.

SECTION 803 — APPLICATION OF CONTROLLED INTERIOR FINISH

Interior finish materials applied to walls and ceilings shall be tested as specified in Section 802 and regulated for purposes of limiting surface-burning by the following provisions:

1. When walls and ceilings are required by any provision in this code to be of fire-resistive or noncombustible construction, the finish material shall be applied directly against such fire-resistive or noncombustible construction or to furring strips not exceeding $1^3/_4$ inches (44 mm) applied directly against such surfaces. The intervening spaces between such furring strips shall be filled with inorganic or Class I material or shall be fire blocked not to exceed 8 feet (2438 mm) in any direction. See Section 708 for fireblocking.

2. Where walls and ceilings are required to be of fire-resistive or noncombustible construction and walls are set out or ceilings are dropped distances greater than specified in paragraph 1 of this section, Class I finish materials shall be used except where the finish materials are protected on both sides by automatic sprinkler systems or are attached to a noncombustible backing or to furring strips installed as specified in Item 1. The hangers and assembly members of such dropped ceilings that are below the main ceiling line shall be of noncombustible materials except that in Types III and V construction, fire-retardant-treated wood may be used. The construction of each set-out wall shall be of fire-resistive construction as required elsewhere in this code. See Section 708 for fire blocks and draft stops.

3. Wall and ceiling finish materials of all classes as permitted in this chapter may be installed directly against the wood decking or planking of Type IV heavy-timber construction, or to wood furring strips applied directly to the wood decking or planking installed and fire blocked as specified in Item 1.

4. An interior wall or ceiling finish that is less than $^1/_4$ inch (6.4 mm) thick shall be applied directly against a noncombustible backing.

EXCEPTIONS: 1. Class I materials.

2. Materials where the qualifying tests were made with the material suspended or furred out from the noncombustible backing

SECTION 804 — MAXIMUM ALLOWABLE FLAME SPREAD

804.1 General. The maximum flame-spread class of finish materials used on interior walls and ceilings shall not exceed that set forth in Table 8-B.

EXCEPTIONS: 1. Except in Group I Occupancies and in enclosed vertical exits, Class III may be used in other means of egress and rooms as wainscoting extending not more than 48 inches (1219 mm) above the floor and for tack and bulletin boards covering not more than 5 per cent of the gross wall area of the room.

2. When a sprinkler system complying with UBC Standard 9-1 or 9-3 is provided, the flame-spread classification rating may be reduced one classification, but in no case shall materials having a classification greater than Class III be used.

3. The exposed faces of Type IV-H.T., structural members, and Type IV-H.T., decking and planking, where otherwise permissible under this code, are excluded from flame-spread requirements

804.2 Carpeting on Ceilings. When used as interior ceiling finish, carpeting and similar materials having a napped, tufted, looped or similar surface shall have a Class I flame spread.

SECTION 805 — TEXTILE WALL COVERINGS

When used as interior wall finish, textile wall coverings, including materials such as those having a napped, tufted, looped, nonwoven, woven or similar surface shall comply with the following:

1. Textile wall coverings shall have a Class I flame spread and shall be protected by automatic sprinklers complying with UBC Standard 9-1 or 9-3, or

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2. The textile wall covering shall meet the acceptance criteria of UBC Standard 8-2 when tested using a product mounting system, including adhesive, representative of actual use.

SECTION 806 — INSULATION

Thermal and acoustical insulation installed on walls or ceilings shall comply with Section 707.

SECTION 807 — SANITATION

807.1 Floors and Walls in Water Closet Compartment and Showers.

807.1.1 Floors. In other than dwelling units, toilet room floors shall have a smooth, hard nonabsorbent surface such as portland cement, concrete, ceramic tile or other approved material that extends upward onto the walls at least 5 inches (127 mm).

807.1.2 Walls. Walls within 2 feet (610 mm) of the front and sides of urinals and water closets shall have a smooth, hard nonabsorbent surface of portland cement, concrete, ceramic tile or other smooth, hard nonabsorbent surface to a height of 4 feet (1219 mm), and except for structural elements, the materials used in such walls shall be of a type that is not adversely affected by moisture. See Section 2512 for other limitations.

EXCEPTIONS: 1. Dwelling units and guest rooms.

2. Toilet rooms that are not accessible to the public and that have not more than one water closet.

In all occupancies, accessories such as grab bars, towel bars, paper dispensers and soap dishes, provided on or within walls, shall be installed and sealed to protect structural elements from moisture.

807.1.3 Showers. Showers in all occupancies shall be finished as specified in Sections 807.1.1 and 807.1.2 to a height of not less than 70 inches (1778 mm) above the drain inlet. Materials other than structural elements used in such walls shall be of a type that is not adversely affected by moisture. See Section 2512 for other limitations.

807.1.4 Shower doors. For shower doors, see Sections 2406.4 and 2407.

807.2 Water Closet Room Separation. See Section 302.6 for requirements to separate water closet rooms.

Figure 7.15.0—*Continued*

7.16.0 Flame Spread Classifications

TABLE 8-A—FLAME-SPREAD CLASSIFICATION

MATERIAL QUALIFIED BY:	
Class	Flame-spread Index
I	0-25
II	26-75
III	76-200

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7.17.0 Maximum Flame Spread Class

TABLE 8-B—MAXIMUM FLAME-SPREAD CLASS[1]

OCCUPANCY GROUP	ENCLOSED VERTICAL EXITWAYS	OTHER EXITWAYS[2]	ROOMS OR AREAS
A	I	II	II[3]
B	I	II	III
E	I	II	III
F	II	III	III
H	I	II	III[4]
I-1.1, I-1.2, I-2	I	I[5]	II[6]
I-3	I	I[5]	I[6]
M	I	II	III
R-1	I	II	III
R-3	III	III	III[7]
S-1, S-2	II	II	III
S-3, S-4, S-5	I	II	III
U	NO RESTRICTIONS		

[1]Foam plastics shall comply with the requirements specified in Section 2602. Carpeting on ceilings and textile wall coverings shall comply with the requirements specified in Sections 804.2 and 805, respectively.

[2]Finish classification is not applicable to interior walls and ceilings of exterior exit balconies.

[3]In Group A, Divisions 3 and 4 Occupancies, Class III may be used.

[4]Over two stories shall be of Class II.

[5]In Group I, Divisions 2 and 3 Occupancies, Class II may be used.

[6]Class III may be used in administrative spaces.

[7]Flame-spread provisions are not applicable to kitchens and bathrooms of Group R, Division 3 Occupancies.

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7.18.0 Firestopping Through-Penetrations

Firestopping through-penetrations

The standard test method for firestopping through-penetrations is ASTM E-814 or ANSI/UL 1479. In CSI and Masterspec specifications written since 1996, general information on firestopping is located in Section 07840. Prior to that, firestopping was located in Section 07270. Other sections such as Insulation, Mechanical and Plumbing may contain specific information on firestopping.

There are several independent laboratories that conduct the tests to evaluate firestopping methods and materials, including Underwriters Laboratories, Omega Point, Warnock Hersey, Southwest Research Institute and Factory Mutual. They publish directories to assist a designer in selecting the most appropriate firestop systems for specific types of piping or mechanical systems.

The laboratory that offers the greatest number of tested firestop systems is Underwriters Laboratories. The 1998 UL Fire Resistance Directory Vol. 2, page 100, offers an explanation of their alpha-numeric locator system.

In a nutshell, the tested firestop system is given a letter designation indicating what type of floor or wall assembly the firestop system has been tested in: concrete, masonry, gypsum, etc. Following the letter is a number designation referring to the type of penetrating item that has been tested, such as metallic pipe, nonmetallic pipe, cable, electrical, etc.

For example, System = CAJ-1044 is deciphered as follows:

C = Either floor or wall

A or J = Concrete floor or wall, with minimum thickness less than or equal to 5 or 8 inches, respectively.

1000 to 1999 = Specific types of metallic piping and specific diameters.

=1044 is the 44th system in the 1000 series of metallic penetrations.

Translation: This system, CAJ-1044, can be specified for use on metallic piping such as steel, iron, or copper tubing and copper pipe with specific outside dimensions, and installed through concrete floors 5 to 8 inches thick or in framed floors.

The system can be used in reverse, selecting the type of piping first by determining the number range (1000 to 1999 is metallic pipe; 2000 to 2999 is nonmetallic pipe, etc.), and then reviewing those systems to find the type of assembly penetrated (a framed wall or floor, concrete or masonry floor or wall, etc.).

Also located in the UL Fire Resistance Directory Vol. 2 are the F, T and L ratings for each firestop system, hourly ratings that indicate specific performance capabilities and correspond to building code requirements. The Directory defines these ratings as follows:

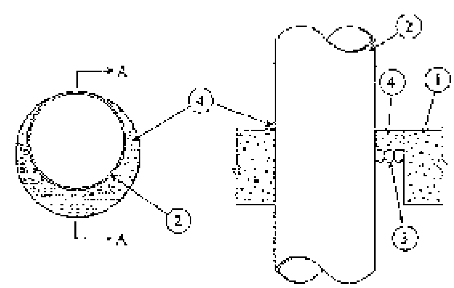
The F rating provides "the time period for which the system is capable of prohibiting the passage of flame through the system and requires acceptable hose stream performance."

The T rating provides "the time period for which the system is capable of limiting the maximum temperature rise on the unexposed surfaced of the wall or floor assembly, on the penetrating item, and on the fill material in the annular space, not to exceed 325° F (181° C) above ambient temperature, and requires acceptable hose stream performance."

The L rating provides "information concerning the amount of air leakage, in cubic feet per minute per square foot of opening through the firestop system and/or 400° F"

Through-Penetration Firestop Systems (XHEZ)
System No. C-AJ-1044

1. Floor or Wall Assembly—Lightweight or normal-weight (100-150 pcf) concrete. Except as noted in table under Item 4, minimum thickness of solid concrete floor or wall assembly is 4-1/2 inches. Floor may also be constructed of any minimum 6-inch-thick UL Classified hollow-core Precast Concrete Units.* When floor is constructed of hollow-core precast concrete units, packing material (Item 3) and caulk fill material (Item 4) to be installed symmetrically on both sides of floor, flush with floor surface. Wall assembly may also be constructed of any UL Classified Concrete Blocks.* Maximum diameter of opening in solid lightweight or normal-weight concrete floor is 32 inches. Maximum diameter of opening in floor constructed of hollow-core precast concrete units is 7 inches.
See Concrete Blocks (CAZT) and Precast Concrete Units (CFTV) categories in the Fire Resistance Directory for names of manufacturers.
1A. Steel Sleeve—(Optional, not shown)—Maximum 15 inches ID (or smaller) Schedule 10 (or heavier) steel sleeve cast or grouted into floor or wall assembly. Sleeve may extend a maximum of 2 inches above top of floor or beyond either surface of wall. Maximum 16 inches ID (or smaller) minimum 0.028 wall thickness (or heavier) galvanized steel sleeve cast or grouted into floor or wall assembly. Sleeve may extend a maximum of 1/2-inch beyond either surface of floor or wall.



SECTION A-A

2. Through Penetrants—One metallic pipe, conduit or tubing to be installed either concentrically or eccentrically within the firestop system. Maximum annular space between pipe, conduit or tubing and edge of through opening or sleeve is dependent on the parameters shown in Item 4. Minimum annular space between pipe or conduit and edge of through opening is zero inches (point contact). Pipe conduit or tubing to be rigidly supported on both sides of floor or wall assembly. The following types and sizes of metallic pipes, conduits or tubing may be used:
A. Steel Pipe—Nom 30 inch diameter (or smaller) Schedule 10 (or heavier) steel pipe.
B. Iron Pipe—Nom 30 inch diameter (or smaller) cast or ductile iron pipe.
C. Conduit—Nom 6-inch diameter (or smaller) rigid steel conduit.
D. Conduit—Nom 4-inch diameter (or smaller) steel electrical metallic tubing.
E. Copper Tubing—Nom 6-inch diameter (or smaller) Type L (or heavier) copper tube.
F. Copper Pipe—Nom 6-inch diameter (or smaller) Regular (or heavier) copper pipe.
3. Packing Material—Polyethylene backer rod or nom 1-inch thickness of tightly packed mineral wool batt or glass fiber insulation firmly packed into opening as a permanent form. Packing material to be recessed from top surface of floor or from both surfaces of wall as required to accommodate the required thickness of caulk fill material (Item 4).
4. Fill, Void or Cavity Material*—Caulk—Applied to fill the annular space flush with top surface of floor. In wall assemblies, required caulk thickness to be installed symmetrically on both sides of wall, flush with wall surface. At point contact location between penetrant and sleeve or between penetrant and concrete, a minimum 1/4 inch diameter bead of caulk shall be applied at top surface of floor and at both surfaces of wall. The hourly F Ratings and the minimum required caulk thicknesses are dependent upon a number of parameters, as shown in the following table:

Minimum Floor Or Wall Thkns, In	Nom Pipe Tube Or Conduit Diameter, In	Max Annular Space, In	Minimum Caulk Thkns, In	F Rating, Hr
2-1/2	1/2 - 12	1-3/8	1/2	2
2-1/2	1/2 - 12	3-1/4	1	2
4-1/2	1/2 - 6	1-3/8	1/4(a)	2
4-1/2	1/2 - 12	1-1/4	1/2	3
4-1/2	1/2 - 20	2	1	3
4-1/2	1/2 - 20	2	1	3
4-1/2	1/2 - 12	3-1/4	1	3
4-1/2	22 - 30	2	2	3
5-1/2	1/2 - 6	1-3/8	1(b)	4

(a) Minimum 2-inch thickness of mineral wool batt insulation required in annular space.
(b) Minimum 1-inch thickness of mineral wool batt insulation required in annular space on both sides of floor or wall assembly. Minimum 1-inch thickness of caulk to be installed flush with each surface of floor or wall assembly.
Minnesota Mining & Manufacturing Co.—CP 25WB+.
*Bearing the UL Classification Marking

Section

8

Acoustics/Sound Control

Contents

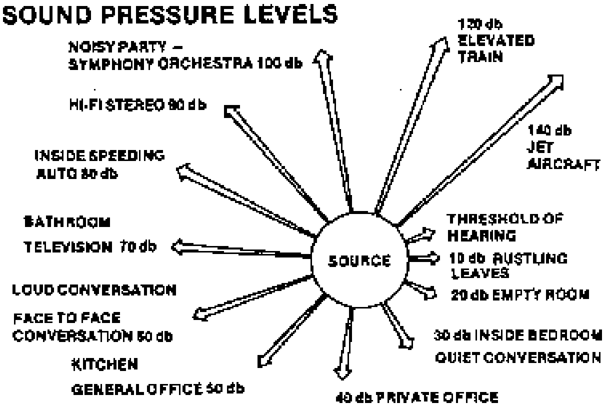
Acoustics is the science of sound and vibration. The control of sound and vibration transmission within a structure involves architectural design and structural, mechanical, and electrical engineering considerations. The end result of a building where acoustical and vibration control is taken into account during design and where these considerations are carried out by the contractor results in the creation of an environment in which people can live and work more comfortably and productively.

8.0.0 What Is Sound?

Sound is a vibration that occurs at various frequencies in an elastic medium. It is generated at a source and it travels through either a gaseous, liquid, or solid environment. Sound-pressure levels are represented in *decibels*—a ratio of intensity of sound, as measured to an intensity equivalent to the threshold of hearing. Changes in decibel levels do not follow arithmetic progressions (e.g., a change in 10-db pressure will result in the perception of hearing sound twice as loud). However, a change of 3 db, up or down, will be barely perceptible. Resistance to sound transmission varies with different frequencies. The span of human hearing ranges from 15 Hertz (Hz) to 20,000 Hz. Sound transmission coefficient factors (STC) are tested at frequencies in the 125- to 4000-Hz range.

8.0.1 Sound Units of Measure

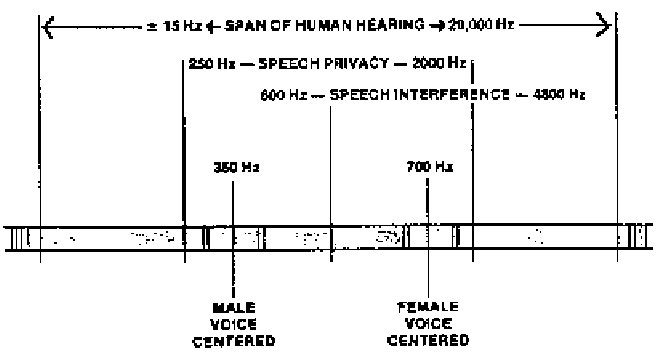
SOUND PRESSURE LEVELS



Sound is a vibration at various frequencies in any elastic medium:
- it is generated by a source;
- it requires a path for transmission: gaseous, liquid, or solid.
- to reach the receiver: usually the ear of a living being.

■ **Sound pressure level** (or loudness) is given in **decibels (db)**: a ratio of the intensity of sound measured to a reference intensity roughly equivalent to the threshold of hearing.
- a change of **10 db** in pressure will result in perceiving the sound as twice as loud, or half as loud.
- a change of **3 db** in pressure will be just perceptible.

FREQUENCY

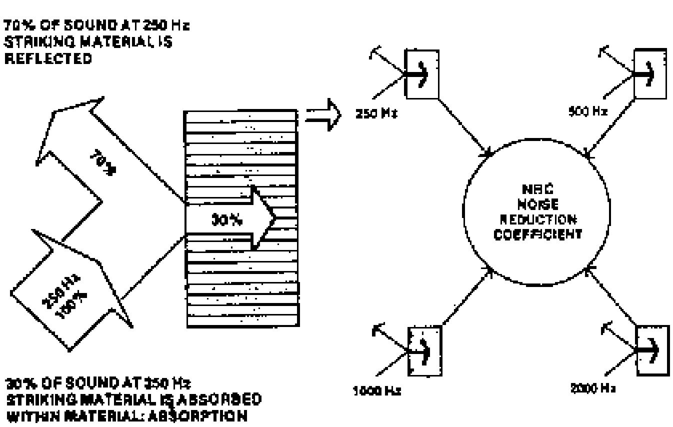


■ **Resistance of materials to sound transmission** and sound transmission loss varies with different frequencies. To establish the STC rating sound transmission loss is tested at all frequencies from 125 to 4000 Hz.

■ **Sound absorption of materials** will also vary with different frequencies; the most commonly used frequencies in testing materials are 125, 250, 500, 1000, 2000, and 4000 Hz.

■ **Frequency band:** a division of audible frequency band into more convenient sections or octave bands centered at the following frequencies: 31.5 at 1000 Hz; 63 at 2000 Hz; 125 at 4000 Hz; and 250 at 8000 Hz.

NOISE REDUCTION COEFFICIENT



■ **Noise Reduction Coefficient** is an arithmetic average -to the nearest .05- of four sound absorption coefficients; or the ratio of sound absorbing effectiveness of a material at four specific frequencies to the effectiveness of a perfectly sound absorbing material at the same frequencies.

■ **Most materials effective in absorbing sound** are porous and lightweight and do not effectively resist transmission of sound through them. Thus a suspended acoustic tile ceiling will allow sound from one space to pass through it into the plenum and down again into an adjacent space.

■ **Sound attenuation factors** have been established by manufacturers to indicate the effectiveness of commonly used acoustic materials in resisting sound transmission to adjacent spaces via the plenum space. Refer to "Performance Data of Architectural Acoustical Materials" published by Acoustical Materials Association.

■ **Sound reverberation** is the continued multiple reflection of sound after it has been stopped at the source:

■ **The amount of reverberation** in a space is measured by reverberation time, or the time required to reduce the energy of reflected sound to one millionth of the level it had when the source was stopped.

■ **The STC of the ceiling** should equal the STC of partitions between adjacent spaces.

8.1.0 Sound and the Office Environment

The American Society of Interior Designers (ASID) hired the Yankelovich Partners in 1992 to determine if noise-level reduction was of major concern to office workers. Seventy percent of the respondents indicated that their productivity would increase if they worked in a less-noisy environment. Changes in the work place have resulted in a noisier office environment today, brought about by:

- Higher work-station densities.
- Increased use of speaker phones.
- Increased use of video conferencing and the resultant higher levels of noise concentrated in a central area.
- Team conferencing and more frequent crosstalk occurring in an open office environment among divider panels not suited to absorb noise effectively.
- The proliferation of computer screens throughout the workplace and the tendency to increase screen size, thereby creates even larger hard-surface areas.

8.2.0 Sound Rating Systems

Various rating systems have been devised to qualify acoustical design. Although many such systems exist, five basic systems are most often encountered by the contractor:

- *STC (Sound Transmission Coefficient)* It evaluates the effectiveness of construction components in isolation speech sound sources.
- *MTC (Music/Mechanical Transmission Class)* Is is used to measure low-frequency sound. The higher the number, the better the acoustic quality of the wall between the source and adjacent areas.
- *dBa (decibel level)* The loudness level that is most often used to weigh human response to sound.
- *RC* It evaluates the constant background noise in a space from a source, such as an air-handling unit.
- *IIC (Impact Insulation Class)* Impact sound transmission is produced when a structural element is set into vibration by direct impact (for example, when someone walks on a concrete floor above an occupied area). The higher the IIC, the better the impact noise control.

Other acoustical terms are also important:

- *Frequency band* A division of audible sound relating to convenient sections or octaves.
- *Noise-reduction coefficient* An arithmetic average, to the nearest 0.05, of four sound-absorption coefficients. The ratio of the sound-absorbing relationship of a material at four specific frequencies, compared to the effectiveness of a perfectly sound-absorbing material at the same frequency.

8.2.1 STC Ratings

It is important to remember that STC ratings apply only to those sounds that have the same frequency spectrum of sound profile as those produced by the human voice. One way to remember this is to think of STC as “speech transmission class.” STC ratings are applicable when audible sound remains within the range of 125 Hz; machinery, HVAC equipment, and high-fidelity recordings occupy the frequency from 20 Hz to 20,000 Hz and must be dealt within a different manner than STC ratings. The higher the STC, the greater the sound barrier required.

8.2.2 Common STC Ratings

- *STC-25* Normal speech can be heard clearly through a barrier.
- *STC 30* Loud speech can be heard and clearly understood. However, normal speech can be heard, but not easily understood.
- *STC 35* Loud speech can be heard, but is difficult to understand.
- *STC 42* Loud speech can be heard, but only faintly.
- *STC 45* Normal speech cannot be heard
- *STC 46 to 50* Loud speech cannot be heard: other loud sounds can barely be heard.

Sound from the source drops off over the distance traveled to reach a partition. As sound travels through a room, sound levels are affected by the surfaces that the sound contacts. Some common acoustic coefficients are (with 1.0 being the highest, absorbing more sound):

Acoustic tile	0.8
Audience of people	0.8
Carpet and pad	0.6
Cloth upholstered seats	0.6
Fabric	0.3
Glass	0.09
Gypsum drywall	0.05
Concrete	0.02
Tile	0.01

8.2.3 Decibel Levels of Common Noises

Rustling of leaves	10 dB
Empty room	20 dB
Inside bedroom, quiet conversation	30 dB
Private office	40 dB
General office area	50 dB
Face-to-face conversation	60 dB
Bathroom/television	70 dB
Inside speeding automobile	80 dB
Hi-fi stereo	90 dB
Noisy party/symphony orchestra	100 dB
Elevated train	120 dB
Jet aircraft	140 dB

8.3.0 Sound Control (General Factors That Affect Acoustical Control)

Sound is divided into two basic types, according to origin: airborne (conversation, music, and street noise) and structure borne (footsteps on a hard surface, telephone ringing, and vibration from machinery rigidly attached to the structure).

The following methods, used individually, or in conjunction with each other, are used to control both airborne and structure-borne sound.

- *Mass* Thicker floor slabs and/or demising partitions, and inertia pads used in conjunction with the vibration isolation of mechanical equipment.
- *Decoupling* Vibration isolators for mechanical equipment, resilient channels attached to either wood or metal studs, or separated rows of studs, foam-backed carpeting, or resilient flooring.
- *Absorption* Using such materials as sound-soak panels, fiberglass batts, or sound-attenuation blankets.
- *Sealants* Use of flexible acoustical sealant to close off open areas, where ducts, electrical and mechanical conduits, and wiring devices have penetrated floors, ceilings, and partitions.

8.4.0 Do's and Don'ts for Drywall Partitions

United States Gypsum Company, in various articles in their *Form & Function* magazine, set forth the following helpful hints:

- *Perimeter seals* Don't use standard weather caulking, which has a tendency to harden and lose the resiliency required for proper sealing. Don't use drywall tape and joint compound that could crack as various building structural components deflect under load. Don't place caulking under the runner track, but place it to fill the perimeter gap between the gypsum board faces and the surrounding floor, wall, and ceiling elements. This is accomplished by placing a heavy bead of caulking adjacent to the runner prior to installing the gypsum board.
- *Penetrations* Do offset electrical/telecommunication penetrations through a demising wall by at least one stud cavity. Do seal the back and sides of any such outlet boxes with acoustical sealant. Apply this acoustical sealant around all ductwork penetrating demising walls.
- *Metal-resilient components* Resilient channel installed where screws are of sufficient length to penetrate the resilient channel, but not penetrate the surface beyond, will decouple and isolate the wall or ceiling components. Don't use screws any longer than those recommended by the manufacturer of the resilient channel. Do allow the channel to float upon installation and maintain a minimum ¼-inch clearance between it and the adjacent assembly.

8.5.0 Typical STC Ratings for Various Types of Concrete and Masonry Walls/Floors

Concrete Masonry Units, Brick, and Concrete Walls

4-inch (51 mm) CMU, brick, or concrete wall	37–42
6-inch (76 mm) CMU, brick, or concrete wall	42–46
8-inch (102 mm) CMU, brick, or concrete wall	47–51
12-inch (153 mm) CMU, brick, or concrete wall	52–56

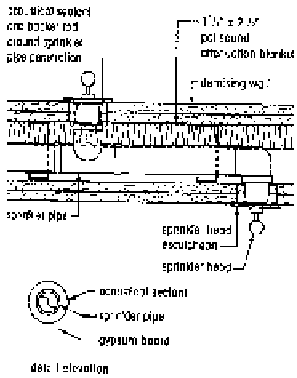
Concrete floors

4-inch (51 mm) slabs	41
6-inch (76 mm) slabs	46
8-inch (102 mm) slabs	51

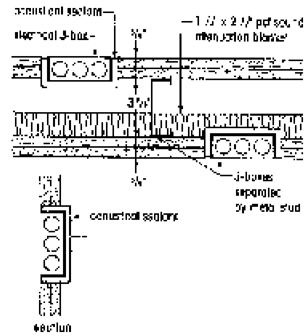
If a resilient suspended ceiling is attached to the underside of a concrete slab, the STC rating will increase by approximately 12. If sleepers are attached to the upper surface of a concrete slab, the STC rating will improve (approximately) by 7.

8.5.1 Do’s and Don’ts (Illustrated)

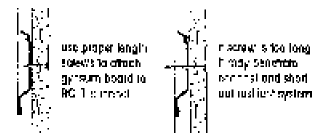
The following dos and don’ts are illustrative of several methods to prevent the transmission of sound from one partitioned area to the next.



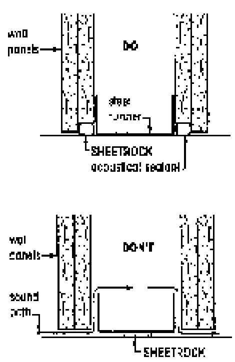
Sprinklers also need acoustical treatment to prevent sound leaks. Offset sprinkler heads on opposite sides of dimising walls by at least one stud cavity.



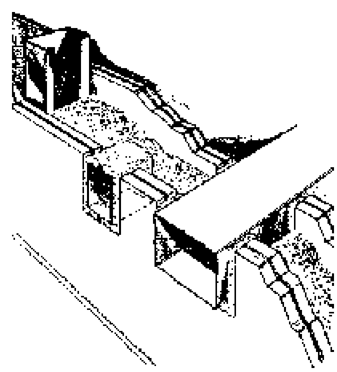
Penetrations for electrical boxes must be acoustically sealed to prevent sound transmission through the wall.



The use of the wrong length of screw can "short out" acoustical separation provided by RC-1 Resilient Channels.



Proper acoustical sealing techniques for drywall partitions involve one properly placed bead of sealant on each side of the stud.



Application of SHEETROCK Acoustical Sealant around ducts effectively seals the wall to reduce sound transmission.

8.6.0 Estimated Wood Floor Sound Performance

Sound transmission and impact-insulation characteristics of a wood-floor assembly can be calculated by adding various components to the basic floor assembly. For example, to the basic wood-floor assembly with an STC frequency of 36, add resilient channel (STC 10) plus ½" sound-deadening board (STC 1) for a total assembly rating of STC 47.

Description	STC frequency IIC	Low frequency
Basic wood floor (wood joist, ¾" decking, ⅝" gypsum board attached directly to ceiling	36	33
Add cushioned vinyl/linoleum	0	2
Add noncushioned vinyl/linoleum	0	0
Add ½" parquet flooring	0	1
Add ¾" Gypcrete	7–8	1
Add 1½" lightweight concrete	7–8	1
Add ½" sound-deadening board	1	5
Add R-19 batt insulation	2	0
Add R-11 batt insulation	1	0
Add 3" mineral-wood insulation	1	0
Add resilient channel	10	8
Add resilient channel with insulation	13	15
Add an extra layer of ⅝" gypsum board	0–2	2–4
Carpet and padding	0	20–25

Source: Southern Pine Council, Kenner, Louisiana.

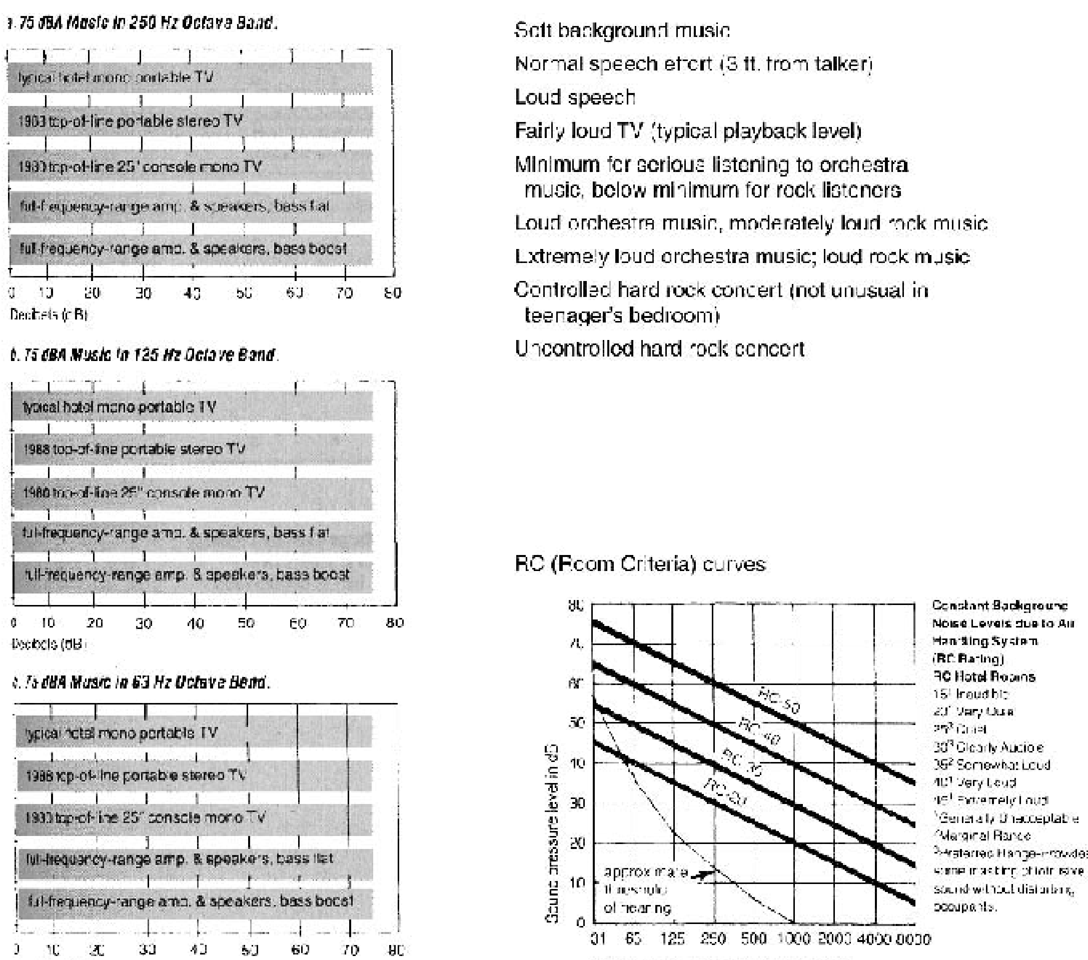
8.7.0 The Challenge of TV and Stereo

Equipment Frequency Spectrums

The sound spectrums produced by five types of sound equipment that can be used in hotel guest rooms are compared in the graphs in Fig. 1. Music is the Source, and it is reproduced at 75 dBA. Figure 1a shows the sound-pressure level in the octave centered at 250 Hz (middle "C" is 256 Hz). Fig. 1b shows the level in the 125-Hz octave and Fig. 1c, the 63-Hz octave. The top source, a typical hotel portable mono (monophonic, monaural) TV, is used as the basic reference source because the industry has so much experience with the success or failure of their isolation systems with this equipment.

It can be seen in Fig. 1a that all equipment easily reproduces the energy in the 250-Hz octave band. The differences begin in the 125-Hz octave (Fig. 1b). A top of the line, 1988 27-in. portable stereo TV performs about the same as a standard portable mono TV in the 125-Hz octave. The console TV and full-range sound system (bass controls set on flat) are 4 or 5 dB louder in this frequency range. A full-range system with controls set to boost bass will be at least 10 dB louder than the portable mono set.

The most significant difference in performance occur in the 63-Hz octave band. The sound produced in the 63-Hz octave band by a typical portable mono TV generally is insignificant. The portable stereo TV is 10 dB louder and the full-range system (bass boost) can easily be 35 dB louder than the mono portable! The amount of sound isolation required at 125 Hz and lower increases as the equipment capabilities to accurately reproduce the recorded music is improved. High-quality stereo equipment, including the portable stereo TV, also produce significantly more sound energy in the 2000-Hz octave band. This fidelity improvement could cause some speech-intrusion problems where they might not have previously existed because the portable mono TV produces little sound at 2000 Hz and above.



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8.7.0 The Challenge of TV/Stereo—Continued

Conclusions

The quality of TV sound has improved significantly during the last few years with the playback equipment, rather than the broadcast or recorded signal, the factor usually limiting the frequency range reproduced. The newer portable stereo TVs extend the frequency range about an octave lower and an octave higher than the typical portable mono TV of the past. The frequency range of stereo TV (broadcast or VCR), albums, cassette tapes, and CDs are similar when played back through a high wattage, full-frequency-range stereo audio system. There might be issues of the quality of sound, but the quantity can be very similar.

It should be expected that stereo TVs will require partition systems with MTC ratings of 4 to 5 points higher than the partition systems used with the older mono systems to achieve about the same degree of acoustical privacy. The table shows that reasonable results can be achieved with STC-50/MTC-45 isolation with the portable mono TV. An STC-54/MTC-50 is required for similar privacy from a stereo TV. Special, high-performance designs are needed when full-frequency-range systems are installed in luxury hotels.

Sound Isolating Partition	Laboratory Sound Rating (assumed as field achieved)		Typical Mono Hotel TV or Radio: 75 dBA Loudness*		Portable High-Quality Stereo TV: 75 dBA Loudness*		Full Range Stereo with Bass Control Flat: 85 dBA Loudness*	
	STC	MTC	Speech	Music	Speech	Music	Speech	Music
A 2-1/2-in. steel studs, single-layer 5/8" SHEETROCK FIRECODE "C" Gypsum Panels, 1-1/2" THERMAFIBER Sound Attenuation Fire Blankets (SAFB) in cavity	44	40	2	2	1	1	0	0
B Same as "A" but with double-layer of panels on one side	51	45	3	3	3	2	1	0
C Same as "A" but with double-layer of panels on both sides	54	50	4	4	4	3	2	2
D 3-5/8-in. steel studs, single 5/8" layer of panels, 3" SAFB in cavity	48	44	3 –	2	2	2	1	0
E Same as "D" but with double-layer of panels on one side	53	51	3 –	3	3	3	2 +	2 –
F Same as "D" but with double-layer of panels on both sides	57	54	4	4	4 –	4	3	2
G 3-1/2-in. 20-ga. steel studs, RC-1 Resilient Channels, single and double-layer 1/2-in. SHEETROCK FIRECODE "C" Gypsum Panels, 3" SAFB in cavity	55	49	4	4	4	3	3 –	2 –
H Same as "G" but with double-layer of panels on both sides	60	54	5	5	5	4	3 –	2 +
I Same as "G" but with double and triple layers of panels	61	56	5	5	5	5	4	3
J USG Double Wall System, 3" SAFB in cavity	60	57	5	5	5	5	4	3

*Key to Rating System
0 Intrusive music or speech significantly above background noise
1 Over 50% sentence intelligibility, music clearly audible
2 About 50% sentence intelligibility, music audible
3 About 0 to 10% sentence intelligibility, music barely audible
4 Speech or music sound may be just perceptible with careful listening
5 Speech and music generally inaudible with careful listening

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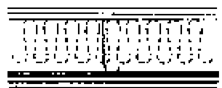
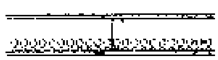
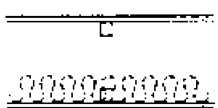
8.8.0 Controlling Octave Band Transmission with Sound-Attenuation Blankets

Partition design (insulation density only variable in each test)		Octave band center frequencies in Hz* 125	250	500	1000	2000	4000	STC Improvement
1. SAFB - 5-in. GF - 6-in. GB - 5/8-in.		dB 1.0	dB 1.8	dB 2.9	dB 1.0	dB 6.2	dB 4.6	4
2. SAFB - 3-in. GF - 3-1/2-in. GB - 5/8-in.		−0.6	1.3	1.3	0.4	3.8	2.3	2
3. SAFB - 3-in. GF - 3-1/2-in. GB - 5/8-in.		−0.6	0.4	1.8	0.6	3.3	2.9	2
4. SAFB - 3-in. GF - 3-in. GB - 1/2-in.		0.5	2.6	1.0	1.3	3.1	2.6	2
5. SAFB - 3-in. GF - 3-1/2 in. GB - 5/8 in.		0.1	0.2	1.2	0	1.6	2.6	2
6. SAFB - 1-1/2-in. GF - 1-1/2-in. GB - 1/2-in.		−0.5	2.0	1.8	2.4	1.0	2.0	0
7. SAFB - 3-in. GF - 3-1/2-in. GB - 5/8-in.		2.5	2.7	2.4	4.4	5.2	3.0	3

*Octave band data is derived from 1/3-octave band data reported to nearest decibel. Conversion from 1/3-octaves to octaves is rounded to nearest 0.1 decibel.
Test Reference Numbers: 1. RAL-TL84-139/TL83-230 2. RAL-TL84-147/TL84-144 3. RAL-TL84-148/TL84-145
4. USG 71508/71405 5. USG 830307/830509 6. USG 71413/71404 7. USG 830436/830501

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8.9.0 STC Ratings for Various Partition Types

Office Partition Selector	Rating[1]
ULTRAWALL Movable Partitions	
1 ULTRAWALL H-Studs[2], 5/8x24" ULTRAWALL Panels each side	STC-42
2 Same as No. 1 with 1" THERMAFIBER Sound Attenuation Fire Blankets in stud cavities	STC-47
3 Same as No. 1 except with double-layer of panels on one side with 3/4" Z-runners	STC-50
4 Systems ULTRAWALL Partition with aluminum ULTRAWALL H-Studs 24" o.c., 5/8x24" ULTRAWALL Panels with joints finished each side with vinyl trim	STC-42
5 Same as No. 4 with 1 1/2" THERMAFIBER Blankets in stud cavities	STC-46
Steel-Stud Drywall Partitions	
6 212ST25 USG Steel Studs, single-layer 1/2" SHEETROCK[3] Brand Gypsum Panels each side	STC-39
7 Same as No. 6 with 1 1/2" THERMAFIBER Blankets in stud cavity	STC-45
8 Same as No. 7 except with double-layer 1/2" SHEETROCK Brand Panels on one side and single-layer on other side	STC-50
9 Same as No. 7 except with double layer 1/2" SHEETROCK Brand Panels on both sides	STC-54
10 358ST25 USG Steel Studs, single-layer 5/8" SHEETROCK Brand Panels each side, 3" THERMAFIBER Blankets in stud cavities	STC-48
11 Same as No. 10 except with double-layer 5/8" SHEETROCK Brand Panels on each side	STC-57

Office Partition Selector	Rating[1]
High-Performance Partitions	
12 358SJ20 USG Steel Studs with RC-1 Resilient Channels on one side, single-layer 5/8" SHEETROCK Brand Panels each side, 3" THERMAFIBER Blankets in stud cavities	STC-54 MTC-47
13 Same as No. 12 except with double-layer 5/8" SHEETROCK Brand Panels opposite RC-1 Channels side	STC-58 MTC-52
14 Same as No. 12 except with double-layer 5/8" SHEETROCK Brand Panels on each side	STC-61 MTC-57
15 Same as No. 14 except with 60SJ20 USG Steel Studs and 5" THERMAFIBER Blankets in stud cavities	STC-62 MTC-58
16 Same as No. 15 except with triple-layer 5/8" SHEETROCK Brand Panels opposite RC-1 Channels side	STC-63 MTC-59

[1] See system folder SA-925 for explanation of STC and MTC rating systems.
[2] All framing members are spaced 24 in. o.c.
[3] All SHEETROCK Brand Gypsum Panels are either FIRECODE or FIRECODE "C" Panels.

STC ratings for walls containing cracks or small openings.

Opening or Crack Size (Area in 100 ft.² Wall)	STC of Wall with No Openings 20	25	30	35	40	45	50	55	60
	STC of Wall Containing Cracks or Openings								
144.0 in.²	17	19	20	20	20	20	20	20	20
72.0 in.²	18	21	22	23	23	23	23	23	23
36.0 in.²	19	23	25	25	25	26	26	26	26
18.0 in.²	20	24	27	29	29	29	29	29	29
9.0 in.²	20	25	28	30	31	32	32	32	32
4.5 in.²	20	25	29	32	34	35	35	35	35
2.25 in.²	20	25	29	33	36	37	38	38	38
1.0 in.²	20	25	30	34	36	40	41	41	41
0.5 in.²	20	25	30	35	39	42	44	44	44
0.25 in.²	20	25	30	35	39	43	46	47	47
0.125 in.²	20	25	30	35	40	44	47	49	50
0.063 in.²	20	25	30	35	40	45	48	51	53

STC limitations imposed on composite constructions by various duct arrangements.

Description of Supply or Return System Serving Adjacent Spaces	Approx. Max. Rating
Supply air via common unlined branch duct	STC-30
Supply air via separate unlined branch duct connected to common unlined main duct	STC-35
Return air through ceiling to common plenum	STC-40
Supply air via common duct with 1-in. thick acoustical lining, min. 10 ft. and two elbows between room outlets	STC-45
Return air through ceiling to common plenum utilizing 5-ft. section of duct with 1-in. acoustical lining and one lined elbow, open ends of duct boots min. 6 ft. apart	STC-50

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8.10.0 Suggested STC Ratings and Construction

Suggested minimum STC ratings for various types of composite office construction.

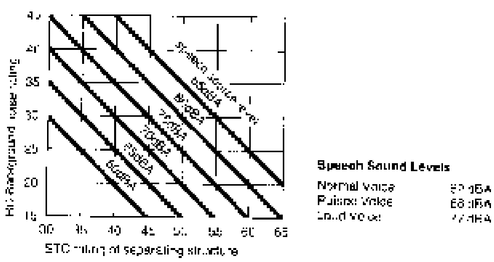
Space Relationship	Background Noise Level RC-30	Background Noise Level RC-35
Executive office to executive office	STC-50	STC-45
Executive office to private office	STC-50	STC-45
Executive office to secretary	STC-45	STC-40
Conference room to private office	STC-45	STC-40
Private office to private office	STC-40	STC-35
Private office to secretary	STC-35	STC-30

STC ratings of partitions with door or window occupying 21% of composite area

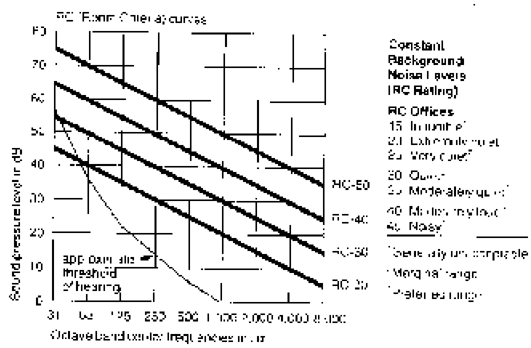
STC of door or window only (columns); STC of wall only (rows)

	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44
36	21	23	24	26	28	30	31	33	34	35	36	36	36	36	37	37
38	21	23	25	26	28	30	32	33	35	36	37	38	38	38	39	39
40	21	23	25	27	28	30	32	34	35	37	38	39	39	40	40	41
42	21	23	25	27	29	30	32	34	36	37	39	40	41	41	42	42
44	21	23	25	27	29	30	32	34	36	38	39	41	42	43	43	44
46	21	23	25	27	29	31	33	34	36	39	40	41	42	44	45	45
48	21	23	25	27	29	31	33	35	36	38	40	42	43	45	46	47
50	21	23	25	27	29	31	33	35	37	38	40	42	44	45	47	48
52	21	23	25	27	29	31	33	35	37	39	40	42	44	46	47	49
54	21	23	25	27	29	31	33	35	37	39	41	43	44	46	48	49
56	21	23	25	27	29	31	33	35	37	39	41	43	45	46	48	50

Selecting appropriate sound control systems depends on RC (Room Criteria) background noise level and speech source levels to be controlled. Each combination of RC rating and STC rating shown here will produce 0 to 10% sentence intelligibility for the speech source indicated.



Room Criteria background noise-level curves in 10 dB increments.



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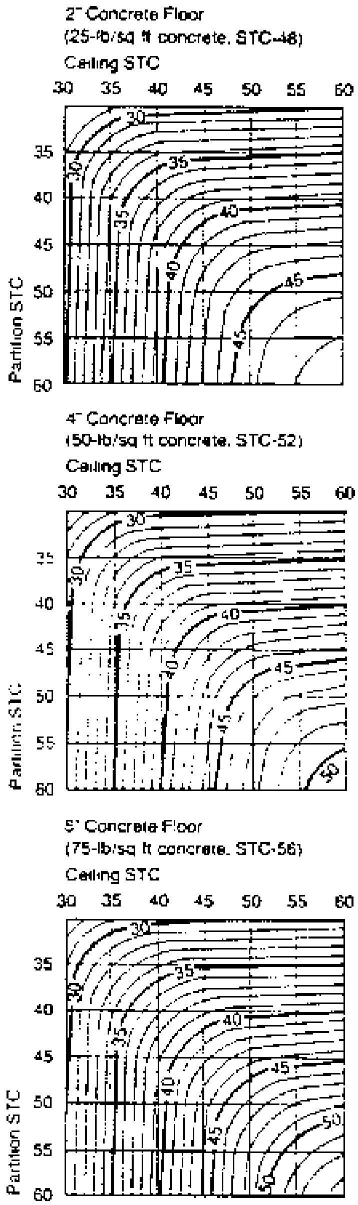
8.11.0 Ratings of 2" to 6" Concrete Slabs and Various STC-Rated Ceiling Assemblies



Composite office construction STC graphs for wall/ceiling systems compared to concrete floor systems of 2 in., 4 in., and 6 in. Note that wall, floor and ceiling areas are considered approximately equal for these graphs and that flanking sound paths are not considered.

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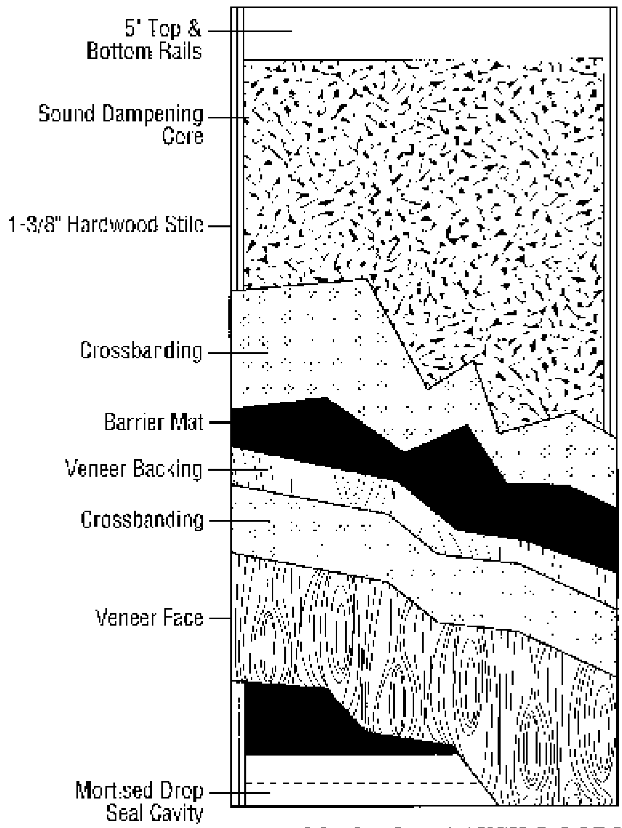
8.12.0 Acoustical Doors and STC Relevancy Chart



ALL ACOUSTICAL FLUSH DOORS
Excep: STC 32& 35

SPECIAL APPLICATION PRODUCTS

STC	DESCRIPTION
53	Two door communicator system
47	Fixed panel, for wall construction
37	Single door in a wood frame
35	Pairs of doors

STILE & RAIL DOORS

STC	DESCRIPTION
38	2-1/4" 90 Minute with threshold
37	2-1/4" 90 Minute without threshold
36	1-3/4" 45 or 60 Minute without threshold
33	2-1/4" standard construction
33	1-3/4" standard construction

STC Relevancy Chart

STC	Speech heard through door
30	Loud speech can be understood fairly well
35	Loud speech audible but not understandable
42	Loud speech audible as a murmur
45	Some loud speech barely audible
50	Loud speech not audible

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8.12.1 Acoustical Door Test Designations

ACOUSTICAL TEST DESIGNATIONS

The first number in each test designation indicates the test method. The second number indicates the year the method was last revised.

If doors tested with old test methods and materials were tested with the current methods and materials the doors would receive lower STC ratings.

STC RATINGS FOR SINGLE DOORS

STC RATINGS	DOOR THICKNESS	TESTED W/LITE	FIRE RATING	WEIGHT PER SQ FT	GASKET SYSTEM
51	2-1/4"	no	20 Minute	15.8	A
48	1-3/4"	no	20 Minute	13.7	A
48	2-1/4"	yes①	None	15.8	A
47	2-1/4"	yes②	None	15.8	A
45	1-3/4"	no	20 Minute	7.0	A
43	1-3/4"	no	20 Minute	7.0	C
42	1-3/4"	no	20 Minute	7.0	B
42	1-3/4"	yes①	None	7.0	B
42	1-3/4"	no	20 Minute	7.0	D
41	1-3/4"	yes②	45 Minute	7.0	B
41	1-3/4"	yes②	20 Minute	8.3	A
40	1-3/4"	yes②	20 Minute	7.0	B
40	1-3/4"	no	45 Minute	9.2	A
40	1-3/4"	no	20 Minute	7.0	F
39	1-3/4"	no	45 Minute	9.2	B
39	1-3/4"	yes③	45 Minute	9.0	B
39	1-3/4"	no	20 Minute	6.7	B
38	1-3/4"	no	None	5.8	F
38	1-3/8"	yes①	None	5.8	F
37	1-3/4"	yes①	None	5.2	B
36	1-3/4"	no	20 Minute	5.2	B
36	1-3/4"	yes③	None	6.7	B
32	1-3/4"	no	20 Minute	6.0	B
31	1-3/4"	no	20 Minute	5.0	B
28	1-3/4"	no	45, 60, 90 Minute	3.6	B

① Tested with solid wood bead, 370 sq. in. of visible lite.

② Tested with metal vision panel, 370 sq. in. of visible lite.

③ Full lite construction tested with 1,820 sq. in. of visible lite, Superlite I-45.

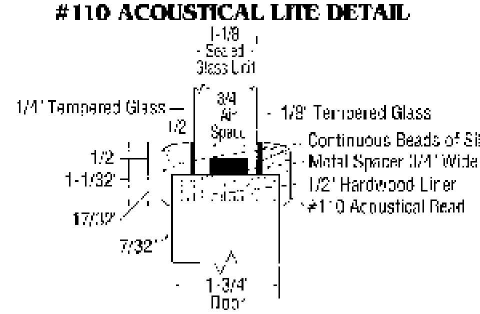
The sound transmission class specified shall be certified by the manufacturer to be based on tests conducted at an independent testing agency in accordance with ASTM E90-90.

Doors tested as ASTM E90-87 must be rated one STC higher and doors tested as ASTM E90-80 must be rated two STC higher than ASTM E90-90. Earlier tests must be three STC higher than E90-90. These differentials account for the variances in obsolete test methods and materials.

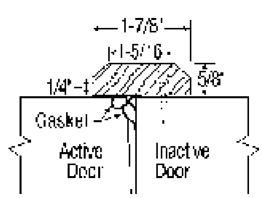
REQUIREMENTS FOR ACOUSTICAL DOORS WITH GLASS WITH WOOD BEAD:

1. Glass required to be a sealed unit.
2. For a 1-3/8" door, order glass units with a 3/8" spacer.
3. For a 1-3/4" door, order glass units with a 3/4" spacer.
4. For a 2-1/4" door, order glass units with a 3/4" spacer. The wood bead is not a lip style bead.
5. When ordering a door with this type of lite, the lite order size is the cut out size. The visible lite is 3/4" less than the order size.
6. Order the glass unit 1/8" less in length and width than the lite order size.

#110 ACOUSTICAL LITE DETAIL



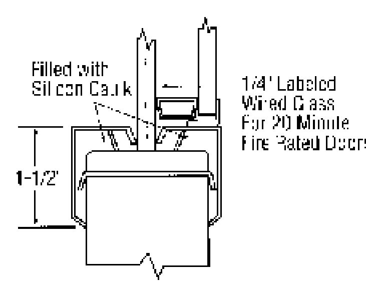
Acoustical Astragal



NOTE: Gaskets shown in noncompressed position.

Metal Vision Panel

Can Be Veneer Wrapped



Order Size: Visible glass center piece
Glass Size: Center piece order size +3/4"
Outer piece order size -1/4"
Cut-out Size: Order size +1-1/2"

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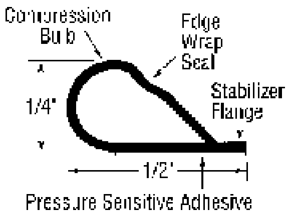
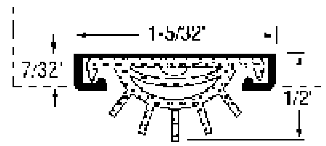
8.12.2 Acoustical Door Technical Information



#S-88 GASKET

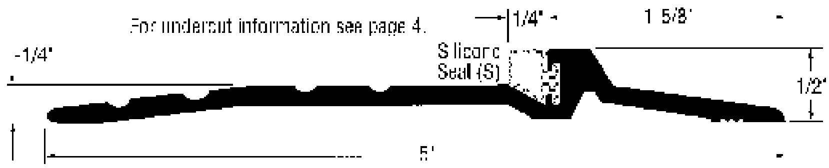
PEMKO GASKET SYSTEM

A — Double S-88 gaskets, 434 door bottom, 2005 threshold.
B — Double S-88 gaskets, 434 door bottom.
C — Double S-88, 234 door shoe, 2005 threshold.
D — 303 acoustical stop, 234 door shoe, 2005 threshold.
E — 303 acoustical stops, 434 drop seal.
F — Double S-88, 411 door bottom.



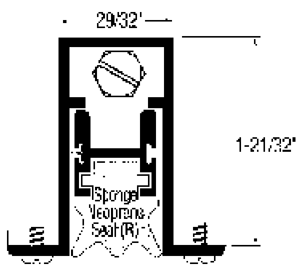
#234 DOOR SHOE

For undercut information see page 4.

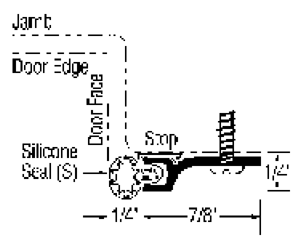


#2005 THRESHOLD

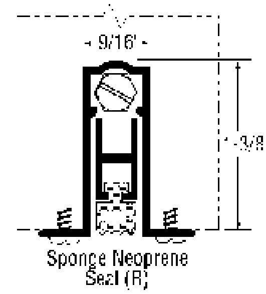
ADA Approved



#434 DROP SEAL



#303 ACOUSTICAL STOP



#411 DOOR BOTTOM

For 1-3/8" Doors

ACOUSTICAL DOOR TECHNICAL INFORMATION		
STANDARDS	♣ AWI Section 1300 7th Edition ♣ NWWDA Industry Standard 1-A-97	
MAXIMUM SIZES	4'0" x 10'0" 20 Minute 4'0" x 8'0" for single doors; 8'0" x 8'0" for pairs. 45 Minute 4'0" x 8'0" for single doors.	
FACES	All available species, sketch face, plastic, medium density overlay.	
EDGES		
Top & Bottom Rails	♣ STC 28, 31, 33, 36: ♣ STC 37 through 53:	Minimum option 1 1/8" hardwood glued to core. 5" glued to core.
Vertical Stiles	♣ STC 31 and 36: ♣ STC 37 through 53: ♣ STC 35 through 53:	Matching or compatible-to-face veneer, 5/8" stave core and 1-3/8" particle core. Stiles glued to core. 1-9/16" glued to core. Veneer edged with edges matching face veneer.
GASKETS	Gasket system is supplied with door and can be installed in standard stopped, hollow metal frames.	
LITES	All lites subject to the following for warranty: ♣ No less than 5" between adjacent cutouts such as hardware, lites, etc. ♣ Total area not to exceed 40% of door area or 50% of door height.	
FINISH	Gardall II, polyurethane, primed, painted, sealed or as specified.	
MACHINING	Prefitted, mortised for appropriate hardware.	
APPLIED MOULDINGS	Allowable on one or both faces. Maximum 3/4" high and 3" wide.	
MATCHING	Virtually unlimited in standard veneers.	
WARRANTY	Interior: Life of original installation. Exterior: Not recommended. A special STC 31 through 51 door for residences around airports is now available with a five-year warranty. Certain geographical locations are subject to special installation requirements.	

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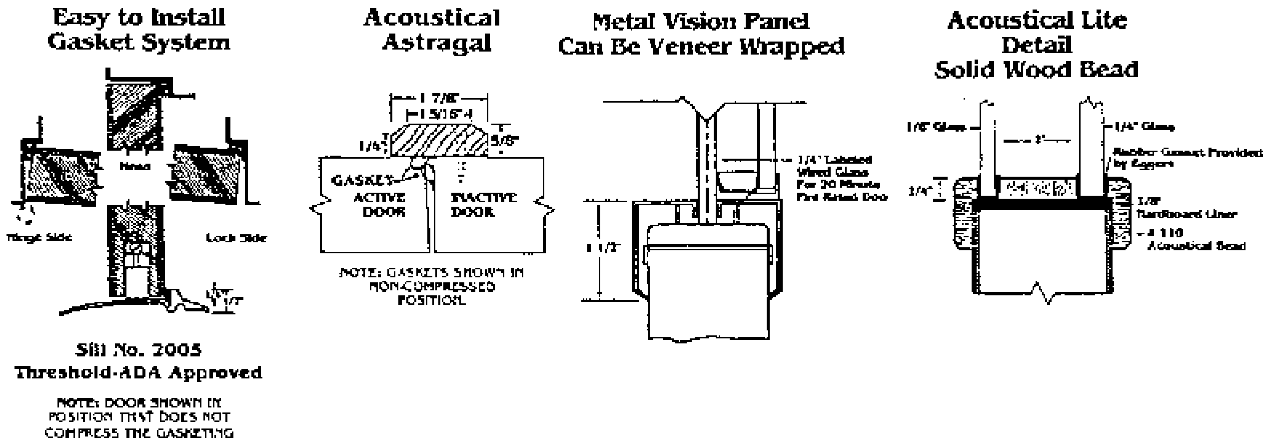
8.12.3 The Effect of Acoustical Doors on STC Ratings



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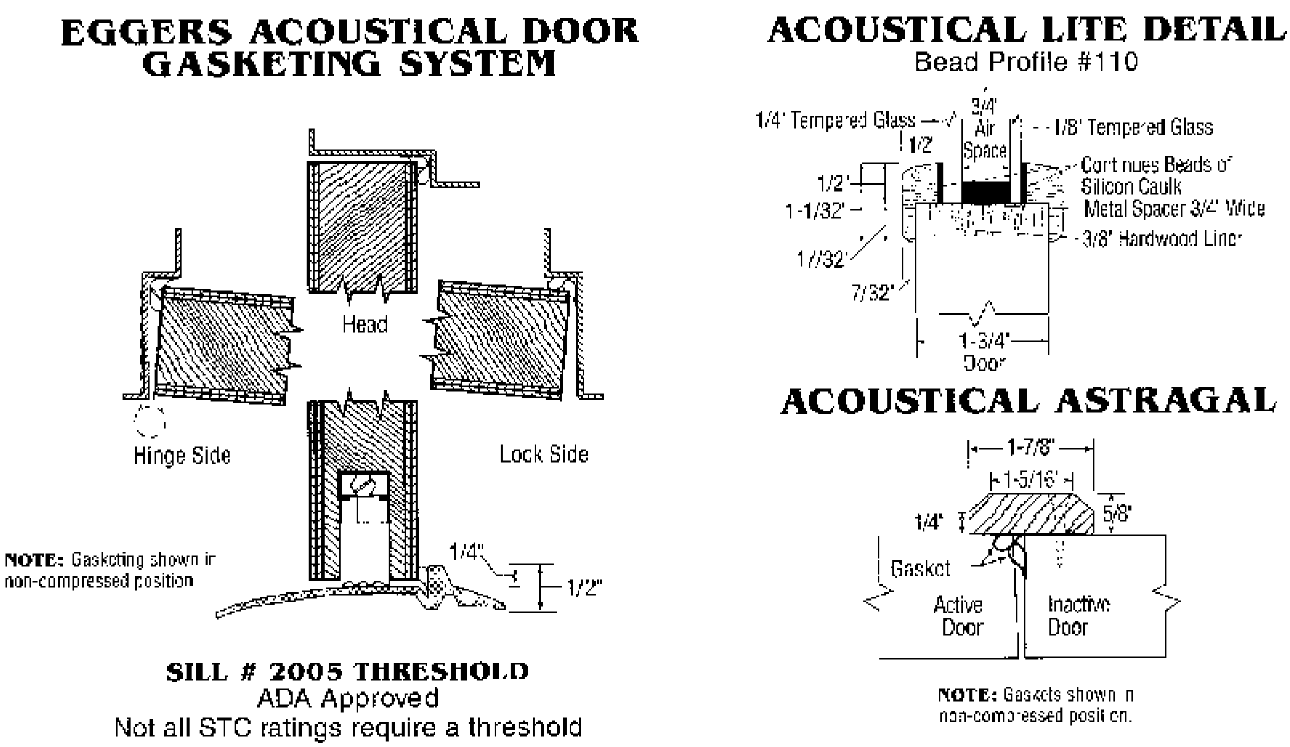
8.12.4 Acoustical Door Gasketing and Lite Details



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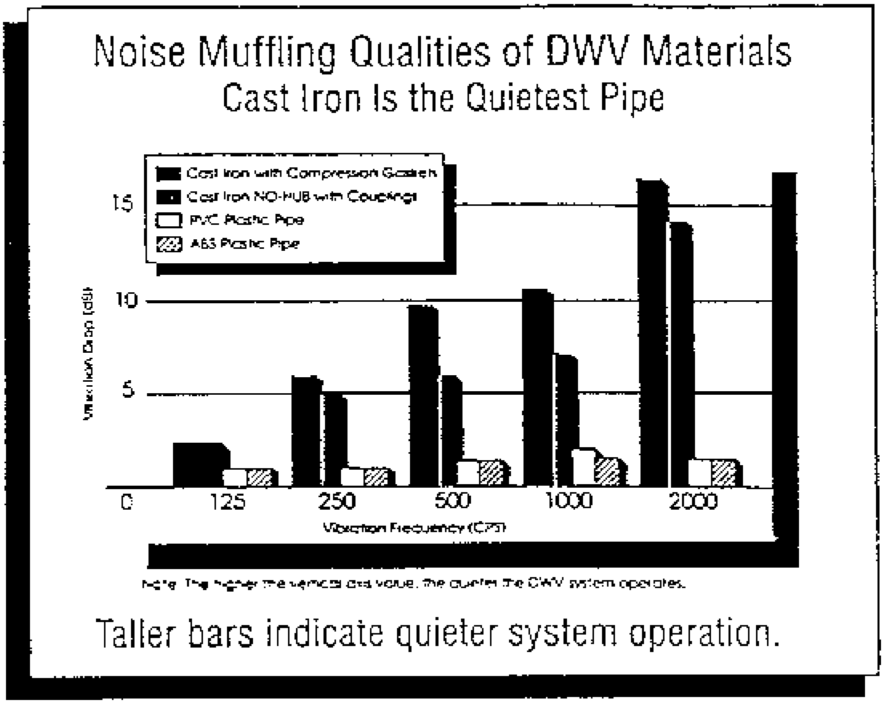
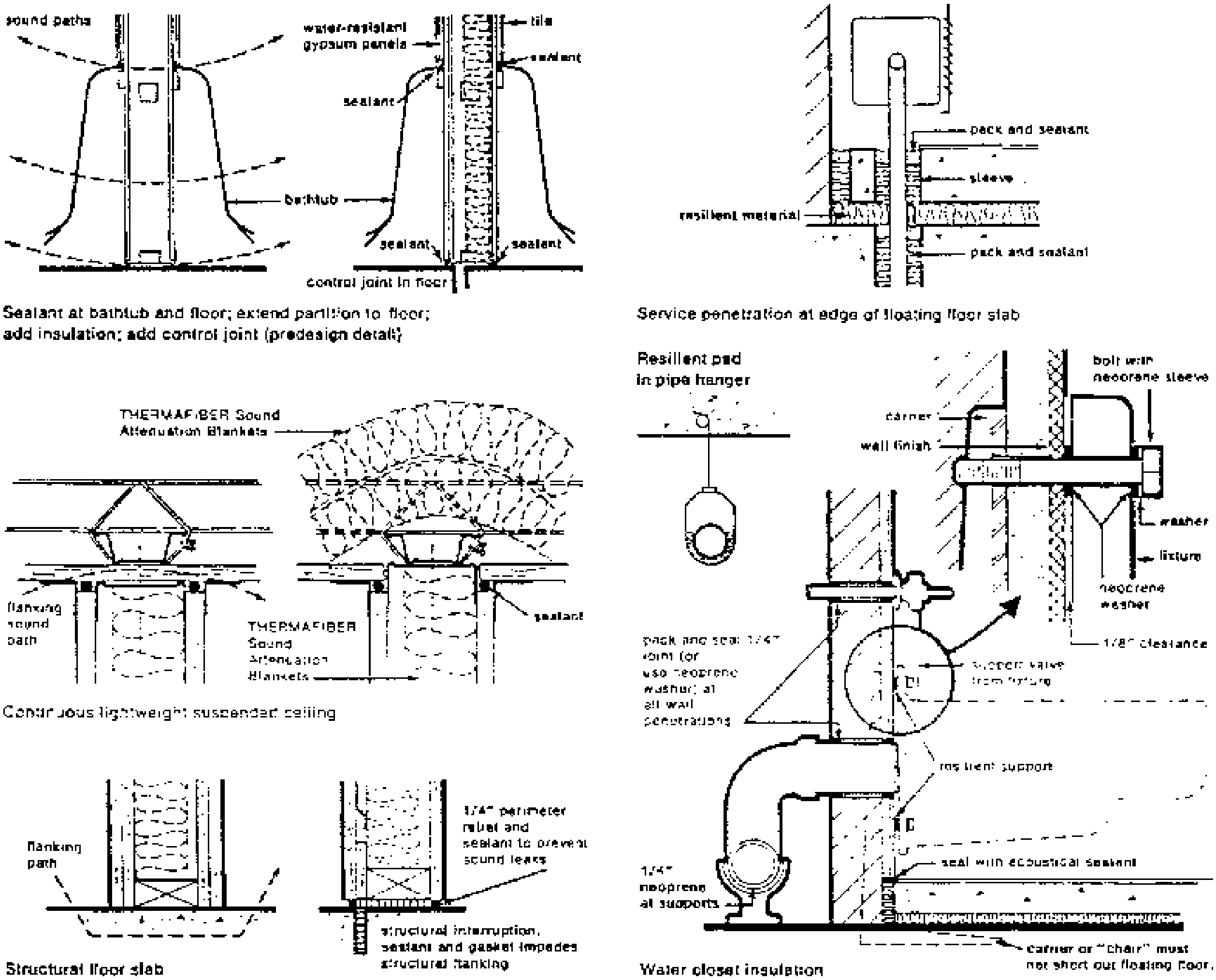
8.13.0 Noise-Muffling Qualities of Various Types of Plumbing Risers



Note: OWV = Drainage, Waste, and Vents

(By permission of Cast Iron Soil Pipe Institute.)

8.14.0 Plumbing Installation Acoustical Considerations



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8.15.0 Duct Systems and Acoustical Considerations

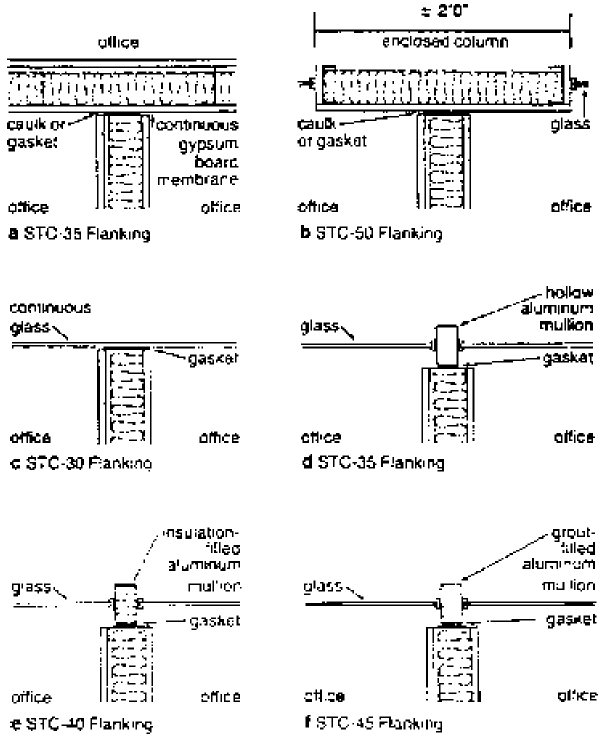
Duct systems in both commercial and residential buildings can be constructed of metal or fiberglass, lined or wrapped with insulating materials. Not only is noise generated by the actual flow of air through the duct system, but noise is generated or can be controlled by the type of material from which the ductwork is constructed.

	Octave band frequency (Hz)					
Description	125	250	500	1000	2000	4000
Bare sheet metal*	0.1	0.1	0.1	0.1	0.1	0.1
Wrapped sheet metal*	0.2	0.2	0.2	0.2	0.2	0.2
Lined sheet metal* (one-inch thick)	0.3	0.7	1.9	5.3	4.8	2.3
Fiberglass duct (one-inch thick)	0.4	1.4	3.3	3.9	5.0	3.7

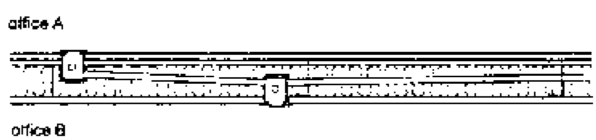
**1978 ASHRAE Transactions,* Vol. 84, Part 1, p. 122

8.16.0 Composite Wall/Electrical Box Installations

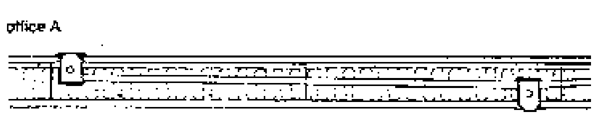
STC limitations imposed on composite constructions by flanking walls and window.



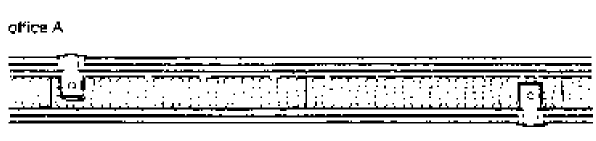
Acoustical details for installing electrical boxes in sound-rated walls. Note that an acoustician usually must develop specific job details for walls rated over STC-60.



a Caulked boxes back-to-back or side-to-side in same stud cavity. Arrangement should not be used with walls rated above STC-40.



b Caulked boxes side-to-side in separate stud cavities, min. 36 in. apart. Arrangement suitable for walls rated up to STC-50.



c Caulked boxes, min. 36 in. apart, conduit from overhead or beneath floor. Arrangement suitable for walls rated up to STC-60.

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8.17.0 Electrical Transformers and Increased Decibel (dBA) Levels

When locating office space adjacent to electrical equipment rooms or electrical closets where sizable electrical transformers are installed, precautions should be taken in wall construction to avoid or lessen the transmission of excessive decibel levels to these areas.

Listed are the transformer ratings and their corresponding decibel sound output.

Transformer rating	Decibel sound output
9	40
15	42
30	42
45	42
75	45
112-½	45
150	45
225	49
300	49
500	53

Section

9

Doors and Windows

Contents

9.14.0 Aluminum door types/sectional dimensions
9.14.1 Aluminum revolving doors
9.15.0 Windows—aluminum, wood, steel, and plastic
9.16.0 Window performance grades and ANSI and NWWDA standards for wood windows
9.17.0 Effect of glazing selections on heat gain
9.17.1 Low-E glazing—illustration
9.18.0 NWWDA air-infiltration standards
9.19.0 Steps required to order wood/clad windows
9.20.0 Aluminum window wall—stick-built construction
9.21.0 Aluminum window wall—shear block fabrication
9.22.0 Aluminum window wall—screw-spline fabrication
9.23.0 Thermal movement and frame deflection
9.24.0 Sloped glazing and skylight configurations
9.25.0 Curtain wall—Quality Control checklist
9.26.0 Interior glass/glazing Quality Control checklist

Numerous configurations of doors and windows are in use in residential, commercial, and industrial construction today.

Sliding, revolving, folding, and vertical rise doors are specified in some projects, but it is the rare construction project that does not include swinging doors—either wood or metal or laminate clad. This section emphasizes these latter three types.

The materials of construction for widows include: wood, steel and aluminum, vinyl, fiberglass, and combinations of these materials. However, the availability of different window configurations allows for a multitude of fenestration configurations: single and double hung, fixed lights, casements, sliders, awnings, and pivots to meet specific architectural designs. This section is devoted to general window design and materials of construction.

9.0.0 Hollow Metal Doors and Frames

Commonly referred to as hollow metal, these doors and frames are available in many standard sizes and configurations and any number of custom design variations. The design and classification standards are established by the Steel Door Institute (SDI) for grades, sizes, metal gauges, and hardware locations.

9.0.1 Classifications of Hollow Metal Doors

Grade I-Standard-duty 1⅝" and 1¾" (Level C)	
Model 1	Full Flush Design
Model 2	Seamless Design
Grade II–Heavy-duty 1¾" (Level B)	
Model 1	Full Flush Design
Model 2	Seamless Design
Grade III–Extra Heavy-duty 1¾" (Level A)	
Models 1 & 1A	Full Flush Design
Models 2 & 2A	Seamless Design
Model 3	Stile and Rail—Flush panel

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.0.2 Standard Opening Sizes for Hollow Metal Doors

STANDARD OPENING SIZE

Opening	Opening Heights								
Widths	1 3/4" Doors							1 3/8" Doors	
2'0"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
2'4"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
2'6"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
2'8"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
2'10"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
3'0"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"	6'8"	7'0"
3'4"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"		
3'6"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"		
3'8"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"		
3'10"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"		
4'0"	6'8"	7'0"	7'2"	7'10"	8'0"	8'10"	10'0"		

Doors

Nominal Design Clearances

The nominal clearance between the door and frame head and jambs shall be ⅛" in the case of both single swing and pairs of doors.

The nominal clearance between the meeting edges of pairs of doors can range from ⅛" to ¼" (⅛" for fire rated doors).

The nominal clearance at the bottom shall be ¾".

The nominal clearance between the face of the door and door stop shall be 1/16".

All clearances are subject to a tolerance of ±1/32".

Construction Features-Full Flush and Seamless

Door Faces

Full Flush Faces

There shall be no visible seams on the surface of the faces.

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.0.3 Hardware Locations and Reinforcing Required for Hollow Metal Doors and Frames

HARDWARE REINFORCING GAGES

HARDWARE TYPES [4]		MINIMUM GAGE		MINIMUM THICKNESS [1]	
		DOOR	FRAME	DOOR	FRAME
HINGES	1 3/8" DOORS	12 [2]	12 [2]	.093	.093
	1 3/4" DOORS	10 [2,3]	10 [2]	.123	.123
MORTISE LOCKS & DEADBOLTS		14 [2]	14 [2]	.067	.067
BORED OR CYLINDRICAL LOCKS		14 [2]	14 [2]	.067	.067
FLUSH BOLTS		14	14	.067	.067
SURFACE BOLTS		14	14	.067	.067
SURFACE APPLIED CLOSERS		14	14	.067	.067
HOLD OPEN ARMS		14	14	.067	.067
PULL PLATES & BARS		16	— —	.053	— —
SURFACE PANIC DEVICES		14	14	.067	.067
FLOOR CHECKING HINGES		7	7	.167	.167
PIVOT HINGES		7	7	.167	.167
KICK & PUSH PLATES		REINFORCING IS NOT REQUIRED			

(1) THE MINIMUM STEEL THICKNESS FOR EACH SPECIFIC GAGE ARE DERIVED FROM PUBLISHED FIGURES OF UNDERWRITERS LABORATORIES.

(2) A THINNER GAGE OF STEEL MAY BE EMPLOYED AS LONG AS THE TAPPED HOLES, USED FOR MOUNTING THE HARDWARE, ARE EXTRUDED TO PRODUCE AN EQUIVALENT NUMBER OF THREADS THAT WOULD BE PROVIDED USING THE GAGE OF MATERIAL INDICATED.

(3) IF THE REINFORCING IS ANGULAR OR CHANNEL SHAPED, 12 GAGE IS PERMISSIBLE.

(4) WHEN REINFORCEMENT IS OMITTED AND THROUGH-BOLTING IS REQUIRED, THE USE OF SPACERS OR SEX-BOLTS SHALL BE PART OF THE SPECIFICATION.

HARDWARE LOCATIONS

Locks, Latches, Roller Latches, and Double Handle Sets		40 5/16" to Centerline of Lock Strike from Bottom of Frame. (Refer to Appendix "C" for Additional Information)
Rim and Mortise Panic Devices		
Cylindrical and Mortise Deadlocks		48 " to Centerline of Strike from Bottom of Frame
Push Plates		Centerline of 45" from the Bottom of Frame
Pull Plates		Centerline of Grip @ 42" from the Bottom of Frame
Combination Push Bar		Centerline of 42" from Bottom of Frame
Hospital Arm Pull		Centerline of Lower Base is 45" from Bottom of Frame with Grip Open at Bottom
Hinges	Top	Up to 11 3/4" from Rabbet Section of Frame to Centerline of Hinge
	Bottom	Up to 13" from Bottom of Frame to Centerline of Hinge
	Intermediate	Equally Spaced Between Top and Bottom Hinges

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.0.4 Metal Thickness of Hollow Metal Doors

TABLE II
METAL THICKNESS/DOORS

GRADE	MODEL	FULL FLUSH OR SEAMLESS		STILES AND RAILS	
		MSG NO.*	MINIMUM THICKNESS	MSG NO.*	MINIMUM THICKNESS
I	1	20	0.032		
	2	20	0.032		
II	1	18	0.042		
	2	18	0.042		
III	1	16	0.053		
	1A	14	0.067		
	2	16	0.053		
	2A	14	0.067		
	3	18	0.042	16	0.053

**Nominal inch equivalent is based on Manufacturers Standard Gage and is subject to normal tolerances.*

Gage vs Minimum Metal Thickness. The minimum steel thicknesses for each specific gage are derived from the published figures of Underwriters Laboratories Inc. Those limits are shown in Table III.

Table III

MSG* NO.	UNCOATED	HOT DIPPED			ELECTROLYTIC		
		A40	A60	G60	"A"	"B"	"C"
12	.093	.093	.093	.093	.093	.093	.093
14	.067	.067	.067	.067	.067	.067	.067
16	.053	.053	.053	.053	.053	.053	.053
18	.042	.042	.042	.042	.042	.042	.042
20	.032	.032	.032	.032	.032	.032	.032

**Nominal inch equivalent is based on Manufacturers Standard Gage and is subject to normal tolerances.*

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.0 Dealing with Hollow Metal Door Installation Problems

Whether the hollow metal frame are "set up and welded" or "knocked down" (KD), if they are not properly stored and installed in metal-framed drywall partitions or masonry openings, problems will arise, if not during actual construction, then certainly during the postconstruction period. Although the contractor might be diligent in supervising and inspecting the installation of hollow metal doors and frames, by their own forces or by a subcontractor, improper storage or less-than-adequate installation procedures can result in problems that require corrective action. Many of these problem installations can be corrected without total removal of either the door or frame.

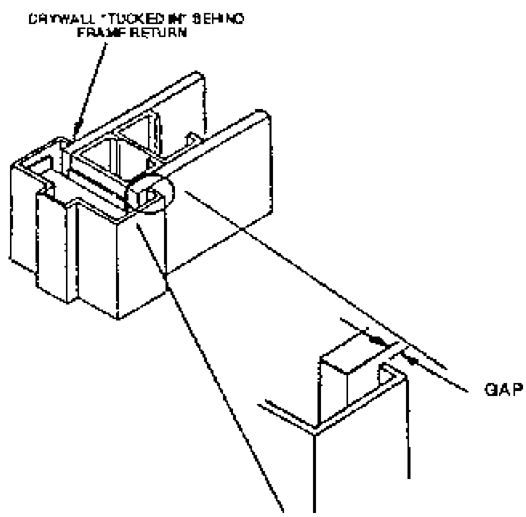
9.1.1 Frame Loose in Drywall Partition

Frame manufacturers closely control the dimensions to which their frames are manufactured. Since automated equipment is used, these dimensions are easily repeated from piece to piece. The majority of cases will reveal that the overall wall thickness has not been properly maintained. Wall thickness conditions can easily vary from undersize to oversize. The thickness should be checked if possible, to verify the wall's compliance with the Job Specification.

Frames installed in drywall walls can use two different anchoring methods as follows

- WELDED OR SNAP-IN STEEL OR WOOD STUD ANCHORS

Some frames use welded or snapped in steel or wood stud anchors. These frames are installed prior to the drywall material being attached to the studs. In this case, the drywall can either be "butted-up" against the return of the frame or be "tucked in" behind the return of the frame. Only in the installation where the drywall is "tucked in" behind the return can there be a condition where the frame is loose on the drywall. Refer to Figure 1 and Figure 2. This gap could be uniform along the entire length (height) of the jamb or could be only in certain areas. Since the frame cannot be removed, the only available options are to caulk the gap or cover it with trim.



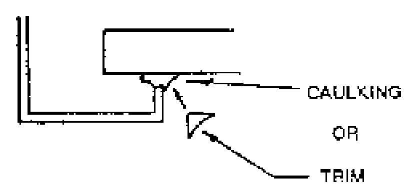


Figure 2

Figure 1

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.2 Frame Loose in Drywall Partition (Another Condition)

This condition should be reported to the appropriate jobsite personnel. The condition can be corrected by putting a bearing plate on each side of the corner and compressing the internal steel studs with a clamp, refer to Figure 8. However, the responsibility for correcting this condition belongs to the subcontractor responsible for the actual wall construction.

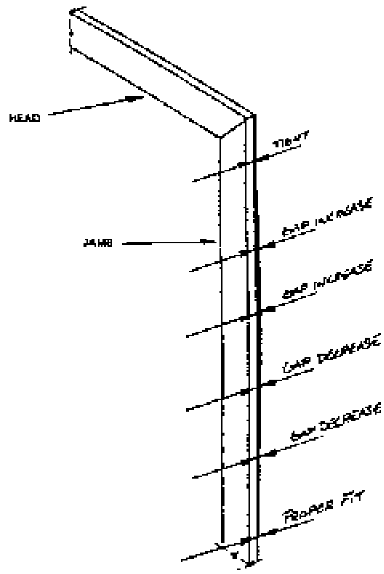


Figure 7

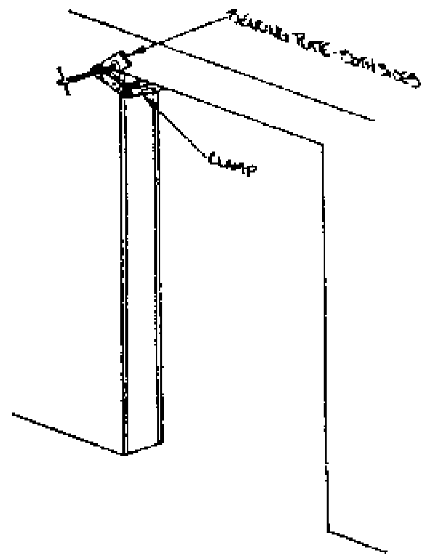


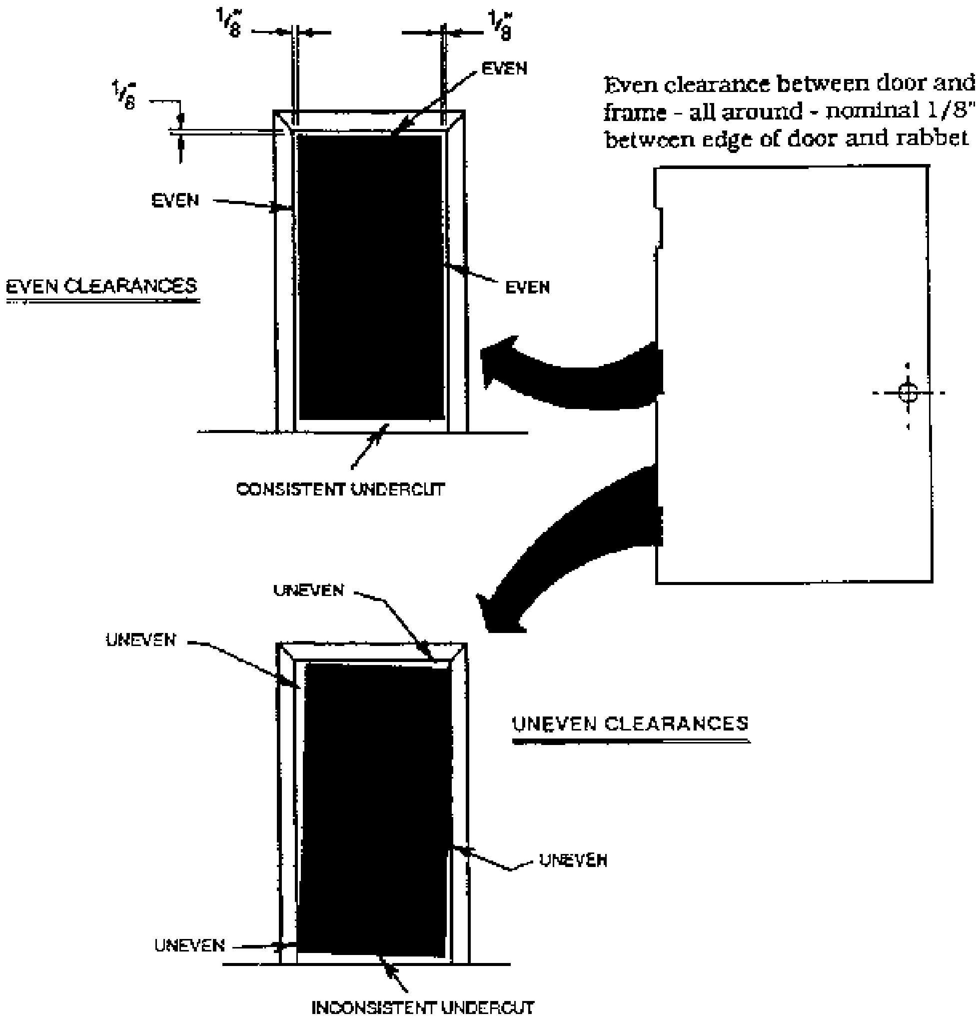
Figure 8

The third condition is different from the first two which talk about the "fit" of the frame over the wall thickness. The third condition is that of compression anchors which have not been tightened. The drywall frame would then be loose across the width of the opening and move from side to side against the rough opening.

The frame should be plumbed, square and secure in the opening by properly adjusting the compression anchors following the manufacturers instructions.

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.3 Improper Door/Frame Clearances



A door and frame are both the same geometric figure, that is, a rectangle. One rectangle, the door, must open and close within another rectangle, the frame. To do so, the clearance between the two must be properly maintained. All standard steel door and frame manufacturers closely hold tolerances which result in a nominal clearance between the door and frame of 1/8 inch. If this clearance is not maintained, an interference will develop and/or hardware misalignment may occur.

From this, it can be seen that proper installation is extremely important in establishing clearances and will prevent a multitude of potential problems from developing.

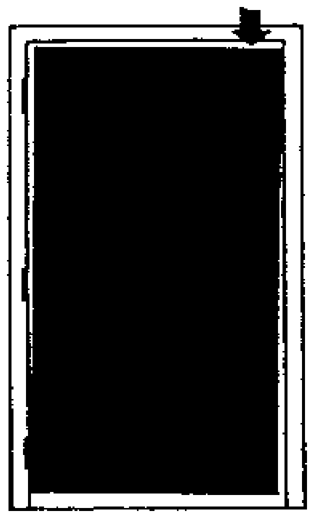
The Steel Door Institute has many publications which were developed to establish industry standards and assist in specifying as well as installing standard steel doors and frames. One publication, SDI-105 will be of assistance regarding the erection and installation of standard steel frames.

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.4 Door Binding and Sagging (Hinge Problems)

Is your door binding ?

Frames which are out of plumb are frequently the cause of faulty operation of locksets and binding of bolts in the strike. Check carefully.

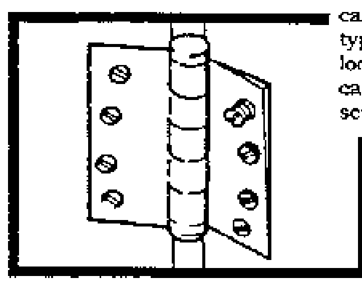


Is Door Sagging ?

If sag cannot be corrected and door and frames returned to plumb relationship, repositioning or shimming the strike may relieve this condition. Additionally filing the strike will compensate for minor mis-alignment (refer to section "Lock fits too tight in strike")

Are hinges worn ?

If excessive wear has occurred on hinge knuckles, door will not be held tightly. Replace hinges.

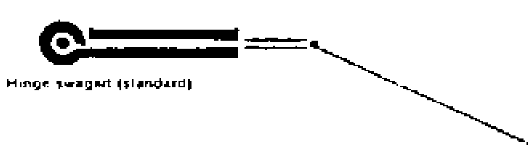


Are hinges loose ?

If hinge screw will not remain tight, the screw can be held in place by the use of a "locktite" type product which prevents the screw from loosening. Additionally, "Nylok" type fasteners can be used to replace the normal machine screws.

Are Hinges Properly Swaged?

The hinge manufacturers specifications should be checked to determine what the proper hinge swage should be.



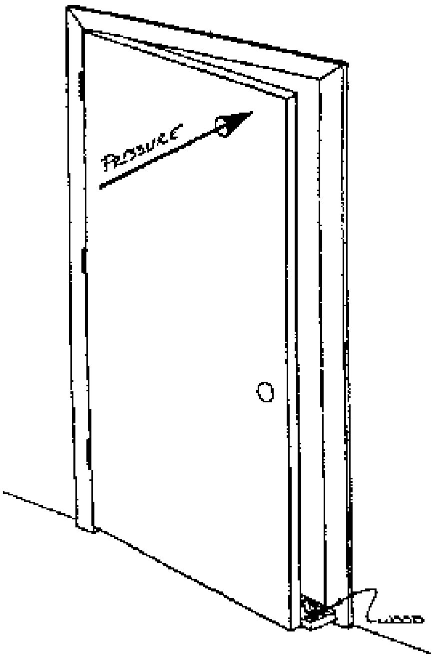
Swaging is a slight offset of the hinge leaf at the barrel which permits the leaves to come together.

Standard swaging of standard weight and heavy weight full mortise hinges when closed to the parallel position provides a 1/16" clearance between leaves.

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

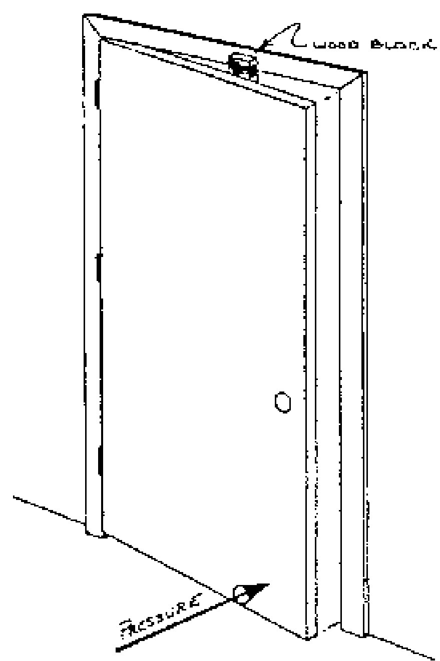
9.1.5 Springing a Twisted Door

It is possible, in some cases, to "spring" the door back to (or much closer to) its ideal position of being parallel with the imaginary plane across the faces of the frame. This can usually be done with the door remaining in the frame. A piece of wood blocking must be placed between the door and frame and pressure is then applied at the twisted area to "spring" the door. However, caution should be exercised on drywall installations since the frame could possibly work loose from the wall, particularly on slip-on drywall type frames.



Twisted door, with top lock area of door "breaking—through" the imaginary plane. Place wood block on floor, between door and frame as shown. Apply pressure to top lock area as shown to "spring" door back into position. Remove wood block, close door and check condition. Repeat if necessary.

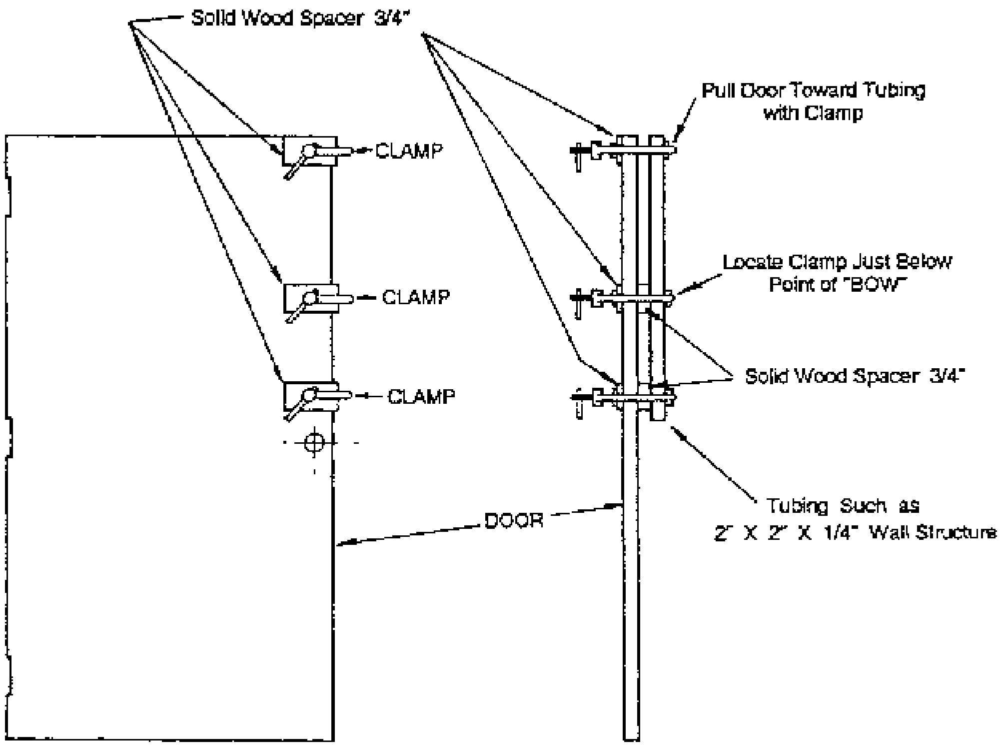
Twisted door, with bottom lock area of door "breaking-through" the imaginary plane. Place wood block between frame head and door as shown. Apply pressure to the bottom lock area as shown to "spring" door back into position. Remove wood block, close door and check condition. Repeat if necessary.



(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.6 Springing a Twisted Door (Another Method)

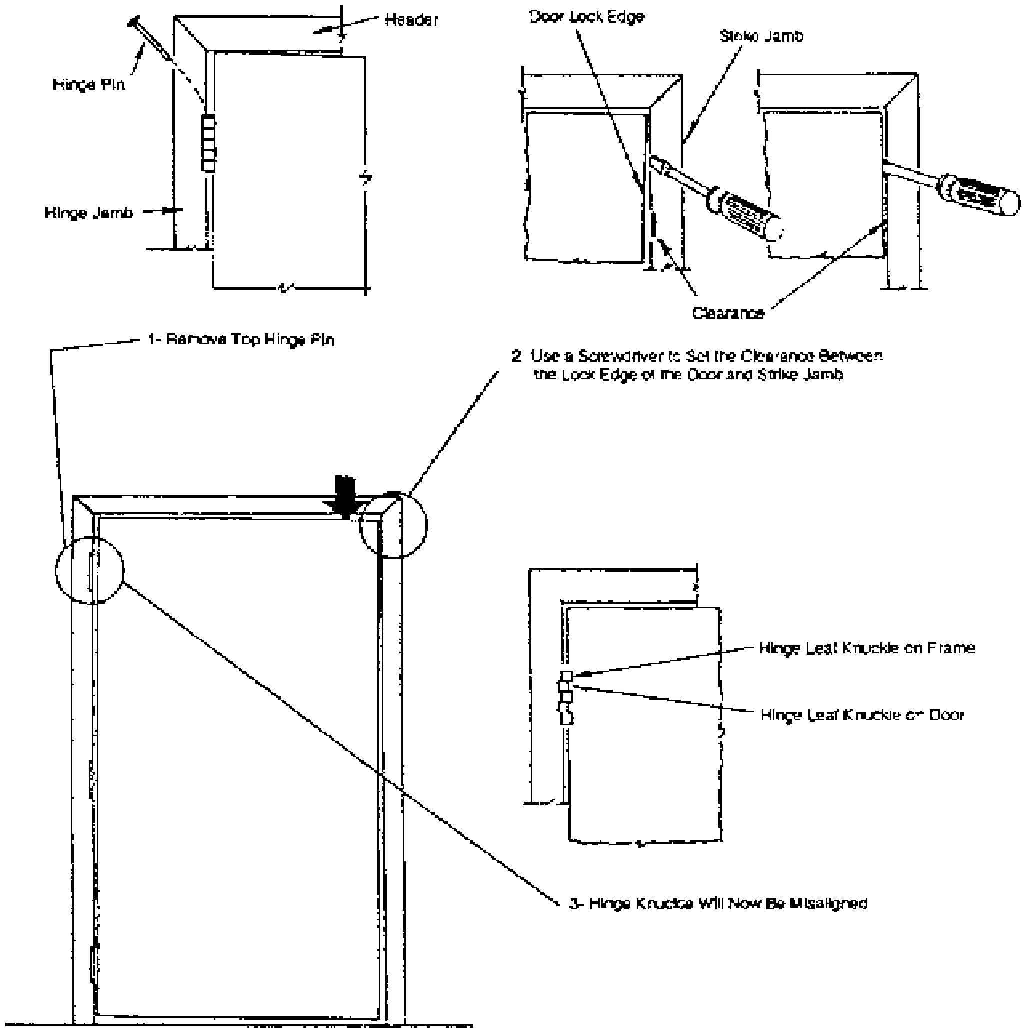
An alternate method can also be used which will allow the door to remain in the opening. This might be appropriate in drywall installations as previously mentioned. Although the example shown reflects the top half of the door, this method could be used on the bottom half of the door as well.



(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.7 Reswagging Hinges

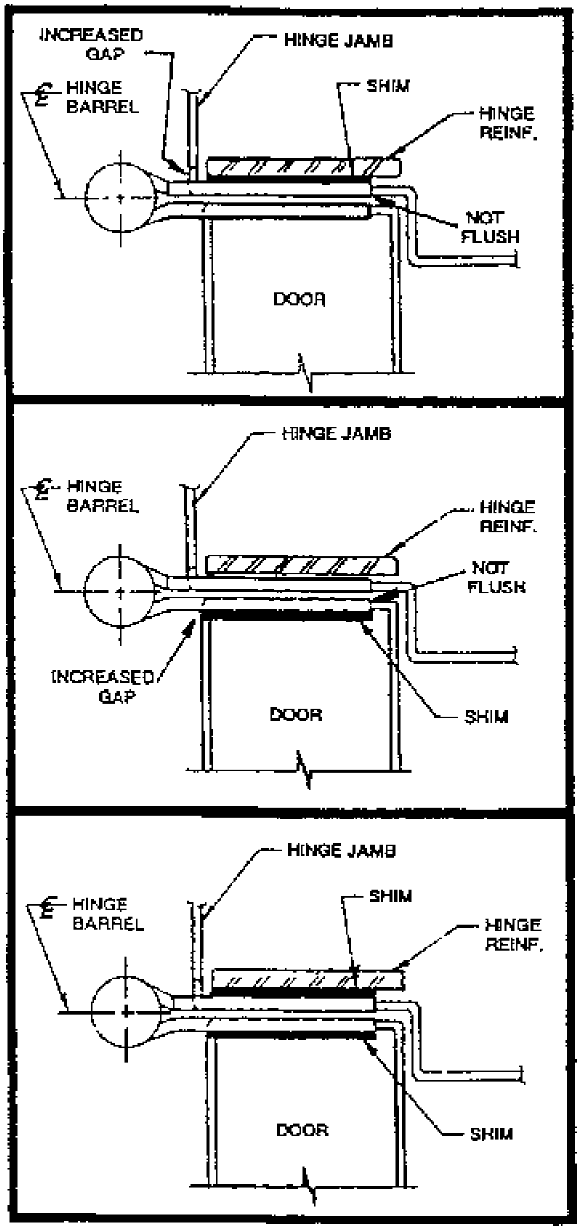
The following example shows how a hinge leaf can be reswaged to correct minor improper door/frame clearances. This particular method allows the reswaging to be accomplished while the door remains in the opening and the hinge leaves remain on the door and frame. The example shows a top hinge reswaged to correct a sag type condition. However, any of the hinges can be reswaged in this manner to compensate for conditions opposite to that of a sag condition.



(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.8 Hinge Binding against Rabbet

Normally, hinge bind is found between the door and rabbet. There are several ways of shimming which will move the door in different directions. The following guidelines should be used in shim applications.



1. A shim can be placed between the frame hinge reinforcement and the hinge leaf. This will move the door toward the strike jamb. However, the hinge notch face gap will be increased and the hinge leaf surface will not be flush with the rabbet surface.

2. A shim can be placed between the door and the hinge leaf. This will also move the door toward the strike jamb. However, an increased gap will be created by the shim and the hinge leaf surface will not be flush with the backset surface on the door.

3. To minimize the gaps and the hinge leaf surfaces not being flush in #1 and #2 above, two shims can be used. These two shims would be half the thickness as those used in #1 or #2. This would minimize gaps and out-of-flush conditions.

(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.1.9 Thermal Bow in a Hollow Metal Door

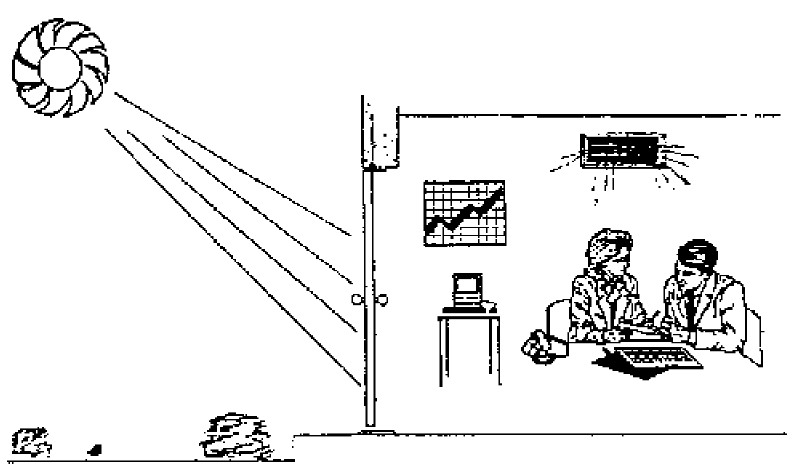
The entire door/frame surface should then be lightly sanded and "feathered" into any heavily sanded areas. The entire surface should then be reprime painted.

* For products which are finish painted, the affected areas should be adequately sanded. If necessary the area should be sanded to bare metal. The entire remaining finish painted area should then be lightly sanded and "feathered" into any heavily sanded areas. If bare metal is showing these areas should be reprime painted and lightly sanded to "feather" into the lightly sanded finish painted areas. The product should then be refinish painted.

**In all cases, when the door is being prepared for top, finish coat painting the surface should be cleaned. Use the same solvent that will be used to thin topcoat paint and thoroughly clean all surfaces to be painted.

<u>**THERMAL BOW**</u>

Installers should be aware of a condition known as Thermal Bow. Thermal Bow is a temporary condition which may occur in metal doors due to the inside-outside temperature differential. This is more common when the direct rays of the sun are on a door surface. This condition is temporary, and to a great extent depends on the door color, door construction, length of exposure, temperature, etc. This condition can often be alleviated by painting the exposed surface a light color. In some cases of extreme cold, this condition may occur in reverse.

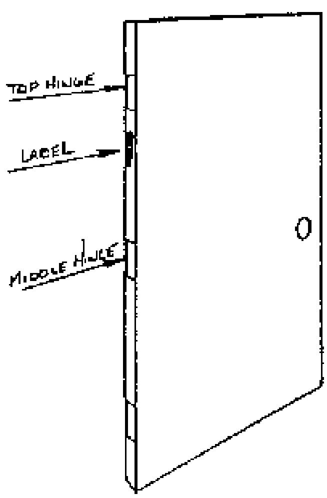


(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.2.0 UL Label Off Fire-Rated Door?

Fire-rated doors are an important element of compliance with building codes and fire-protection standards. Consequently, proper control of the labels that are attached to the doors is top priority for the manufacturer, code official, and labeling agency. The manufacturer must account for every label used and the label can only be applied at the manufacturer's facility or at an authorized distributor of the manufacturer. These are the only places at which a label can be affixed to a product. Once the product is in the field, whether it's installed or not, even the manufacturer is not allowed to attach labels unless a representative of the labeling agency has inspected the product for compliance with the manufacturer's procedures. As you can see, not just anyone can attach labels to doors in the field and not just anyone can be in possession of fire-rating labels. Only authorized individuals can be in possession of fire-rating labels. Only authorized individuals can be in possesson of and attach labels to fire-rated products in the field. Anything other than this is illegal!

All labels on fire-rated doors are located in the same place. Be sure that you are looking for the label in the right location. The label will be located on the hinge edge of the door between the top and middle hinge. If the label is not present, you should contact the distributor who provided the door. They, in turn, will initiate the appropriate action to correct the missing-label problem.

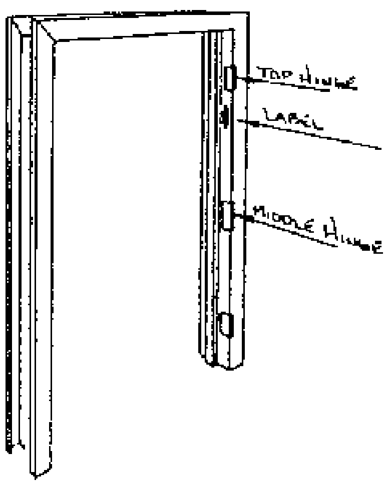


(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.2.1 UL Label Off Fire-Rated Frame?

Like doors, fire-rated frames are an important element of compliance with building codes and fire-protection standards. Consequently, proper control of the labels that are attached to the frame is top priority for the manufacturer, code official, and labeling agency. The manufacturer must account for every label used and the label can only be applied at the manufacturer's facility or at an authorized distributor of the manufacturer. These are the only places that a label can be affixed to the product by the manufacturer. Once the product is in the field, whether it is installed or not, even the manufacturer is not allowed to attach labels unless a representative of the labeling agency has inspected the product for compliance with the manufacturer's procedures. As you can see, not just anyone can attach labels to frames in the field and not just anyone can be in possession of fire-rating labels. Only authorized individuals can be in possession of and attach labels to fire-rated products in the field. Anything other than this is illegal!

All labels on fire-rated frames are located in the same place. However, it should be noted that some frames have an embossed label, rather than the surface-attached label. The embossed label is actually "stamped" into the frame rabbet. Whether the label is surface-attached or embossed, it is located in the same place, on the hinge jamb between the top and middle hinge. If the label or embossment is not present, you should contact the distributor who provided the frame. They, in turn, will initiate the appropriate action to correct the missing-label problem.



(By permission of the Steel Door Institute (SDI), Cleveland, Ohio.)

9.3.0 Hollow Metal Door Paint Problems

Paint Peeling to Bare Metal

Two conditions must be considered when evaluating paint peeling to bare metal.

Primer Paint Only

If the product is only primer painted, then poor adhesion between the primer and bare metal has occurred. This can usually be attributed to inadequate surface preparation before priming. The bare metal must be adequately prepared to ensure good primer paint adhesion.

The door should be completely sanded, washed with an appropriate solvent, and reprimed. The sanding and washing operations should provide an adequate surface to ensure good primer adhesion.

Primer Paint and Top (Finish) Coat

The failure could be caused by either poor surface preparation before priming or the use of a non-compatible finish paint, which has reacted with the primer and lifted all paint to bare metal. In either case, the corrective measures would be the same. The door should be completely sanded and washed with an appropriate solvent. The door should then be reprimed. Lightly sand the primer coat, wipe, and finish paint with a compatible top coat.

In all cases, when the door is being prepared for top, finish-coat painting, the surface should be cleaned. Use the same solvent that will be used to thin top-coat paint and thoroughly clean all surfaces to be painted.

Paint in Tapped Holes

Both hollow metal doors and frames have various holes that are drilled and tapped. These holes are in various components, such as reinforcements. All of the components are brought together as an assembly prior to the painting operation.

There are a variety of painting methods which manufacturers can use. Some of these methods could result in a paint buildup in the tapped holes of the reinforcements. The buildup could, occasionally, make installation of the screw difficult. The buildup should be removed to make screw installation easier and assure that the screws are properly sealed.

The best method of cleaning the tapped holes is to use an actual thread tap that matches the screw thread. It will easily cut through and clean the paint buildup by simply running the tap in and out of the hole. If the buildup is not as great and extra screws are available (or can be obtained) the screw can be run in and out of the hole to clean minor buildup prior to final screw installation.

Water Stain Damage

Water stain damage is a direct result of improper storage of prime-painted products. If the product is still in primer (no finish coat has been applied), the condition is easily detectable:

- Initially, the water stain appears as a discoloration or variance in sheen or gloss in the primer. A specific area or areas can be distinctly noticed, which look and possibly feel different from the rest of the product.
- If the water stain has existed for a considerable length of time and was caused by enough water, rust will start to appear through the discolored areas.

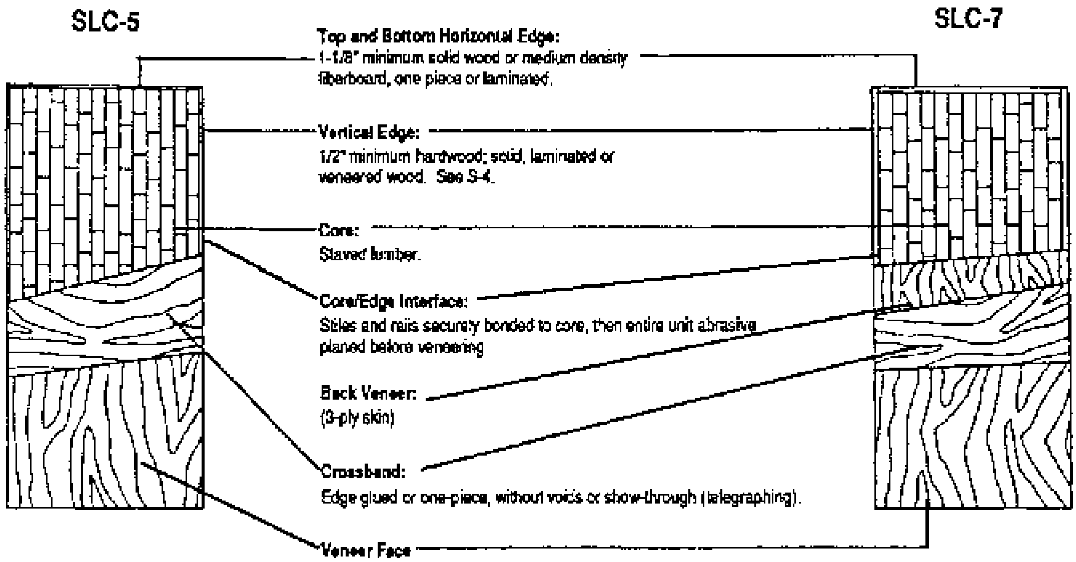
If the product has had a finish coat of paint applied, water stain damage can cause failure of the finish coat as well.

- This condition can be detected by finish-paint failure randomly on the door, as well as the appearance of uniform rust development in those areas. In some cases, the finish paint will show good adhesion in those areas, but will also show a uniform layer of rust developing through the finish paint.

These conditions can be attributed to improperly stored prime products that were exposed to water.

- For products that are prime only, the affected areas should be adequately sanded. If necessary, the area should be sanded to bare metal.

9.4.0 Wood Veneer Doors, Stave Lumber Core—Specifications and Grades



GRADES:	PREMIUM	CUSTOM	ECONOMY
Veneer face:	Minimum 1/50". A Grade. Edge glued joints.	Minimum 1/50". A Grade. Edge glued joints.	Mill option. B Grade. Mill option.
Veneer match:	Book, slip or random. Center, balanced or running.[1] Pair and set match.	Book, slip or random. Running. Pair and set selected for similar color and grain.	No match. No match. No match.
	Door and transom match.	Transom selected for similar color only.	No match.
Vertical edges:	Same species visible surface. Sanded ease. No visible joints allowed.	Compatible species visible surface. Sanded ease. Visible joints allowed on hinge edge.[3]	Mill option. Mill option.
Lights[2], louvers[4] and moulding:	Same species lumber, or veneered, or metal vision frames.	Compatible species lumber or metal vision frames.	Mill option.
Transoms:	Bottom horizontal edge runs full width. Matching species lumber or veneered.	Bottom horizontal edge runs full width. Compatible species lumber or veneered.	No match.

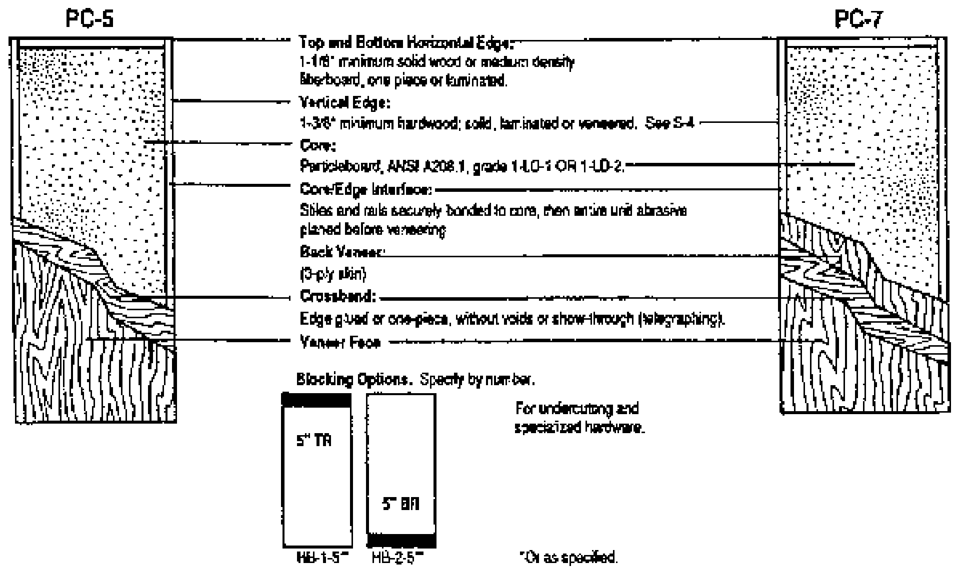
[1]Veneer match to be selected by architect.
[2]Maximum 1,296 sq in. for 20-minute doors.
[3]Visible joints allowed on both edges for opaque finish.
[4]Louvers not allowed in 20 minute doors.

NOTE: 9-ply door constructions are available and may be specified when evaluated or approved by the design professional.

NOTE: Due to scarcity of Birch lumber, Birch faced doors may use compatible species edges, lights, and moulding in premium grade.

(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

9.4.1 Wood Veneer Doors, Particleboard Core—Specifications and Grades



GRADES:	PREMIUM	CUSTOM	ECONOMY
Veneer face:	Minimum 1/50". A Grade. Edge glued joints.	Minimum 1/50". A Grade. Edge glued joints.	Mill option. B Grade. Mill option.
Veneer match:	Book, slip or random. Center, balanced or running.[1] Pair and set match. Door and transom match.	Book, slip or random. Running. Pair and set selected for similar color and grain. Transom selected for similar color only.	No match. No match. No match. No match.
Vertical edges:	Same species visible surface. Sanded ease. No visible joints allowed.	Compatible species visible surface. Sanded ease. Visible joints allowed on hinge edge.[3]	Mill option. Mill option. Mill option.
Lights,[2] louvers[4] and moulding:	Same species lumber, or veneered, or metal vision frames.	Compatible species lumber or metal vision frames.	Mill option.
Transoms:	Bottom horizontal edge runs full width. Matching species lumber or veneered.	Bottom horizontal edge runs full width. Compatible species lumber or veneered.	No match.

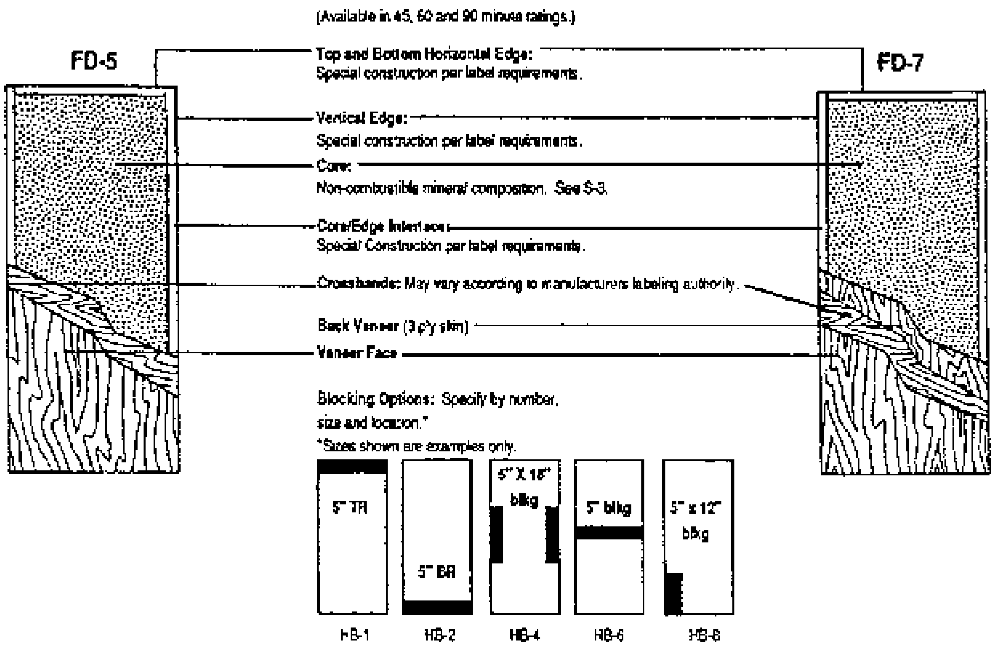
[1]Veneer match to be selected by architect.
[2]Maximum 1,296 sq in. for 20-minute doors.
[3]Visible joints allowed on both edges for opaque finish.
[4]Louvers not allowed in 20-minute doors.

NOTE: 9-ply door constructions are available and may be specified when evaluated or approved by the design professional.

NOTE: Due to scarcity of Birch lumber, Birch faced doors may use compatible species edges, lights, and moulding in premium grade.

(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

9.4.2 Wood Veneer Doors—Mineral Core—Specifications and Grades



GRADES:	PREMIUM	CUSTOM	ECONOMY
Veneer face:	Minimum 1/50". A Grade. Edge glued joints.	Minimum 1/50". A Grade. Edge glued joints.	Mill option. B Grade. Mill option.
Veneer match:	Book, slip or random. Center, balanced or running. Pair and set match. Door and transom match.	Book, slip or random. Running. Pair and set selected for similar color and grain. Transom selected for similar color only.	No match. No match. No match. No match.
Vertical edges:	Same species visible surface. Sanded ease. No visible joints allowed.	Compatible species visible surface Sanded ease. Visible joints allowed on hinge edge.[3]	Mill option. Mill option.
Lights,[2] louvers,[4] and moulding:	Special construction per label requirements.	Special construction per label requirements.	Mill option.
Transoms:	Bottom horizontal edge runs full width. Special construction per label requirements	Bottom horizontal edge runs full width. Special construction per label requirements.	No match.

[1]Veneer match to be selected by architect.
[2]Maximum 100 sq in. for 60- and 90-minute rated doors. Maximum 1,296 sq in. for 45-minute rated doors.
[3]Visible joints allowed on both edges for opaque finish.
[4]Fusible link louvers are allowed in 45-, 60- and 90 minute doors.

NOTE: 9-Ply door constructions are available and may be specified when evaluated or approved by the design professional.

NOTE: Due to scarcity of birch lumber, Birch faced doors may use compatible species edges, lights, and molding in premium grade.

(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

9.4.3 Specifying Ash, Birch, or Maple Face Veneers for Wood Flush Doors

ROTARY CUT VENEER — GRADE A

Bold random grain pattern; veneer from one log; matched for grain and color at veneer joints

For This Appearance:	*Specify:*
Color contrast (heartwood/sapwood)	Rotary cut, grade A per NWWDA I.S. 1-A (1993), book matched • Natural ash • Natural birch • Natural maple
All light colored wood[1] (sapwood)	Rotary cut, grade A per NWWDA I.S. 1-A (1993), book matched • White ash • White birch • White maple
All dark colored wood[1] (heartwood)	Rotary cut, grade A per NWWDA I.S. 1-A (1993), book matched • Brown ash • Red birch

PLAIN SLICED VENEER — GRADE A

Cathedral and straight grain pattern; veneer from one log; matched for grain and color at veneer joints

For This Appearance:	*Specify:*
Color contrast (heartwood/sapwood)	Plain sliced, grade A per NWWDA I.S. 1-A (1993), book matched • Natural ash • Natural birch • Natural maple
All light colored wood[1] (sapwood)	Plain sliced, grade A per NWWDA I.S. 1-A (1993), book matched • White ash • White birch • White maple
All dark colored wood[1] (heartwood)	Plain sliced, grade A per NWWDA I.S. 1-A (1993), book matched • Brown ash • Red birch

ROTARY CUT VENEER — GRADE B (LOWER COST ALTERNATIVE)

Bold random grain pattern; veneer may be from more than one log; pleasing matched[2]

For This Appearance:	*Specify:*
Color contrast (heartwood/sapwood)	Rotary cut, grade B per NWWDA I.S. 1-A (1993) • Natural ash • Natural birch • Natural maple
All light colored wood[1] (sapwood)	Rotary cut, grade B per NWWDA I.S. 1-A (1993) • White ash • White birch • White maple
All dark colored wood[1] (heartwood)	Rotary cut, grade B per NWWDA I.S. 1-A (1993) • Brown ash • Red birch

[1]Limited availability.

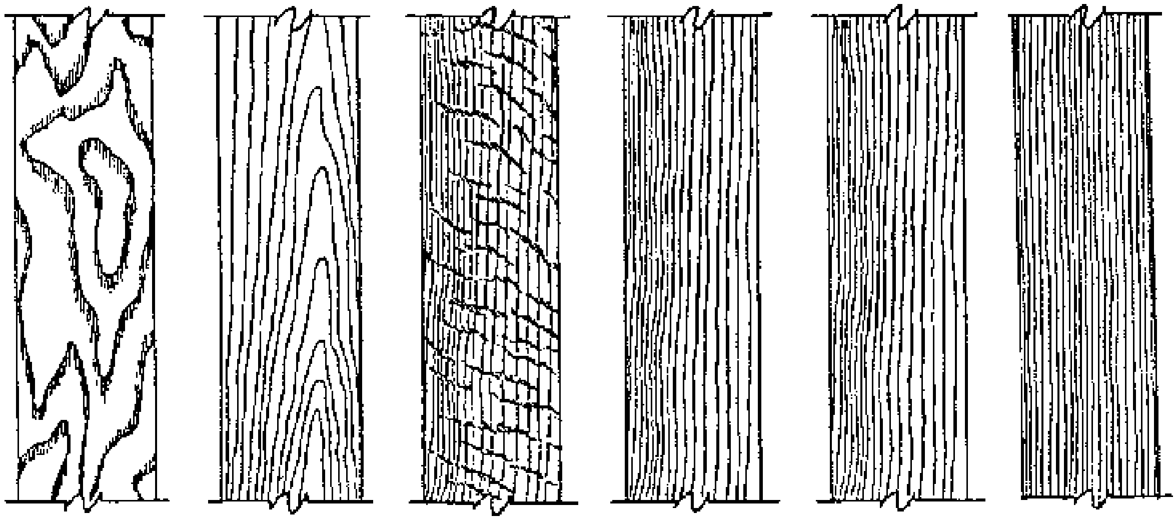
[2]Pleasing match: A face containing components which provides a pleasing overall appearance. The grain of the various components need not be matched at the joints. Sharp color contrasts at the joints are not permitted.

Additional information on face veneers may be found in the following publications:

- NWWDA Industry Standard I.S. 1-A (1993) Architectural Flush Doors
- Hardwood Plywood and Veneer Association (HPVA) Interim Standard HP-1 1993 for Hardwood and Decorative Plywood

(By permission from the Window and Door Manufacturers Association, Des Plaines, Illinois.)

9.5.0 Appearance of Standard Wood Veneer Cuts



Rotary Cut

Flat Cut: Plain Sliced

Quarter Cut: Red & White Oak

Quarter Cut: Other Species

Rift-Cut: Red & White Oak

Comb Grain: Red & White Oak

Veneer Cuts

The way in which a log is cut, in relation to the annual growth rings, determines the appearance of veneer. The beauty of veneer is in the natural variations of texture, grain, figure, color, and the way it is assembled on a door face.

Faces will have the natural variations in grain inherent in the species and cut. Natural variations of veneer grain and pattern will vary from these illustrations.

Rotary

This cut follows the log's annual growth rings, providing a general bold random appearance.

Flat Cut (Plain Sliced)

Slicing is done parallel to a line through the center of the log. Cathedral and straight grained patterns result. The individual pieces of veneer are kept in the order they are sliced, permitting a natural grain progression when assembled as veneer faces.

Quarter Cut

A series of stripes is produced. These stripes vary in width from species to species. Flake is a characteristic of this cut in red and white oak.

Rift-Cut (only in Red & White Oak)

The cut slices slightly across the medullary rays, accentuating the vertical grain and minimizing the "flake." Rift grain is restricted to red and white oak.

Comb Grain (only in Red & White Oak)

Limited availability. This is a rift-cut veneer distinguished by the tightness and straightness of the grain along the entire length of the veneer. Slight angle in the grain is allowed. Comb grain is restricted to red and white oak. See section G-11 for maximum grain slope. There are occasional cross bars and flake is minimal.

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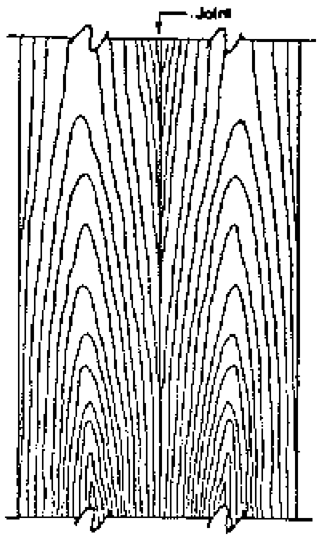
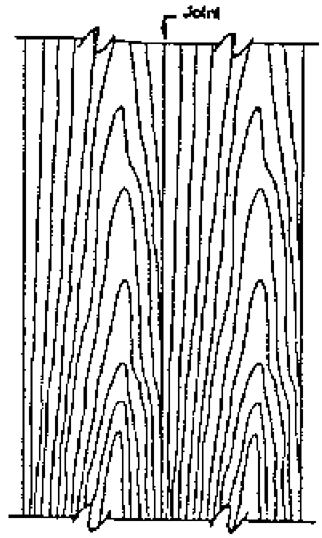
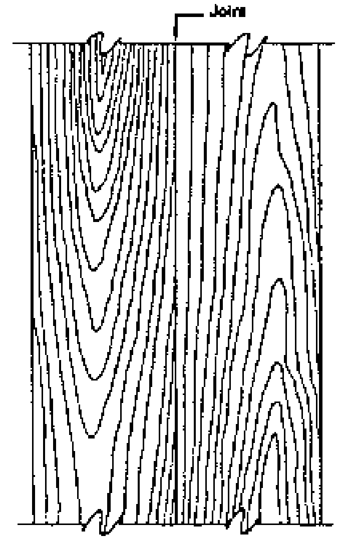
9.5.1 Matching of Individual Veneer Skins



Book Match



Slip Match



Random Match

Book Match

The most commonly used match in the industry. Every other piece of veneer is turned over so adjacent pieces are opened like two adjacent pages in a book. The veneer joints match and create a mirrored image pattern at the joint line, yielding a maximum continuity of grain. Book matching is used with rotary, plain sliced, quarter, rift cut or comb grain veneers.

Barber Pole Effect in Book Match

Because the "tight" and "loose" faces alternate in adjacent pieces of veneer, they may accept stain differently, and this may yield a noticeable color variation called barber poling. See slip match for further information on color variation. Barber pole can be minimized through proper sanding and finishing techniques.

Slip Match

Adjoining pieces of veneer are placed in sequence without turning over every other piece. The grain figure repeats, but joints won't show mirrored effect. Slip matching is often used in quarter cut, rift-cut and comb grain veneers to eliminate the barber pole effect. However, it may cause a sloping appearance of the veneer, especially in larger veneers.

Pleasing Match

A face containing components which provides a pleasing overall appearance. The grain of the various components need not be matched at the joints. Sharp color contrasts at the joints of the components are not permitted.

Random Match

A random selection of individual pieces of veneer from one or more logs. Produces a "board-like" appearance. It is most commonly used in opaque finish grades.

Note to Specifiers:
The matching of veneers at a joint line must be specified.

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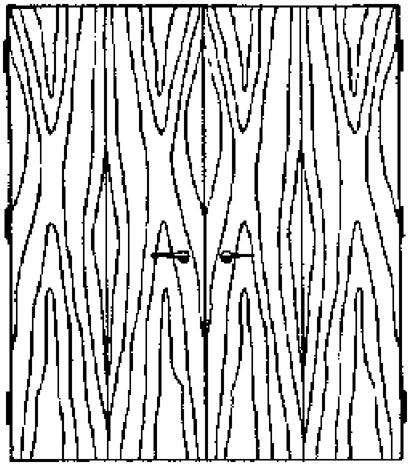
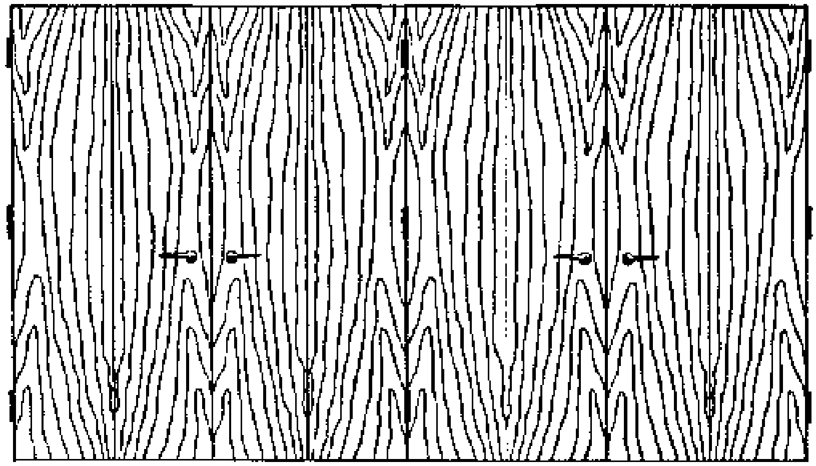
9.5.2 Appearance of Doors in Pairs or Sets



Pair Match



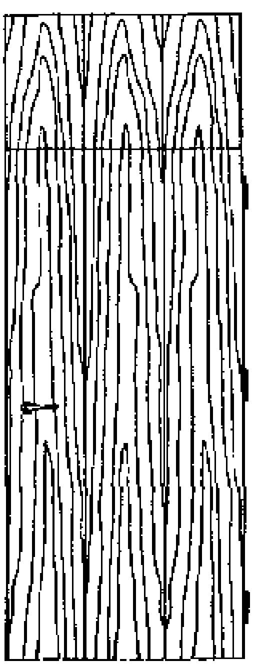
Set Match

Pair Match
Doors may be specified as pair matched.

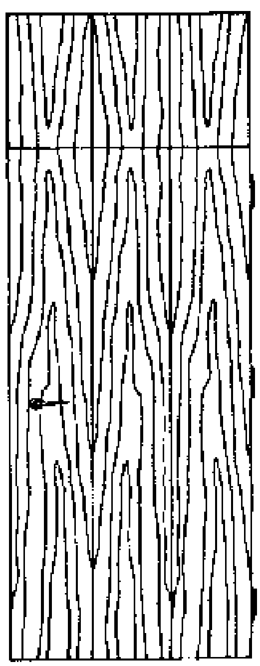
Set Match
Sets of doors may be specified as matching.

> ***Note to Specifiers:***
> *Illustrations show center matched faces. Pairs and sets may also be manufactured with running or balance match faces.*

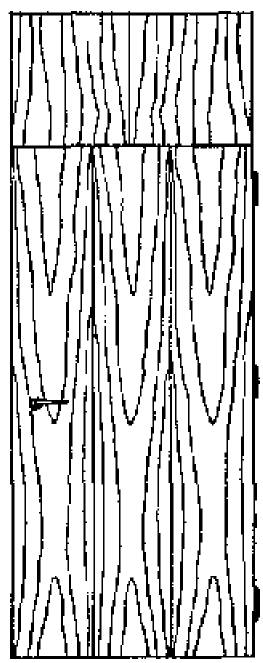
Appearance of Doors with Transoms



Continuous Match



End Match



No Match

Continuous Match
Provides optimum veneer utilization as each single piece of veneer extends from the top of the transom to the bottom of the door. Veneer length may limit this option.

End Match
Single piece of veneer extends from the bottom to the top of the door with a mirror image at the transom.

No Match
Economy grade only.

> ***Note to Specifiers:***
> *Slight misalignment of veneer grain may occur between the transom and door. A variation of grain alignment from side to side is considered acceptable for transom matching as follows:*
> *Single door and transom: 3/8"*
> *Pair of doors with single transom: 1/2"*

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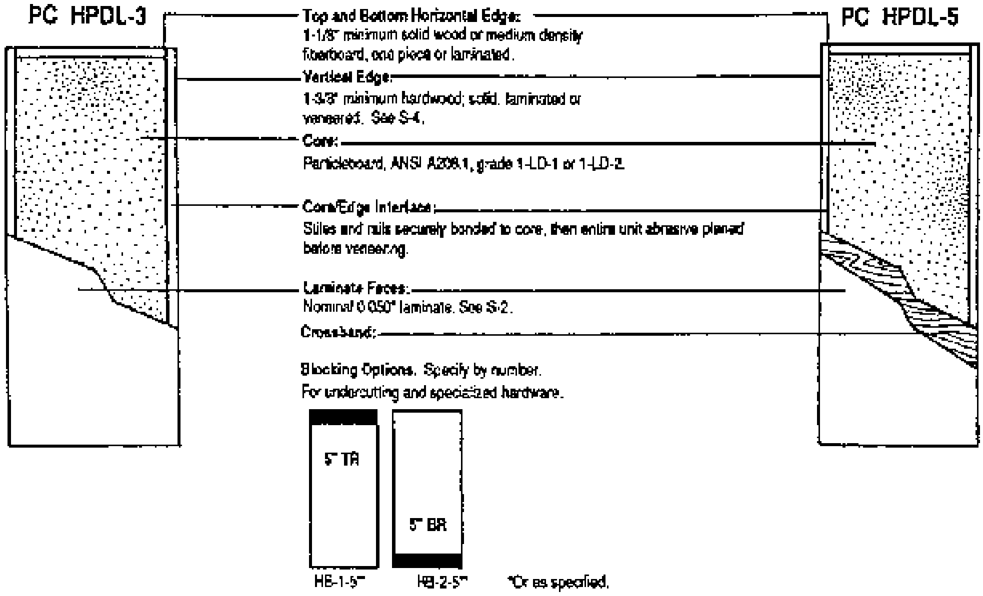
9.6.0 Laminate-Faced Particleboard Core Doors—Specifications and Grades



GRADES:	PREMIUM	CUSTOM	ECONOMY
Laminate faces:	Nominal 0.050" high pressure laminate.[1] See S-2.	Nominal 0.050" high pressure laminate.[1] See S-2.	Nominal 0.050" high pressure laminate.[1] See S-2.
Vertical edges for woodgrain patterns:	Matching 0.050" laminate, or lumber or veneer for transparent finish.[2]	Matching 0.050" laminate, or lumber or veneer for transparent finish.[2]	Mill option.
	No visible joints allowed.	Joints allowed on hinge edge.	
Vertical edges for solid colors:[4]	Matching 0.050" laminate or close grain hardwood for paint finishes.[2] No visible joints allowed.[6]	Matching 0.050" laminate or close close grain hardwood for paint finishes.[2] No visible joints allowed.[6]	Mill option.
Lights,[3] louver,[5] and moulding for woodgrain patterns:	Compatible species, lumber or veneer with transparent finish,[2] or primed metal vision frame or louver.	Compatible species lumber or veneer for finishing or primed metal vision frame or louver.	Mill option
Lights,[3] louvers,[5] and moulding for solid colors:[4]	Close grain hardwood for paint finish or primed vision frame or louver	Close grain hardwood for paint finish, or primed vision frame or louver.	Mill option.
Transom-bottom horizontal edges for woodgrain patterns:	Matching 0.050" laminate, or designated species, lumber or veneer for transparent finish. No visible joints allowed.	Matching 0.050" laminate or compatible species lumber or veneer for finishing. No visible joints allowed.	Mill option.
Transom-bottom horizontal edges for solid colors:[4]	Matching 0.050" laminate, or close grain hardwood for paint finish.	Matching 0.050" laminate, or close grain hardwood for paint finish.	Mill option.

[1]Pair matching not available.
[2]Species and stain for entire wood trim package to be selected by architect.
[3]Maximum 1 296 sq. in. for 20-minute rated doors.
[4]Includes other nonwood patterns.
[5]Louvers not allowed in 20-minute doors.
[6]Visible joints allowed on both edges if for opaque finish.

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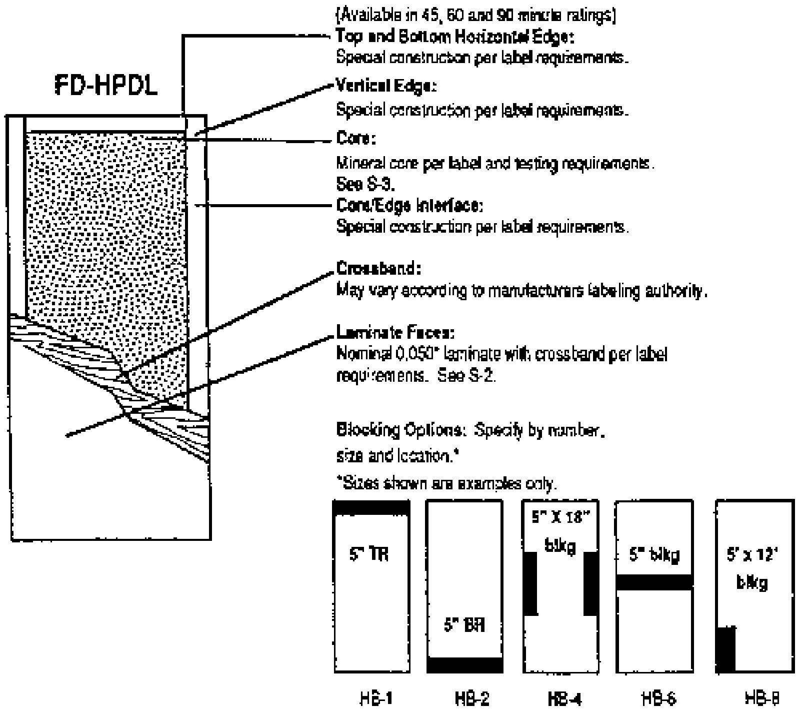
9.6.1 Laminate-Faced Mineral Core Doors—Specifications and Grades



GRADES:	PREMIUM	CUSTOM	ECONOMY
Laminate faces:	Nominal 0.050" high pressure laminate[1] with crossband per label requirements.	Nominal 0.050" high pressure laminate[1] with crossband per label requirements.	Nominal 0.050" high pressure laminate[1] with crossband per label requirements.
Vertical edges for woodgrain patterns:	Matching 0.050" laminate, or lumber or veneer for transparent finish.[2]	Matching 0.050" laminate or lumber or veneer for transparent finish.[2]	Mill option.
	No visible joints allowed.	Joints allowed on hinge edge.	
Vertical edges for solid colors:[4]	Matching 0.050" laminate; or close grain hardwood or special construction for paint finishes.[3] No visible joints allowed.[5]	Matching 0.050" laminate or close grain hardwood or special construction for paint finishes.[3] No visible joints allowed.[5]	Mill option.
Lights,[3] louvers, and moulding for woodgrain patterns:	Special construction per label requirements.	Special construction per label requirements.	Mill option.
Lights,[3] louvers, and mouldings for solid colors:[4]	Special construction per label requirements.	Special construction per label requirements.	Mill option.
Transom-bottom horizontal edges for woodgrain patterns:	Special construction per label requirements.	Special construction per label requirements.	Mill option.
Transom-bottom horizontal edges for solid colors:[4]	Special construction per label requirements.	Special construction per label requirements.	Mill option.

[1]Pair matching not available.
[2]Species and stain for entire wood trim package to be selected by architect.
[3]Maximum 100 sq. in. for 60- and 90-minute rated doors. Maximum 1,296 sq. in. for 45-minute rated doors.
[4]Includes other nonwood patterns.
[5]Visible joints allowed on both edges if for opaque finish.

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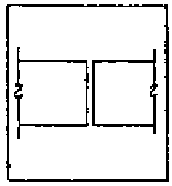
9.7.0 Wood Door Construction Details

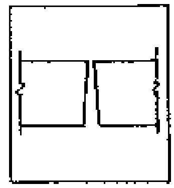
General Moulding Requirements

- Species shall match or be compatible with face veneer or laminate.
- Specify transparent or opaque finish.
- Moulding shall be free of open defects, shake, splits, or doze.
- Moulding must be smooth and free of visible knife, saw, or sanding marks.
- Specify following options.

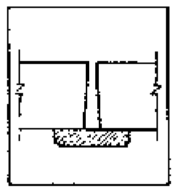
Meeting Edge Options — Specify by number



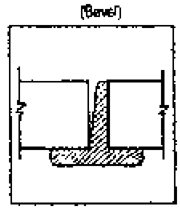
Option E1: Meeting Edge (No Bevel)



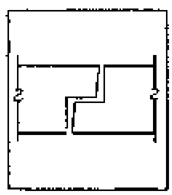
Options E2: Meeting Edge (Bevel)



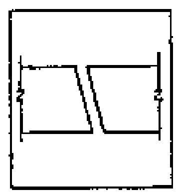
Option E3: Flat Astragal



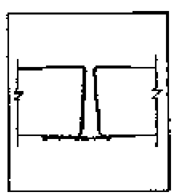
Option E4: Tee Astragal



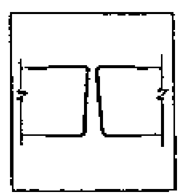
Option E5: Rabbeted



Option E6. Parallel Bevel (Double Egress)

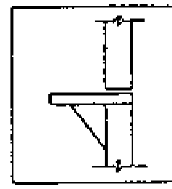


Option E7: Metal Edge Guard and Astragal

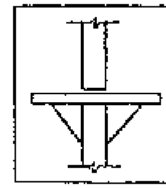


Option E8: Metal Edge Guard

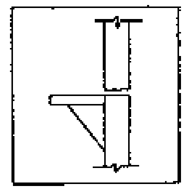
Dutch Door Options — Specify by number



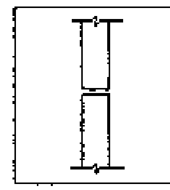
Option D1: One side shelf



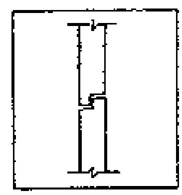
Option D2: Two side Shelf



Option D3. 20-Minute shelf



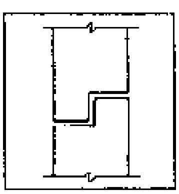
Option D4: No shelf



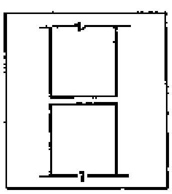
Option D5: Rabbeted meeting rails.

Transom Meeting Edge Options

Specify by number



Option T1: Rabbeted



Option T2: Nonrabbeted

> ***Note to Specifiers:***
> *Options E1, E2, E5, E6, E7, E8 available for fire doors per individual manufacturer's approval. Some may require fire-retardant treated edges.*

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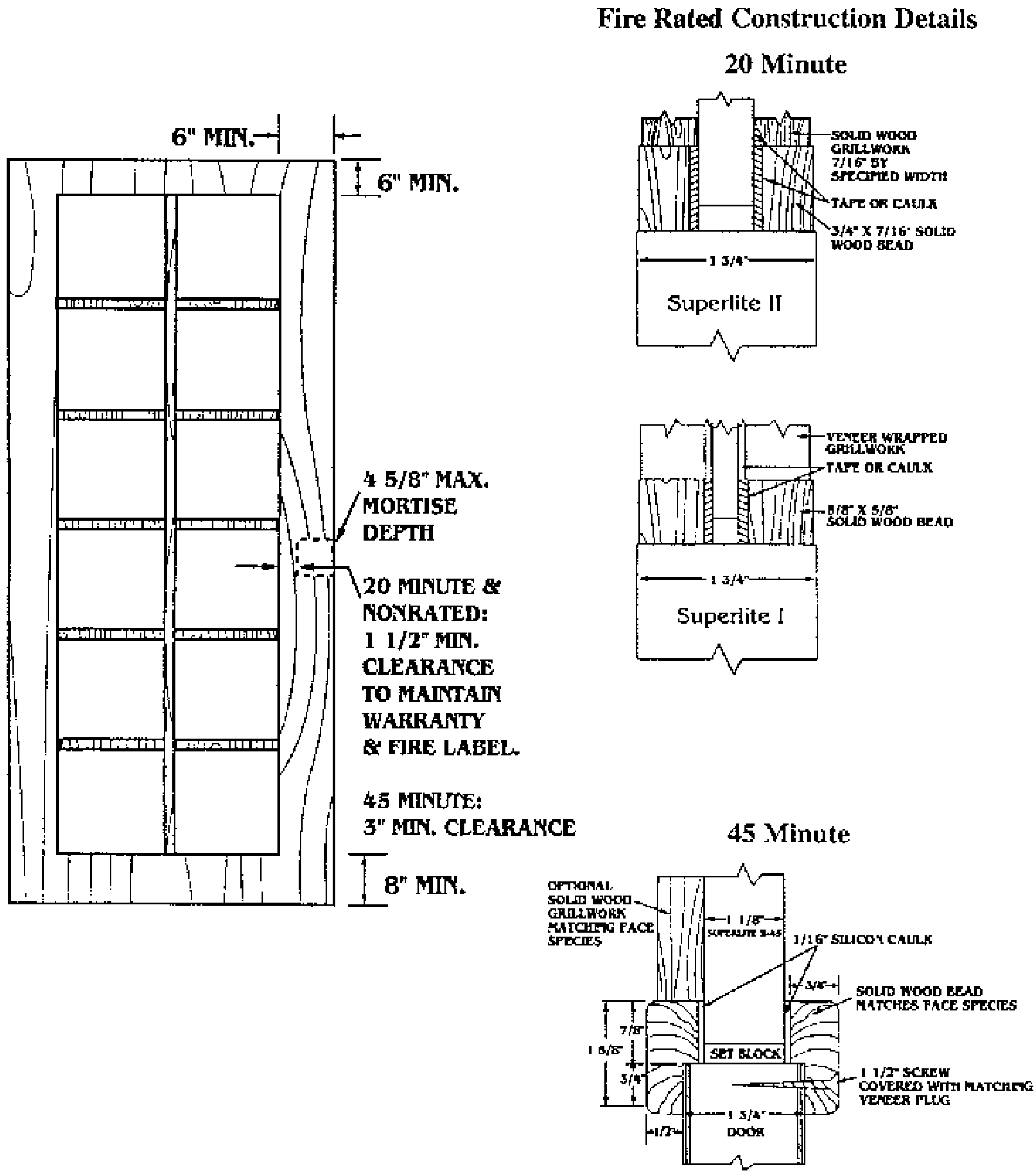
9.8.0 Fire-Rated Wood Door Construction

Fire-rating construction for wood doors with large lites.



(By permission of Eggers Industries, Two Rivers, Wisconsin.)

9.8.1 Fire-Rated, Sound-Retardant, Lead Lined, Electrostatic Shield Doors

Fire Door Ratings and Openings Classifications

The Model Codes have established a fire door rating and operating classification system for use in protecting door openings in fire resistive rated wall constructions. The Fire Door Ratings table describes these doors. The Fire Door classifications table provides the relationship of the fire resistive ratings of doors and the use and rating of the wall in which the door opening is installed.

All fire doors must meet the requirements of ASTM E-152 and bear certifying labels of an independent testing agency approved by the building official.

Installation is required to be in accordance with the National Fire Protection Association's Publications NFPA 80, "Fire Doors and Windows," and NFPA 101, "Life Safety Code."

Labeling and Listing

The Model Codes require fire doors to be labeled. Essentially, a label indicates the rating and use of a door. It is a permanent identifying mark attached to the door by the manufacturer. A testing organization provides random unannounced inspection of the production of the fire door. The manufacturer, by labeling the door, indicates compliance with the standard fire test for fire doors and NFPA 80. In addition to the door, the door frame and hardware are required to be labeled for use with a specific fire door. All fire doors must be self-closing and self-latching.

Fire Door Ratings

LABEL	RATING	DESCRIPTION	WALL RATING
20-minute	1/3 hr	For smoke and draft control between rooms or office corridors.	1 hr
45-minute	3/4 hr	In corridor and room partitions.	1 hr
60-minute	1 hr	In one-hour enclosures in vertical exitways.	1 hr
90-minute	1-1/2 hr	In two-hour enclosures in vertical exitways.	2 hr

Special Function Doors

Sound Retardant (Acoustical):

Sound Transmission Class (STC) ratings are prescribed in ASTM Standard E-90. Door thickness may exceed 1-3/4". 1-3/4" doors with gasketing can provide varying STC ratings. These doors generally have cores with a damping compound which prevents the faces from vibrating in unison. Consult manufacturer for special stop, gasketing and automatic bottom seal requirements. Contact NWWDA for 1989 Acoustical Test conducted by Warnock Hersey, document #495-0015.

> ***Note to Specifiers:***
> *Specify the Sound Transmission Class (STC) required.*

Lead Lined (X-ray):

These doors are manufactured with a continuous lead sheet from edge to edge in the center of the door or between the crossbanding and the core.

> ***Note to Specifiers:***
> *Specify the thickness of the lead which determines the shielding rating.*

Bullet Resistant:

These doors are manufactured with special materials which resist penetration by shots of various calibers. Resistance may be rated as resistant to medium power, high-power or super-power small arms and high-power rifles.

Electrostatic Shield:

These doors are manufactured with wire mesh either in the center of the core or between the crossbanding and the core. The mesh is grounded with electrical leads through the hinges to the frame.

> ***Note to Specifiers:***
> *Specify the number and location of electrical leads.*

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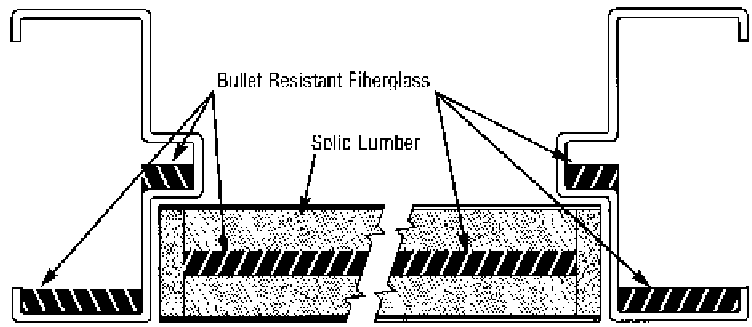
9.8.2 Bullet-Resistant Wood Doors

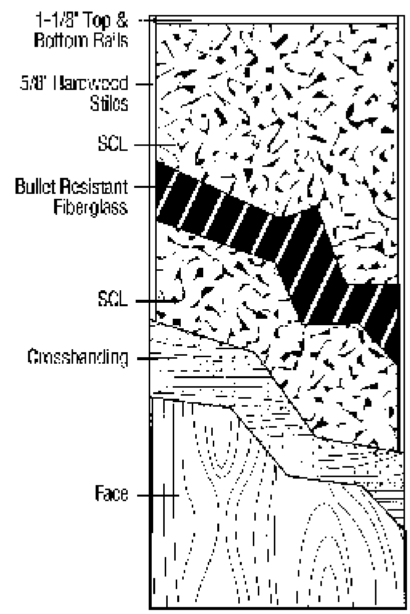
- For quality architectural projects where security is a concern, Eggers offers the visual beauty of wood with the bullet resistance of steel.
- Eggers' bullet resistant doors and panels are available faced with foreign and domestic veneers, high-pressure laminates and medium-density overlay (for paint finishes). Frames are not offered veneered.
- The bullet resistant reinforced fiberglass utilized in this construction has been tested in accordance with U.L. 752 and N.I.J. 0108.01 or U.S. State Department standards. This material is also approved by the U.S. Marshall Service.
- All four protection ratings are eligible for a U.L. 20 minute fire label.
- Glazing is available in doors up to the required ballistics rating.

Recommended Installation
(Door or Frame Available Individually)



Resistant Test Results

LEVEL	PROTECTION RATING	U.L./N.I.J. RATING	WEIGHT PER SQ. FT.
1	.357 magnum 1250 ft./sec. 9mm 1090 ft./sec.	Medium power small arms U.L./N.I.J. II-A	5.1
2	.357 magnum 1450 ft./sec. 9mm 1175 ft./sec.	High power small arms U.L./N.I.J. II	6.8
3	.44 magnum 1470 ft./sec. 9mm 1400 ft./sec.	Super power small arms U.L./N.I.J. III-A	7.8
4	30.06 rifle 2410 ft./sec. 7.62mm NATO 2750 ft./sec.	High power rifle U.L./N.I.J. III	16.0



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9.9.0 Data Required to Order PreMachined Wood Doors

PREFIT & PREMACHINED DOOR SCHEDULE

FRAME OPENING SIZE X

CORE TYPE SCHEDULE C

ELEVATION TYPE SCHEDULE E

ORDER NO.

PREFIT DOOR SIZE X X

BLOCKING IF REQUIRED

HARDWARE GROUP/SET

PAGE

ITEM NO.

HINGES

SIZE

MFG. NO.

TEMPLATE NO.

TOP OF DOOR TO TOP OF HINGE

HINGE BACKSET

FLOOR LINE

LOCK

MFG. NO.

TEMPLATE NO

LOCK BACKSET

TOP OF DOOR TO CENTER OF LOCKFRONT

℄ OF STRIKE

LITE

BD # ______ MVP# ______

SIZE–W ______ X L ______

LOCKSTILE ______

TOP RAIL ______

LOUVER

SIZE–W ______ X L ______

LOCKSTILE ______

BTM RAIL ______

TYPE ______

BOXSTRIKE - TEMP.

FLUSH BOLTS - TEMP

MORTISE HOLDER/STOP - DEGREE OF OPG. - TEMP

OTHER HARDWARE-REMARKS ______

DOOR NO. TOTAL DOORS THIS PAGE ______	SWING

8/96

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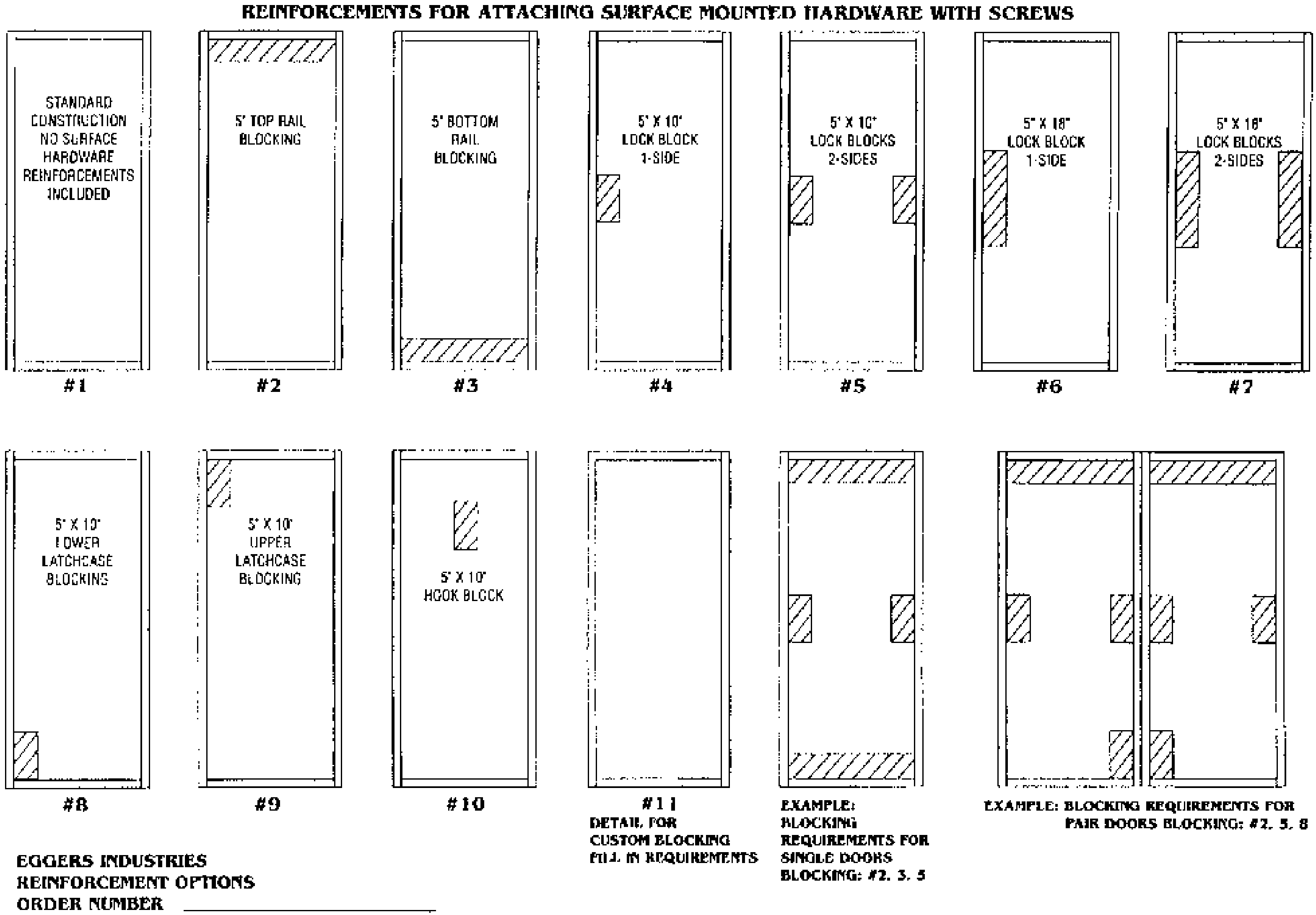
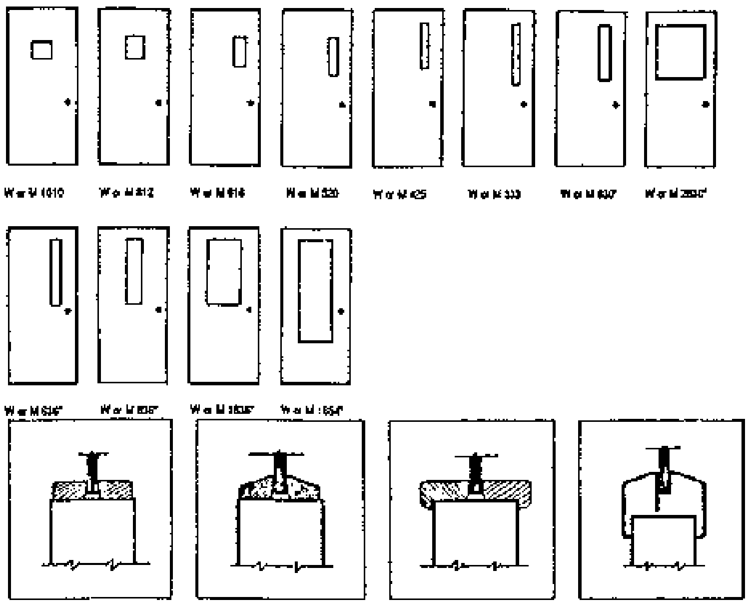
9.9.1 Hardware and Special Reinforcing Requirements



(*By permission of Eggers Industries, Two Rivers, Wisconsin.*)

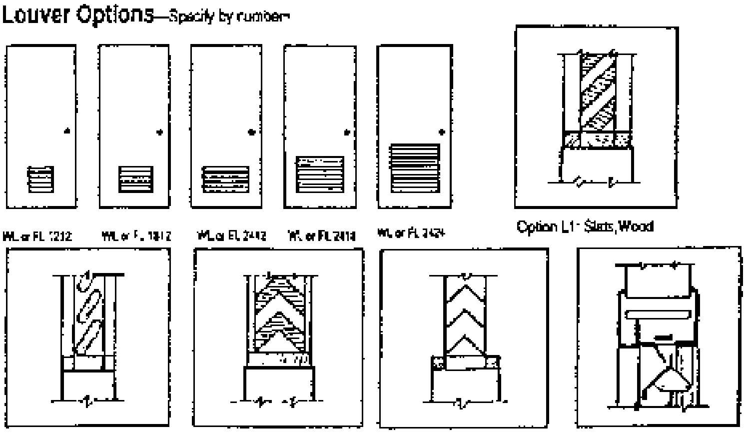
9.9.2 Wood Door Glazing and Louver Options

Glazing Options—Specify by number



Option M1: Recessed Moulding
Option M2: Recessed Moulding
Option M3: Lip Moulding
Option M4: Metal Vision Frame

Louver Options—Specify by number



Option L1: Slats, Wood
Option L2: Slats, Wood
Option L3: Chevrons, Wood
Option L4: Chevrons, Metal
Option L5: Fusible Link

W=Wood mouldings
M=Metal vision frames

All cutouts for metal or wood vision panels must be a minimum of 6" from the edge of the door or other cutouts for louvers, locks, closers and/or other hardware cutouts. This 6" distance must be maintained or the fire label and warranty will be voided. For non-fire-rated doors, the distance is 5". The cut out areas shall not exceed 40 percent of the area of the door. In addition, cutouts shall not exceed half the height of the door.
See Note to Specifiers.

* These sizes of glass are not approved for 1 and 1-1/2 hour fire doors. All sizes shown are approved for 20-minute, 45-minute, and nonlabeled wood doors

[1] Other sizes and details available.

Note to Specifiers:
Using a 10" margin between the edge of the door and the edge of any cutout near the lock area will eliminate most label and warranty conflicts.

Designation indicates size. For examples: 1836 is 18 inches wide and 36 inches high.

WL=Wood Louver. Not allowed by NFPA 80 in fire doors or 20-minute doors.
FL=Fusible Link Louver. Not allowed in 20-minute doors.

All fusible link louvers must be 8" from the bottom of the door to the bottom of the louver cutout and 6" from the edge of the louver cutout to the edge of the door or other cutouts for vision panels, locks, closers, and for other hardware cutouts. These minimum dimensions must be maintained or the fire label and warranty will be voided.

[1] Other sizes and details available.

(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

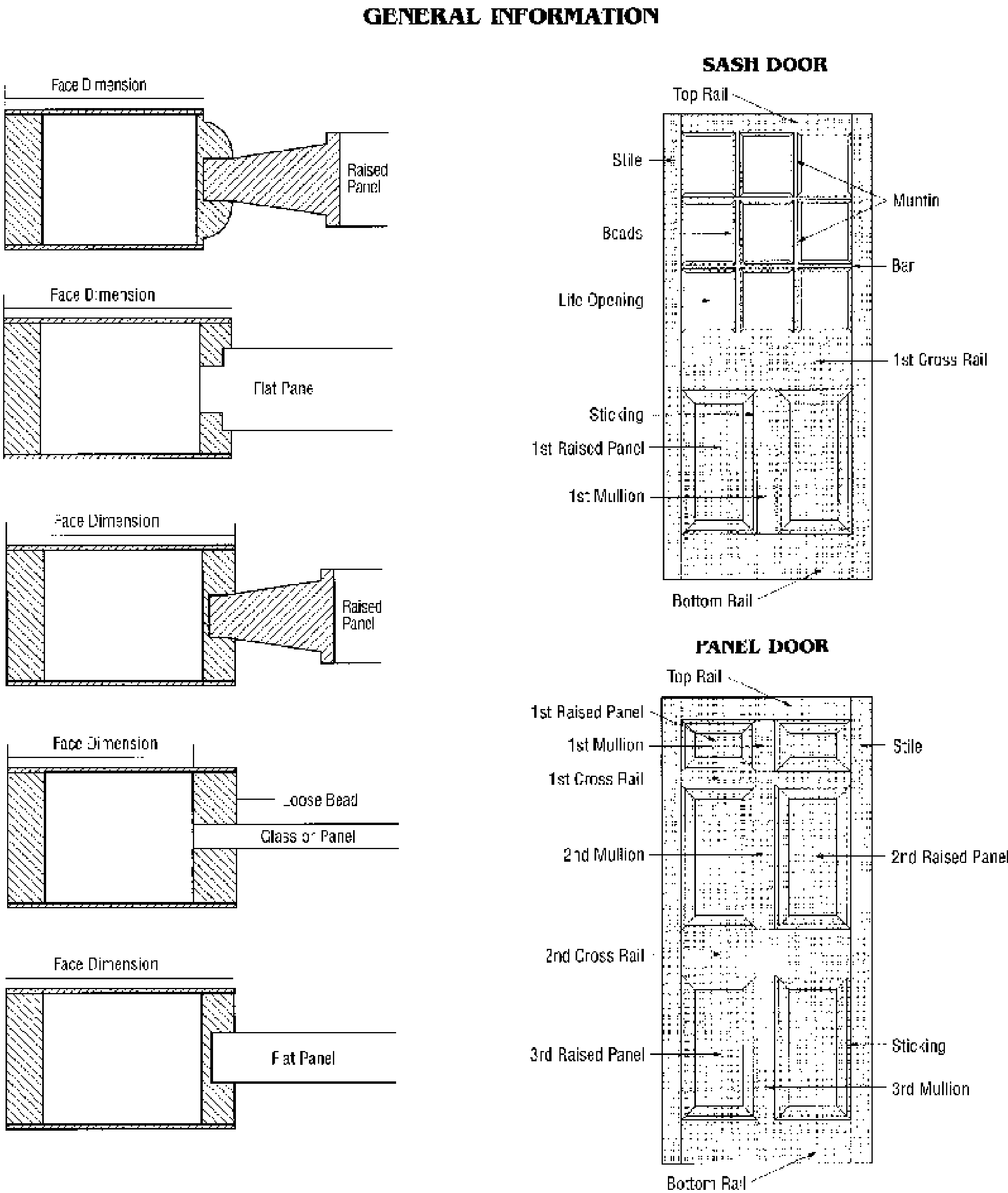
9.9.3 NWWDA's Architectural Door Code Specification Descriptions

NWWDA'S DOOR SPECIFICATION DESCRIPTOR	DESCRIPTION
PC - 5 *	Two-ply face, stiles and rails securely glued to particleboard core and sanded before veneering.
PC - 7 *	Three-ply face, stiles and rails securely glued to particleboard core and sanded before veneering.
PC - HPDL - 3 *	High-pressure decorative laminate glued directly to core assembly--stiles and rails securely glued to particle-board core and sanded before laminating.
PC - HPDL - 5 *	High-pressure decorative laminate glued to hardwood crossbands on core assembly--stiles and rails securely glued to particleboard core and sanded before laminating.
FPC - 5 *	Two-ply face stiles and rails not glued to particleboard core before veneering.
FPC - 7 *	Three-ply face, stiles and rails not glued to particleboard core before veneering.
FPC - HPDL - 5 *	High-pressure decorative laminate glued to hardwood crossbands on core assembly--stiles and rails not glued to particleboard core before laminating.
SLC - 5 *	Two-ply face stiles and rails securely glued to stave lumber core and sanded before veneering.
SLC - 7 *	Three-ply face. Stiles and rails securely glued to stave lumber core and sanded before veneering.
SLC - HPDL - 5 *	High-pressure decorative laminate glued to hardwood crossbands on core assembly -- stiles and rails securely glued to stave lumber core and sanded before laminating.
FSLC - 5 *	Two-ply face. Stiles and rails not glued to stave lumber core before veneering.
FSLC - 7 *	Three-ply face. Stiles and rails not glued to stave lumber core before veneering.
FD 90 MIN - 5 7 HPDL	Fire-Rated Door, labeled for 90 minutes.
FD 60 MIN - 5 7 HPDL	Fire-Rated Door, labeled for 60 minutes.
FD 45 MIN - 5 7 HPDL	Fire-Rated Door, labeled for 45 minutes.
FD 20 MIN *	Smoke & Draft Control Door, labeled for 20 minutes
IHC - 7	Institutional Hollow Core
SHC - 7	Standard Hollow Core
SR	Sound Retardant
LL	Lead Lined
ES	Electrostatic Shield
BR	Bullet Resistant

* All PC, FPC, SLC, FSLC are available as labeled 20-minute fire-rated doors meeting building code requirements.
Note: Doors manufactured to this standard will fulfill the requirements of regular door functions. Doors are available which exceed these basic construction requirements. For details about these doors consult individual door manufacturers. For illustrations of doors described above, see pages 27 through 38 of this standard.

(By permission from the Window and Door Manufacturers Association, Des Plaines, Illinois.)

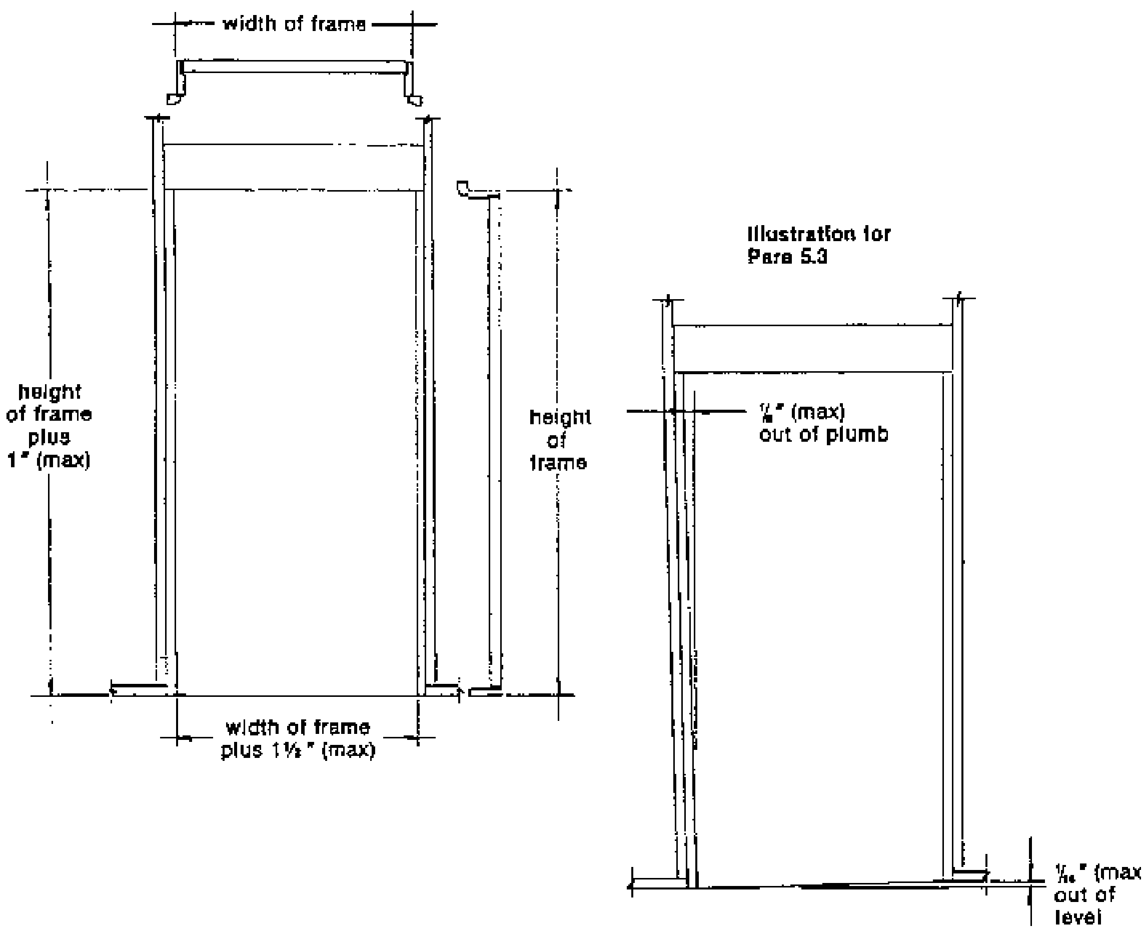
9.9.4 Sash and Panel Door Parts Nomenclature



(By permission of Eggers Industries, Two Rivers, Wisconsin.)

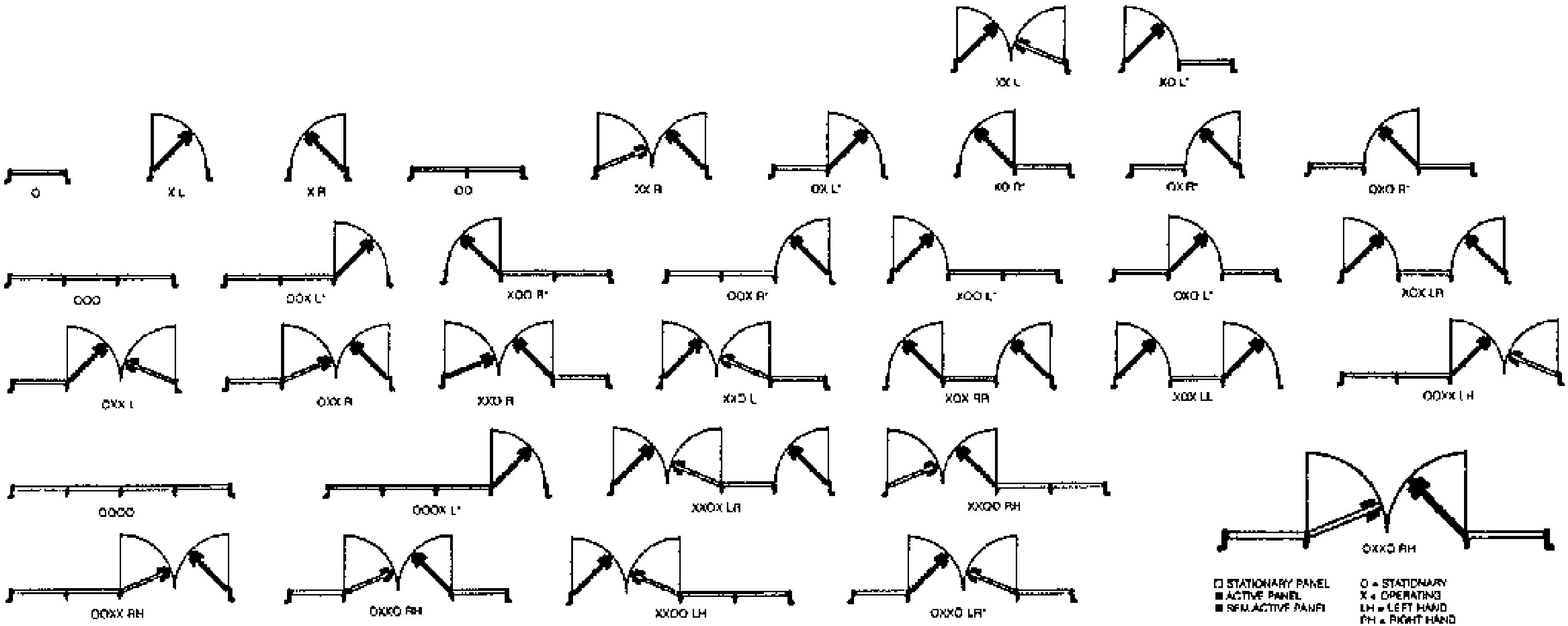
9.10.0 Installation of Exterior Wood Swinging Doors

- Measure the rough opening for size, out of plumb, and out of square.
- Check the existing subsill and ensure that it is level.
- Review the maufacturer's installation tolerances and instructions for proper dimensions.
- In the absence of any manufacturer's information, the rough opening should be no more than 1½-inches wider and no more than 1-inch higher than the outside dimensions of the door frame jamb.
- The rough opening should be no more than ⅛-inch out of plumb over the height of the opening.
- The subsill should be capable of being leveled to within 1⁄16-inch over the width of the opening, but not sloped to the interior of the structure.



(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

9.10.1 Defining Fixed and Hinged Portions of French Door Assemblies



(By permission of Marvin Windows and Doors, Warroad, Minnesota.)

9.11.0 Warp Tolerance and Telegraphing Tolerances for Wood Doors

Warp

Warp is any distortion in the door itself, and it does not refer to the door in relation to the frame or the jamb in which it is hung. Warp is measured by placing a straightedge or a taut string on the concave face and determining the maximum distance from the straight edge or string to the door face. The accompanying table and drawing illustrate the standard and test.

Door Thickness	Door Size	Warp, a defect when maximum deviation exceeds
1-3/8" [35 mm]	3'-0" x 7'-0" or smaller [900 x 2100 mm]	1/4" [6 mm]
1-3/4" [44 mm] or thicker	3'-6" x 7'-0" or smaller [900 x 2100 mm]	1/4" [6 mm]
1-3/4" [44 mm] or thicker	Larger than 3'-6" x 7'-0" [900 x 2100 mm]	1/4" [6 mm] in any 3'-6" x 7'-0" section [900 x 2100 mm]
NOTE: 1-3/8" doors are not recommended for sizes in excess of 3'-0" x 7'-0"		

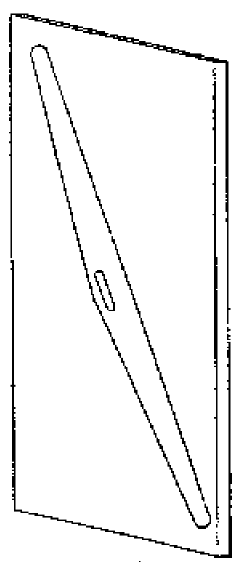


Illustration of Warp Test

Show-through or Telegraphing

Telegraphing is any distortion in the face veneer of a door caused by variations in thickness between the core materials and/or the vertical or horizontal edge bands. In any grade, variation from a true plane in excess of 0.010" in any three-inch span is considered a defect. The accompanying drawing illustrates the typical condition. (The selection of high-gloss finishes should be avoided because they tend to accentuate natural variations in material and construction.)

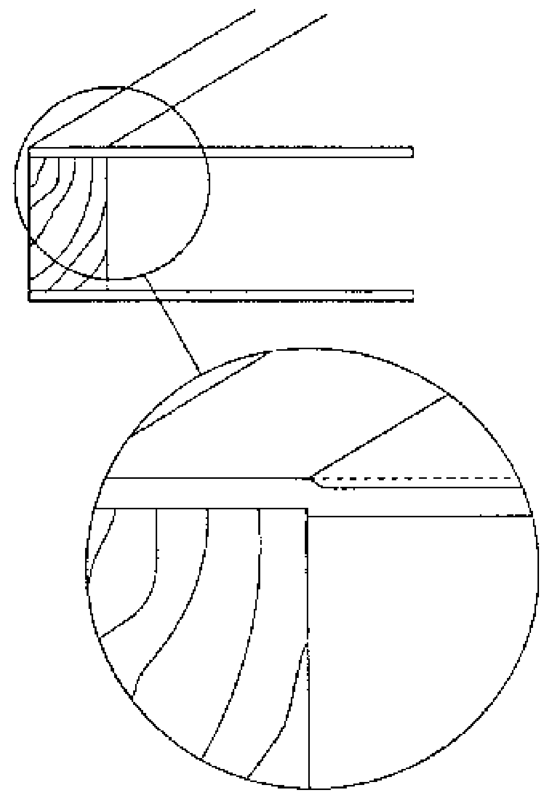


Illustration of show-through test

(By permission of the National Wood Window and Door Association, Des Plaines, Illinois.)

9.12.0 How to Store, Handle, Finish, Install, and Maintain Wood Doors

Installation

1. The utility or structural strength of the doors must not be impaired when fitting to the opening, in applying hardware, in preparing for lights, louvers, plant-ons, or other detailing.
2. Use two hinges for solid-core doors up to 60 inches in height, three hinges up to 90 inches in height, and an additional hinge for every additional 30 inches of height or portion thereof. Interior hollow-core doors weighing less than 50 pounds and not over 7'6" in height can be hung on two hinges. Use heavy weight hinges on doors over 175 pounds. Pivot hardware can be used in lieu of hinges. Consult the hinge or pivot hardware manufacturer with regard to weight and size of hinges or pivots required.
3. Clearances between top and hinge door edge and door frame should be a minimum of ⅛" (3.2 mm). For a single door latch edge, the clearance should be ⅛" (3.2 mm). For a pair of doors, the meeting edge clearance should be ¹⁄₁₆" (1.6 mm) per leaf. The bottom edge should be ¾" (19 mm) max-

imum from the top of a noncombustible floor and ⅜" (10 mm) maximum from the top of a noncombustible sill.

4. All hardware locations, preparations, and methods of attachment must be appropriate for the specific door construction. Templates for specific hardware preparation are available from hardware manufacturers or their distributors.
5. When light or louver cutouts are made for exterior doors, they must be protected to prevent water from entering the door core.
6. Pilot holes must be drilled for all screws that act as hardware attachments. Threaded to the head screws are preferable for fastening hardware to nonrated doors and are required on fire-rated doors.
7. In fitting for height, do not trim the top or bottom edge by more than ¾ inches unless accommodated by additional blocking. Trimming of fire-rated doors must be in accordance with NFPA 80.
8. Doors and door frames should be installed plumb, square, and level.

Cleaning and Touchup

1. Inspect all wood doors prior to hanging them on the job. Repair noticeable marks or defects that might have occurred from improper storage and handling.
2. Field repairs and touchups are the responsibility of the installing contractor upon completion of initial installation. Field touchups shall include the filling of exposed nail or screw holes, refinishing raw surfaces resulting from job fitting, repairing job-inflicted scratches and mars, and final cleaning of finished surfaces.
3. When cleaning door surfaces, use a nonabrasive commercial cleaner designed for cleaning wood door or paneling surfaces that do not leave a film residue that would build up or affect the surface gloss of the door finish.

Adjustment and Maintenance

1. Ensure that all doors swing freely and do not bind in their frame. Adjust the finish hardware for proper alignment, smooth operation, and proper latching, without unnecessary force or excessive clearance.
2. Review with the owner/owner's representative how to periodically inspect all doors for wear, damage, and natural deterioration.
3. Review with the owner/owner's representative how to periodically inspect and adjust all hardware to ensure that it continues to function as it was originally intended.
4. Finishes on exterior doors could deteriorate because of exposure to the environment. To protect the door, it is recommended that the condition of the exterior finish be inspected at least once a year and refinished as needed.

Storage and Handling

1. Store doors flat on a level surface in a dry, well-ventilated building. Doors should not come in contact with water. Doors should be kept at least 3½" off the floor and should have protective coverings under the bottom door and over the top. Covering should protect doors from dirt, water, and abuse, but allow for air circulation under and around the stack.
2. Avoid exposure of interior doors to direct sunlight. Certain species (e.g., cherry, mahogany, walnut, and teak) in an unfinished state are more susceptible to discoloration if exposed to sunlight or some forms of artificial light. To protect doors from light damage after delivery, opaque wrapping of individual doors could be specified.
3. Do not subject interior doors to extremes of heat and/or humidity. Do not allow doors to come in contact with water. Prolonged exposure could cause damage. Buildings where humidity and temperature are controlled provide the best storage facilities (recommended conditions 25–50% RH and 50–90°F).

4. Do not install doors in buildings that have wet plaster or cement unless they have been properly finished. Do not store doors in buildings with excessive moisture content. HVAC systems should be operating and balanced.
5. Doors should always be handled with clean hands or while wearing clean gloves.
6. Doors should be lifted and carried when being moved, not dragged across one another.

Finishing

1. Wood is hygroscopic and dimensionally influenced by changes in moisture content caused by changes within its surrounding environment. To ensure uniform moisture exposure and dimensional control, all surfaces must be finished equally.
2. Doors should not be considered ready for finishing when initially received. Before finishing, remove all handling marks, raised grain, scuffs, burnishes, and other undesirable blemishes by block sanding all surfaces in a horizontal position with a 120-, 150-, or 180-grit sandpaper. Solid-core flush doors, because of their weight, naturally compress the face veneer grain while in the stack. Therefore, sanding of the overall surface will be required to open the veneer grain to receive a field applied finish evenly. To avoid cross-grain scratches, sand with the grain.
3. Certain species of wood, particularly oak, might contain extractives that react unfavorably with foreign materials in the finishing system. Eliminate the use of steel wool on bare wood, rusty containers or other contaminants in the finishing system.
4. A thinned coat of sanding sealer can be applied prior to staining to promote a uniform finish and avoid sharp contrasts in color or a blotchy appearance. Door manufacturers are not responsible for the final appearance of field-finished doors. It is expected that the painting contractor will make adjustments, as needed, to achieve desired results.
5. All exposed wood surfaces must be sealed, including top and bottom rails. Cutouts for hardware in exterior doors must be sealed prior to installation of hardware and exposure to weather.
6. Dark-colored finishes should be avoided on all surfaces if the door is exposed to direct sunlight, in order to reduce the chance of warping or veneer checking.
7. Water-based coatings on unfinished wood could cause veneer splits, highlight joints, and raise wood grain. If used on exterior doors, the coating should be an exterior-grade product. When installed in exterior applications, doors must be properly sealed and adequately protected from the elements. Please follow the finish manufacturer's recommendations regarding the correct application and use of these products.
8. Be sure that the door surface being finished is satisfactory in both smoothness and color after each coat. Allow adequate drying time between coats. Desired results are best achieved by following the finish manufacturer's recommendations. Do not finish doors until a sample of the finish has been approved.
9. Certain wood fire doors have fire-retardant salts impregnated into various wood components that make the components more hygroscopic than normal wood. When exposed to high-moisture conditions, these salts will concentrate on exposed surfaces and interfere with the finish. Before finishing the treated wood, reduce the moisture content below 11% and remove the salt crystals with a damp cloth followed by drying and light sanding. For further information on fire doors, see the NWWDA publication regarding *Installing, Handling & Finishing Fire Doors.*

9.12.1 Care and Installation at the Jobsite

How to Store, Handle, Finish, Install and Maintain Wood Doors

Preface: Improper storage, handling, finishing and installation of wood doors may result in severe damage to the doors. The following guidelines will help to maintain the high quality products supplied by wood door manufacturers.

A. Storage and Handling

- Store doors flat on a level surface in a dry, well-ventilated building. Doors should be kept at least 3-1/2" off the floor and should have protective coverings under the bottom door and over the top. Covering should protect doors from dirt, water and abuse but allow for air circulation under and around the stack. Avoid exposure to direct sunlight.
- Certain species (e.g., Cherry, Mahogany, walnut, teak) are more susceptible to discoloration if exposed to either sunlight or some forms of artificial light. To protect doors from light damage after delivery, opaque plastic wrapping of individual doors should be specified.
- Do not subject interior doors to extremes of heat and/or humidity. Prolonged exposure may cause damage. Buildings where humidity and temperature are controlled provided the best storage facilities (recommended conditions 30–50% RH and 50–90° F.)
- Do not install doors in buildings that have wet plaster or cement unless they have been properly finished. Do not store doors in buildings with excessive moisture content - HVAC systems should be in operation and balanced.
- Doors should always be handled with clean hands or while wearing clean gloves.
- Doors should be lifted and carried when being moved, not dragged across one another.

B. Finishing

- Wood is hygroscopic and dimensionally influenced by changes in moisture content caused by changes within its surrounding environment. To assure uniform moisture exposure and dimensional control all surfaces must be finished equally.
- Doors may not be ready for finishing when initially received. Before finishing, remove all handling marks, raised grain, scuffs, burnishes and other undesirable blemishes by block sanding all surfaces in a horizontal position with a 120, 150 or 180 grit sandpaper. To avoid cross grain scratches, sand with the grain.
- Certain species of wood, particularly oak, contain chemicals which react unfavorably with foreign materials in the finishing system. Eliminate the use of steel wool on bare wood, rusty containers or any other contaminate in the finishing system.
- A thinned coat of sanding sealer should be applied prior to staining to promote a uniform appearance and avoid sharp contrasts in color or a blotchy appearance.
- All exposed wood surfaces must be sealed including top and bottom rails. Cutouts for hardware in exterior doors must be sealed prior to installation of hardware and exposure to weather.
- Dark colored finishes should be avoided on all surfaces if the door is exposed to direct sunlight, in order to reduce the chance of warping or veneer checking.
- Oil based sealers or prime coats provide the best base coat for finishing. If a water-based primer is used it should be an exterior grade product. Note: Water-based coatings on unfinished wood may cause veneer splits, highlight joints and raise wood grain and therefore should be avoided. If a water-based primer is desired, please contact the finish supplier regarding the correct application and use of these products.
- Be sure the door surface being finished is satisfactory in both smoothness and color after each coat. Allow adequate drying time between coats. Desired results are best achieved by following the finish manufacturers' recommendations. Do not finish door until a sample of the finish has been approved.
- Finishes on exterior doors may deteriorate due to exposure to the environment. In order to protect the door it is recommended that the condition of the exterior finish be inspected at least once a year and refinished as needed.
- Note: Certain wood fire doors have fire retardant salts impregnated into various wood components that makes the components more hygroscopic than normal wood. When exposed to high moisture conditions, these salts will concentrate on exposed surfaces and interfere with the finish. Before finishing, reduce moisture content in the treated wood below 11% and remove the salt crystals with a damp cloth followed by drying and light sanding. For further information on fire doors see NWWDA publications regarding Installing, Handling & Finishing Fire Doors.

(By permission from the Window and Door Manufacturers Association, Des Plaines, Illinois.)

C. Installation

- The utility or structural strength of the doors must not be impaired in fitting to the opening, in applying hardware, in preparing for lights, louvers, plants-ons or other detailing.
- Use two hinges for solid core doors up to 60" in height, three hinges for doors up to 90" in height and an additional hinge for every additional 30" of door height or portion thereof. Interior hollow core doors weighing less than 50 pounds and not over 7'6" in height may be hung on two hinges. Use heavy weight hinges on doors over 175 pounds. Consult manufacturer with regard to weight and size of hinges required.
- Clearances between door edges and door frame should be a minimum of 1/16" on the hinge edge. For latch edge and top rail the clearance should be 1/8" (+0",-1/16".)
- All hardware locations, preparations for hardware and methods of hardware attachment must be appropriate for the specific door construction. Templates for specific hardware preparation are available from hardware manufacturers or their distributors.
- When light or louver cutouts are made for exterior doors, they must be protected in order to prevent water from entering the door core. Metal flashing at the bottom of the cutout is one satisfactory method.
- Pilot holes must be drilled for all screws that act as hardware attachments. Threaded to the head screws are preferable for fastening hardware to non-rated doors and are required on fire-rated doors.
- In fitting for height, do not trim top or bottom edge by more than 3/4" unless accommodated by additional blocking. Do not trim top edge of fire doors.
- Doors and door frames should be installed plumb, square and level.
- When installed in exterior applications, doors must be properly sealed and adequately protected from the elements. Flashing should be applied at the head, jambs and sill.

D. Cleaning and Touchup

- Inspect all wood doors prior to hanging them on the job. Repair noticeable marks or defects that may have occurred from improper storage and handling.
- Field touchup shall include the filling of exposed nail or screw holes, refinishing of raw surfaces resulting form job fitting, repair of job inflicted scratches and mars, and final cleaning of finished surfaces. Field repairs and touchups are the responsibility of the installing contractor.
- When cleaning door surfaces, use a nonabrasive commercial cleaner designed for cleaning wood door or paneling surfaces, that do not leave a film residue that would build up or effect the surface gloss of the door finish.

E. Adjustment and Maintenance

- Inspect all wood doors prior to hanging them on the job. Repair noticeable marks or defects that may have occurred from improper storage and handling.
- Review with the owner/owner's representative how to periodically inspect all doors for wear, damage and natural deterioration.
- Review with the owner/owner's representative how to periodically inspect and adjust all hardware to ensure that it continues to function as it was originally intended.

Fire Door Requirements

- General
  Install Fire doors as required by NFPA Pamphlet 80. All 45-, 60-, and 90-minute rated doors may be hung with either half surface or full mortise hinges. Core reinforcements can be specified to permit hardware to be surface mounted with screws. Labels shall not be removed from fire-rated doors
- 20-, 45-, 60-, and 90-minute rated doors. Preparation of fire door assemblies for locks, latches, hinges, remotely operated or monitored hardware, concealed closers, glass lights, vision panels, louvers, astragals and laminated overlays shall be performed in conformance with the manufactures inspection service procedure under Label Service. Exception: Jobsight preparation for surface applied hardware, function holes for mortise locks, holes for labeled viewers, a maximum 3/4 inch (1.9cm) wood and composite door undercutting, and protection plates shall permitted. Surface applied hardware is applied to the face of a door without removing material from the door other than round holes drilled through the face of the door to receive cylinders, spindles, similar operational elements and through bolts. The holes shall not exceed a diameter of 1 inch (25.4mm) with the exception of cylinders*.

> ***Note to Specifiers:***
> *Include these requirements in your specifications. See Guide Specification. Door manufacturer's warranties do not cover appearance of job site applied finishes.*

Notes: *NFPA Pamphlet 80, Fire Doors and Fire Windows, 1992 Edition.

Continued

9.12.2 Finish System Descriptions

A variety of wood finishes is available, from single stains to multiple-step processes. When selecting a finish, consider the desired appearance, exposure, and maintenance it will require.

These 13 finishing systems represent the general range of finishes available from door manufacturers or woodworking manufacturers. Unless otherwise specified, manufacturers will furnish their standard finish system.

STANDARD AND SELECT FINISH SYSTEMS

Systems 1, 2, 7, 9: Lacquers

Standard lacquers (System 1), or non-catalyzed lacquers, are compatible with a wide variety of colorants, coloring methods, and sheen control which allow recoating and repair.

Lacquers usually contain nitrocellulose, which may be modified to achieve a variety of properties such as water white clarity, plus resistance to moisture, alcohol, and abrasives.

The valuable properties of many lacquers are due to their method of cure. Lacquer film dries by solvent evaporation. Each layer is soluble in the others applied over it, and all blend in a monolithic layer.

Catalyzed lacquer systems (System 2) contain an ingredient for faster drying and harder film. They have the strength and higher solids of conversion coatings.

Vinyl lacquer systems are catalyzed lacquers that have a plastic rather than a nitrocellulose base.

Acrylic lacquer systems are water-clear systems with excellent non-yellowing qualities. Both water and solvent reducible systems are available.

Water reducible acrylic lacquer systems (System 7) have higher solids, but do not contain the volatile flammable solvents typical of lacquers.

Opaque lacquers (System 9) are pigmented alkyd nitrocellulose lacquers available in many colors and gloss ranges. A catalyst can be added to opaque lacquers for extra hardness and improved chemical and abrasive resistance.

Systems 3 and 10: Conversion Varnish

Conversion varnish (System 3) exhibits excellent resistance to household chemicals. Similar in composition to catalyzed lacquer except for nitrocellulose, the solids in this finish make it economical; one coat can equal two of lacquer.

Opaque conversion varnish (System 10) is a high solids, catalyzed system. It provides high resistance to chemicals, moisture, and scratches.

System 4: Catalyzed Vinyl

Catalyzed vinyls (System 4) are the most chemically resistant of conversion coatings. They are appropriate for laboratories and industrial applications where chemical and solvent resistance is necessary.

SUPER AND SPECIALIZED FINISH SYSTEMS

The most important chemical products in the super finishes are polyesters and polyurethanes. Each has it own unique set of properties, and both share many general performance characteristics.

Systems 8 and 12: Polyesters

Polyesters provide chemical resistance. Essentially 100% solids, when applied they cure to a heavy coating that has as much as 80% of the hardness of glass.

Clear Polyester (System 8) and **Opaque Pigmented Polyester** (System 12) are films with high resistance to cold checks and crazing.

Systems 5, 11, 13: Polyurethanes

Polyurethanes are second only to polyesters for build, gloss, and durability. Also highly resistant to caustic materials, Catalyzed Polyurethane (System 5) and Opaque Catalyzed Polyurethane (System 11) are commonly used for exposure to exterior conditions, severe temperature changes, and ultraviolet radiation.

Since polyesters have strong filling, build, leveling, and hardness traits, they can be combined with polyurethanes (System 13) to achieve high gloss and endurance. The final product excels in appearance, burnish, texture, and overall durability. The resistance properties of the finish improve as it ages.

(By permission from the Window and Door Manufacturers Association, Des Plaines, Illinois.)

System 6: Oils

Oiled finishes provide a natural, rich look which accentuates the beauty of the wood grain. However, oiled surfaces tend to dry out, leaving the wood with a thirsty, aged look that requires re-oiling every six months.

Synthetic Penetrating Oil (System 6) is a special oil composition that strongly resists water spots, holds an oiled appearance a long time, and is easy to repair. A stain can be applied to the wood or color added to the oil for a variety of effects.

An oil finish effect can also be created by using catalyzed vinyls. Similar in appearance, they generate strong performance characteristics: resistance to abrasion, chemicals, humidity, and cold checks; plus excellent clarity and color retention.

Penetrating oil with stain or color added may be used prior to the vinyl to provide wood color and grain clarity. The oil must be compatible with the vinyl system.

G-18: Sample Submission

Door manufacturers will provide standard colors for selection.

To specify nonstandard colors and sheens, the architect is to provide two or more samples at least 8"x11" showing the desired finish effect on the wood species and cut to be used.

Samples to bear identification of the project, architect, general contractor, and door supplier. The door manufacturer may elect to submit samples in sets of two or more, illustrating the possible range of variations. The finished sample sets then become the final criteria for evaluating color and finish appearance conformity.

Variations can be expected due to the nature of wood, such as the barber pole effect in book matching, color variation from door to door due to veneer color variation, variations from heartwood and sapwood, etc.

G-19: Job Site Finishing

Because of the many uncontrollable variables that exist at a site, such as temperature and moisture variation, dust and other factors, door manufacturers' warranties do not cover the appearance of finishes applied at the job site.

For additional information see the NWWDA Publication "How to Store, Handle, Finish, Install and Maintain Wood Doors", on page 24.

Continued

9.13.0 Glossary of Wood Door Terminology

Barber Pole
- An effect in book matching of veneers resulting from tight and loose sides of veneers having different light reflections when finished.

Beveled Edge
- An edge of the door which forms an angle of less than 90 degrees with the wide face of the door, such as a 3 degree beveled edge.

Bevel
- A machine angle other than a right angle, i.e., a 3-degree bevel which is equivalent to a 1/8-inch drop in a 2-inch span (1mm in 16mm).

Blister
- Spot or area where veneer does not adhere.

Book Size
- The height and width of a door prior to prefitting.

Brashness
- Condition of wood characterized by a low resistance to shock and by abrupt failure across the grain without splintering.

Bullet Resistant Doors
- Doors which resist penetration by shots of varying caliber. Resistance may be rated as resistant to medium power, high power or super power small arms and high power rifles.

Butt Joint
- A joint formed by square edge surfaces (ends, edges, faces) coming together; end butt joint, edge butt joint.

Chalk
- White or other color chalk marks used by the mills for some form of identification to the mill or for marking defects for repair.

Chatter
- Lines appearing across the panel at right angles to the grain giving the appearance of one or more corrugations resulting from bad setting of sanding equipment.

Chicken Tracks
- Expression denoting scars which give the particular effect of a chicken's footprint, caused by air roots or vines. Small sections of chicken tracks appear to be part of the wood when more highly densified. The problem of chicken track is the shape and number. It is approximately the same color as the surrounding wood but usually a little darker. Chicken track that generally follows the grain, and is of an individual line rather than a series of lines merging on each other, is not considered to be a defect.

Clustered
- When a defect described in the grading rule is sufficient in number and sufficiently close together to appear to be concentrated in one area.

Compatible Edge Band (CE)
- When relating door edge to face appearance, the edge may not be the same species as the face, however, it may be similar in overall color, grain, character and contrast as the face. (See Matching Edge Band [ME]).

Composition Face Panels
- A door face panel composed of a wood derivative.

Core (Hollow)
- A core assembly of strips or other units of wood, wood derivative, or insulation board with intervening hollow cells or spaces which support the outer faces. Typical constructions are as follows:

  Mesh or Cellular. A hollow core composed of strips of wood, wood derivative, or insulation board, interlocked and running horizontally, vertically or diagonally throughout the core area with air cells and/or spaces between the strips and supporting the outer faces.

Core (Mineral)
- A fire-resistant core material generally used in wood doors requiring fire ratings of 3/4 hour or more.

Core (Solid)
- The innermost layer or section in flush door construction. Typical constructions are as follows:

  Particleboard. A solid core of wood or other lignocellulose particles bonded together with a suitable binder, cured under heat and pressed into a rigid panel in a flat platen press.

  Stave. A solid core of wood blocks or strips.

  Wood Block, Lined. A solid core of two parts; a central wood block core bonded to two core liners of wood or other lignocellulose materials.

Crossbanding
- A ply placed between the core and face veneer in 5-ply construction or a ply placed between the back and face of a 3-ply skin in 7-ply construction. When the crossbanding has directional grain it is placed at right angles to the grain of the face veneer. When used with laminate face doors, crossbanding may consist of more than one ply.

Cross Break
- Separation (break) of the wood cells across the grain. Such breaks may be due to internal strains resulting from unequal longitudinal shrinkage, or to external forces.

Dead Knots (Open Knots)
- Openings where a portion of the wood substance of the knot has dropped out or where cross checks have occurred to present an opening.

Decay
- The decomposition of wood substance by fungi.

Delamination
- Separation of plies or layers of wood or other materials through failure of the adhesive joint.

Discolorations
- Stains in wood substances. Some common veneer stains are sap stains, blue stains, stain produced by the chemical action caused by the iron in the cutting knife coming into contact with the tannic acid in the wood, and those resulting from the chemical action of the glue.

Doze
- A form of incipient decay characterized by a dull and lifeless appearance of the wood, accompanied by a lack of strength and softening of the wood.

Edge Band
- A strip along the outside edges of the two sides and/or top and bottom of the door. (See stiles/vertical edges.)

  High Pressure Decorative Laminate Edge Band

  A separate strip of high pressure decorative laminate, applied to the edges of the stile or rail.

End Match
- A single piece of veneer extends from the bottom to the top of the door with a mirror image at the transom.

Face Veneer
- The outermost exposed wood veneer surface of a veneered wood door.

(By permission from the Window and Door Manufacturers Association, Des Plaines, Illinois.)

Fill (Putty Repairs)
- A repair to an open defect, usually made with fast drying plastic putty. Should be well made with non-shrinking putty of a color matching the surrounding area of the wood. To be flat and level with the face and panel, and to be sanded after application and drying.

Finger Joint
- A series of interlocking fingers precision cut on the ends of two pieces of wood which mesh together and are held rigidly in place with adhesive.

Fire Rated Doors
- A door which has been constructed in such a manner that when installed in an assembly and tested will pass ASTM E-152 "Fire Test of Door Assemblies", and can be rated as resisting fire for 20 minutes (1/3 hour), 30 minutes (1/2 hour), 45 minutes (3/4 hour) (C), 1 hour (B), or 1-1/2 hours (B). The door must be tested and carry an identifying label from a qualified testing and inspection agency.

Flake, Ray
- Portion of a ray as it appears on the quartered surface. Flake can be a dominant appearance feature in oak and is sometimes referred to as flake.

Gaps
- Open splits in the inner ply or plies, or improperly joined veneer when joined veneers are used for inner plies.

Grain
- The direction, size, arrangement and appearance of the fibers in wood or veneer.

Grain Slope
- Expression of the angle of the grain to the long edges of the veneer component.

Grain Sweep
- Expression of the angle of the grain to the long edges of the veneer component over the area extending 1/8 of the length of the piece from ends.

Gum Pockets
- Well-defined openings between rings of annual growth, containing gum or evidence of prior gum accumulations.

Gum Spots
- Gum or resinous material of color spots caused by prior resin accumulations sometimes found on panel surfaces.

Hairline
- Thin, perceptible line showing at the joint of two pieces of wood.

Heartwood
- The nonactive center of a tree generally distinguishable from the outer portion (sapwood) by its darker color.

Holes, Worm
- Holes resulting from infestation by worms greater than 1/16 inch in diameter and not exceeding 5/8 inch in length.

Inconspicuous
- Barely detectable with the naked eye at a distance of 6 feet to 8 feet.

Indentations
- Areas in the face that have been compressed as the result of residue on the platens of the hot press or handling damage through the factory.

Joint
- The line of juncture between the edges or ends of two adjacent sheets of veneer.

Joint, Open
- Joint in which two adjacent pieces of veneer do not fit tightly together.

Kiln-Dried
- Lumber dried in a closed chamber in which the removal of moisture is controlled by *artificial* heat and usually by relative humidity.

Knife Marks
- Very fine lines that appear across the panel that can look as though they are raised resulting from some defect in the lathe knife that cannot be removed with sanding.

Knot
- Cross section of tree branch or limb with grain usually running at right angles to that of the piece of wood in which it occurs.

Knots, Blending Pin
- Sound knots 1/4 inch or less in diameter that do not contain dark centers. Blending pin knots are detectable at a distance of 6 to 8 feet and do not seriously detract from the overall appearance of the panel.

Knot Holes
- Voids produced by dropping of knots from the wood in which they were originally embedded.

Knots, Open
- Openings where a portion of the wood substance of the knot was dropped out, or where cross checks have occurred to present an opening.

Knots, Pin
- Sound knots 1/4 inch or less in diameter containing dark centers.

Knots, Sound, Tight
- Knots that are solid across their face and fixed by growth to retain their place.

Lap
- A condition where the veneers composing plywood are so misplaced that one piece overlaps the other and does not make a smooth joint.

Lock Block
- A concealed block the same thickness as the door stile or core which is adjacent to the stile at a location corresponding to the lock location and into which a lock is fitted.

Matching Edge Band (ME)
- Edge band must be the same species as the face veneer.

Medium Density Fiberboard (MDF)
- The generic name for a panel manufactured from lignocellulosic fibers combined with a synthetic resin or other suitable binder and bonded together under heat and pressure in a hot press by a process in which the entire bond is created by the added binder.

Medium Density Overlay
- A thermosetting resin impregnated paper applied to a door face to provide the optimum surface for paint finish.

Not Restricted
- Allowed, unlimited.

Open Filler
- A minor defect which is not filled.

Partial Filler
- A minor defect which is partially hidden by finish materials.

Patches
- Matching wood pieces carefully inserted and glued into the door face after defective portions have been removed.

Pitch
- Bleeding resin. Small area, usually black or dark brown in color, containing a resinous material which still is partly liquid.

Continued

Plain Sliced

- Veneer sliced parallel to the pith of the log and approximately tangent to the growth rings to achieve flat cut veneer. Plain sliced veneer can be cut using either a horizontal or vertical slicing machine or by the half-round method using a rotary lathe.

Pleasing Match

- A face containing components which provides a pleasing overall appearance. The grain of the various components need not be matched at the joints. Sharp color contrasts at the joints of the components are not permitted.

Prefitting

- Trimming of the door for width and/or height.

Puttied

- See "Fill."

Putty Smear

- Where putty has been incorrectly placed in surrounding area of wood as well as into the open defect that the putty was intended to repair. Putty smears are not allowed where the expressions "well puttied" is used.

Quartered

- Veneer produced by cutting in a radial direction to the pith to the extent that ray flake is produced, and the amount of which may be unlimited.

Rails

- The cross or horizontal pieces of the core assembly of a wood flush door.

Repairs

- A patch, shim, or filler material inserted and/or glued into veneer or a panel to achieve a sound surface.

Repairs, Blending

- Wood or filler insertions similar in color to adjacent wood so as to blend well.

Rift Cut

- Veneer produced by cutting at a slight angle to the radial to produce a quartered appearance without excessive ray flake.

Rotary Cut

- Veneer produced by centering the entire log in a lathe and turning it against a broad cutting knife.

Rough Cut

- Irregular shaped areas of generally uneven corrugation on the surface of veneer.

Sanding (Chatter, Dust, Burns)

- The degree of defects allowed in the sanding of the face or back.

Sapwood

- The living wood of lighter color occurring in the outer portion of a tree.

Shake

- A separation along the grain of wood in which the greater part occurs between the rings of annual growth.

Sharp Contrast

- For the purpose of this standard, this term means the veneer of lighter than average color should not be joined at the edges with veneer of darker than average color, and that two adjacent pieces of veneer should not be widely dissimilar in grain, figure and natural character markings.

Shims

- A split repaired in a piece of wood veneer, preferably from the same piece of veneer from which the face is made to ensure good color and grain match. The grain running in the same direction as the split to be inconspicuous to the naked eye, and free of any gaps where the shim joins the veneer. To be glued into the split and sanded after being made. Color matched.

Show Through (Telegraphing)

- A defect caused by the outline and/or surface irregularities, such as frame parts, core laps, voids, etc., that is visible through the face veneers.

Skin

- The hardwood plywood (usually 3-ply), hardboard or composition panel, whether flat or configured, which are used for facings for flush wood doors.

Slight

- Nearly unnoticeable or the naked eye.

Splits

- Separation or absence of wood fiber running parallel with the grain.

Standard Door

- By industry practice, a standard door is book size in both width and height.

Stiles/Vertical Edges

- The upright or vertical pieces of the core assembly of a wood flush door.

  Measurement

  The width of the vertical edge/stile shall be measured at its widest side (the wide side of a beveled door).

Streaks, Mineral

- Natural discolorations of the wood substance.

Tape

- Strips of gummed paper used to hold the edges of the veneer together at the joints prior to gluing.

Telegraphing

- See "Show Through".

Very Slight

- Unnoticeable to the naked eye.

Vine Streaks (Mark.)

- Scars in the wood generally caused by the stems of clinging vines or by their hair-like roots which cling to the tree trunk. Live vine streaks produce sound scars. Dead vine streaks contain either dead residue of the vine, or the remaining pocket similar to bark pocket. Most vine streaks run across the grain, and therefore, all vine streaks are considered defects in accordance with restrictions described in these rules.

Voids

- See "Gaps."

Warp

- Any distortion in the plane of a door itself and not its relationship to the frame or jamb in which it is to be hung. The term warp includes bow, cup and twist, which are defined as follows:

  Bow. A flatwise deviation from a straight line drawn from top to bottom; a curvature along the length of the door

  Cup. A deviation from a straight line drawn from side to side; a curvature along the width of the door.

  Twist. A deviation in which one or two corners of the door are out of plane with the other corners of the door.

Wood Flush Door

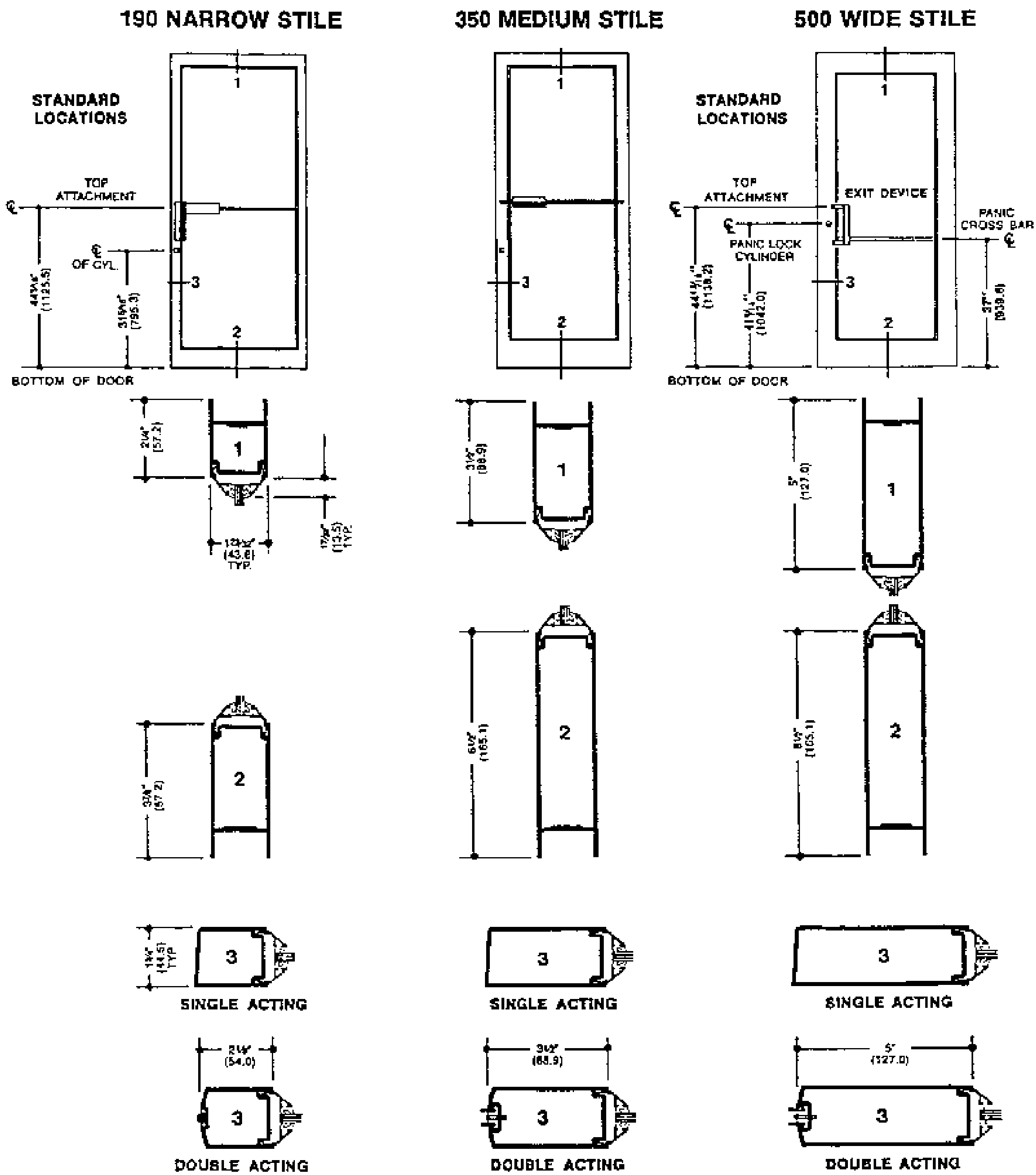
- An assembly consisting of a core, stiles and rails and/or edge bands, with 2 or 3 plies of veneer on each side of the core assembly. All parts are composed of wood, wood derivatives or high pressure decorative laminates.

Worm Track or Scar

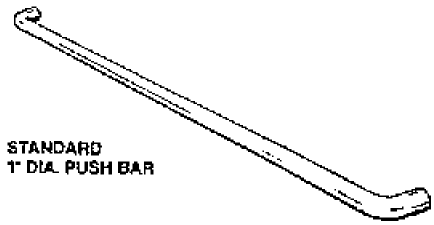
- The groove or resulting scar tissue in the wood caused by worms or other borers.

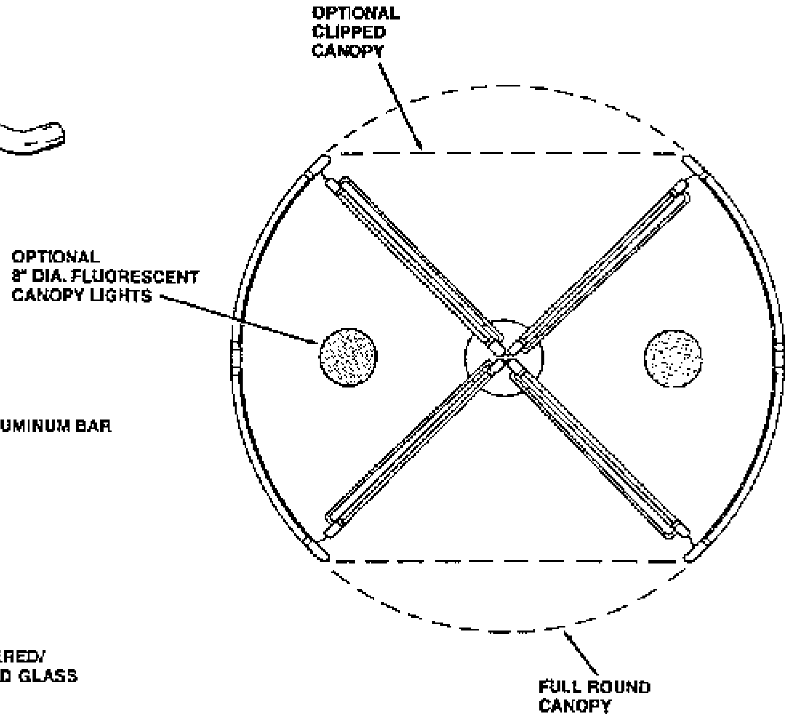
Continued

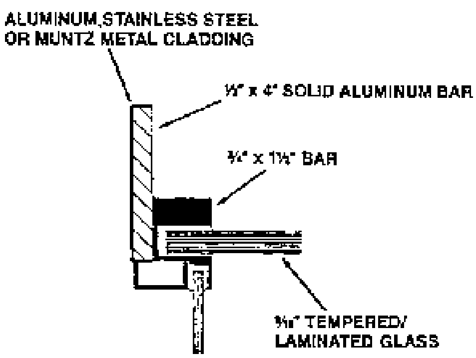
9.14.0 Aluminum Door Types/Sectional Dimensions



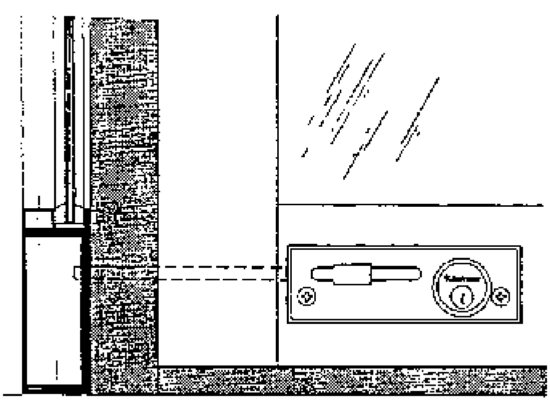
9.14.1 Aluminum Revolving Doors



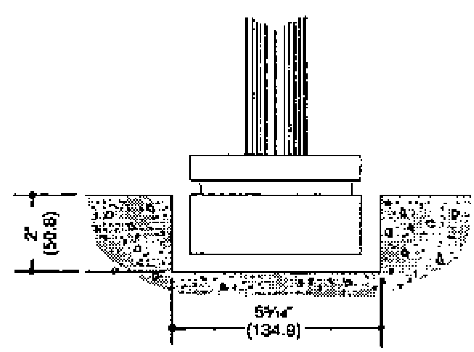




GLASS ROOF DETAIL



STANDARD LOCK LOCATED IN BOTTOM
RAIL OF TWO ADJACENT WINGS.



BOTTOM BEARING FLOOR
BLOCK-OUT

9.15.0 Windows—Aluminum, Wood, Steel, and Plastic

Aluminum Windows

According to ANSI/AAMA-101, aluminum used in the manufacture of windows must meet the following specifications:

- *Yield strength* 16,000 psi (110.24 MPa)
- *Tensile strength* 22,000 psi (151.6 MPa)
- *Coefficient of thermal expansion* 13 × 10 to the 6-inch/(2.45 cm) degree Fahrenheit (to convert F to C, subtract 32 and divide by 1.8)

Aluminum windows are susceptible to corrosion if their painted or anodized surfaces are exposed to the environment. Unless airborne contaminants are removed periodically by washing, they will attract and hold moisture. In combination with pollutants, over time, the exposed painted or anodized metal surface will be attached.

Aluminum is an excellent heat and cold transmitter. Without a thermal break in the window frame, it will always present a cold interior surface during winter months. Aluminum window components tend to expand and contract rapidly in response to temperature changes, causing stresses on improperly installed glazing. If these stresses become excessive, cracks will develop in the glazed section. However, aluminum windows are very cost-effective; are manufactured in a wide range of sizes, configurations, and colors; and are generally maintenance-free, compared to wood windows.

Steel Windows

These windows are usually constructed of hot-rolled, #12 steel and are classified by the minimum combined weight of the outside frame and vent member.

- *Residential grade* Minimum 2.0 pounds (0.9 kilogram) with maximum 1 inch (2.54 cm) from front to back. The maximum dimension is 6½ feet (1.98 meters) and the maximum spacing of mullions is 3½ feet (1.07 meters).
- *Standard grade* Minimum 3.0 pounds per lineal foot (1.36 kilograms per 30.48 cm) with a maximum of 1¼ inches (3.17 cm) front to back, ¾ inch (1.9 cm) vertical muntin required in projected vents over 4½ feet (1.37 meters) wide. The maximum glazed area is 60 square feet (5.58 square meters) and a maximum dimension is 10 feet (3.05 meters). For combined units, a maximum mullion spacing of 6½ feet (1.98 meters) is permitted.
- *Heavy intermediate grade* Minimum of 3.5 pounds per lineal foot (1.58 kilograms per 30.48 cm) with a maximum of 1 15/16 inches (3.33 cm) from front to back, ¾ inches (1.90 cm) vertical muntin in projected vents over 5 feet (1.52 meters). The maximum glazed area is 84 square feet (7.8 square meters). For combined units, a maximum spacing of mullions is 6½ feet (1.98 meters).
- *Heavy custom grade* Minimum 4.2 pounds per lineal foot (1.91 kilograms per 30.48 cm) with a maximum of 1½ inches (3.8 cm) from front to back of the ventilator and the supporting frame.

Steel windows exhibit great strength, allowing for large glazed areas. Thermal expansion is minimal, but thermal breaks in the frames are required to prevent the transmission of heat and cold from exterior to interior areas. These windows require periodic maintenance to ensure the integrity of their protective coatings to prevent rusting of their components.

Plastic/Vinyl Widows

Vinyl windows are manufactured to ASTM D4216 specifications that require the minimum properties of the polyvinylchloride (PVC) to have an impact resistance of 0.65 four pounds per inch (0.045 kilograms per square centimeter) of notch, a tensile strength of 5000 psi (34.5 Mpa), a modulus of elasticity in tension of 0.29×10^6, deflection temperature under load at 140 degrees F (77°C) and a coefficient of expansion of less than 2.2 × 10 to the minus 5th inch (2.54 cm)/inch (2.54 cm)/degree Fahrenheit (to convert F to C, subtract 32 and divide by 1.8).

Vinyl windows can be manufactured in many textures and colors, including wood-finish lookalikes. Although stabilizers are added to the vinyl compound, some dark colors have been known to fade or distort when exposed to strong sunlight for extended periods of time. Vinyl windows are difficult to refinish if damaged or if the color fades. Vinyl windows exhibit excellent thermal properties, do not expand or contract to any noticeable degree when subjected to heat or cold and are relatively maintenance-free and cost-effective.

Wood Windows

Wood windows offer beauty and warmth, as well as exhibiting excellent thermal qualities. Protection from the elements and condensation requires that both interior and exterior surfaces are either painted or otherwise sealed to prevent wood rot. Several manufacturers offer aluminum or vinyl cladding to minimize exterior maintenance.

9.16.0 Window Performance Grades and ANSI and NWWDA Standards for Wood Windows

Grades of Performance

	Pass	Grade 20	Grade 40	Grade 60
Preliminary (Design) Load: (Minimum test pressure sustained without damage, psf)	13.3	13.3	26.6	40
Operating Force (Pounds of force)		25	30	35
Air Infiltration: (Maximum infiltration at test pressure)	0.34	0.34	0.25	0.10
Water Penetration: (Minimum test pressure sustained without leakage, psf)	2.86	2.86	4.43	6.24

Grades of Performance*
(Metric Units)

	Grade 20	Grade 40	Grade 60
Preliminary Load: (Minimum test pressure sustained without damage, Pa)	638	1277	1920
Operating Force (Newtons)	111	133	156
Air Infiltration: (Maximum air infiltration in cfm at 1.56 psf test pressure)	5.26×10–4	3.81×10–4	1.55×10–4
Water Penetration: (Minimum test pressure sustained without leakage, Pa)	137	215	300
Structural Performance: (Minimum test pressure sustained without damage, Pa)	960	1920	2880

*The loads and levels prescribed in this table are actual quantities to be applied or measured during testing and do not include consideration of safety factors.

(Reprinted from NWWDA I.S. 2–87)

American National Standards Institute (ANSI)
National Wood Window and Door Association (NWWDA)
Standards for Wood Window Units I.S. 2–87

	Air Infiltation ASTM E-283	Water Infiltration ASTM E-547	Physical Load ASTM E-330
Grade 20- Suitable for residential construction	At an air pressure of 1.56 psf (25 mph), not more than .34 cubic feet per minute (cfm) per lineal foot of sash crack perimeter	No water shall pass beyond interior of unit in a 15 minute test, 5 gals. per hour per sq. ft. (equals 8" of rain per hour), under air pressure of 2.86 psf (34 mph)	Positive--20 psf (89) mph is applied to the exterior of the window, held for 10 seconds and released. Negative – Same as above as applied to the interior of the window and released. No glass breakage, no hardware damage nor deformation shall result in malfunction. Residual deflection to any member shall not exceed .4% of its span.
Grade 40- Suitable for light commercial construction	Same as above, not more than .25 cubic feet per minute	Same as above under air pressure of 4.43 psf (42 mph)	Same as above with positive and negative testing done under 40 psf (126.5 mph)
Grade 60- Suitable for heavy commercial construction	Same as above, not more than .10 cubic feet per minute	Same as above under air pressure of 6.24 psf (50 mph)	Same as above with positive and negative testing done under 60 psf (154.9 mph)

(By permission of Marvin Windows and Doors, Warroad, Minnesota.)

9.17.0 Effect of Glazing Selections on Heat Gain

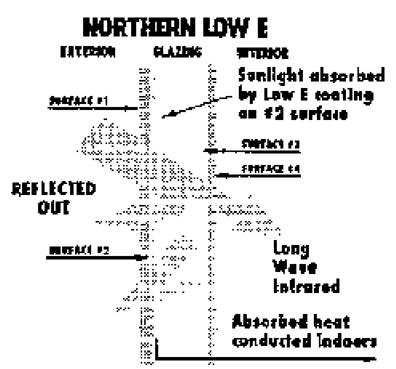
Heat Gain and Performance Data

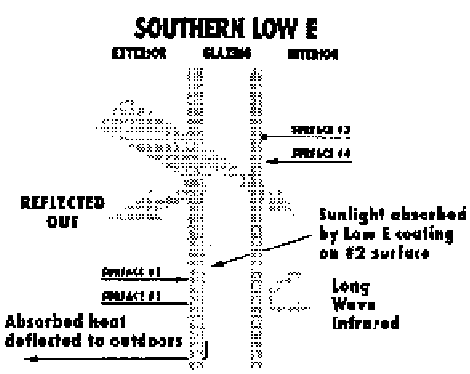
Heat Gain Data

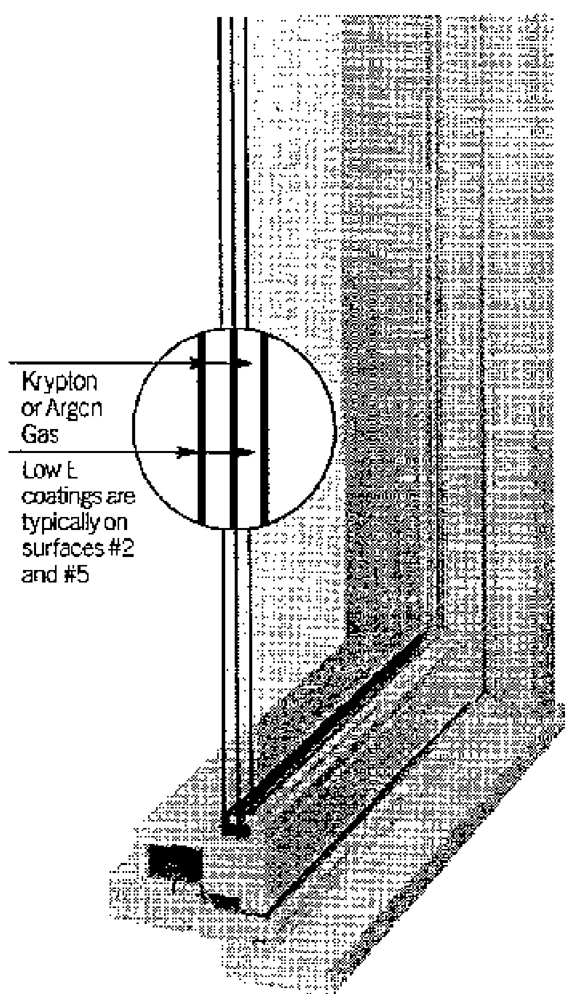
In areas of the U.S. where cooling is the major energy cost, glazing may be the most important factor in energy-saving. That's because cooling costs are based almost solely on heat gains transmitted through the glass. The accompanying table is used to show maximum heat gain by type of glass.

Clear	Heat Gain	Tinted Grey/Bronze	Heat Gain	Medium Performance Reflective	Heat Gain
Single-pane 3/32" or 1/8"	214	Single-pane grey 1/4" (for comparison only)	165	Single-pane bronze (for comparison only)	106
Single-pane 1/4" (for comparison only)	208	Single pane bronze 1/4" (for comparison only)	168		
Double-pane (for comparison only)	186				
Double-pane high-performance insulating	113	Double-pane high-1 performance sun insulating			

9.17.1 Low-E Glazing—Illustration







9.18.0 NWWDA Air-Infiltration Standards

Operating force refers to maximum amount of force, expressed in pounds, required to open and close a window unit.

Air Infiltration • Testing

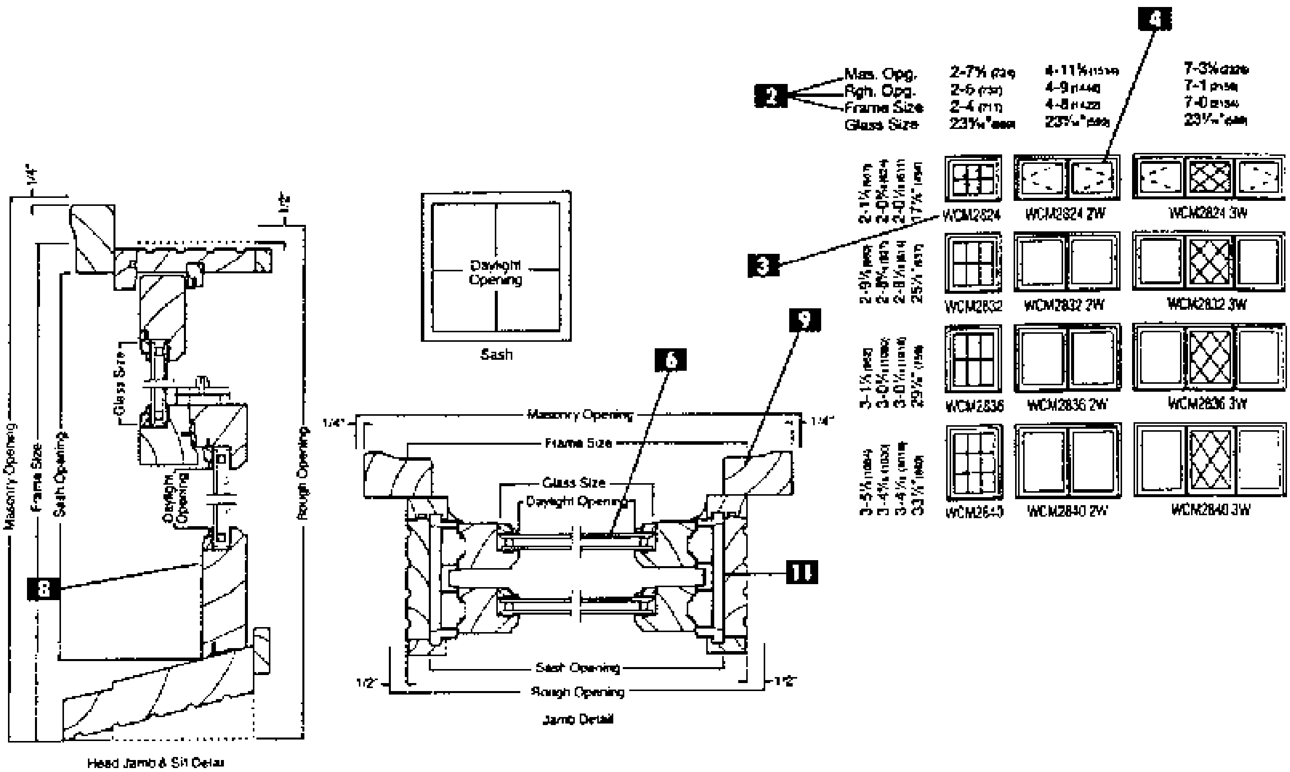
NWWDA I.S. 2.93- DP Ratings	DP15	DP20	DP25	DP30	DP35	DP40
Design pressure (psf)	15	20	25	30	35	40
Structural test pressure (psf)	22.5	30	37.5	45	52.5	60
Water infiltration (psf)	2.86	3.00	3.75	4.50	5.25	6.00
Air infiltration @ 1.57 psf (cfm/ft^2)	.37	.37	.25	.25	.25	.15
Operating force (lb)	25	25	30	30	30	35

NWWDA I.S.3 (old I.S. 2-87)	Grade 20	Grade 40	Grade 60
Design pressure (psf)	13.3	26.6	40.0
Structural test pressure (psf)	20	40	60
Water infiltration (psf)	2.86	4.43	6.24
Air infiltration @ 1.57 psf (cfm/ft^2)*	.34	.25	.10
Operating force (lb)	25	30	35

*Note: I.S. 2-87 - air infiltration @ 1.57 psf (cfm/lin. ft. of crack)

Note: Windows had been previously rated by the structural test pressure attained (e.g., Grade 20, 40, and 60); however, units today are rated by using design pressure (DP) ratings.

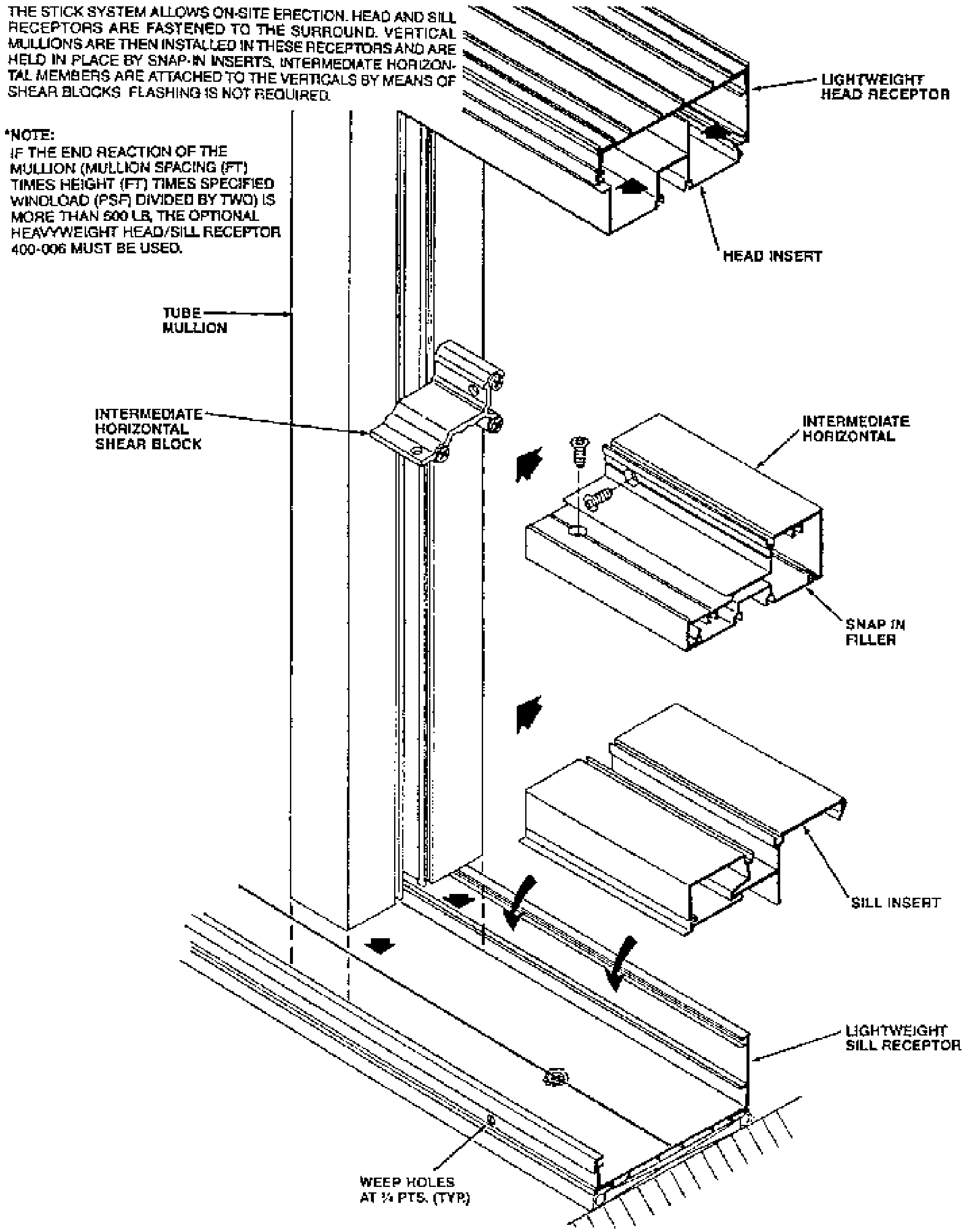
9.19.0 Steps Required to Order Wood/Clad Windows



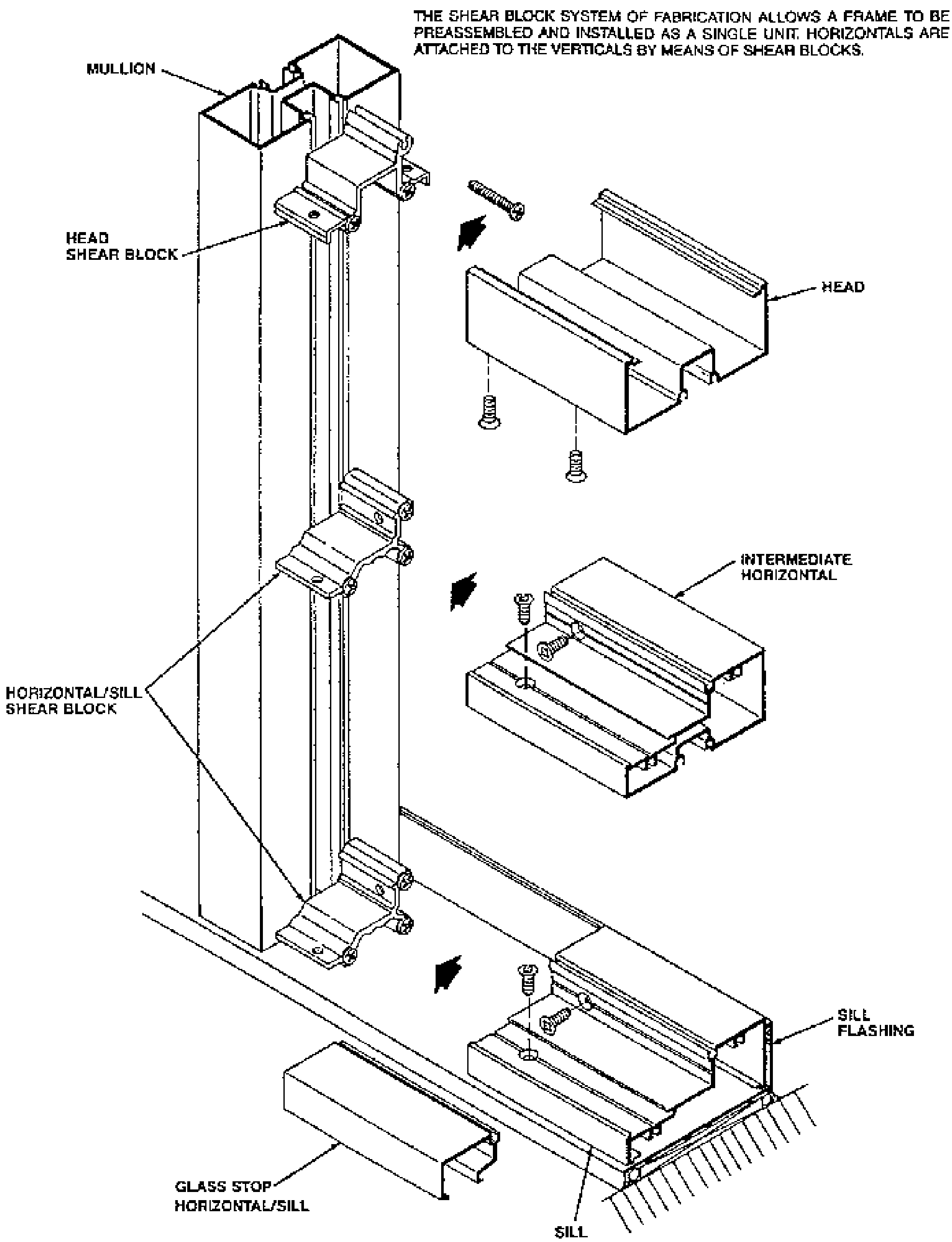
Items to consider when placing an order for windows:

1. Select style and material (wood, wood/clad, etc.).
2. Determine product size by using the rough opening, masonry opening, and frame size.
3. Identify manufacturer's unit number.
4. Specify operation.
5. Specify screens, if required.
6. Specify any glazing options.
7. Specify interior wood finish (bare or factory primed).
8. Specify exterior wood finish (bare, factory primed, and clad).
9. Specify color of hardware options, any drips, metal accessory items.
10. Specify type of exterior casing.
11. Specify jamb width.
12. Select any additional options.

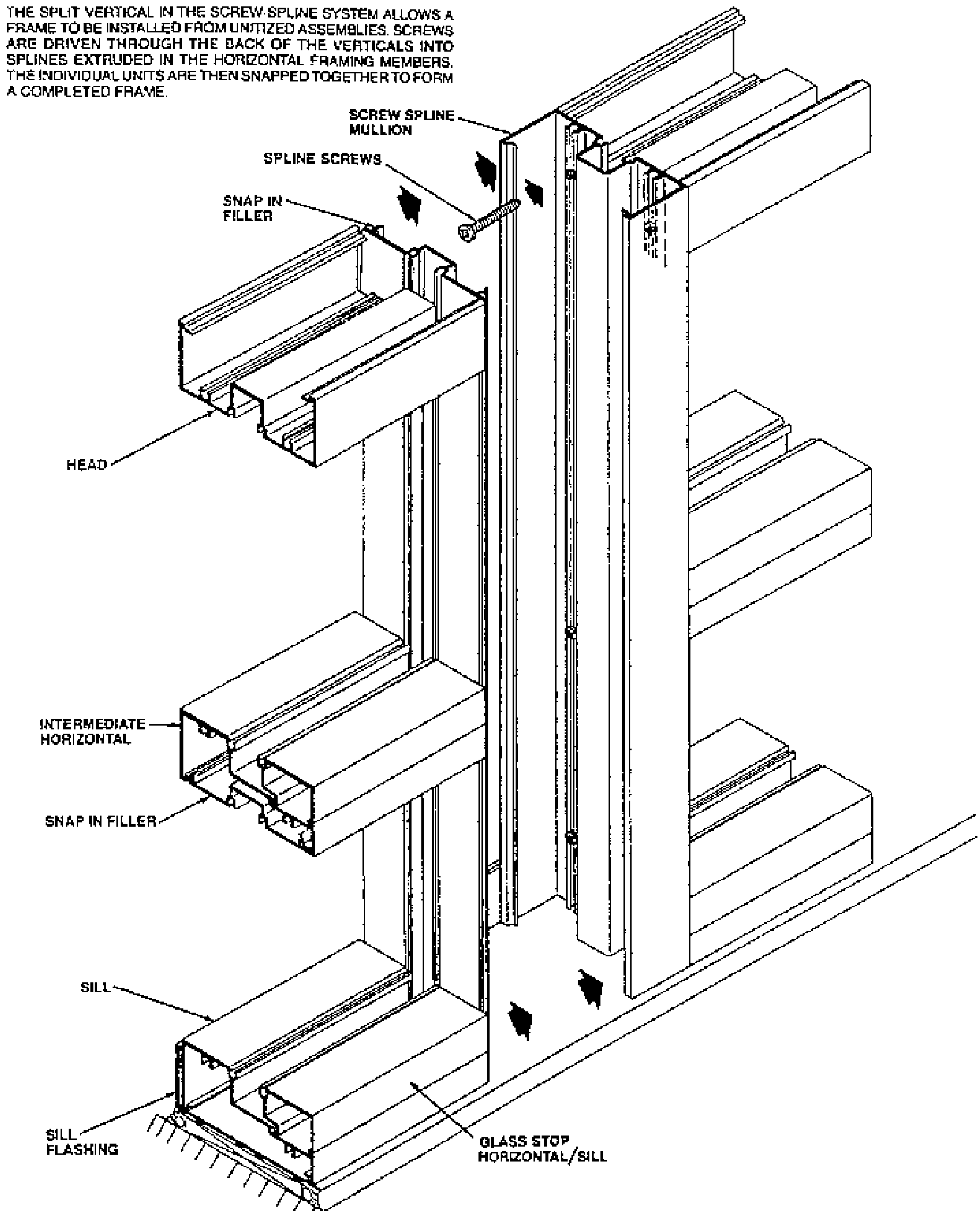
9.20.0 Aluminum Window Wall—Stick-Built Construction



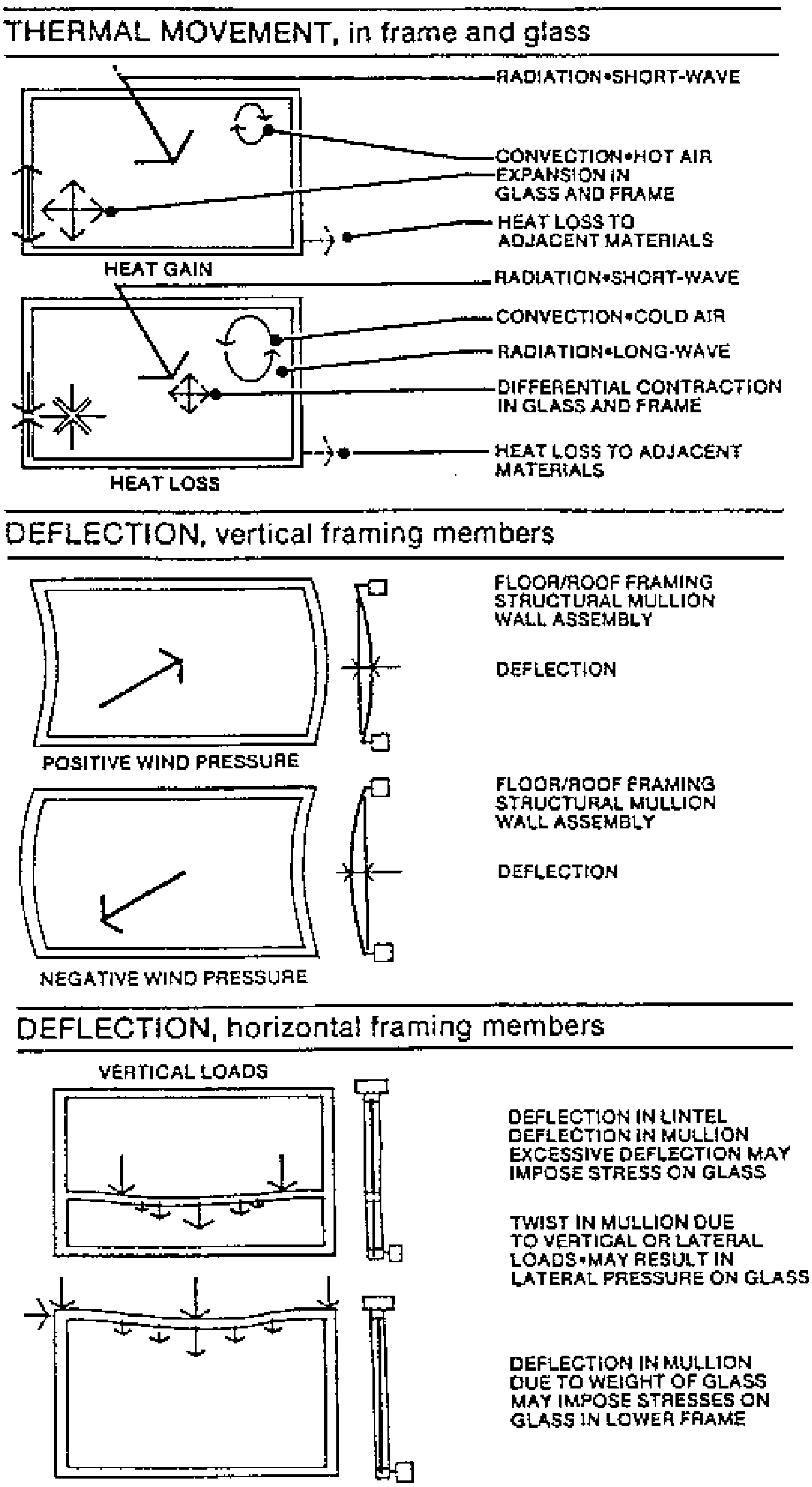
9.21.0 Aluminum Window Wall—Shear Block Fabrication



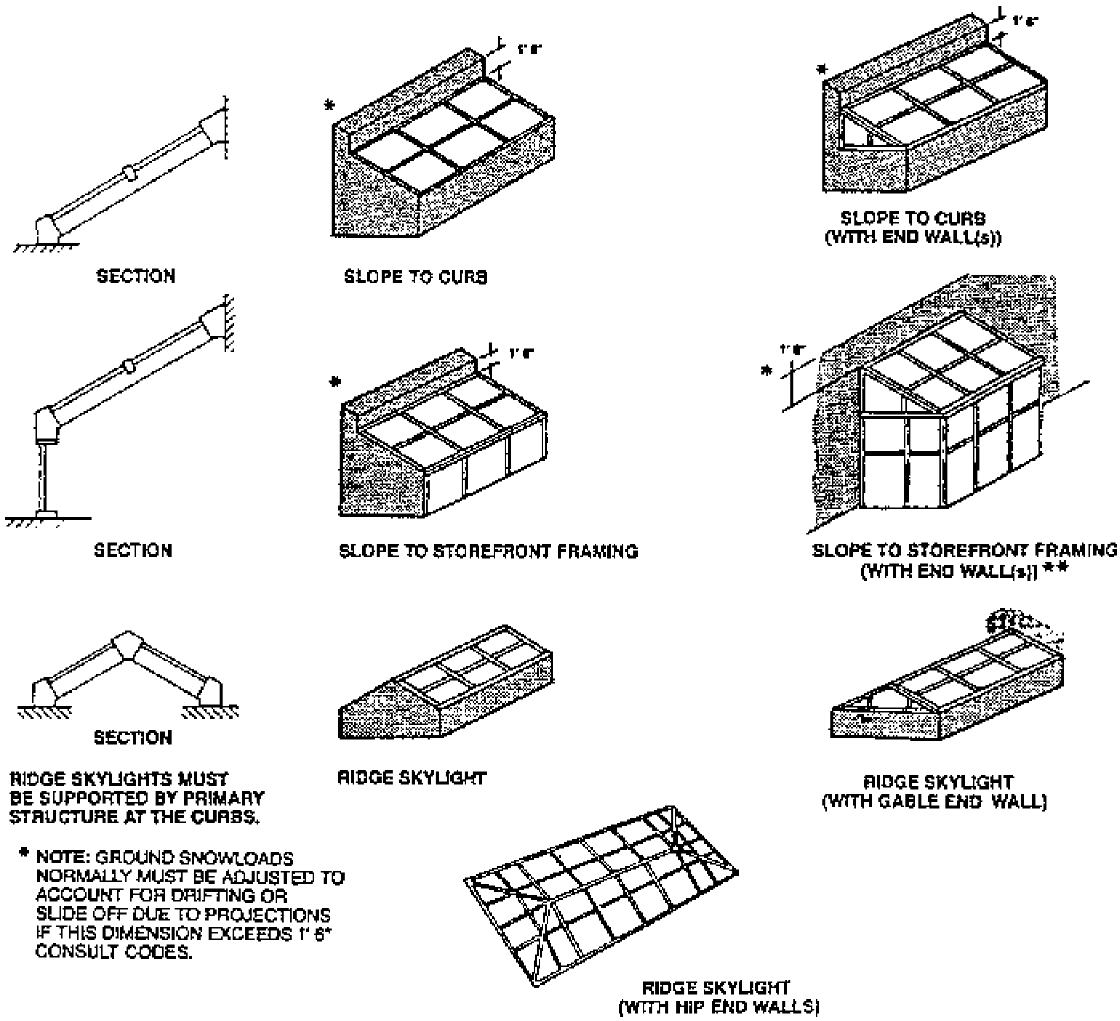
9.22.0 Aluminum Window Wall—Screwspline Fabrication



9.23.0 Thermal Movement and Frame Deflection



9.24.0 Sloped Glazing and Skylight Configurations



9.25.0 Curtain Wall—Quality Control Checklist

Quality Control Checklist

Project no.

Section: **Curtain Wall**

No. **08900**

Date

1. Shop drawings and samples are approved and on site.
2. Check panel for shipping damage after uncrating.
3. Metal extrusions match full size details.
4. Check patterns and colors, match samples.
5. Coating and finishes meet design requirements.
6. Joint sealer at shop-assembled joints as required.
7. Shop-applied sealant is provided as required.
8. Sound deadening insulation as required.
9. Color matches between panels and parts in range.
10. Dissimilar metals and materials are isolated.
11. Field-applied sealant is of proper type and color.
12. Expansion joints are provided between units.
13. Weep holes are clean before and after erection.
14. Erection tolerances: maintain alignment and plumbness.
15. Reveals are of consistent size and alignment.
16. Anchorage to structure for wind load is present and appears secure.
17. Observe permanent tightening after alignment.
18. Debris, especially spray fireproofing, is removed.
19. Exterior is maintained clean after erection.
20. Exterior is free from cementitious materials.
21. Final cleaning is performed as required.
22. Check for distortion in glass.
23. Check for distortion in metal wall panels.
24. Establish date for planned rework.
25. Check for water intrusion; jointery, sealants, etc., where curtain wall meets other materials.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

9.26.0 Interior Glass/Glazing—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Interior Glass and Glazing

No.
08801

Date

1. Approved submittals; shop drawings, samples, product data, certificates as required, are on site.
2. UL labels as required.
3. Materials are properly stored on site and protected.
4. All materials furnished and approved types; thicknesses and sizes.
5. All accessory items and glazing materials furnished and approved types.
6. Environmental, climatic and temperature conditions are suitable at installation.
7. Substrates and surfaces to be glazed are clean and primed as required.
8. Rabbets filled without voids.
9. Glasing gaskets complete bond.
10. Glass set tight, straight, with proper bite and adequate clearance.
11. Glazing materials trimmed and cleaned from glass, stops and frames.
12. No rattling, no looseness.
13. Glass clean, no face imperfections, no glass edge damage.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________

Section

10

Finish Hardware

Contents

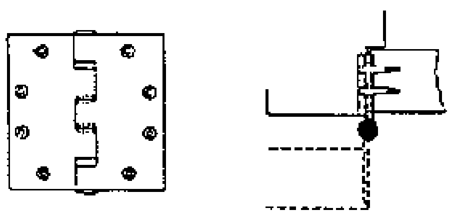
10.0.0 Introduction to Contents

Finish hardware selections and specifications span a wide range of functions, materials of construction and decorative requirements. The information contained in this section touches on hardware mainstays: locksets, latchsets with trim and cylinders, hinges (butts), panic devices, and informative specification tables. Although much of this information was furnished by two manufacturers, it remains very much generic in nature.

10.1.0 Door Hinges (Types and Illustrations)

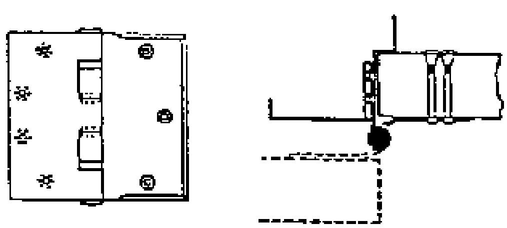
The butts are available in a wide range of metals.

Full Mortise



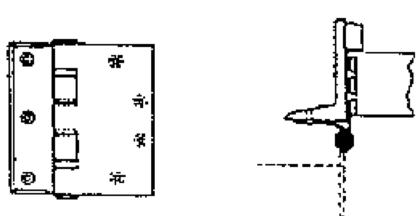
These butts have two equal square-edged leaves; one is mortised into the door and the other into the frame. It is available in standard, heavy, or extra heavy weight.

Half Surface



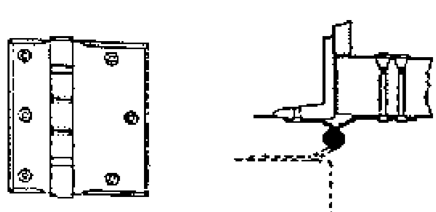
These butts have two equal leaves; one is square-edged and the other is bevel-edged; the square edge is mortised into the frame, the bevel edge is surface mounted on the door. It is available in standard and heavy weight.

Half Mortise



These butts have two equal leaves; one is square edged and the other is bevel edged; the square edge is mortised into the door edge and the bevel edge is mounted on the frame. It is available in standard and heavy weight.

Full Surface

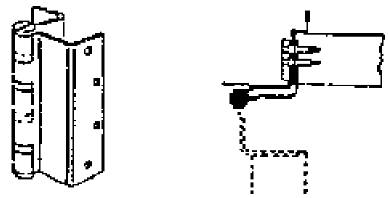


Two bevel-edged leave butts are of unequal size; one is mounted on the frame, the other on the door.

10.1.0 Door Hinges (Types and Illustrations)—Continued

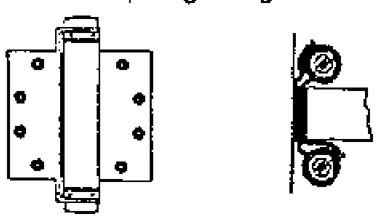
All of the above butts are generally available in sizes referring to their height: 4½" (11.43 cm), 5" (12.7 cm), and 6" (15.24 cm).

Special Butts

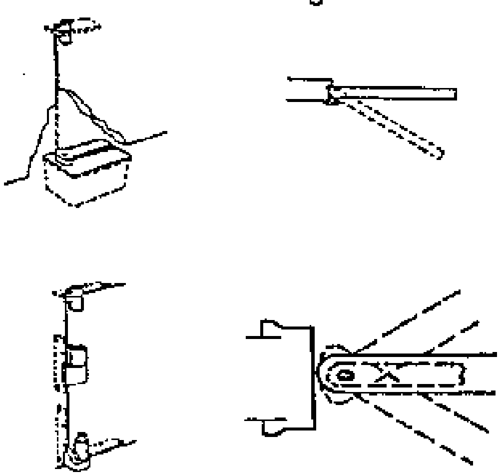


Swing clear/full mortise are also available in half-surface, half-mortise, and full-surface configurations. These types of butts provide an unobstructed clear frame opening when door is in the 90° open position. It is available in either a single- or double-acting configuration, usually mortised into the door and frame, providing closing action without a separate closer.

Spring Hinge

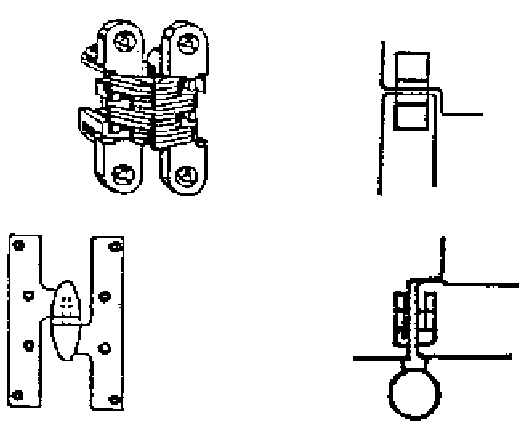


Pivot Hinges



Offset pivot hinges are mortised into the top and bottom edges of the door and into the frame jamb at the top and bottom. These hinges can also be mortised into the floor and the top of the frame. Center pivot hinges are attached to the top and bottom edges of the door and either into the top and bottom of the frame or into the floor and the top of the frame. Fully mortised into the edge of the door and frame, the hinge portion is not visible when the door is closed, except when the Paumelle or Olive Knuckle hinge is used, the olive-shaped portion is visible as an architectural feature.

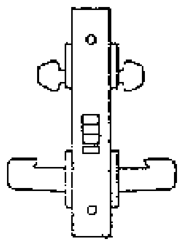
Invisible Hinges



10.2.0 Lockset and Latchset Configurations and Functions


If shaded, knob or lever rigid at all times

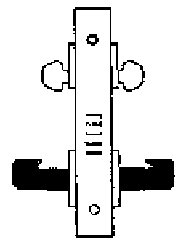
16 PUBLIC ENTRANCE



- Guardbolt deadlocks latch bolt
- Latchbolt retracted by either lever unless outside lever is locked by key inside
- Key outside retracts latch bolt when outside lever is locked

ANSI	8200 Levers	7800 Knobs
F09	8216	7816

17 UTILITY

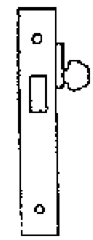


- Guardbolt deadlocks latchbolt
- Both levers rigid at all times
- Latchbolt retracted by key either side

ANSI	8200 Levers	7800 Knobs
*	8217	7817

* ANSI does not list this function

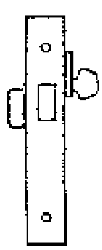
20 DEADLOCK



- Deadbolt operated from outside by key
- No inside operation

ANSI	8200	7800
F18	8220	N/A

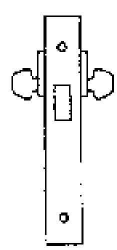
21 DEADLOCK



- Deadbolt operated from outside by key
- Deadbolt operated from inside by turn lever

ANSI	8200	7800
F17	8221	N/A

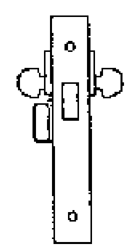
22 DEADLOCK



- Deadbolt operated from either side by key

ANSI	8200	7800
F16	8222	N/A

23 CLASSROOM DEADLOCK



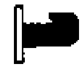
- Deadbolt operated from either side by key
- Deadbolt retracted by turn lever inside, but turn lever will not project it

ANSI	8200	7800
*	8223	N/A

* ANSI does not list this function

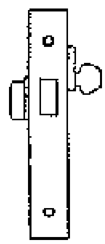
(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.2.0 Lockset and Latchset Configurations and Functions—Continued



If shaded, knob or lever rigid at all times

03 CLASSROOM DEADLOCK

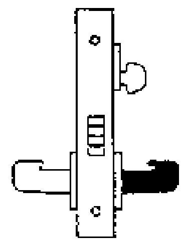


- Deadbolt operated from outside by key
- Turn lever inside retracts deadbolt only, but will not project it

ANSI	8200 Levers	7800 Knobs
*	8203	N/A

* ANSI does not list this function

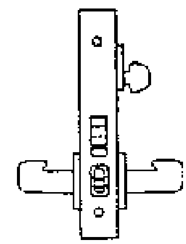
04 STOREROOM OR SERVICE



- Guardbolt deadlocks latchbolt
- Latchbolt retracted by lever inside or key outside
- Outside lever rigid at all times

ANSI	8200 Levers	7800 Knobs
F07	8204	7804

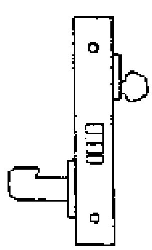
05 OFFICE



- Guardbolt deadlocks latchbolt
- Latchbolt retracted by either lever unless outside lever is locked by toggle in lock front
- Key outside retracts latch bolt when outside lever is locked

ANSI	8200 Levers	7800 Knobs
F04	8205	7805

06 STOREROOM OR SERVICE

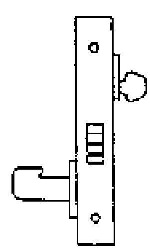


- Guardbolt deadlocks latchbolt
- Latchbolt retracted by lever inside or key outside
- Outside cylinder only

ANSI	8200 Levers	7800 Knobs
*	8206	7806

* ANSI does not list this function

13 EXIT LATCH

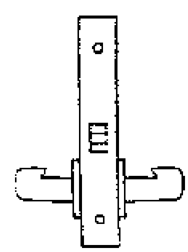


- Guardbolt deadlocks latchbolt
- Latchbolt retracted by lever inside
- No outside trim

ANSI	8200 Levers	7800 Knobs
*	8213	7813

* ANSI does not list this function

15 PASSAGE



- Latchbolt retracted by either lever

ANSI	8200 Levers	7800 Knobs
F01	8215	7815

(By permission from Sargent division ASSA ABLOY, New Haven, Connecticut.)

10.3.0 Heavy-Duty Mortise Cases, Hubs, and Spring Cartridges

HEAVY DUTY CASE, CAP & INSIDE FRONT

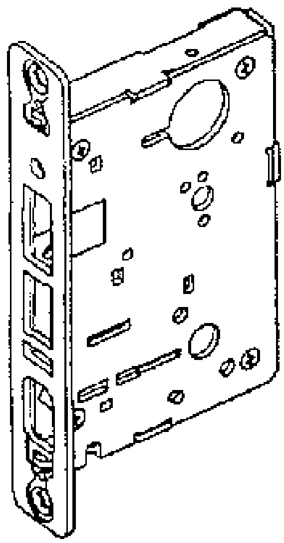
High impact strength is achieved through increased thickness of the case and cap to .109 and the inside front to .125

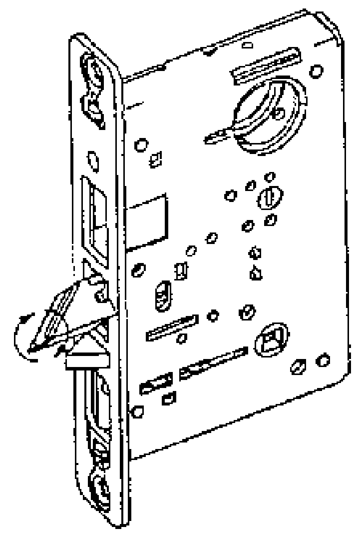
SIMPLE REVERSIBILITY

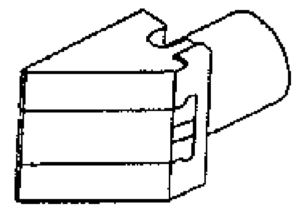
Instructions on each lockbody facilitates quick field reversibility for rehanding, using a standard screwdriver. Rehanding is done without opening the lockbody.

STAINLESS STEEL LATCHBOLT

Stainless steel ¾" one-piece antifriction, reversible latchbolt.





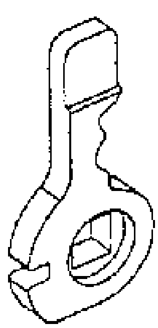


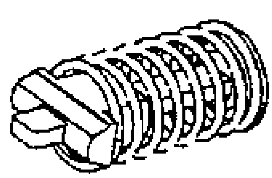
UNIVERSAL STRIKE

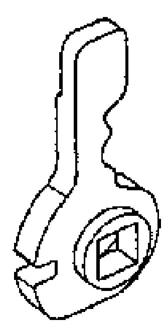
Universal, nonhanded, curved-lip strike to simplify ordering and installation. Wrought box strike furnished standard.

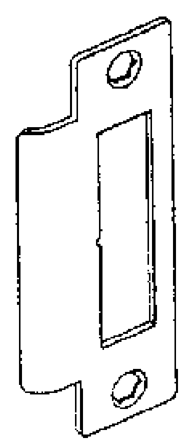
HEAVY DUTY HUBS & SPRING CARTRIDGE

Heavy duty hubs and spring cartridge provide superior strength and cycle life of the lock. Stainless steel hubs are available for institutional requirements.









(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.4.0 Strikes (Illustrated)

All sets are packed standard with a universal nonhanded curved lip ANSI 4⅞" strikes. See chart below for part number and Lip Lengths. Standard is 1¼" lip length. Part Number 82-0110.

STRIKES — 82-0108

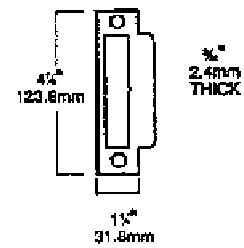
Part No.	Lip Length
82-0109	1⅛"
82-0110	1¼"
82-0111	1⅜"
82-0112	1½"
82-0113	1¾"
82-0114	2⅛"
82-0115	2⅜"
82-0116	2½"
82-0117	2¾"

To order strikes separately, give strike part number and finish. Strikes ordered separately are furnished with wood screws and without strike boxes.

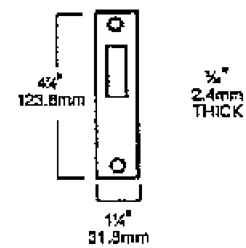
STRIKES — 877 OBS

Door Thickness	Part No. RHRB	Part No. LHRB
1¾"	82-0332	82-0333
2"	82-0334	82-0335
2¼"	82-0236	82-0337
2½"	82-0338	82-0339
2¾"	82-0340	82-0341
3"	82-0342	82-0343

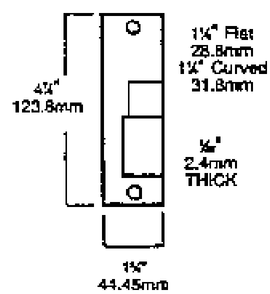
82-0108 SERIES STRIKES



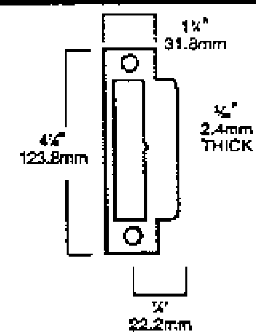
78-0034 DEADBOLT STRIKE



877 OPEN BACK STRIKE



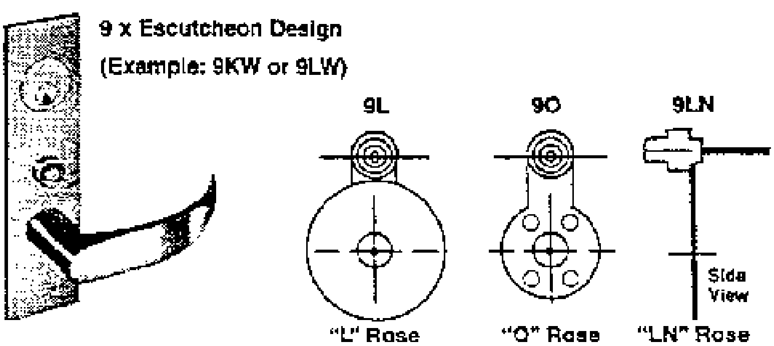
82-0229 FLAT LIP STRIKE



For use on pairs of doors

HOTEL LOCK INDICATORS
(PREFIX 50-)

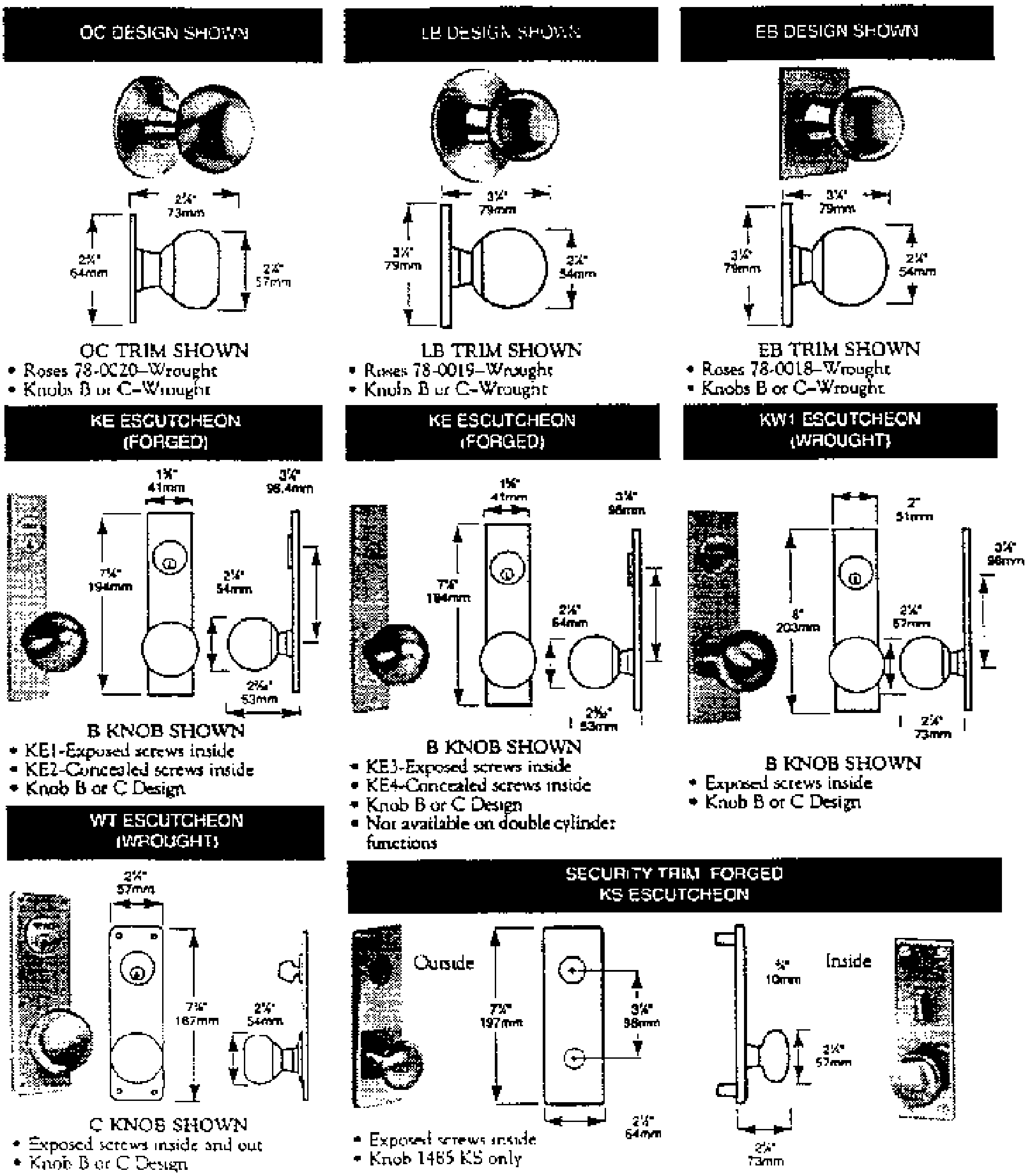
Available in 7700 and 8100 Series only. Wrought brass, bronze. For 50 function only. To order add 50-prefix to lockset designation. (Example: 50-7850 or 50-8250) Not available for narrow front locksets (1-prefix)



WROUGHT STRIKE BOX

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.5.0 Door Knob Designs

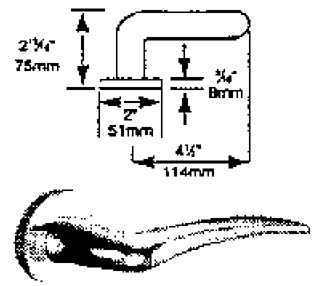


(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.6.0 Lever Handle Designs

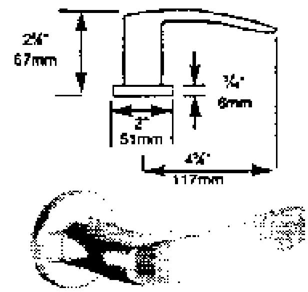
Any lever design can be used with any rose design.

LNA
ROSE: LN LEVER A



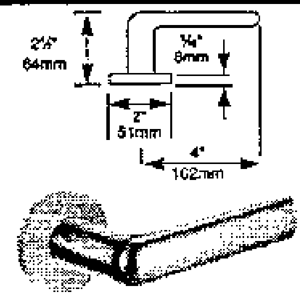
"A" LEVER (HANDED)
- Lever is forged or cast
- LN rose shown

LNB
ROSE: LN LEVER B



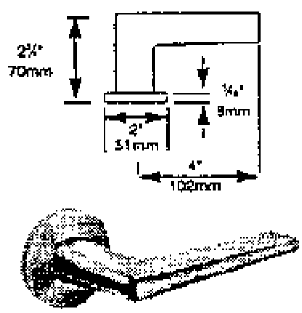
"B" LEVER
- Lever is forged or cast
- LN rose shown

LNE
ROSE: LN LEVER E



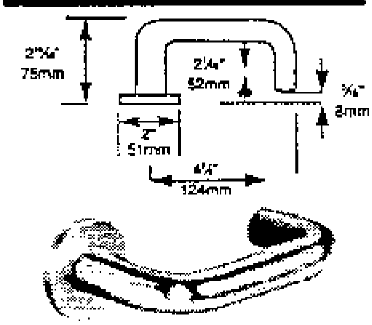
"E" LEVER
- Lever is forged or cast
- LN rose shown

LNF
ROSE: LN LEVER F



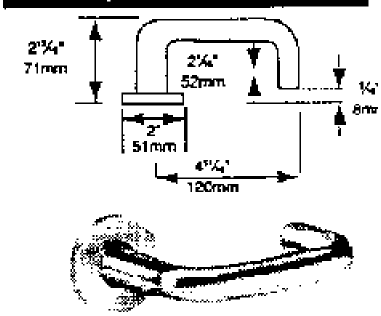
"F" LEVER
- Lever is forged or cast
- LN rose shown

LNH
ROSE: LN LEVER H



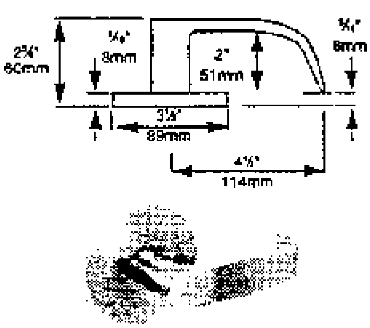
"H" LEVER
- Lever is hollow
- LN rose shown

LNJ
ROSE: LN LEVER: J



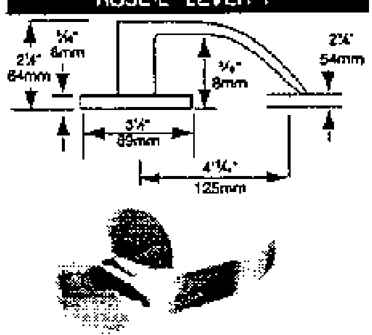
"J" LEVER
- Lever is solid
- LN rose shown

LL
ROSE: L LEVER: L



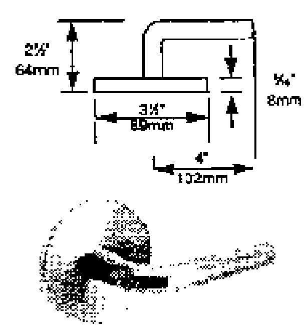
"L" LEVER
- Lever is forged or cast
- L rose shown

LP
ROSE: L LEVER: P



"P" LEVER
- Lever is forged or cast
- L rose shown

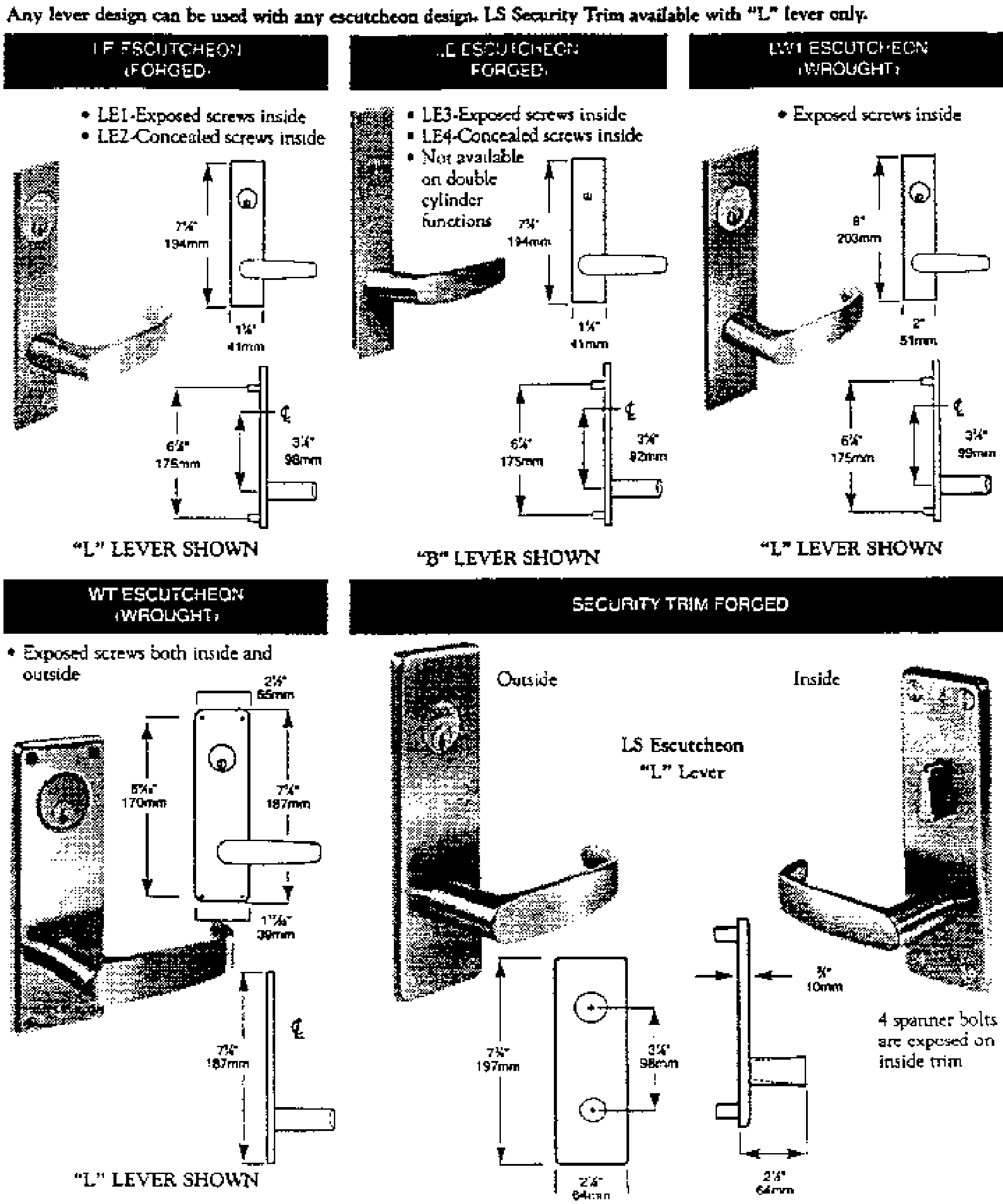
LW
ROSE: L LEVER: W



"W" LEVER
- Lever is solid rod
- L rose shown

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

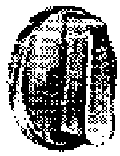
10.6.1 Lever Handle Designs (Forged and Wrought)



(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

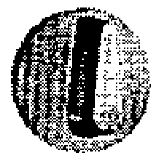
10.7.0 Turn Levers

130 W



Brass, bronze or stainless steel. Wrought plate, wrought lever. Furnished with flat spindle. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D. Used with 7800 locksets.

130 KB

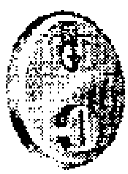


Forged brass, bronze or stainless steel. Furnished with flat spindle. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D. Used with 8200 rose trim.

130 KA

Forged brass, bronze or stainless steel. Furnished with flat spindle. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D. Used with 78-0018E rose.

184 W

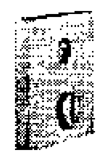


Brass, bronze or stainless steel plate. Brass or stainless steel button. Furnished with flat spindle. For 65 function with sectional trim using 130W Turn Lever. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D.

184 KB

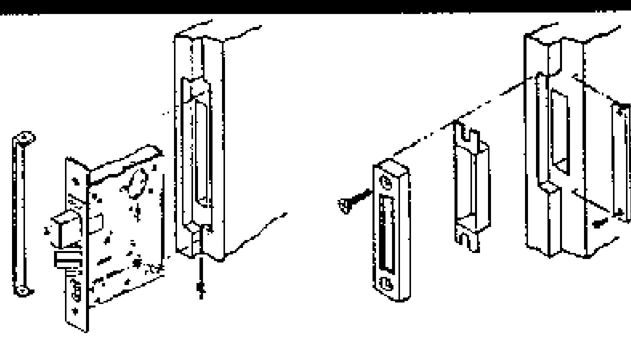
Brass, bronze or stainless steel. Furnished with flat spindle. For 65 function using 130 KB Turn Lever. Furnished with flat spindle. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26D, 32, 32D.

184 KA



Brass, bronze or stainless steel. Furnished with flat spindle. For 65 function using 130 KA Turn Lever. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26D, 32, 32D.

RABBETED DOOR KIT NO. 677



Kit adapts 7800 and 8200 locks for rabbeted doors. Kit No.2-677 consists of rabbeted strip and strike. Kit furnished standard for 1¾" doors. Specify when using 2¼" thick doors. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D.

OUTSIDE EMERGENCY RELEASE KEY

No. 14-0057. Carbon steel.

126 T-TURN

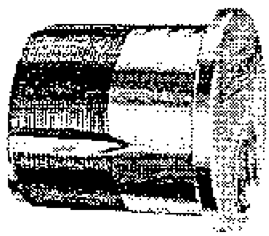
(USED IN LIEU OF KNOB FOR 7800 SERIES LOCKSETS)

Brass or bronze. Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D. Spindle engages hub on one side of lockset only.

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.8.0 Mortise Cylinders

40 SERIES TYPE CYLINDER

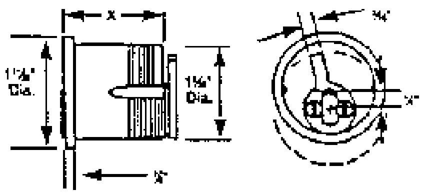


Cylinder: Brass

Cap: Brass, Bronze and Stainless Steel.

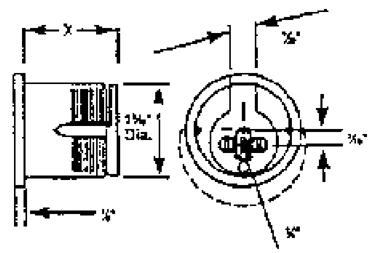
Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D.

Furnished standard with No. 97 Compression Ring.



Length under cylinder head										
No.	41	42	43	44	46	48	50	52	54	56
Length Including cam (dim x)	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	2 3/4"	3"

HOTEL TYPE MORTISE CYLINDER (PREFIX 50-) 50-40 SERIES



Cylinder: Brass

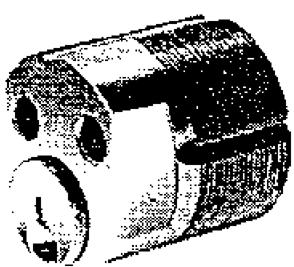
Cap: Brass, Bronze and Stainless Steel.

Finishes: 4, 15

For use only with Sargent Escutcheon Trim (KE, LE) See Function table for cam required.

Length under cylinder head				
No.	50-41	50-42	50-43	50-44
Length including cam (dim x)	1 1/8"	1 1/4"	1 3/8"	1 1/2"

MORTISE CYLINDERS, EXPOSED BARREL ONLY 78-40 SERIES

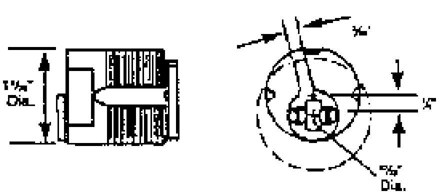


Cylinder: Brass

Cap: Brass, Bronze and Stainless Steel.

Finishes: 4, 15

For use only with Sargent Escutcheon Trim (KE, LE) See Function table for cam required.

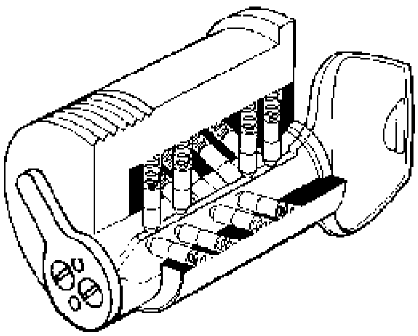


Door Thickness	Cylinder
1 3/4"	6 pin; single cylinder function only
2"	6 or 7 pin; single cylinder functions only
2 1/4"	6 or 7 pin; all lock functions

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

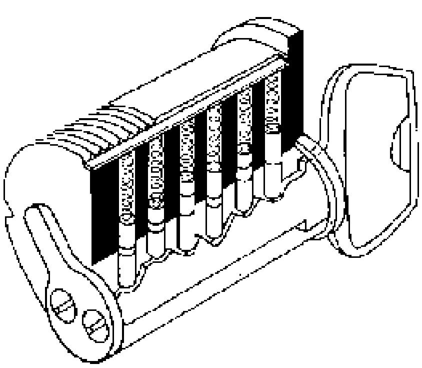
10.8.1 How High-Security Cylinders Differ from Conventional Ones

KESO SECURITY SYSTEM CYLINDER



Cutaway view of the cylinder illustrates one of the 24,500 different patterns of key pins available within any one Sargent Keso Security System installation. Exceptionally precise manufacturing tolerances and the absence of splits, even in masterkeying, makes the cylinder highly pick-resistant.

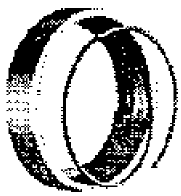
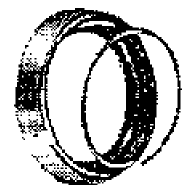
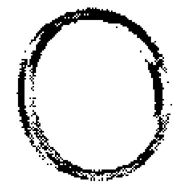
CONVENTIONAL CYLINDER



A conventional cylinder always has its key pins equally spaced in one row only. When masterkeying is employed, split pins are introduced and the number of safe day key changes is greatly reduced. Conventional cylinders usually contain only 5, 6 or 7 pins.

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

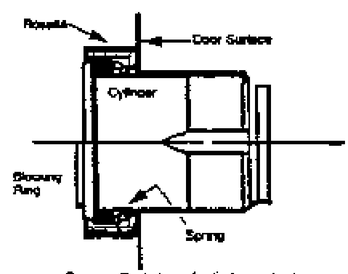
10.8.2 Rosette and Blocking Rings for Cylinders

NO. 1KB ROSETTE	NO. 97 ROSETTE	NO. 90 BLOCKING RING
		
Cast Brass, Bronze and Stainless Steel Finishes: 3, 4, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D 1 1/2" diameter, 5/16" projection No. 1 KB-2 7/16" projection No. 1 KB-3 9/16" projection	Brass, Bronze and Stainless Steel Finishes: 3, 4, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D 1 11/16" diameter 9/32" projection	Brass, Bronze and Stainless Steel Finishes: 3, 4, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D 1 3/8" diameter; 1/16", 1/8", 3/16", 1/4", 3/8" projections. Specify projection required when ordering.

HOW TO FIND YOUR ROSETTE AND BLOCKING RING REQUIREMENTS

Rosettes and ring requirements are coded by letters A through L in the table to the right. Each letter represents a rosette or ring as listed below. As an example, a 41 cylinder for a 1 3/8" door using KE escutcheon trim for a single cylinder function would require (A) a No. 97 Rosette: and (H) a No. 90 1/8" Blocking Ring.

A. No. 97 Rosette (includes spring)
B. No. 97-02 Spring
C. No rosette or ring required
D. 1KB Rosette (includes spring)
E. 1KB-2 Rosette (includes spring)
F. 1KB-3 Rosette (includes spring)
G. No. 90 1/16" Blocking Ring
H. No. 90 1/8" Blocking Ring
J. No. 90 3/16" Blocking Ring
K. No. 90 1/4" Blocking Ring
L. No. 90 3/8" Blocking Ring



Crosscut illustration of cylinder application

ESCUTCHEON TRIM

Trim	KE, KW,			LE, LW		
Function	Single Cylinder			Double Cylinder		
Door	1⅜	1¾	2¼	1⅜	1¾	2¼
41 Cylinder 5 or 6 pin	B H	C	– J	B H H	B	–
42 Cylinder 5, 6 or 7 pin	B K	C	C K	B J K	B	C
43 Cylinder 5, 6, or 7 pin	B L	B J	C	B J L	B L	B H

SECTIONAL TRIM

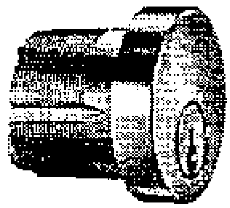
Trim	KS, LS					
Function	Single Cylinder			Double Cylinder		
Door	1	1¾	2¼	1⅜	1¾	2¼
41 Cylinder 5 or 6 pin	–	A	–	–	A H	–
42 Cylinder 5, 6 or 7 pin	–	A	A	–	A K	A
43 Cylinder 5, 6, or 7 pin	– K	A	A L	– H	A L	A J

Trim	KS, LS					
Function	Single Cylinder			Double Cylinder		
Door	1	1¾	2¼	1⅜	1¾	2¼
41 Cylinder 5 or 6 pin	E H	D	–	F H J	E H	–
42 Cylinder 5, 6 or 7 pin	F K	D G	D	F J K	F K	D
43 Cylinder 5, 6, or 7 pin	F L	E J	D	F J L	F H	E H

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.8.3 Miscellaneous Cams for Mortise Cylinders

MORTISE ADJUSTABLE FRONT CYLINDER



Cylinder: Brass
Cap: Brass, Bronze and Stainless Steel.
Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D.
No cylinder ring or rosette is required. Spring action front adjust 1/16" to assure proper mounting of cylinder. Available with three different cap heights to accommodate various door and trim thicknesses. Can be used with most trim except escutcheon designs.

			Cylinder No.			
No.	Cap Size	Dim A	35-41	35-42	35-43	35-44
Length	5	5/16"	31/32"	1 3/32"	1 7/32"	1 11/32"
Including	7	7/16"	31/32"	1 3/32"	1 7/32"	
cam (dim.x)	9	9/16"	23/32"	27/32"	31/32"	1 3/32"

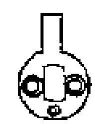
Also available for use with hotel function locks, for ordering cylinders only. Example: 35-50-7-2-US26D.

CAMS AND APPLICATIONS

Application	All Functions Except 92 and 16 Functions inside Cylinder and 50 Function Hotel Cylinder	92 and 16 Functions inside and all Functions with 84 Prefix
Standard Cams	 13-0660	 13-0661
Construction Cylinder Cam required for 41 use only	 13-0662	 13-0663
Slotted Cam required for a 6 pin key on a 5 pin cylinder or 7 pin key on a 6 pin cylinder	 13-0664	 13-0665

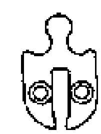
APPLICATIONS

For use with 50 function



13-2045 Hotel Cylinder Cam

For use with 4280 key switch

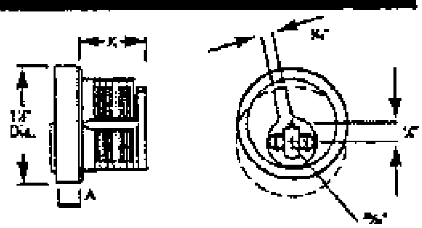


13-0921 Standard Cloverleaf Cam

35-40 SERIES CYLINDER-CAP HEIGHT REQUIREMENTS

When ordering cylinders, use the following suffixes as required:

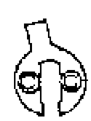
Suffix 2	Hotel Cam
Suffix 3	Short Cam
Suffix 5	5/16" Cap Height
Suffix 7	7/16" Cap Height
Suffix 9	9/16" Cap Height



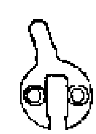
Trim Function	All Designs — Sectional Trim					
	Single Cyl			Double Cyl		
	1⅜"	1¾"	2¼"	1⅜"	1¾"	2¼"
35-41 Cylinder 6 PIN	7/16"	5/16"	—	9/16"	7/16"	—
35-42 Cylinder 6 or 7 PIN	—	1/16"	5/16"	—	9/16"	5/16"
35-43 Cylinder 6 or 7 PIN	—	—	5/16"	—	—	7/16"

MISCELLANEOUS CAMS

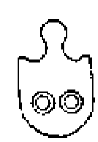
Manufacturer and Lock Number	Desc.	Cam No.	Cam with Cylinder
Adams Rite 1850	Offset Cam	13-0512	47-41-101
Adams Rite 4050	Offset Cam	13-0513	47-141-101
Adams Rite 4150	Offset Cam	13-0511	47-141-101
Adams Rite 4250	Offset Cam	13-0513	47-142-101
Adams Rite 4350	Offset Cam	13-0513	47-142-101
Adams Rite 4070	Offset Cam	13-0513	47-142-101
Schlage "L" Latch	Cam	13-0938	—



13-0512



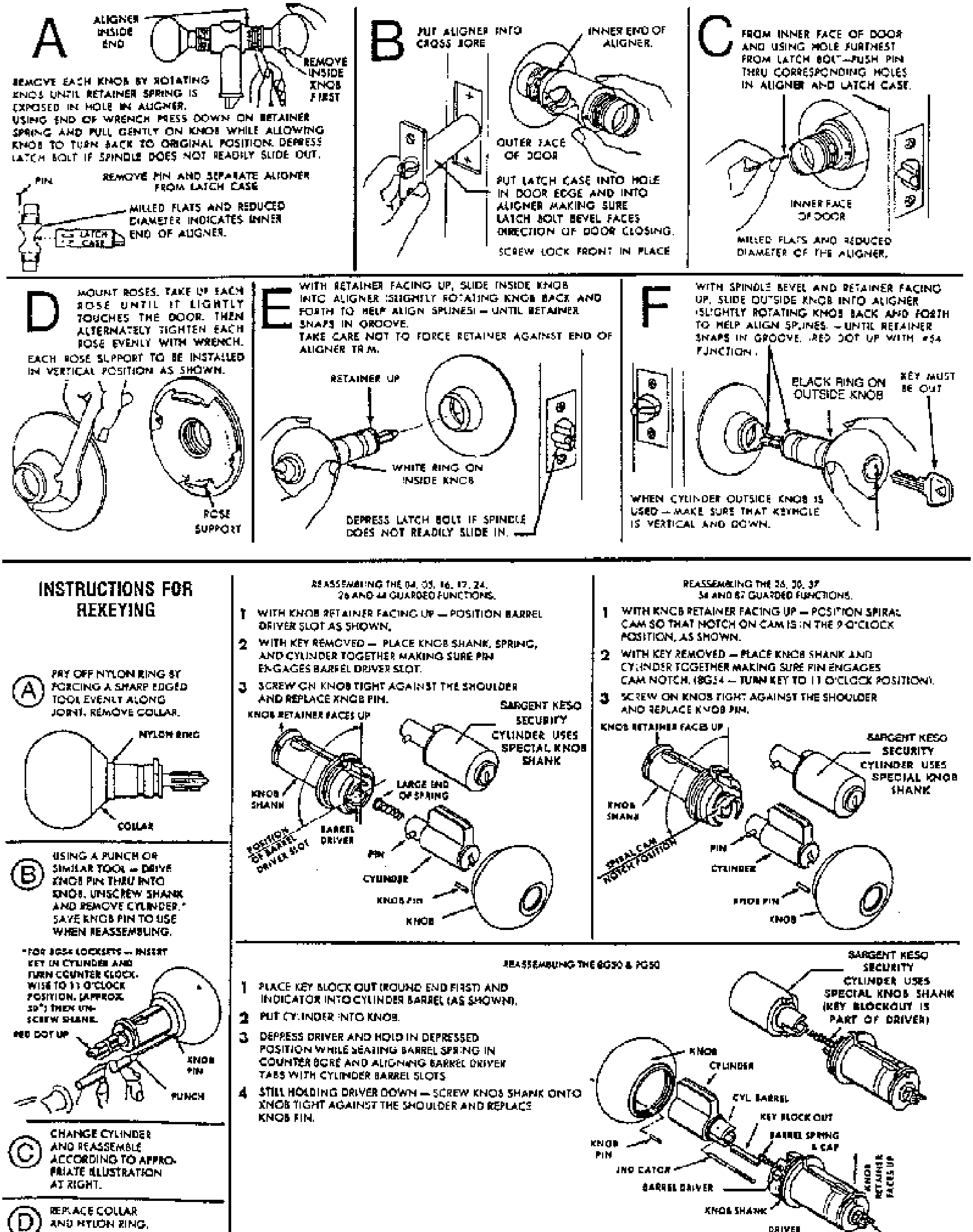
13-0513



13-0938

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.9.0 Illustrated Instructions for Cylindrical Lockset Installation



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

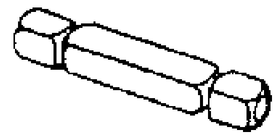
10.10.0 Deadbolts, Spindles, Security Fasteners and Guard Bolts

STAINLESS STEEL DEADBOLT

Stainless steel deadbolt with hardened steel rollers has a 1" throw.

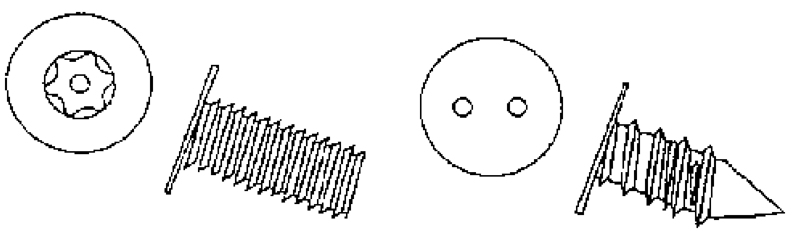
SPINDLES

Durable spindle design provides security and integrity of the lockbody by shearing off under extreme loads while preventing any damage to the lockbody. Inside and outside spindles operate independently.



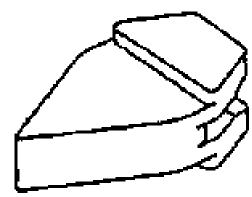
SECURITY HARDWARE

Six-lobe security screws (prefix 36-) or spanner head (prefix 37-) are available.



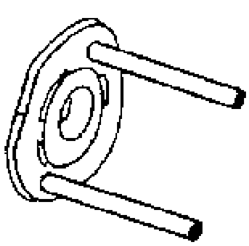
STAINLESS STEEL GUARD BOLT

Stainless steel, nonhanded guardbolt.



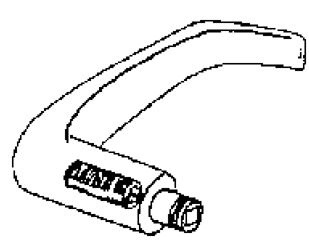
THRU-BOLTED TRIM

Mortise lock trim is thru-bolted to ensure proper alignment and security. Greater torque resistance.



TRIM CONVERTIBILITY

Outside trim levers or knobs can be easily disassembled by unscrewing the retaining nut to separate the rose/escutcheon from the lever or knob.



(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.11.0 Construction Key Systems—Illustrated

CONSTRUCTION KEY SYSTEMS (PREFIX-21)

The Sargent construction keying system protects the building owner by providing temporary masterkeying during the construction period. Regular day and masterkeys are retained by the distributor and cannot be duplicated or obtained by unauthorized personnel during construction. Temporary keys become inoperative when the regular keys are turned over to the building owner.

Orders for this system must show individual item numbers for each lock, and where room or opening numbers are known, they also must appear with each lockset.

To order prefix 21, see Sargent cylinder catalog for more details.

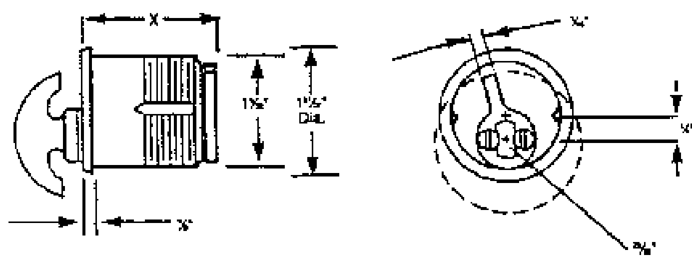
MORTISE CYLINDER TURN LEVER 124 SERIES

Cylinder: Brass
Turn Lever: Brass, Bronze, Aluminum
Cap: Brass, Bronze and Stainless Steel
Finishes: 3, 4, 9, 10, 10B, 10BL, 20D, 26, 26D, 32, 32D
Furnished standard with No. 97 Compression Ring

Length under cylinder head

No.	124-41	124-42	124-43	124-44	124-46
Length Including Cam (dim. x)	1⅛"	1¼"	1⅜"	1½"	1¾"

Cam No.	Description
124-1	Sizes 41 through 46 x cam for standard cylinder
124-3	Sizes 41 through 46 x cam for 16 and 37
124-8	Sizes 41 through 46 x cam for inside cylinder or 7892
124-101	Sizes 41 through 46 x cam for Adams Rite 1850 Lock



Pins and drivers for cylinder

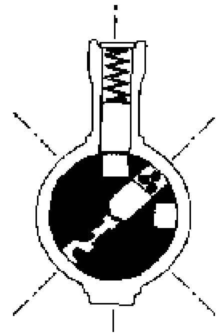
	ORDERING NO.	PIN NO.	LENGTH
Bottom Plus	13-0064	1	.170
	13-0065	2	.190
	13-0066	3	.210
	13-0067	4	.230
	13-0068	5	.250
	13-0069	6	.270
	13-0070	7	.290
	13-0071	8	.310
	13-0072	9	.330
	13-0073	10	.350
Master Plus/Drivers	13-0051	2	.040
	13-0052	3	.060
	13-0053	4	.080
	13-0054	5	.100
	13-0055	6	.120
	13-0056	7	.140
	13-0057	8	.160
	13-0058	9	.180
	13-0058	10	.200

(By permission from Sargent Manufacturing Company, New Haven, Connecticut.)

10.11.1 Construction Master Keying—Illustrated

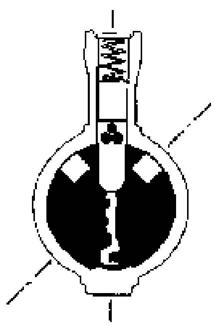
The SARGENT Cylinder will employ what is known in the industry as the Lost Ball method of construction master keying. Use the 21- as the prefix when ordering this feature. This feature will be used on the New SARGENT Master Key Systems.

Example shows Lost Ball construction feature in last chamber of cylinder. Construction feature can be used in any chamber.

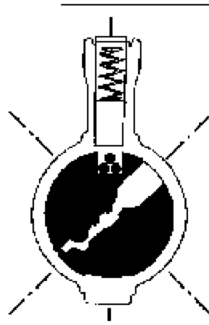


Construction key rotating cylindrical plug.

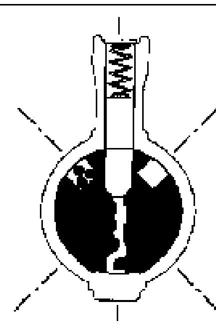
To Void Construction Key



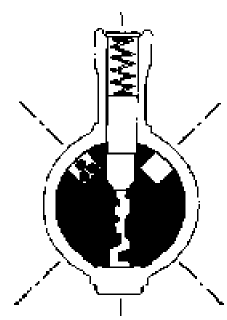
Change key inserted in cylinder.



Change key rotating. Construction balls fall into hole in the side of plug.



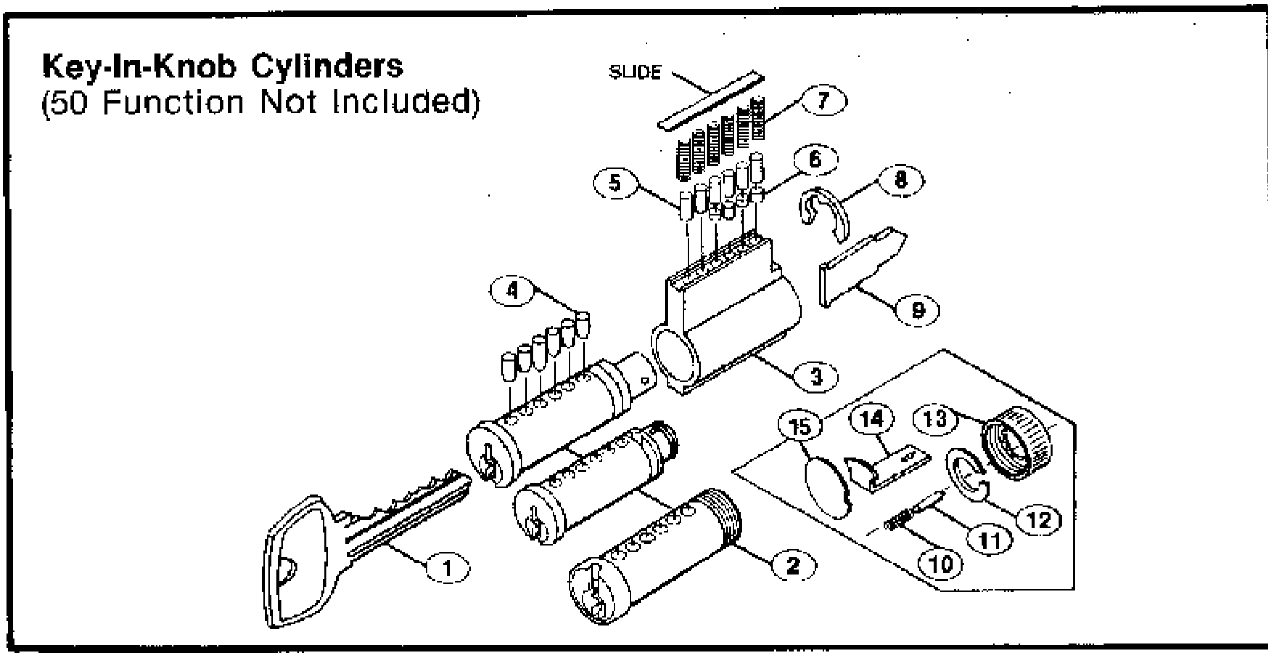
Change key rotated to position for extraction. Construction key now voided from cylinder.



Construction key inserted after balls are trapped. Driver now extends into plug chamber. Construction key will not rotate.

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.11.2 Key-in-Knob Cylinder—Exploded View



Key to parts:

1. Key blank
2. Plug and pin assembly
3. cylinder body and slide assembly
4. bottom pin
5. top pin
6. master pin
7. compression spring
8. retaining ring
9. cylinder tail piece
10. cylinder cap spring
11. cylinder cap pin
12. cylinder tail washer
13. cylinder cap
14. cylinder tail piece
15. blocking piece

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.11.3 Removable Core Cylinders and Core Cams

REMOVABLE CORE CYLINDERS

Sargent removable core offers security and convenience by making keying changes a simple matter. Rekeying and transferring keying to another door is facilitated because it is no longer necessary to disassemble the lock. A special control key releases the locking cam of the cylinder core and allows immediate removal of the core. Virtually unlimited key changes are possible, and removable core cylinders can be master keyed or grand master keyed. Removable core is available across the Sargent line of padlocks, deadlocks, bored locks and exit devices.

CONSTRUCTION REMOVABLE CORE KEYED CYLINDERS (PREFIX 64-)

The Sargent removable construction core system protects the security of an owner's masterkey system during the period of construction. It is used throughout the construction period in lieu of the permanent masterkeyed cores. This prevents the keys to the permanent system from becoming available to unauthorized persons. Upon completion of the building, the temporary construction cores are removed and replaced with the permanent removable cores which are inoperative by the construction keys. During the construction period, locks can be furnished with returnable cylinders, or plastic disposable cores. Temporary cylinders (64 prefix) are installed only in doors which must be locked during construction. The disposable plastic core (prefix 60) is recommended for all nonessential locking doors of the construction period.

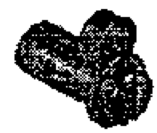
It will be the distributor's responsibility to:

- Deliver all permanent cores to the job site
- Remove all the temporary cores and install permanent cores
- Inspect each lockset to ensure satisfactory operation of permanent cores
- Deliver to building owner all day, master and control keys for the permanent system
- Return all temporary cores to New Haven on a return goods authorization (RGA)

REMOVABLE CORES ONLY SERIES 6300

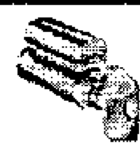
For all locksets 6-pin only
Finishes: 4, 15
When ordering, give all pertinent keying information

DISPOSABLE PLASTIC CORE



May be used for those doors that do not require locking during the construction period. (prefix 60-)
These cores are ordered with 60-7805-OB-26D

OLD STYLE REMOVABLE CORE



Available for existing systems only
Permanent Removable Cores (Prefix 51-)
If ordering for existing construction key system, give all pertinent keying information.

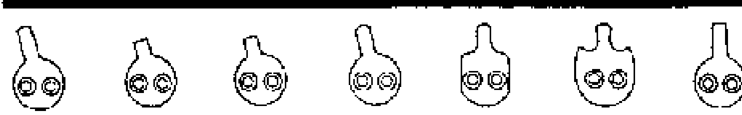
Old Style Construction Removable Core (Prefix 52-)
A separate order for permanent cores, with all necessary keying information and item numbers, for identical purposes, should accompany the lockset order. The permanent cores will be shipped directly to the distributor and not to the job site.

Mortise Type Cylinder Series 6340 & 50-6343 (for Hotels)
Brass
Cap: Brass, Bronze and Stainless Steel
Finishes: 3, 4, 9, 10, 10B, 10B, 20D, 26, 26D, 32, 32D.
Furnished standard with No. 97 compression ring.
Cam is permanently staked to body and cannot be changed in field.
50-6343 is available in C series keyways only for use in hotel function locks.

Removable Core Mortise Cylinders Series 040 and 1400
140-6 pin system Cylinder: Brass

Length under cylinder head				
No.	041	042	043	044
Length Including Cam	1[illegible]"	1[illegible]"	1[illegible]"	1[illegible]"

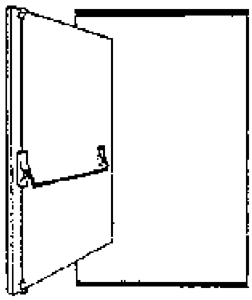
REMOVABLE CORE CAMS

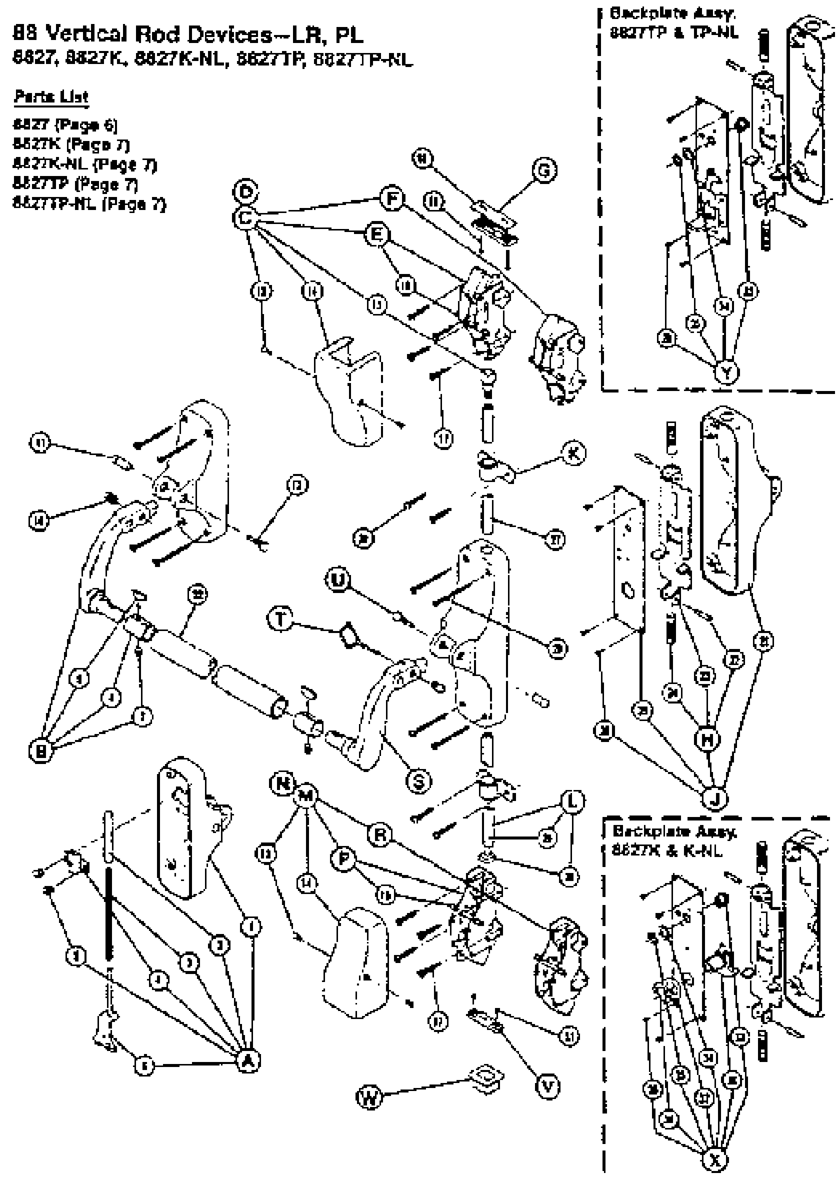


13-0542 Standard Sargent Cam	13-0806 92 and 16 Standard Sargent Cam	13-0832 Adams Rite 1850 4710	13-0813 Adams Rite 4050's	13-0922 4280 Switch Lock	13-0924 Schlage "L" Latch	Straight X1-3000

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.12.0 Panic Devices (Concealed/Surface—Applied Vertical Rod Devices)





(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.0 Panic Devices (Concealed/Surface—Applied Vertical Rod Devices)—Continued

Parts List–8827 Vertical Rod Device–LR, PL

Reference Illustration Page 5

Item	Qty.	Part No.	Description	
A	1	101713	End Case Assy.–Brz.	X
A	1	101714	End Case Assy.–Alum.	X
A	1	101715	End Case Assy.–St. Stl	X
B	1	100729	Lever Arm Assy.–LH–Brz.	X
B	1	100746	Lever Arm Assy.–LH–Alum.	X
B	1	101487	Lever Arm Assy.–LH–St. Stl.	X
C	1	101754	Top Latch Case Assy.–LR–Brz	X
C	1	101755	Top Latch Case Assy.–LR–Alum.	X
C	1	101756	Top Latch Case Assy.–LR–St. Stl.	X
D	1	101760	Top Latch Case Assy.–PL–Brz.	X
D	1	101761	Top Latch Case Assy.–PL–Alum.	X
D	1	101762	Top Latch Case Assy.–PL–St. Stl.	X
E	1	101750	Top Latch Bolt & Chassis Assy.–LR	
F	1	101752	Top Latch Bolt & Chassis Assy.–PL	
G	1	030296	299 Strike Assy.–Top	X
H	1	102701	Rod Control Assy.	
J	1	101707	Center Case Assy.–Brz.	X
J	1	101708	Center Case Assy.–Alum.	X
J	1	101709	Center Case Assy.–St. Stl.	X
K	2	101648	Rod Guide Assy.–Brz.	X
K	2	101774	Rod Guide Assy.–Alum.	X
K	2	101775	Rod Guide Assy.–St. Stl.	X
L	1	101777	Bottom Vertical Rod Assy.–Brz.	X
L	1	103234	Bottom Vertical Rod Assy.–St. Stl.	X
M	1	101757	Bottom Latch Case Assy.–LR–Brz.	X
M	1	101758	Bottom Latch Case Assy.–LR–Alum.	X
M	1	101759	Bottom Latch Case Assy.–LR–St. Stl.	X
N	1	101763	Bottom Latch Case Assy.–PL–Brz.	X
N	1	101764	Bottom Latch Case Assy.–PL–Alum.	X
N	1	101765	Bottom Latch Case Assy.–PL–St. Stl.	X
P	1	101751	Bottom Latch Bolt & Chassis Assy.–LR	
R	1	101753	Bottom Latch Bolt & Chassis Assy.–PL	
S	1	100744	Lever Arm Assy.–RH–Brz.	X
S	1	100747	Lever Arm Assy.–RH–Alum.	X
S	1	101486	Lever Arm Assy.–RH–St. Stl.	X
T	1	103868	Wedge Tite Package	
U	1	103865	Lever Arm Axle Package	
V	1	030602	248L4 Strike Assy.	
W	1	030659	304L Strike Assy.	
1	1	960517	End Case–Brz.	X
1	1	960518	End Case–Alum.	X
1	1	960519	End Case–St. Stl.	X
2	1	951081	Spring Tube	
3	1	953630	Spring	
4	1	951910	Spring Tube Bracket	
5	2	963094	#8-32 × 5/16" PPHMS–Thd. Form.	
6	1	107582	Spring Stop Sub-Assy.	

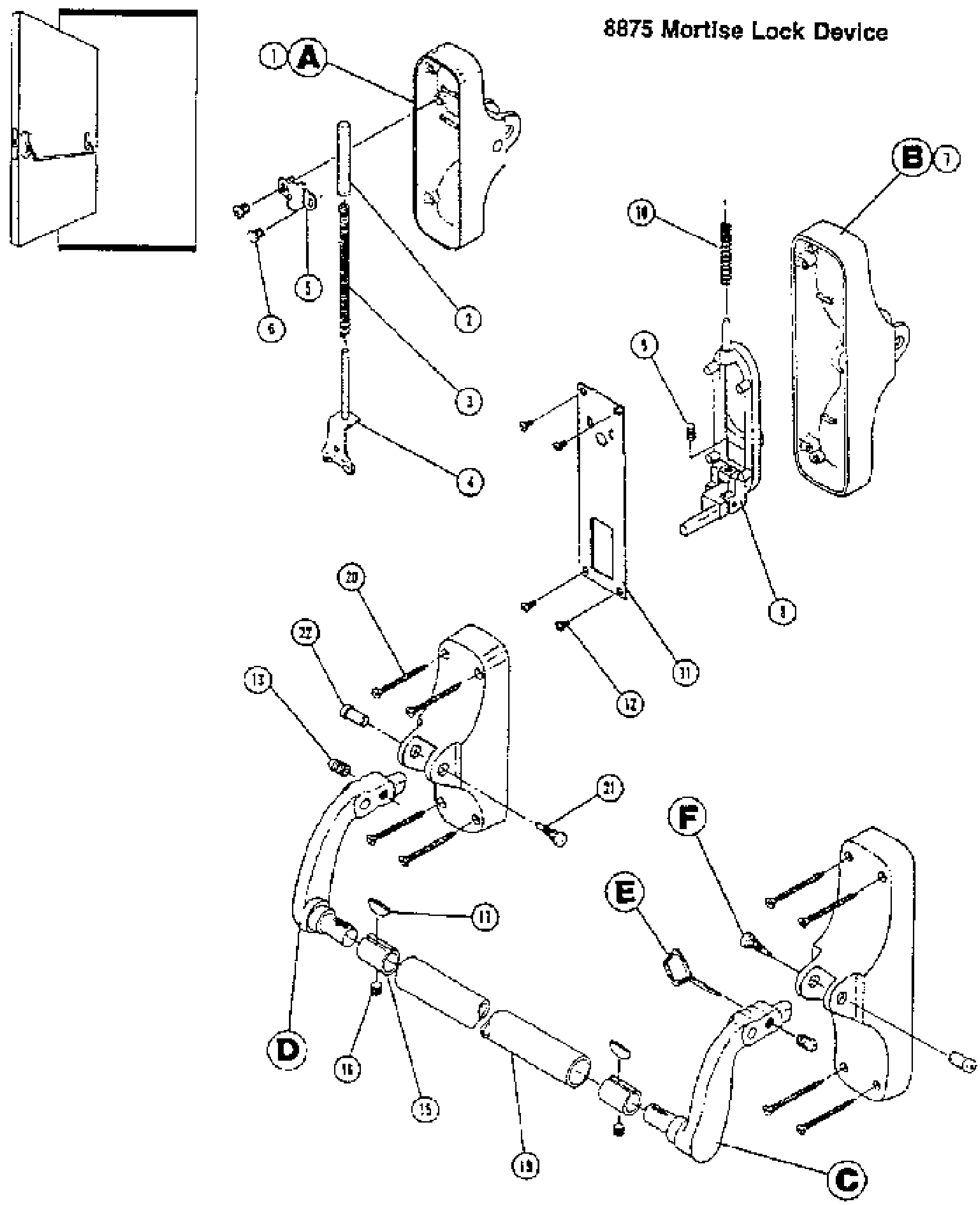
Item	Qty.	Part No.	Description	
7	2	963851	Wedge Tite Adaptor Screw (5/16"–18 × 1/4" Set Scr.)	
8	2	965676	Tube Attaching Ring	
9	2	956520	Attaching Ring Wedge	
10	1	968485	Dog Screw	
11*	2	969573	88 Axle–Female	
12*	2	969572	88 Axle–Male	
13	4	956010	#8-32 × 1/4" FPHMS–Brz.	X
13	4	956011	#8-32 × 1/4" FPHMS–St. Stl.	X
14	2	960548	Top & Bottom Latch Case Cover–Brz.	X
14	2	960585	Top & Bottom Latch Case Cover–Alum.	X
14	2	960586	Top & Bottom Latch Case Cover–St. Stl.	X
15	1	960577	Top Rod Connector–LR	
15	1	967341	Top Rod Connector–PL	
16	4	960652	Special Chassis Nut	
17	8	965288	#10-12 × 10-24 × 1" PBHCS	
18	1	945521	Adjusting Shim	
19	2	965289	#10-12 × 10-24 × 1 1/4" OPHCS	X
20**	4	965286	#10-12 × 10-24 × 1" PTHCS–Brz.	X
20**	4	965287	#10-12 × 10-24 × 1" PTHCS–St. Stl.	X
21	1	960421	Center Case–Brz.	X
21	1	960422	Center Case–Alum.	X
21	1	960423	Center Case–St. Stl.	X
22	2	963193	1/8" × 1 5/16" Lg. Spirol Pin	
23	1	961229	Rod Control	
24	2	961283	Rod Adaptor	
25	1	952530	Back Plate	
26	4	963095	#8-32 × 3/8" Lg. FPHMS–Thd. Form.	
27	1	961628	Top Vertical Rod–Brz.	X
27	1	960581	Top Vertical Rod–St. Stl.	X
28**	8	965291	#10-12 × 10-24 × 2" OPHCS–Brz.	X
28**	8	965292	#10-12 × 10-24 × 2" OPHCS–St. Stl.	X
29	1	963585	1/8" × 1/2" Roll Pin	
30	1	960578	Bottom Rod Connector	
31	2	963008	#10-24 × 1/2" Lg. OPHMS	
32	1	060275	Cross Bar Tube–Std.–27 1/2" Lg.	X
32	1	061275	Cross Bar Tube–Knurled–27 1/2" Lg.	X
32	1	060295	Cross Bar Tube–Std.–29 1/2" Lg.	X
32	1	061295	Cross Bar Tube–Knurled–29 1/2" Lg.	X
32	1	060360	Cross Bar Tube–Std.–36" Lg.	X
32	1	061360	Cross Bar Tube–Knurled–36" Lg.	X
32	1	060420	Cross Bar Tube–Std.–42" Lg.	X
32	1	061420	Cross Bar Tube–Knurled–42" Lg.	X
32	1	060500	Cross Bar Tube–Std.–(Longer than 42")	X
32	1	061500	Cross Bar Tube–Knurled–(Longer than 42")	X
*	1	103865	Lever Arm Axle Package	
**	1	900500	Mtg. Screw Package	X
***	1	900534	Mtg. Screw Package	X

X designates items that are finished.

Note: For ordering parts provide the part number, description, total quantity and finish required.

(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.1 Panic Devices (Mortise Lock Devices)



(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.1 Panic Devices (Mortise Lock Devices)—Continued

Parts List—8875-F Mortise Lock Device

Item	Qty.	Part No.	Description	
A	1	101716	End Case Assy.—Brz.	X
A	1	101717	End Case Assy.—Alum.	X
A	1	101718	End Case Assy.—St. Stl.	X
B	1	101695	Center Case Assy.—RH—Brz.	X
B	1	101696	Center Case Assy.—RH—Alum.	X
B	1	101697	Center Case Assy.—RH—St. Stl.	X
B	1	101698	Center Case Assy.—LH—Brz.	X
B	1	101699	Center Case Assy.—LH—Alum.	X
B	1	101700	Center Case Assy.—LH—St. Stl.	X
C	1	109867	Lever Arm Assy.—RH—Brz.	X
C	1	109868	Lever Arm Assy.—RH—Alum.	X
C	1	109869	Lever Arm Assy.—RH—St. Stl.	X
D	1	109858	Lever Arm Assy.—LH—Brz.	X
D	1	109859	Lever Arm Assy.—LH—Alum.	X
D	1	109860	Lever Arm Assy.—LH—St. Stl.	X
F	1	103865	Lever Arm Axle Package	
1	1	960912	End Case—Brz.	X
1	1	960913	End Case—Alum.	X
1	1	960914	End Case—St. Stl.	X
2	1	951081	Spring Tube	
3	1	953630	Spring	
4	1	107682	Spring Stop Guide Assy.	
5	1	951910	Spring Tube Bracket	
6	2	963094	#8-32 × 5/16" PPHMS—Thd. Form.	
7	1	960915	Center Case—Brz.	X
7	1	960916	Center Case—Alum.	X
7	1	960917	Center Case—St. Stl.	X
8	1	104367	Latch Control Finger Assy.—RH	
8	1	100693	Latch Control Finger Assy.—LH	
9	1	951780	Flat Point Set Screw	
10	1	958643	Spring	
11	1	960756	Back Plate	
12	4	963096	#8-32 × 3/4" PFHMS—Self Tap	
15	2	965676	Tube Attaching Ring	
16	2	963851	Wedge Tite Adaptor Screw	
17	2	956520	Attaching Ring Wedge	
19	1	060275	Cross Bar Tube—Std.—27½" Lg.	
19	1	061275	Cross Bar Tube—Knurled—Std.—27½" Lg.	
19	1	060295	Cross Bar Tube—Std.—29½" Lg.	
19	1	061295	Cross Bar Tube—Knurled—Std.—29½" Lg.	
19	1	060360	Cross Bar Tube—Std.	
19	1	061360	Cross Bar Tube—Knurled—Std.—36" Lg.	
19	1	060420	Cross Bar Tube—Std.—42" Lg.	
19	1	061420	Cross Bar Tube—Knurled—Std.—42" Lg.	
19	1	060500	Cross Bar Tube—Custom—(Lger. than 42")	
19	1	061500	Cross Bar Tube—Custom—Knurled—(Lger. than 42")	
20	8	965291	#10-12 × 10-24 × 2" OPHCS—Brz.	
20	8	965292	#10-12×10-24×2" OPHCS—St. Stl.—Alum.	
21**	2	969572	88 Axle—Male	
22**	2	969573	88 Axle—Female	
*	1	900500	Mounting Screw Package	
**	1	103865	Lever Arm Axle Package	

X designates items that are finished.

Note: For ordering parts provide the part number, description, total quantity and finish required.

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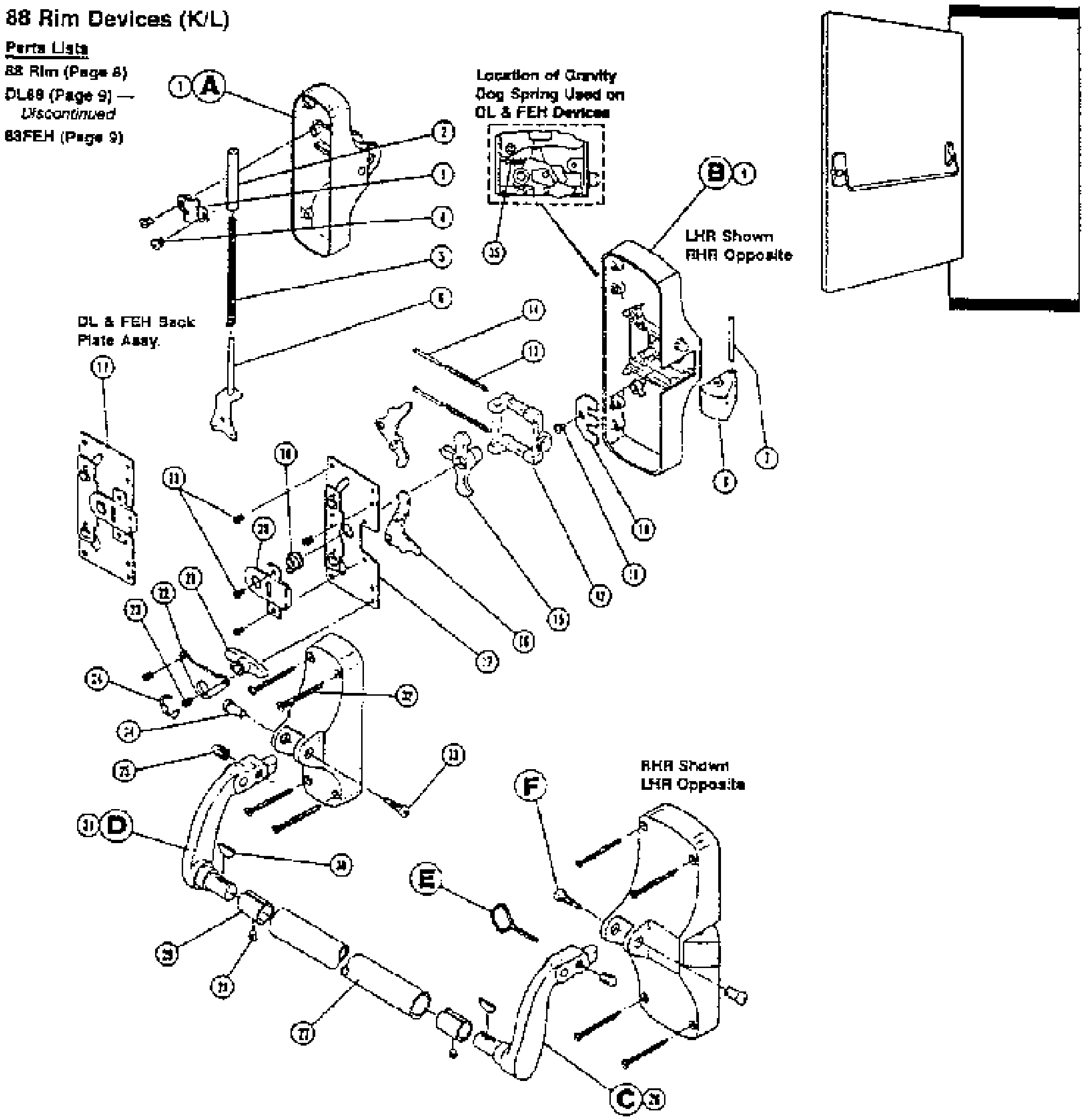
10.12.2 Panic Devices (Rim Devices Conventional and Enclosed Push-Bar Type)



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10.12.2 Panic Devices (Rim Devices Conventional and Enclosed Push-Bar Type)—Continued

Parts List–88 Rim Device–K/L
Reference Illustration–Page 7

Item	Qty.	Part No.	Description	
A	1	101713	End Case Assy.–Brz.	X
A	1	101714	End Case Assy.–Alum.	X
A	1	101715	End Case Assy.–St. Stl.	X
B	1	104154	Center Case Assy.–RH–Brz.	X
B	1	104155	Center Case Assy.–RH–Alum.	X
B	1	104156	Center Case Assy.–RH–St. Stl.	X
C	1	100744	Lever Arm Assy.–RH	X
C	1	100747	Lever Arm Assy.–RH	X
C	1	101486	Lever Arm Assy.–RH	X
D	1	100729	Lever Arm Assy.–LH	X
D	1	100746	Lever Arm Assy.–LH	X
D	1	101487	Lever Arm Assy.–LH	X
E	1	103868	Wedge Tite Key	
F	1	103865	Lever Arm Axle Pack	
1	1	960517	End Case–Brz.	X
1	1	960518	End Case–Alum.	X
1	1	960519	End Case–St. Stl.	X
2	1	951081	Spring Tube	
3	1	951910	Spring Tube Bracket	
4	2	963094	#8-32 × 5/16" PPHMS–Thd. Form.	
5	1	953630	Spring	
6	1	107682	Spring Stop Sub-Assy.	
7	1	945503	Latch Bolt Axle	
8	1	100751	Latch Bolt Sub-Assy.	X
9	1	101653	Center Case Sub-Assy.–Brz.–LH & RH	X
9	1	101654	Center Cash Sub-Assy.–Alum.–LH & RH	X
9	1	101655	Center Case Sub-Assy.–St. Stl.–LH & RH	X
10	1	960675	Latch Retainer Plate	
11	1	963098	#10-24 × 5/16" Lg. PPHMS–Thd. Form.	
12	2	952280	Latch Tail	
13	2	966762	Latch Tail Spring	
14	2	963059	1/8" × 1¼" Lg. Rd. Hd. Rivet	
15	1	951960	Master Cam	
16	1	965420	Knob Cam Lift	
17	1	104150	Back Plate Sub-Assy.	
18	1	965506	K Cylinder Cam	

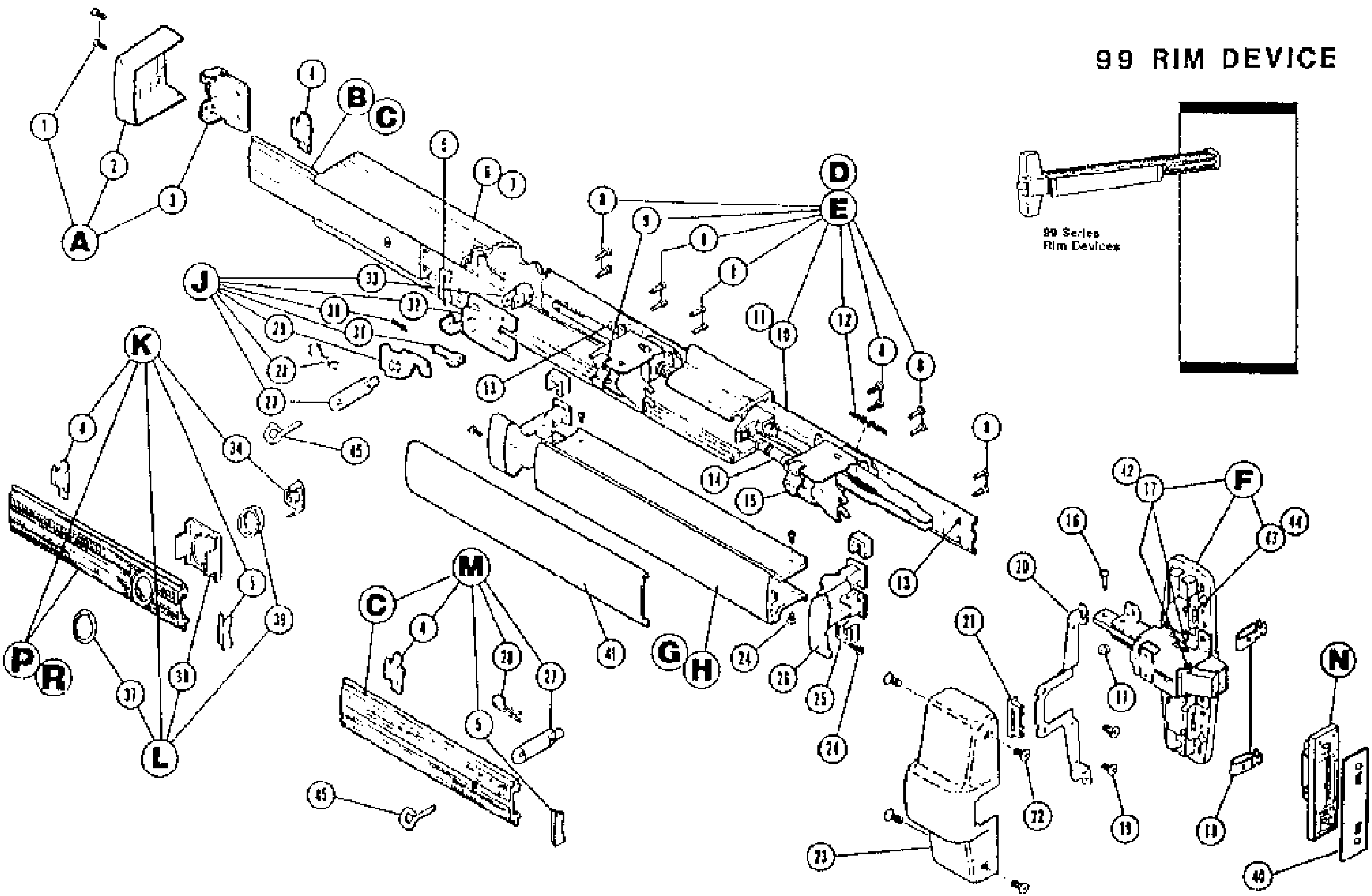
Item	Qty.	Part No.	Description	
19	5	963094	#8-32 × 5/16" Lg. PPHMS–Thd. Form.	
20	1	965503	Auxiliary Back Plate	X
21	1	951950	Knob Cam	
22	1	965418	Knob Cam Bracket	
23	1	963712	#8-32 × 3/8" Lg. PPHMS–Thd. Form.	
24	1	963103	Snap Ring–Truarc #5133-62	
25	2	968485	Dog Screw	
26	1	101444	Lever Arm & Adaptor Assy.–RH–Brz.	X
26	1	101446	Lever Arm & Adaptor Assy.–RH–Alum.	X
26	1	101479	Lever Arm & Adaptor Assy.–RH–St. Stl.	X
27	1	060275	Cross Bar Tube–Std.–27½" Lg.	
27	1	061275	Cross Bar Tube–Knurled–27½" Lg.	
27	1	060295	Cross Bar Tube–Std.–29½" Lg.	
27	1	061295	Cross Bar Tube–Knurled–29½" Lg.	
27	1	060360	Cross Bar Tube–Std.–36" Lg.	
27	1	061360	Cross Bar Tube–Knurled–36" Lg.	
27	1	060420	Cross Bar Tube–Std.–42" Lg.	
27	1	061420	Cross Bar Tube–Knurled–42" Lg.	
27	1	060500	Cross Bar Tube–Custom–(Longer than 42")	
27	1	061500	Cross Bar Tube–Custom–Knurled–(Longer than 42")	
28	2	963851	Wedge Tite Adapt. Screw (5/16"-18 × 5/8" Set Scr.)	
29	2	965676	Tube Attaching Ring	
30	2	956520	Attaching Ring Wedge	
31	1	101445	Lever Arm & Adaptor Assy.–LH–Brz.	X
31	1	101447	Lever Arm & Adaptor Assy.–LH–Alum.	X
31	1	101480	Lever Arm & Adaptor Assy.–LH–St. Stl.	X
32*	8	965291	#10-12 × 10-24 × 2 OPHCS–Brz.	
32*	8	955292	#10-12 × 10-24 × 2 OPHCS–St. Stl.	
33**	2	969572	88 Axle–Male	
34**	2	969573	88 Axle–Female	
*	1	900500	Mounting Screw Package	X
**	1	103865	Lever Arm Axle Package	

X designates items that are finished.

Note: For ordering parts provide the part number, description, total quantity and finish required.

(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.3 Panic Devices (Rim Devices and Other Types of Pushes)



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10.12.3 Panic Devices (Rim Devices and Other Types of Pushes)—Continued

Parts List–99 Rim Device

Item	Qty.	Part No.	Description	
A	1	110293	Mechanism End Cap	X
B	1	110671	Std. Cover Plate Assy. 2'6"-3'0" Door	X
C	1	110672	Std. Cover Plate Assy. 3'1"-4'0" Door	X
D	1	110760	Base Plate Assy. 2'6"-3'0" Door	
E	1	110761	Base Plate Assy. 3'1"-4'0" Door	
F	1	110831	Center Case Assy. (Less Cover)	
G	1	109823	Push Bar Sub-Assy. 2'6"-3'0" Door	
H	1	109824	Push Bar Sub-Assy. 3'1"-4'0" Door	
J	1	107970	Dogging Sub-Assy	
K	1	050115	CD Conversion Kit	
L	1	107815	Cylinder Hardware Assy.	
M	1	050114	Std. Conversion Kit	
N	1	030298	299 Strike	
P	1	110673	CD Cover Plate Assy. 2'6"-3'0" Door	X
R	1	110674	CD Cover Plate Assy. 3'1"-4'0" Door	X
1	2	963911	#8 32 × 1/2" OPHMS Thd. Cut	
2	1	970256	Mechanism Case End Cap	X
3	1	970151	Mechanism Case Mounting Bracket	
4	1	967033	Anti-Rattle Spring	
5	1	966298	Cover Bearing Insert	
6	1	968144	Mechanism Case 2'6"-3'0" Door	X
7	1	968146	Mechanism Case 3'1"-4'0" Door	X
8	12	963094	#8-32 × 5/16" PPHMS	
9	1	970079	Bearing Strip	
10	1	970033	Base Plate—2'6"-3'0" Door	
11	1	970034	Base Plate—3'1"-4'0" Door	
12	1	968555	Latch Return Spring	
13	4	970183	Rubber Bumper	
14	1	969613	Shock Absorber	
15	1	969612	Holder	
16	1	969520	Control Link Pin	
17	3	964066	Retaining Ring (Truarc #T5304-18)	
18	2	968101	Cover Retaining Clip	

Parts List–99 Rim Device

Item	Qty.	Part No.	Description	
19	2	964166	#12-24 × 1/2" PPHMS-T/Cut Type T	
20	1	969841	Bracket	
21	1	969400	Cover Bearing Insert	
22	4	964041	#8-18 × 1/2" FPHSMS-Type A	X
23	1	969398	99 Rim Center Case Cover (Zinc)	X
23	1	970092	99 Rim Center Case Cover (Brs.)	X
24	6	964041	#8-18 × 1/2" FPHMS (Undercut AB)	
25	4	960496	Push Bar Guide	
26	2	968650	Push Bar End Cap	X
27	1	968112	Dogging Shaft	
28	2	963909	#22 Hitch Pin	
29	1	969941	Dogging Hook	
30	1	966384	Dogging Spring	
31	1	968115	Dogging Spring Guide	
32	1	968117	Dogging Housing	
33	1	958114	Dogging Axle	
34	1	968116	CD Actuator Arm	
37	1	951267	Cylinder Collar	X
38	1	957032	Cylinder Locating Washer	
39	1	959010	Cylinder Lock Nut	
40	1	945521	Adjusting Shim	
41	1	057016	Std. Push Bar Trim—2'6"-3'0" Door	X
41	1	057023	Std. Push Bar Trim—3'1"-4'0" Door	X
41	1	057116	Knurled Push Bar Trim—2'6"-3'0" Door	X
41	1	057123	Knurled Push Bar Trim—3'1"-4'0" Door	X
41	1	057216	Embossed Push Bar Trim—2'6"-3'0" Door	X
41	1	057223	Embossed Push Bar Trim—3'1"-4'0" Door	X
42	2	959467	Latch Bolt Pin	
43	2	957448	Latch Link Pin	
44	2	954085	Retaining Ring (Truarc T5304-15)	
45	1	959066	Special Hex Key	
	1	900561	Device Mounting Screw Package	
	1	900263	299 Strike Mounting Screw Package	X

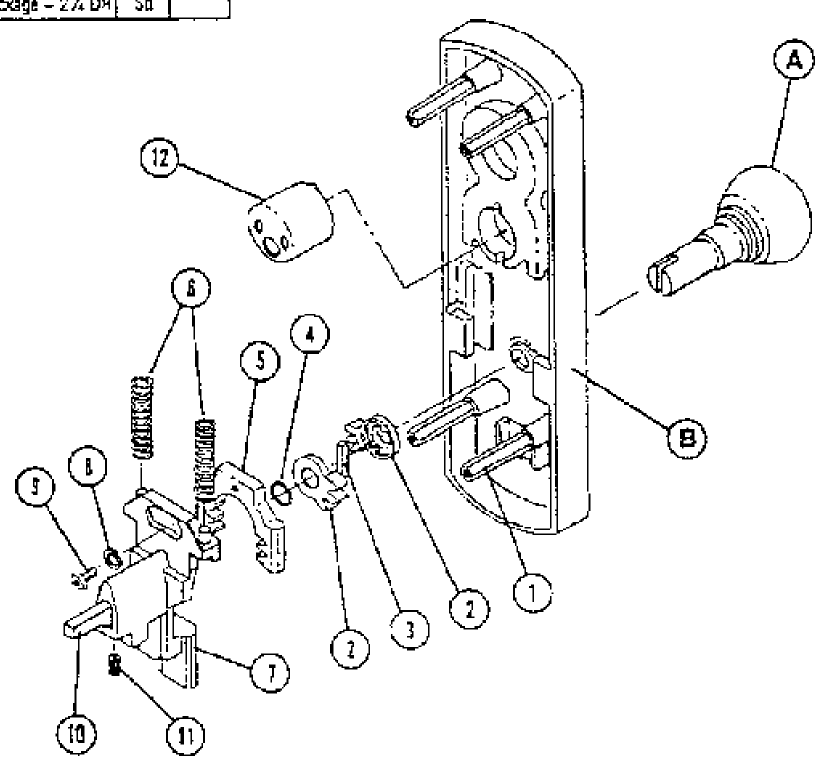
X Designates items that are finished.

(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.4 Panic Devices (Outside Trim)

Parts List – 991K-R&V Trim

Item #	Qty	Part #	Description	Mat'l	Fin. (X)
		047011	991K-R&V Trim	Brs	X
		047013	991K-R&V Trim (Knurled Knob)	Brs	X
A	1	110537	Orbit Knob Assy	Brs	X
A	1	110538	Orbit Knob Assy (Knurled)	Brs	X
B	1	110539	991K-R&V Trim Plate Assy	Brs	X
1	4	969546	Hex Stud	Stl	
2	2	969551	Pinion Gear	Stl	
3	1	969544	Straight Key	Stl	
4	1	963767	Retaining Ring (Truarc #5100-43)	Stl	
5	1	969537	Slider Rack	Stl	
6	2	969012	Spring	Stl	
7	1	969535	Slider	Stl	
8	1	963925	#10 Internal Tooth Lock Washer	Stl	
9	1	964086	#10-24 x 3/4" Button Hd. Cap Screw	Stl	
10	1	969545	Rim & Vertical Finger	Stl	
11	1	963638	1/4-20 x 3/4" Soc. Set Screw	Stl	
12	1	968201	Cylinder Retaining Cup	Stl	
		900837	Mounting Screw Package – 1¾ DR	Stl	
		900838	Mounting Screw Package – 2¼ DR	Stl	



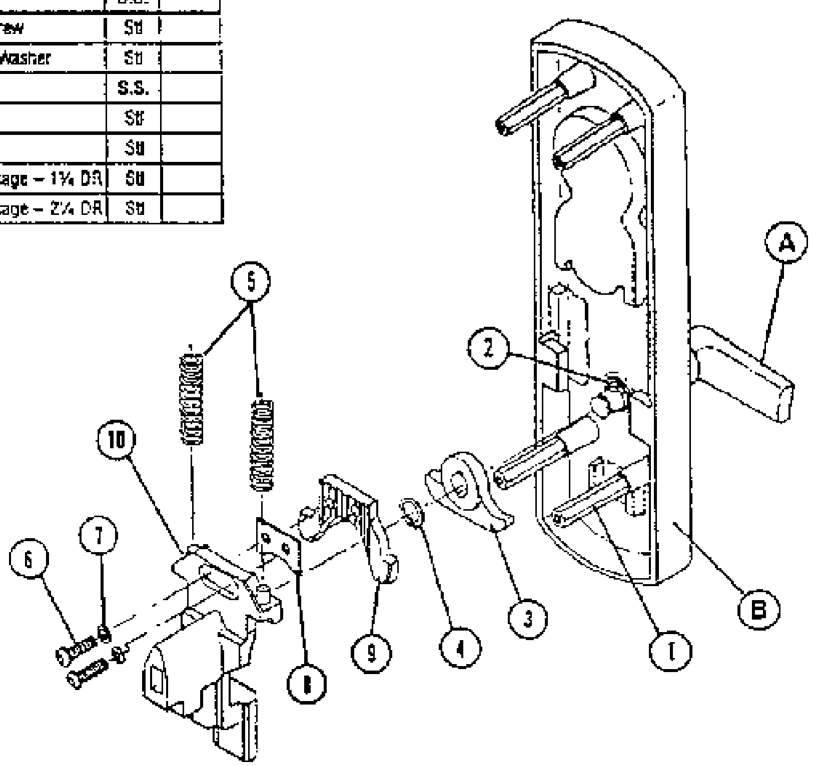
991K-R&V Trim

(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.12.4 Panic Devices (Outside Trim)—Continued

Parts List – 992L-BE-M Lever Trim

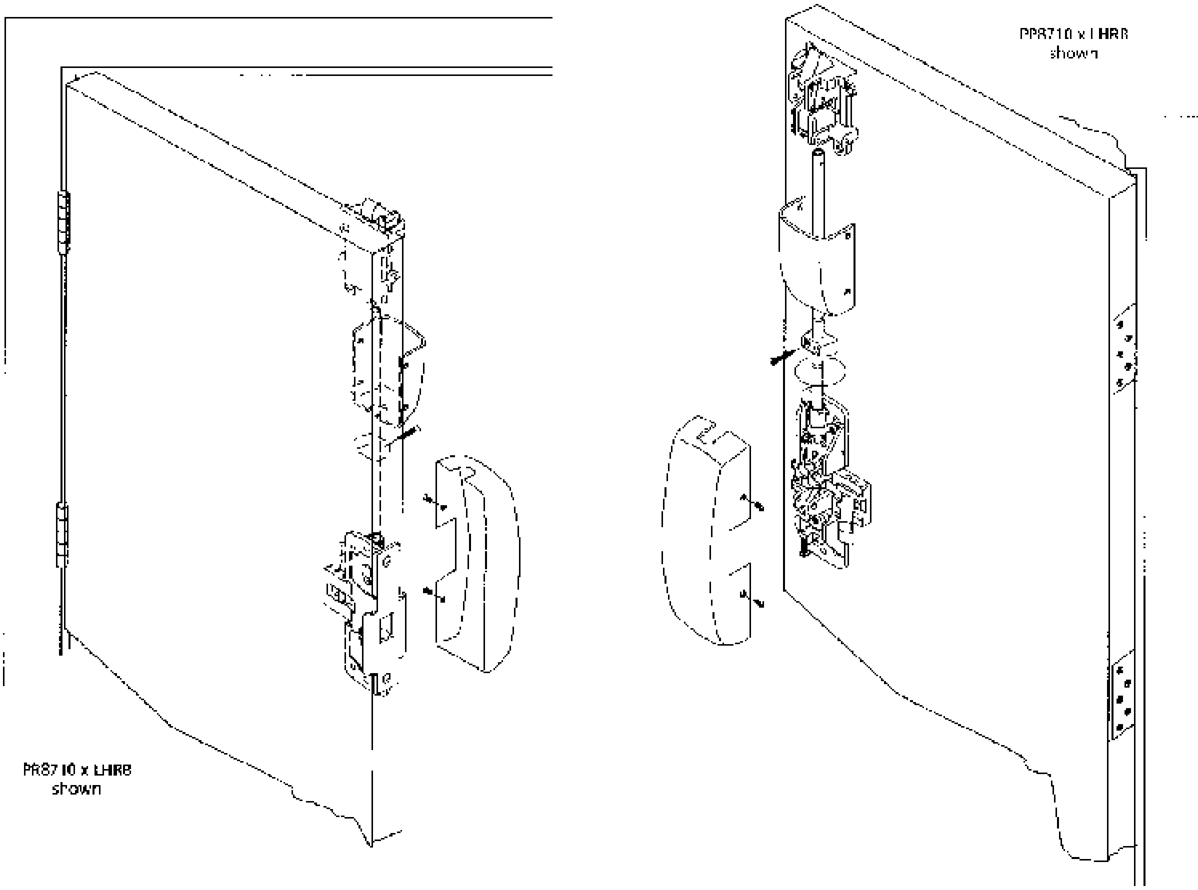
Item #	Qty	Part #	Description	Mat'l	Fin. (X)
A	1	110792	#01 Lever Assy	Brs	X
A	1	111895	#01 Lever Assy	Brz	X
A	1	111667	#02 Lever Assy	Brs	X
A	1	111668	#02 Lever Assy	Brz	X
A	1	110791	#03 Lever Assy	Brs	X
A	1	111643	#03 Lever Assy	Brz	X
A	1	110793	#06 Lever Assy	Brs	X
A	1	111644	#06 Lever Assy	Brz	X
A	1	111665	#07 Lever Assy	Brs	X
A	1	111666	#07 Lever Assy	Brz	X
A	1	111681	#12 Lever Assy – RHR	Brs	X
A	1	111683	#12 Lever Assy – LHR	Brs	X
A	1	111682	#12 Lever Assy – RHR	Brz	X
A	1	111684	#12 Lever Assy – LHR	Brz	X
A	1	111663	#17 Lever Assy	Brs	X
A	1	111664	#17 Lever Assy	Brz	X
B	1	110798	Trim Plate Sub-Assy	Brs	X
C	1	110787	Slider Assy	Stl	
1	4	969546	Hex Stud	Stl	
2	1	969556	Shear Pin	Stl	
3	1	969548	Turnpiece Cam	Stl	
4	1	964097	Retaining Ring – Truarc #5101-43	Stl	
5	2	959504	Lift Spring	S.S.	
6	2	954086	#10-24 x ¾" Cap Screw	Stl	
7	2	963925	#10 Int. Tooth Lock Washer	Stl	
8	1	970120	Adjustment Shim	S.S.	
9	1	969536	Slider Yoke	Stl	
10	1	969535	Slider	Stl	
	1	900837	Mounting Screw Package – 1¾ DR	Stl	
	1	900836	Mounting Screw Package – 2¼ DR	Stl	



992L-BE-M Lever Trim

(By permission from Von Duprin Exit Devices—Ingersoll-Rand, Inc., Indianapolis, Indiana.)

10.13.0 Double Egress Mortise/Latchbolt Devices



PP8700

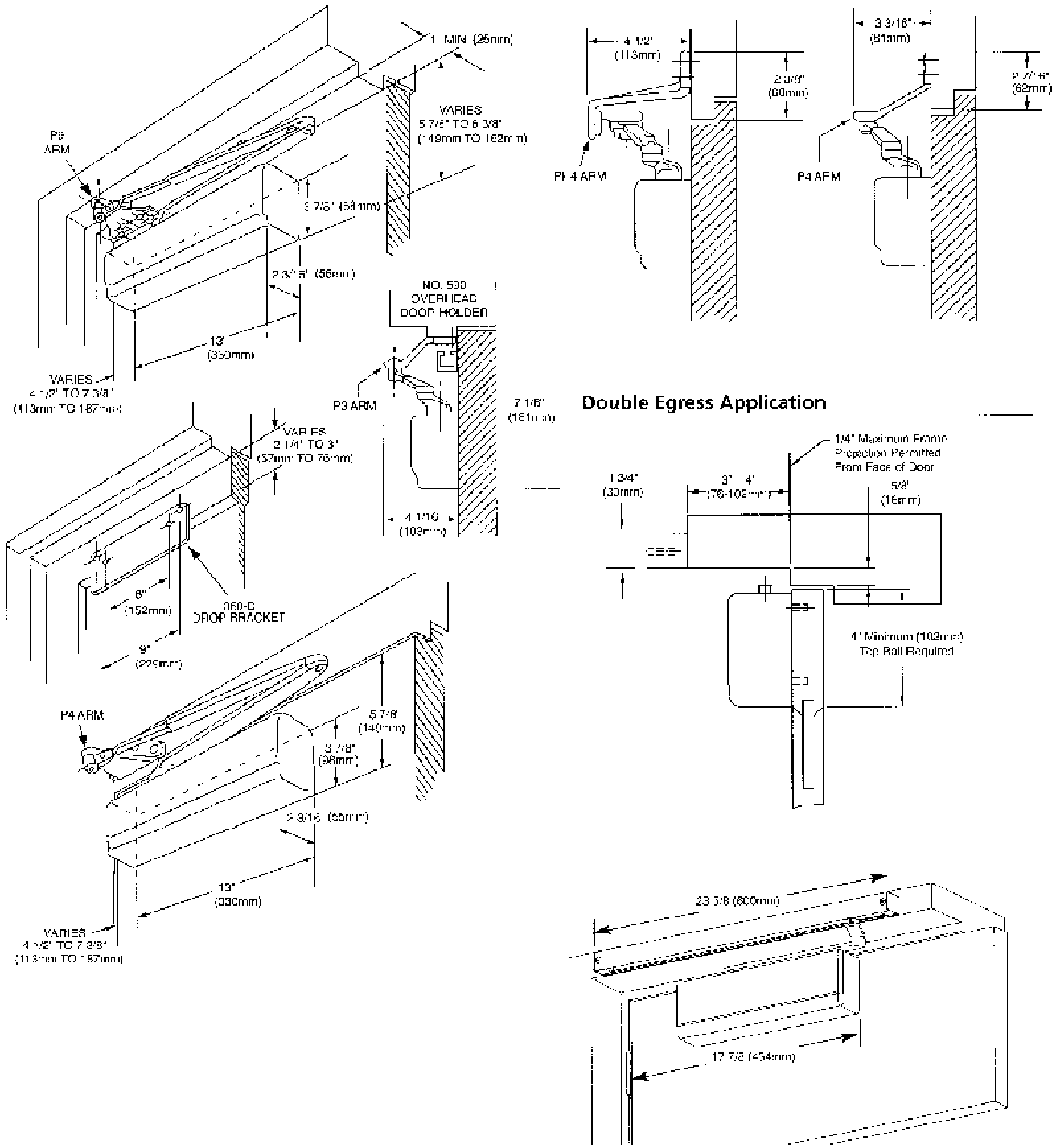
Denotes Pair of Doors or Double Egress applications using a mortise center case where the latchbolt **projects** into the other door. Only one PP8700 series exit will work with one PR8700 series exit device as a pair.

PR8700

Denotes Pair of Doors or Double Egress applications using a mortise center case where the latchbolt is **recessed** into the mortise case and pushes the projected latchbolt out of the way for egress purposes. Only one PR8700 Series exit will work with one PP8700 series exit device as a pair.

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.0 Closers—Parallel Arm Application

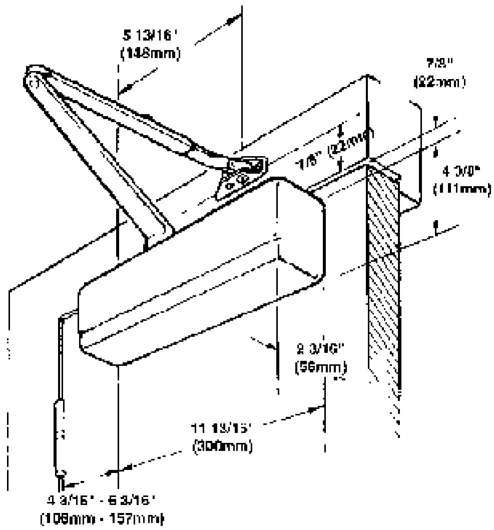


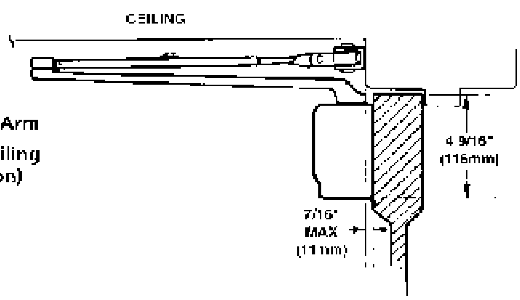
(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.1 Closers—Standard Application

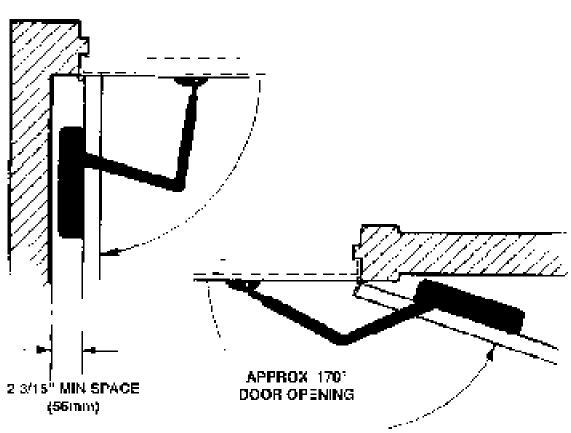
Standard Application

25-O Arm



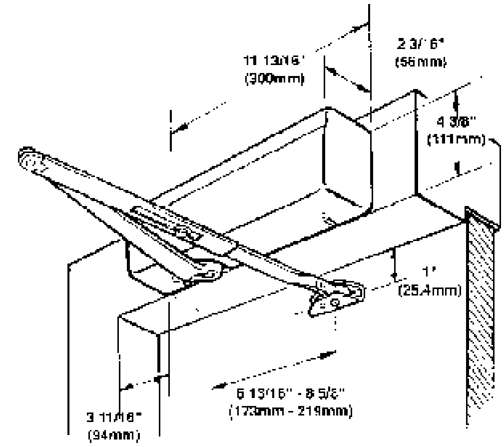


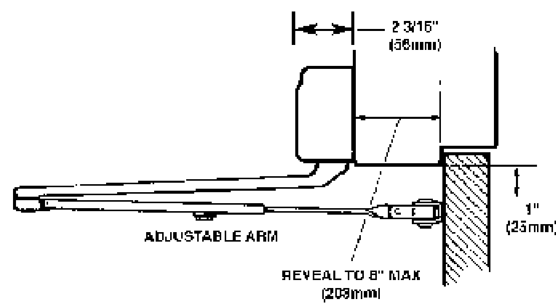
25-OLC Arm
(Low ceiling condition)



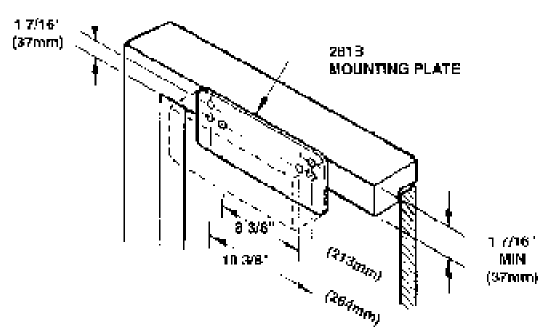
Top Jamb Application

25 OZ Arm



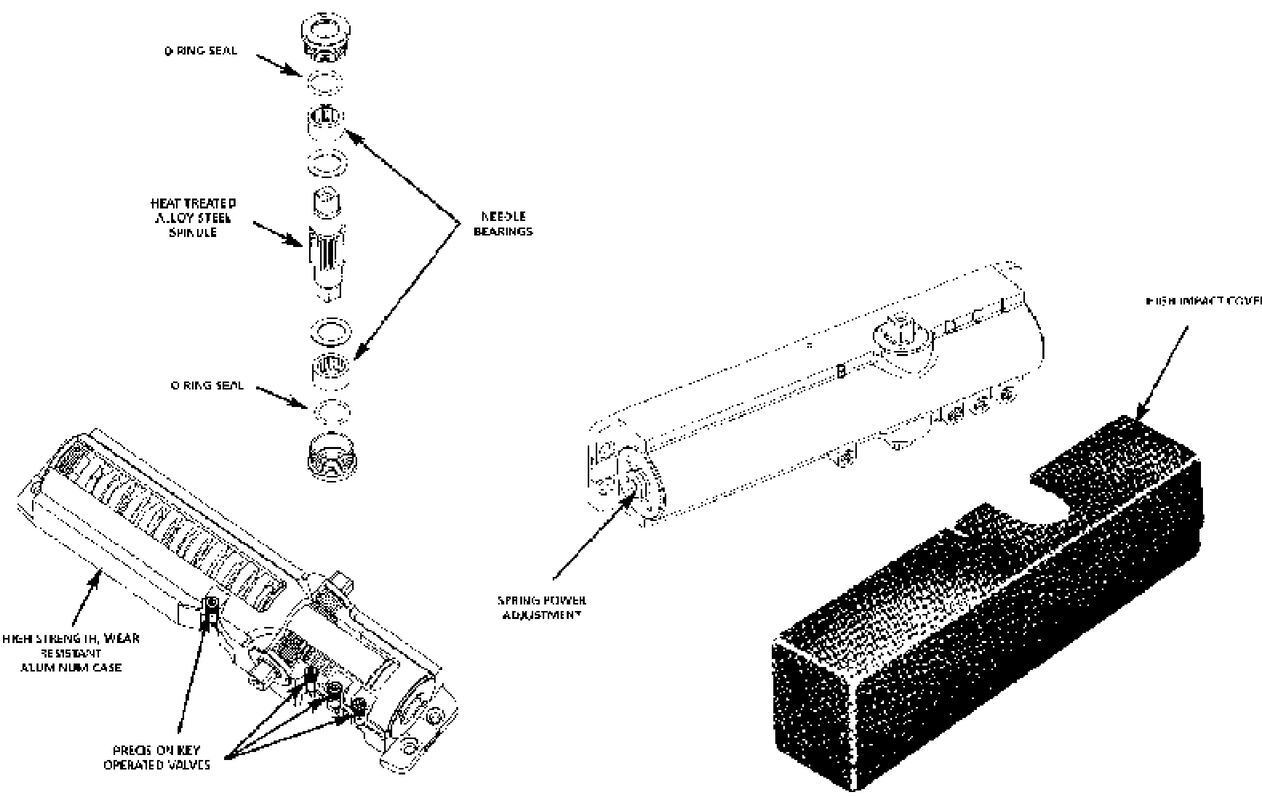


Top Jamb Application (with low ceiling)



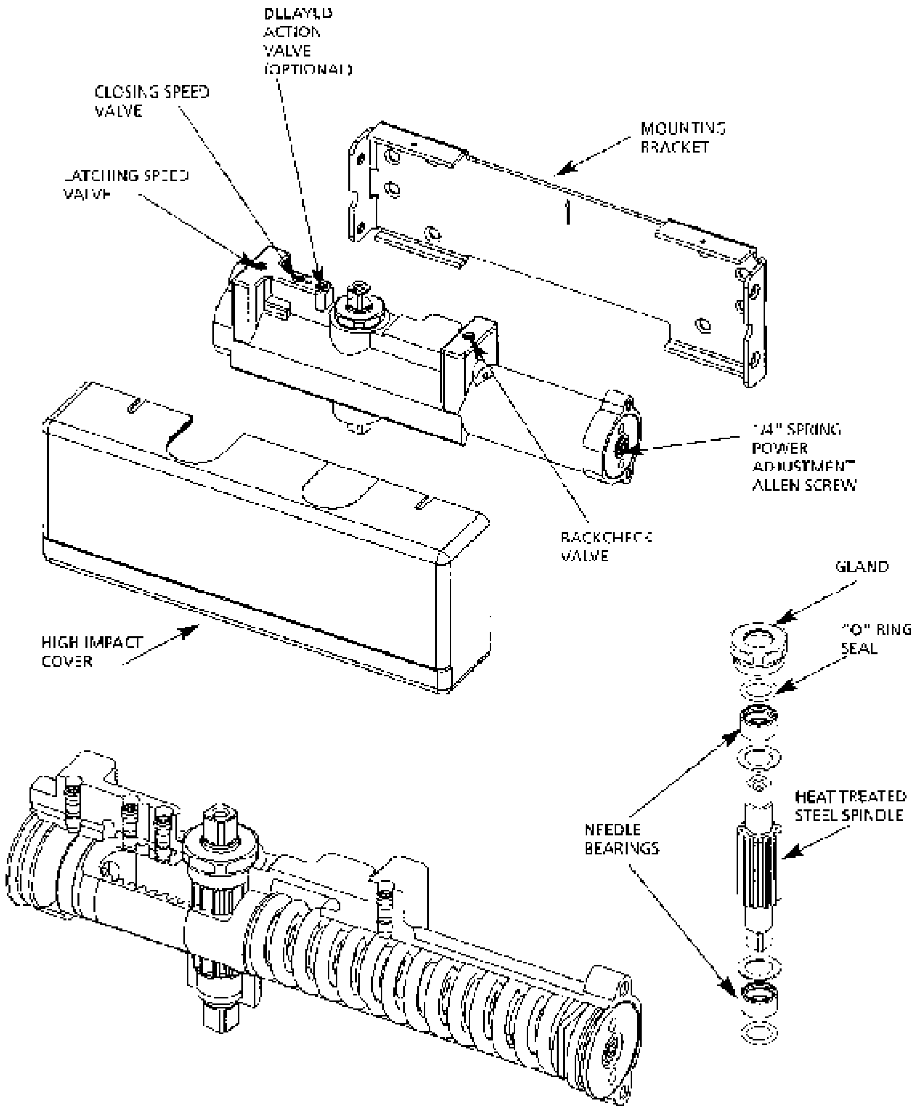
(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.2 Closers—Spring Powered—Exploded View



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.3 Closers—Spring Powered, with Delay Valve—Exploded View



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.4 Closers—Door Opening, Closing Cycles

Door Opening Cycle

The door opening cycle compresses the springs and positions the fluid to control the other cycles.

Backcheck

The backcheck cycle is controlled by the backcheck valve. This cycle enables the closer to slow the opening swing of the door. This is a standard feature of all SARGENT 1430/1431 Series Closers. It should be stopped by a wall, floor or SARGENT overhead stop.

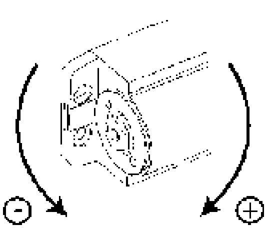
Delayed Action Cycle

The delayed action cycle is controlled by the delayed action valve. This is an option that slows the speed of the closer through the cycle arc to an almost imperceptible movement. This allows more time for those with walkers or wheel chairs to pass through the opening. The delayed action feature is furnished with backcheck as standard.

To order: Suffix DA to the closer 1430 DA x O x EN

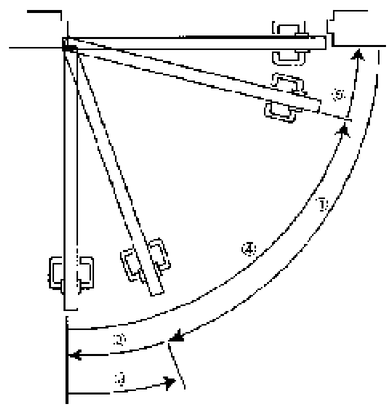
Adjustable Spring Feature

The 1430/1431 Series Closers provide adjustable spring power to accommodate various installations.



Door Closing and Latching Cycles

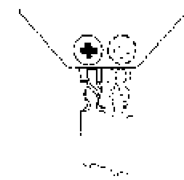
Two separate valves control the door closing and latching speeds. The closing cycle controls the speed of door closing from the full opened position to approximately five inches from the closed position. The latching cycle controls this last five inches.



1. Opening Cycle
2. Backcheck Cycle
3. Delayed Action Cycle
4. Closing Cycle
5. Latching Cycle

Arm Leverage Adjustments

The 1430/1431 Series Door Closers have the provision to adjust the leverage of the "O", "RO", "OLC", "OZ", "OZA", "F", "FZ" and "FZA" arms by changing the pivot position of the arm in the foot. The foot itself does not have to be removed from the door or jamb.



ANSI Specifications

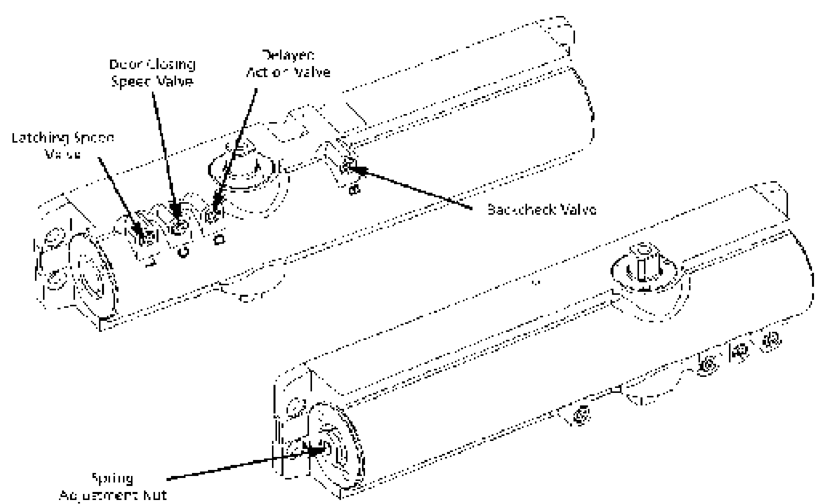
The 1430/1431 Series Door Closers are certified in accordance to ANSI/BHMA Standard A156.4 Grade 1.

Underwriters Laboratories and "UL Listed to Canadian safety standards" Listing SARGENT 1430/1431 Series Door Closers have been listed by the Underwriters Laboratories, Inc. as follows:

"For Self-Closing Doors without hold open feature"

"For automatic doors with hold-open arm embodying fusible link release.

Conforms to standards UL 10C and UBC 7-2 (1997). Positive Pressure Fire Test



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.14.5 Closers—Adjustments

Closer Adjustment

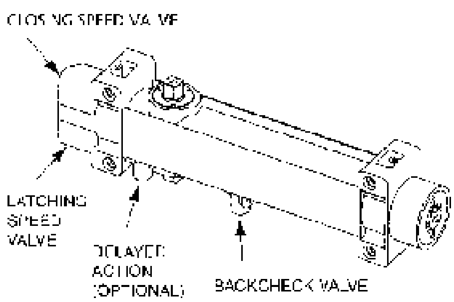
All 351 closers are equipped with key control valves to discourage unauthorized tampering with closing cycle adjustments.

Door and Latching Speeds

Two separate valves control the closing speed of the door. The door speed valve controls the speed of the door from full opening to within approximately 2" to 10" of the closed position. The latching speed valve controls the speed of the door from approximately 2" to 10" to full closing, turning either valve in a clockwise direction slows the speed of the door.

Backcheck

Backcheck is designed to start at approximately 70° door opening. The backcheck feature is not to be used as a positive stop. A door stop must be used.



Adjustable Spring Feature

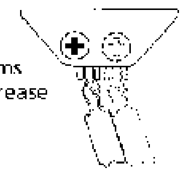
All door closers offer an adjustable spring feature. Spring power of the closer can be increased from a size 1 closer to a size 6 by turning the spring adjustment nut clockwise.

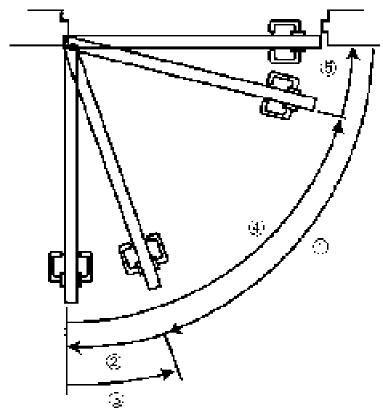
Delayed Action (optional feature)

A delayed action feature is available for all applications and arms. This feature permits the door to close very slowly through the delayed action cycle range. Closers with this feature are furnished with backcheck as standard.

Arm Leverage Adjustment

Closers using 'O' or 'T' arms have the provision to increase closing power by 15% by adjusting foot pivot.





1. Opening Cycle
2. Backcheck
3. Delayed Action Cycle
4. Closing Cycle
5. Latching Cycle

All Weather Fluid Standard

Through Bolts and Mortise Nuts

When through bolting is ordered, factory will furnish mortise nuts only for use with the machine screws furnished with the closer. Nuts are sized to accommodate 1 3/8" (35mm) or 1-3/4" (44mm) thick doors. Specify thickness when ordering. If not specified, nuts for a 1-3/4" (44mm) door will be furnished. For 2-1/4" (57mm) thick doors, thru bolts will be furnished with mortise nuts. Thru bolting is not recommended for 2-1/4" (57mm) thick hollow metal doors unless a bridge type reinforcement is provided to prevent collapse of top rail when thru bolts are tightened.

Use of Auxiliary Door Stops

A door stop is recommended to serve as a final stop in order to protect the wall, trim, door and closer. This is true for all cases whether or not a door closer holder arm, or closer with backcheck is used.

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10.15.0 Exit Devices—Push Rail Type

Overview

The SARGENT Electroguard® is designed for any 80 Series Exit Device which requires a delay on egress. Common applications of the Electroguard® include maternity wards, Alzheimer's patient areas, psychiatric facilities and airports for security or control purposes. When the device is armed through the use of the cylinder in the rail assembly and the push rail is depressed for more than two seconds, the horn in the rail assembly will sound. During the next fifteen seconds, the push rail cannot be fully depressed to exit. After fifteen seconds, the rail assembly unlocks and egress is granted.

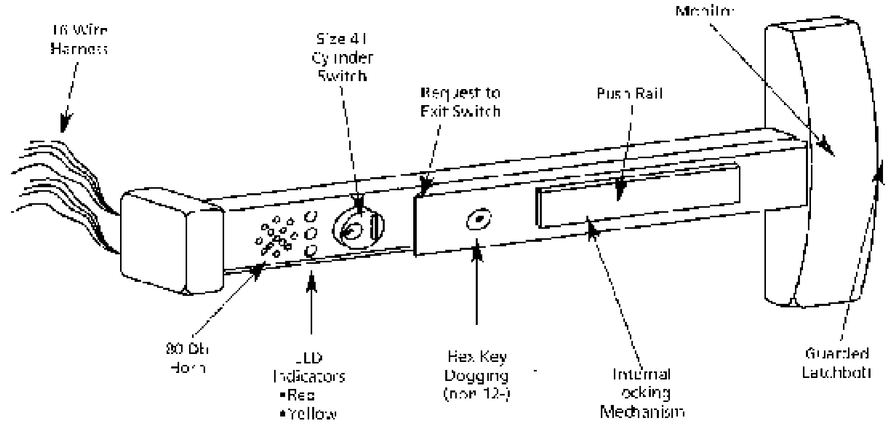
Depending on the outside trim being used, free ingress is allowed for up to ten seconds. If the latchbolt is retracted for more than ten seconds, the unit will go into an irreversible alarm condition. This prevents latchbolt tampering. If ten seconds is not desirable, an external inhibit control can be used which overrides this delay: key switch, card reader, key pad, etc.

This device will provide a momentary release (adjustable 5-80 seconds) when the cylinder in the rail assembly is used to egress. The system can also be de-energized during the day through the maintained mode and armed in the evening. Several options are available to be integrated with the Electroguard®: fire alarm, remote alarm, door position, external inhibit input, voice output, latchbolt status, and gang release.

Standard Features

- Fire Alarm Input
- Remote Alarm
- Door Position Sensor
- Inhibit Input
- Voice Module Output
- Latchbolt Monitor
- Ganged Release Output
- Ganged Release Input

RHRB Rim Device Shown



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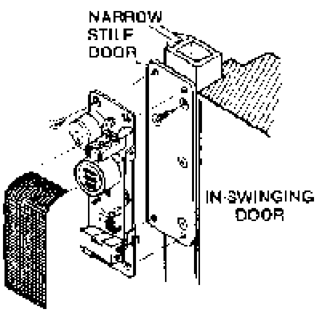
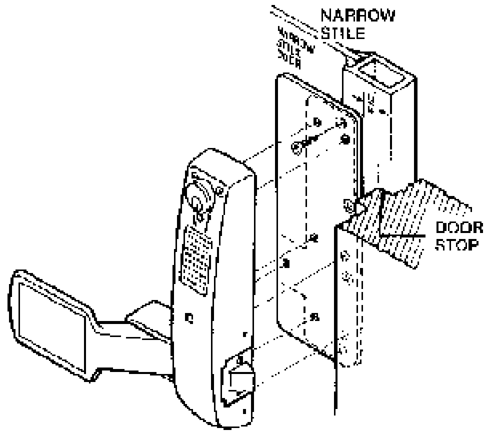
10.15.1 Exit Devices—Suggested Mounting Locations for Alarm Type Devices

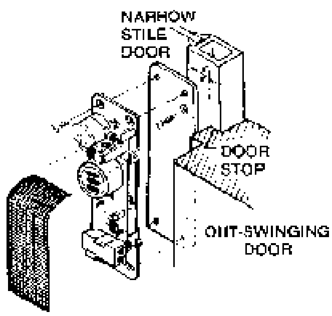
Narrow Stile Mounting Plates

3273 Narrow Stile Mounting Plate for 540/550 Alarms

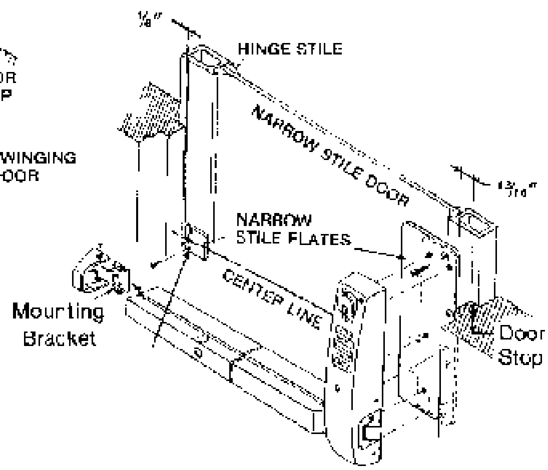


3274 Narrow Stile Mounting Plate for 5100 device



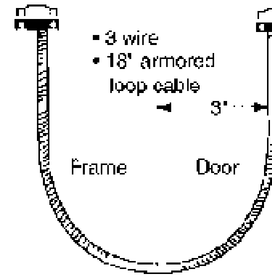


3275 Narrow Stile Mounting Plates for 5800 device



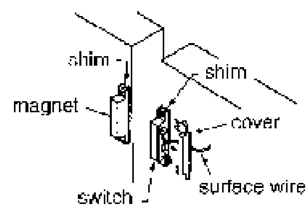
Accessories

3261 Armored Door Loop



3285 Door Status Switch

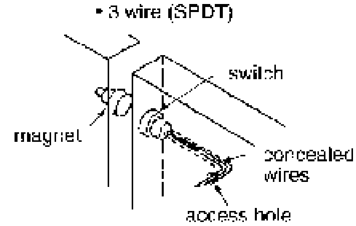
• Surface applied



• Not available for 540 Alarms.

3287 Door Status Switch

• Concealed
• 3 wire (SPDT)



• Not available for 540 Alarms.

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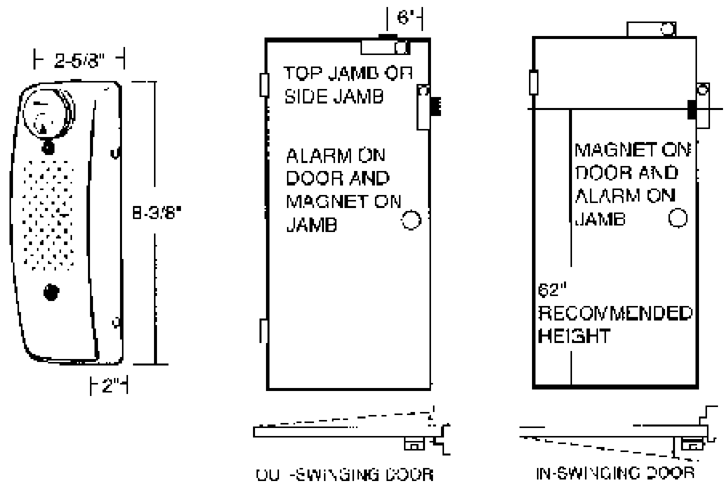
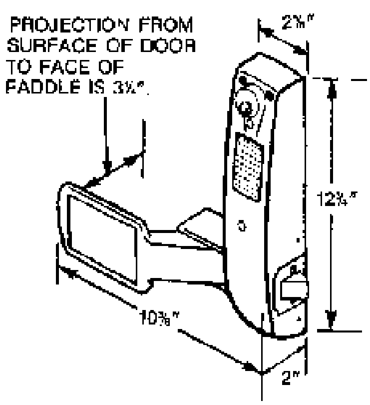
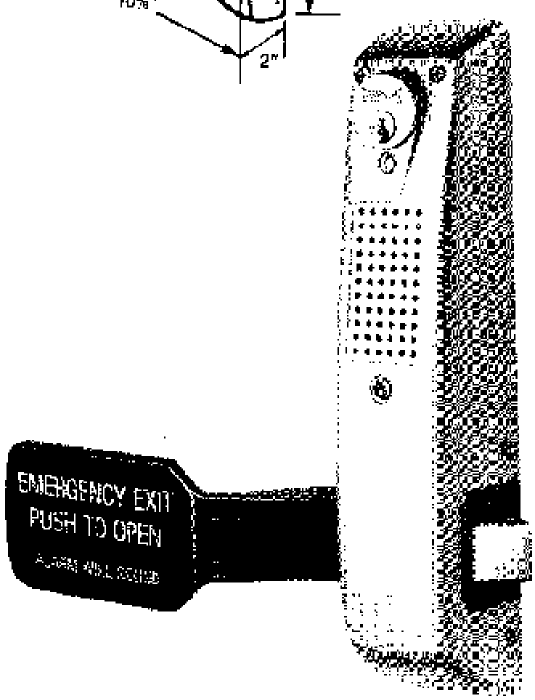
10.15.2 Exit Devices—Emergency Push to Open







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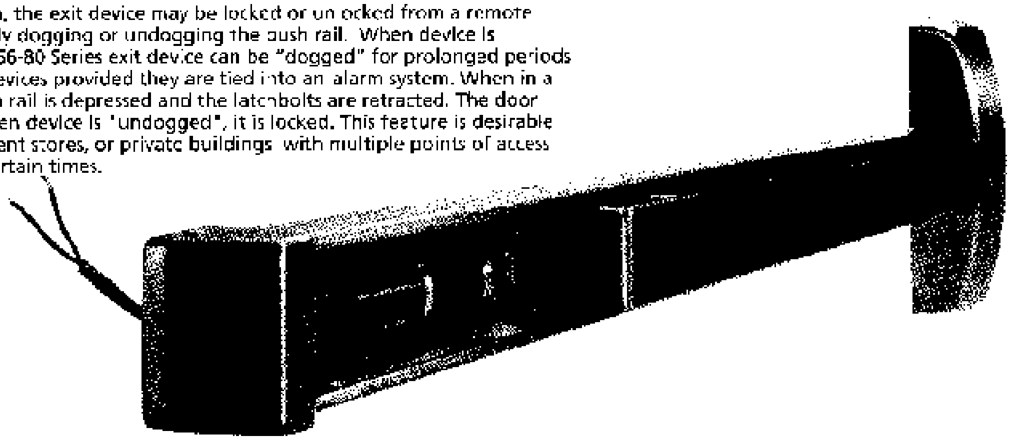
10.15.3 Exit Devices—Remote Latch Retraction

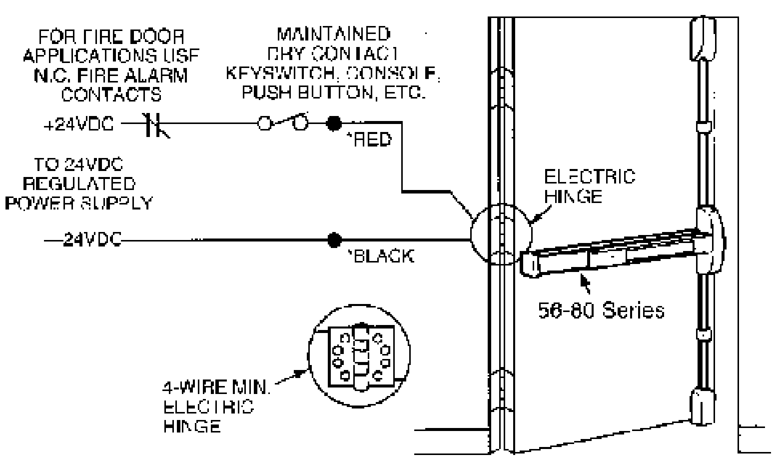
With remote latch retraction, the exit device may be locked or unlocked from a remote location while simultaneously dogging or undogging the push rail. When device is "dogged", it is unlocked. A 56-80 Series exit device can be "dogged" for prolonged periods of time even on fire-rated devices provided they are tied into an alarm system. When in a "dogged" position, the push rail is depressed and the latchbolts are retracted. The door functions as a push/pull. When device is "undogged", it is locked. This feature is desirable on schools, offices, department stores, or private buildings with multiple points of access that must be accessible at certain times.



Features

- Available for all 80 Series exit devices: rim, mortise, vertical rod, concealed vertical rod (MD/WD) and center top latch (PP8700/PR8700/SP8700)
- Power Requirements: 24VDC Regulated/Filtered Power Supply (3510 or 3530)
- Normal operation: .450 amp
- Power supplied through continuous circuit hinge
- Can be used for continuous and intermittent use
- UL Listed for Class II Circuitry
- Available for panic and fire exit hardware (12-)
- Manual dogging available upon request
- Monitors push rail status (55-) by signalling monitor panel indicating when unit is dogged/undogged
- Signal switch (55-) available with (56-). Used with door operator
- Authorized Entry, Door Control, and Door Status systems

Application Diagram



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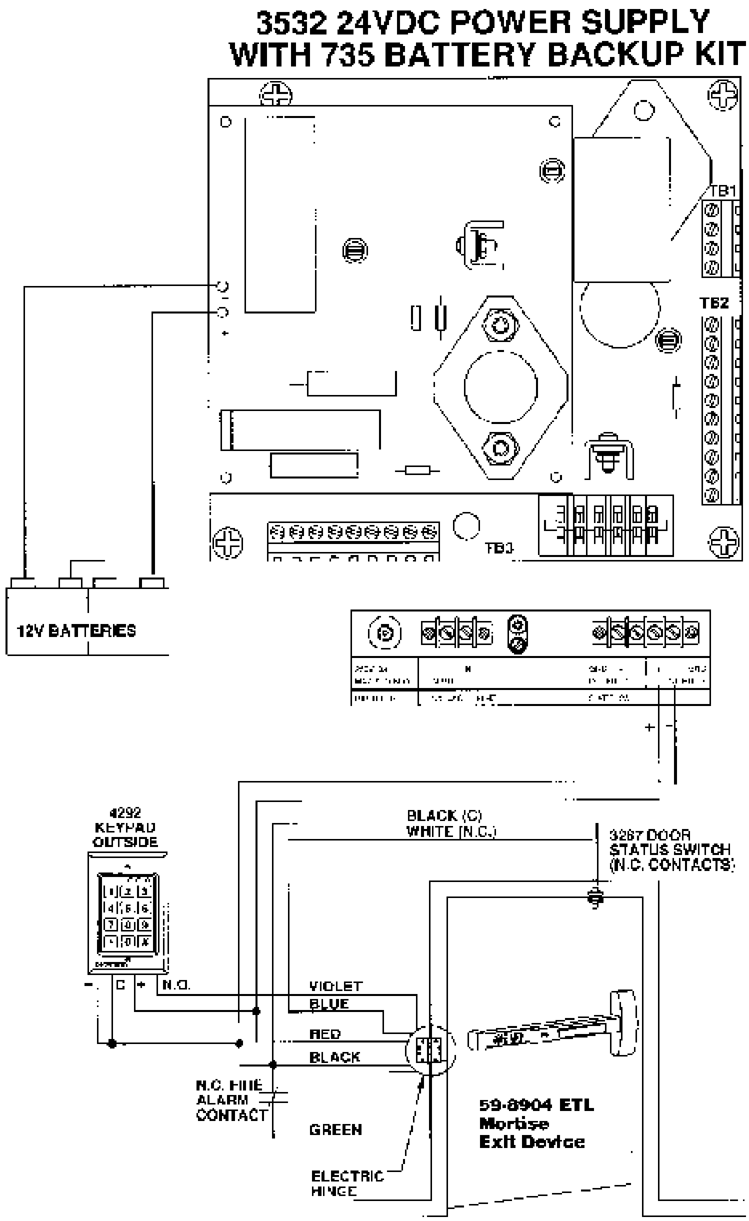
10.15.4 Exit Devices—DC Powered, Battery Back-up

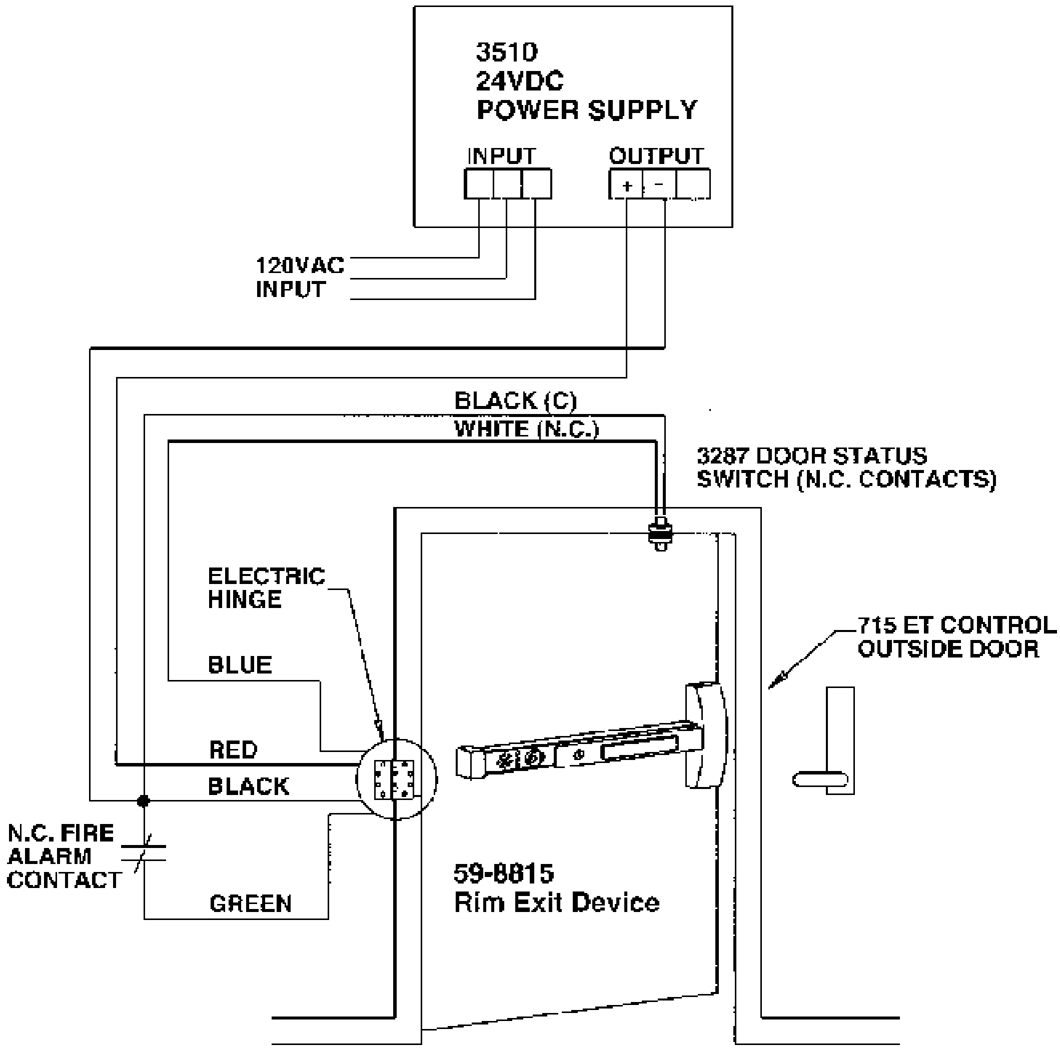
The following is a point-to-point wiring diagram for the Electroguard[3], with an eight-wire electric hinge, door status switch, fire alarm contact, 3532 power supply with 735 battery backup kit and external inhibit (key switch or keypad). This system provides entry from the exterior through the cylinder of the outside trim. The keypad de-energizes the system from a remote location which allows someone to enter by key without contact sounding the alarm. The door status switch provides added security to the opening by initiating the alarm if the door is held open after an authorized egress has taken place or the door is forced open while in the armed state.



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.15.5 Exit Devices—Point-to-Point Wiring Diagrams

The following is a point-to-point wiring diagram for the Electroguard®, with door status switch and fire alarm contact with a four-wire electric hinge. This application has a door status switch which will not allow the unit to be armed when the door is open. Free entry is allowed but controlled; the unit will alarm when the door is held opened for 10 seconds or greater unless the unit is placed in a maintained egress mode.



* If door status and/or fire alarm contact of device is not used, connect to black(-) lead of Electroguard® device.

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10.15.6 Exit Devices—Basic Components for a Single-Door System

Locking Devices

Electromechanical Exit Device Trim (773, 774, 775, 776)

Electromechanical Mortise Lock (7800/ 8200)

Electromechanical Cylindrical Lock (8/10 Line)

Electromagnetic Lock (1581/1582)

Latch Retraction (56-)

Electroguard® (59-)

Access Control Devices

Keypad (4291, 4292)

Key Switch (4370 Series)

Push Button (4241)

Power Supplies

3510 (24VDC @ 1.8 amps Regulated)

3530 Series (24VDC @ 2.0 amps Regulated)

3560 (24VDC @ 7.2 amps Regulated)

3263 (9VDC @ 1.5 amps)

Remote Monitor/Control

Control and Monitoring Panel (4414 or 4418 with Junction Box)

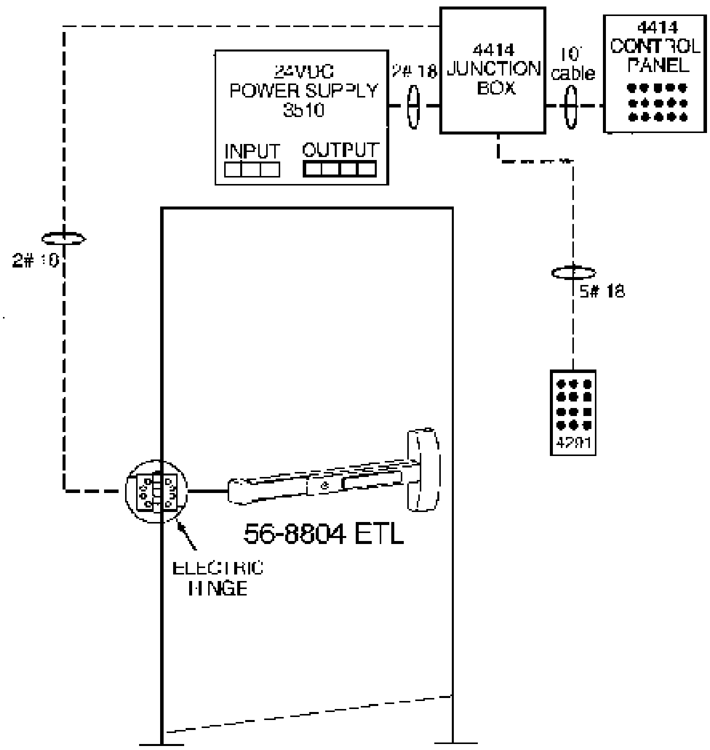
Horn (4380H)

Switches

Signal Switch (55-prefix)

Exit Device Delayed Egress (57-prefix)

Signal Switch in outside trim (54-700)



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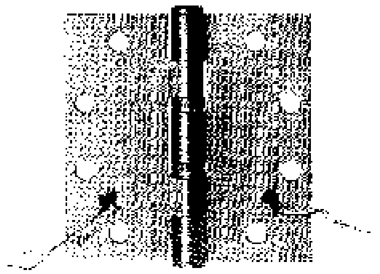
10.16.0 Concealed Circuit Hinges and Armored Door Loops

TA2714 Concealed Circuit Hinge



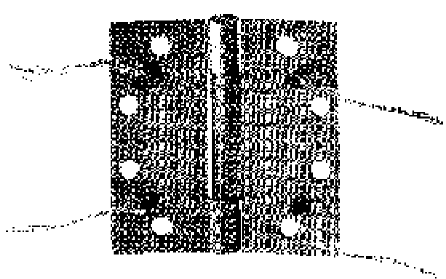
Back View

- 4 1/2" x 4 1/2" - CC4
- 1 amp capacity – low voltage 24V per circuit
- Full Mortise – steel base
- 4 wire
- 28 gage wire
- Wires contained within hinge - invisible and tamperproof
- Available in PC or 26D
- Consult McKINNEY catalog for additional sizes, finishes and styles

TA2314 Concealed Circuit Hinge

- 4 1/2" x 4 1/2" - CC4
- 1 amp capacity – low voltage 24V per circuit
- Full mortise – brass base
- 28 gage wire – contained in hinge - invisible and tamperproof
- Available in 26D only

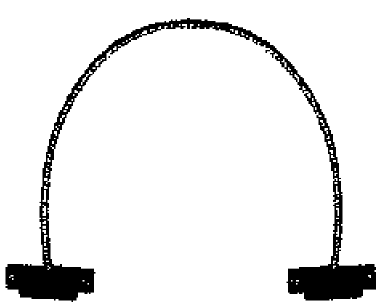
TA714 Concealed Circuit Hinge



Back View

- 4 1/2" x 4 1/2" - CC12
- 1 amp capacity — low voltage 24V per circuit
- 12 wire power transfer required when all options are used for Electroguard
- 28 gage wire
- Wires contained within hinge - invisible and tamperproof
- Available in PC or 26D

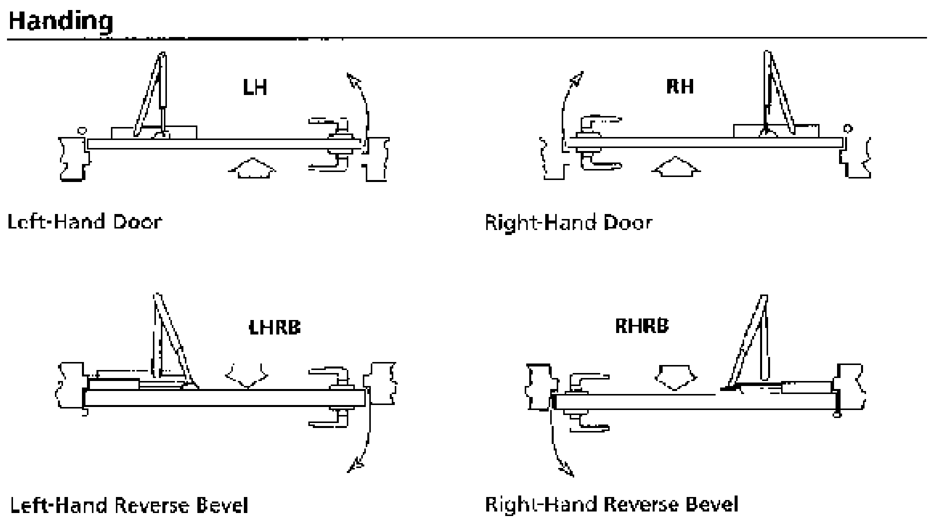
3261 Armored Door Loop



- Used to transfer power where electric hinge is not practical (from frame to door stile)
- Used where Electroguard® requires maximum 3 wires
- 3 wire capability, 22 gage in conduit
- 18" armored loop cable
- 1/4" diameter flex tubing
- Easy mount power transfer

(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.17.0 Door Handing—Illustrated



(By permission from Sargent Manufacturing Co., 100 Sargent Drive, New Haven, Connecticut.)

10.18.0 Standard Keying Terms, Codes, and Designations

Standard keying terms

Keys and Terms	Abbreviation	Definition
Change key	—	Individual lock key.
Keyed Differently	KD	Each lock is set to a different key combination.
Keyed alike	KA	Two or more locks set to the same key combination, KA2, KA3, KA4 etc.
Masterkey	MKD	Operates any given quantity of cylinders with different key changes.
Grand Masterkey	GMKD	Operates all individual locks already operated by two or more masterkeys.
Great grand Masterkey	GGMKD	Operates all locks under the various masterkeys and grand masterkeys already established.
Emergency key	EMKD	Operates hotel locks having shut out feature which blocks entry by all other keys.
Construction key	CK	Operates all cylinders designated for a temporary period during construction.
Control key	—	Key to remove active core of cylinders.
Keyway	—	Broaching in cylinder barrel.
Key section	—	Sidewarding in cylinder match broaching in barrel.
"To operate"	—	Identifying a key or keys to operate other cylinders having different key change (Note: Never use phrase "to pass" or "subject to").
"To be operated by"	—	Identifying a cylinder to be operated by one or more individual keys other hand its own key (Note: Never use phrase "to pass" or "subject to").
Lock out key	—	Permits hotel management to lock door against use of all other keys except emergency key.
Single keyed	SKD1	Cylinders operated by their change key only (in a master, grand or great grand masterkey system).

Standard keying code

1. Use two letters for both masterkeyed and grand masterkeyed systems.
   a. Masterkey systems have change key numbers prefixed. Example: 1AA, 2AA
   b. Grand masterkey systems have change key numbers suffixed. Example: AA1, AA2
2. Each change combination has a different number affixed to letter symbol. Every keyed different cylinder must be listed with a different number. Cylinders in keyed alike groups will have the same number affixed.
3. Letter symbol only (A) indicates to be operated by grand masterkey only, no change key (single letter would not be used at all in simple masterkey system).
4. Two letter symbol only (AA) indicates to be operated by: AA masterkey and A grand masterkey only, no change key.
5. Symbol A1, A2; these are changes under the "A" grand masterkey only.
6. Symbol GGM1, GGM2; these are changes under great grand masterkey only.
7. Symbol 1AA, 2AA, etc., used in great grand masterkey system. The change numbers are prefixed on all locks operated by masterkeys under great grand masterkey only—no grand masterkey operates these locks.
8. Symbol SKD1, SKD2, etc.—single keyed—used for locks in a master, grand master or great grand masterkey system. These locks operated by their change keys only (not masterkeyed, grand masterkeyed, etc.).

Examples

SIMPLE MASTERKEY SYSTEM

Masterkey AA
Change key 1AA
2AA
3AA

GRAND MASTERKEY SYSTEM

Grand Masterkey A

MasterkeyAA	MasterkeyAB	MasterkeyAC
Change key AA1	AB1	AC1
AA2	AB2	AC2
AA3	AB3	AC3

10.19.0 Finish Symbols and Descriptions of These Finishes

(McKinney, BHMA, U.S. Government Codes.)

McKINNEY	DESCRIPTION	BASE BHMA	U.S. FINISH	MATERIAL
P	Primed for Painting	600	USP	Steel
2C	Zinc Plated, Commercial	602	US2C	Steel
2G	Zinc Plated, Government Specification	603	US2G	Steel
3	Bright Brass	605 632	US3	Brass Steel
4	Dull Brass	606 633	US4	Brass Steel
5	Dull Brass, Oxidized	609 638	US5	Brass Steel
7	Brass, Nickel Oxidized, Bright Relieved	610 636	US7	Brass Steel
9	Bright Bronze	611 637	US9	Bronze Steel
10	Dull Bronze	612 638	US10	Bronze Steel
10B	Antique Bronze, Oiled	613 640	US10B	Bronze Steel
11	Dull Bronze, Oxidized	616 643	US11	Bronze Steel
14	Bright Nickel Plated	618 645	US14	Brass, Bronze Steel
15	Dull Nickel Plated	619 646	US15	Brass, Bronze Steel
15A	Nickel Oxidized, Relieved	620 647	US15A	Brass, Bronze Steel
17A	Half Polished Iron, Smooth	621 648	US17A	Brass, Bronze Steel
20	Statuary Bronze, Light	623 649	US20	Bronze Steel
20A	Statuary Bronze, Dark	624 650	US20A	Bronze Steel
26	Bright Chromium	625 651	US26	Brass, Bronze Steel
26D	Dull Chromium	626 652	US26D	Brass, Bronze Steel
32	Polished Stainless Steel	629	US32	Stainless Steel Series 300
32D	Dull Stainless Steel	630	US32D	Stainless Steel Series 300
AP	Aluminum Powder Coat	—	—	Steel
BZ	Zinc Plated — Buffed Bright	—	—	Steel
DZ	Zinc Plated — Dull	—	—	Steel
D2	Co-Lac, Medium	—	—	Steel
D3	Co-Lac, Dark	—	—	Steel
D4	Co-Lac, Black	—	—	Steel
PG	Powdered Gold	—	—	Steel
PW	Powdered White	—	—	Steel
PB	Powdered Beige	—	—	Steel
PN	Powdered Neutral	—	—	Steel
3C	US3, with Clear Powder Coat	—	—	Steel
4C	US4, with Clear Powder Coat	—	—	Steel

Finishes on McKinney hinges comply with U.S. standards. Where a special finish or a matched finish is required, a sample should be submitted. McKinney rust resisting finish is specified by prefixing S to catalog number.

10.20.0 Recommended Number of Hinges and Frequency of Operations

RECOMMENDED NUMBER OF HINGES PER DOOR, EITHER WOOD OR METAL

Door Height, In. (mm)	Number of Hinges per Door
Up to 60 (1524)	2
60 to 90 (1524 to 2286)	3
90 to 120 (2286 to 3048)	4

RECOMMENDED SIZE OF HINGES PER DOOR, EITHER WOOD OR METAL

Door		Hinge	
Thickness In. (mm)	Width In. (mm)	Height In. (mm)	Gauge
1-3/8 (35)	up to 36 (914)	3-1/2 (89)	.123
1-3/8 (35)	over 36 (914)	4 (102)	.130
1-3/4 (44)	up to 36 (914)	4-1/2 (114)	*.134
1-3/4 (44)	over 36 - 48 (914 - 1219)	5 (127)	*.134
1-3/4 (44)	over 48 (1219)	6 (152)	*.160
2-2-1/2 (51-64)	up to 42 (1067)	5 (127) HW	.190
2-2-1/2 (51-64)	over 42 (1067)	6 (152) HW	.190

*Heavy hinges should be used on all extra heavy doors or those exposed to high frequency use! Five knuckle heavy weight hinges are four bearing. The following gauges of metal apply:
Heavy weight 4-1/2" (114) high = .180" gauge
Heavy weight 5" (127) high = .190" gauge
Heavy weight 6" (152) high = .190" gauge
Note: Five knuckle 8" (203) high hinges have six bearings.

EXPECTED FREQUENCY OF DOOR OPERATION

One Cycle = one complete opening and closing.

Installation Type	Expected Frequency Daily	Expected Frequency Yearly	
Commercial			
Commercial store entrance	5,000	1,500,000	High
Office building entrance	4,000	1,200,000	High
Theatre entrance	1,000	450,000	High
School entrance	1,250	225,000	High
School restroom door	1,250	225,000	High
Store or bank entrance	500	150,000	High
Office building restroom door	400	118,000	High
School corridor door	80	15,000	Average
Office building corridor door	75	22,000	Average
Store restroom door	60	18,000	Average
Residential			
Entrance	40	15,000	Low
Restroom door	25	9,000	Low
Corridor door	10	3,600	Low
Closet door	6	2,200	Low

NOTE: School classroom doors have approximately the same frequency as school restroom doors. We recommend that bearing hinges be used on all above categories other than "residential."

10.21.0 ASTM Specifications Applicable to Finish Hardware Requirements

Products Comply With:

ASTM B-117—Salt spray (fog) testing (paint test).

ASTM C-236—Test for thermal conductance and transmittance of built-up sections by means of the guarded hot box.

ASTM C-553—Specifications for mineral fiber blanket and felt insulation (industrial type).

ASTM D-610—Method of evaluating degree of rusting on painted steel surfaces.

ASTM D-714—Method of evaluating degree of blistering of paints.

ASTM D-1735—Method for water fog testing of organic coatings.

ASTM D-3359—Measuring adhesion by tape test (paint).

ASTM E-90—Recommended practice for laboratory measurement of airborne sound transmission loss of building partitions.

ASTM E-152—Fire tests of door assemblies.

ASTM E-283—Test for rate of air leakage through window.

ASTM E-413—Classification for determination of sound transmission class.

Foam Core Standards—Polystyrene/Polyurethane

ASTM C-165—Method for measuring compressive properties of thermal insulations.

ASTM C-177—Test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded hot plate apparatus.

ASTM C-203—Test for breaking load and calculated flexural strength of preformed block-type thermal insulation.

ASTM C-272—Test for water absorption of core materials for structural sandwich constructions.

ASTM C-273—Shear test in flatwise plans of flat sandwich construction or sandwich cores.

ASTM C-303—Test method for density of preformed block-type thermal insulation.

ASTM C-518—Test method for steady-state heat flux measurements and thermal transmission properties by means of the heat flow meter apparatus.

ASTM C-355—Test for water vapor transmission of thick materials.

ASTM C-578—Specification for preformed, block-type cellular polystyrene thermal insulations.

ASTM D-732—Test for shear strength of plastics by punch tool.

ASTM D-1621—Test for compressive strength of rigid cellular plastics.

ASTM D-1622—Test for apparent density of rigid cellular plastics.

ASTM D-1623—Test for tensile and tensile adhesion properties of rigid cellular plastics.

ASTM D-2842—Test for water absorption of rigid cellular plastics.

ASTM D-2856—Test for open cell content of rigid cellular plastics by the air pycnometer.

ASTM D-2863—Measuring by minimum oxygen concentration to support candle-like combustion of plastics (oxygen index).

ASTM E-84—Test for surface burning characteristics of building materials.

ASTM E-96—Test methods for water vapor transmission of materials.

Steel & Galvanizing Standards

ASTM A-366—Specification for steel, carbon, cold-rolled sheet, commercial quality.

ASTM A-525—Specification for steel sheet, zinc-coated (galvanized) by the hot-dip process, general requirements.

ASTM A-526—Specification for steel sheet, zinc-coated (galvanized) by the hot-dip process, commercial quality.

ASTM A-568—Specification for steel, carbon, and high strength low-alloy hot-rolled strip, and cold-rolled sheet, general requirements.

ASTM A-569—Specification for steel, carbon (0.15 maximum percent), hot-rolled sheet and strip, commercial quality.

ASTM A-591—Specification for steel sheet, electrolytic zinc-coated.

ASTM A-620—Specification for steel sheet, carbon, cold-rolled, drawing quality, special killed.

ASTM A-642—Specification for steel sheet, zinc-coated (galvanized) by the hot-dip process, drawing quality, special killed.

ANSI/SDI 100—Recommended specifications for standard steel doors and frame.

ANSI A250.5-1994—Performance test procedure for steel door frames and frame anchors.

ANSI A123.1—Standard nomenclature for steel doors and steel door frames.

ANSI A224.1—Standard test procedure and acceptance criteria for prime-painted steel surfaces for steel doors and frames.

ANSI A250.4-1994—Test procedure and acceptance criteria for physical endurance for steel doors and hardware reinforcings.

A115 Series Of Door & Frame Preparation Standards

ANSI A115.1—Specifications for standard steel door and steel frame preparations for mortise locks 1-3/8" (35) and 1-3/4" (44) doors.

ANSI A115.2—Specifications for standard steel doors and frame preparation for bored or cylindrical locks for 1-3/8" (35) and 1-3/4" (44) doors.

ANSI A115.4—Specifications for standard steel doors and frame preparation for lever extension flush bolts.

ANSI A115.5—Specifications for steel frame preparation for 181 Series and 190 Series deadlock strikes.

ANSI A115.6—Specifications for standard steel door and steel frame preparation for preassembled door locks (unit lock).

ANSI A115.8—Specifications for door and frame preparation for floor closer center hung, single, or double acting.

ANSI A115.9—Specifications for hospital door roller latches.

ANSI A115.11—Specifications for standard steel door and frame preparation for mortise locks for 1-3/8" (35) doors.

ANSI A115.12—Specifications for standard steel door and steel frame preparation for offset intermediate pivot.

ANSI A115.13—Specifications for standard steel door and steel frame preparation for tubular deadlocks.

ANSI A115.14—Specifications for standard steel doors for open back strikes.

ANSI A2.2—Fire tests of door assemblies (UL 10B).

ANSI A155.1—Fire door frames UL 63 (outdated).

ANSI/NFPA 105—Installation of smoke and draft control door assemblies.

10.22.0 Finish Hardware—Quality Control Checklist

Quality Control Checklist

Project no.

Section: **Finish Hardware**

No. **08711**

Date

1. Hardware schedule, product data, and samples are approved and on site.
2. Hardware is installed in accordance with manufacturer's templates and instructions.
3. Finishes are as required and finishes match in each area.
4. Hardware is removed and/or protected during painting and cleaning operations.
5. Recommended order of inspection:

In hardware storage room before installation

Door butts and hinges during and after installation

Locksets, latchsets, and exit bolts during and after installation

Door closers after installation

Door stops, holders, and push, pull and kickplates after installation.

BUTTS AND HINGES

6. Ball bearing, oilite, or nylon type is provided as required.
7. Solid brass, bronze, aluminum, or stainless steel is provided if required.
8. Fire-door hinges are steel with ball bearings or as otherwise approved for a labeled assembly.
9. Mortise-type hinges are mortised flush.
10. Mortise hinges on door leaf to 1/4" from stop side of door, and jamb leaf 5/16" from stop (3/8" and 7/16" on very thick doors) unless otherwise req'd.
11. Unless otherwise required, top hinge is mounted 5" below finish door frame and bottom hinge is mounted 10" above finish floor. Intermediate hinges are spaced and mounted equidistantly from top and bottom hinges and from each other.
12. Sufficient throw is provided to clear trim, and leaf can swing functionally as required.
13. NRP hinges are provided as required and setscrews are tightly screwed down.
14. One-half surface hinges are used on composite doors.

LOCKSETS AND LATCHSETS

15. Predrilled or jig bored provides most accurate installation. After boring, no planing is allowed on lockset edge.
16. Mortise for strike provides for full latchbolt projection. Fire assemblies require full throw, and in some instances dead bolts will not latch without full projection.
17. Backsets are provided as required and clear stops.
18. Mortised sets are installed with lock mortising machine if required.
19. Cylinder cores are installed with tumblers up.

DOOR CLOSERS

20. Closers are attached to metal doors with sex bolts unless otherwise required.
21. Observe operation of closers as soon as possible after installation for proper operation - - silent closing and smooth operation at arc opening. Panic devices are properly latching.
22. Verify that closers are adjusted by hardware supplier representative if required.
23. Closers are adjusted after air-moving system is operational.

continued on next page

Finish Hardware continued

EXIT BOLTS AND FLUSH BOLTS

24. Exit cross bars are level, with both ends firmly attached to lever arms, and return at same time when depressed or released. To and bottom bolts are fully seated in strikes on vertical rod devices.
25. Latch bolt enters strike and seats properly on rim or mortise lock devices. If equipped with dead-locking bolt, observe that proper operation is provided.
26. Label agrees with door assembly rating and no "dogging" features are allowed.
27. Panic bolts have mullion stabilizers at mullions unless otherwise not required, i.e., structural mullions.
28. Automatic bolts (required by state ordinances on inactive leaf of a pair of doors) have 3/4" bolt throw in strike with sufficient depth.

TOPS, HOLDERS AND PLATES

29. Provide every door with a door stop as required by schedule.
30. Stops or holders to be attached to wallboard, plaster, etc., are screwed to solid blocking.
31. Verify wiring, outlet boxes, etc., are provided for magnetic holders. Magnetic holders to be installed horizontally in same location as closer to prevent door warp unless otherwise required.
32. Centerline of push plate is 45" from finish floor, and centerline of pull plate is 42" from finish floor, unless otherwise required.
33. Kick plates clear stops on push side of door and not more than 1" is exposed on each edge of door unless otherwise required.
34. Push, pull, and kickplates are attached per specification and manufacturer's requirements.

MISCELLANEOUS HARDWARE AND ITEMS

35. Sliding-door tracks are installed level and door is plumb. If separate tracks are used, bracket supports are to be directly over hangers when door is open or closed (especially required on fire-rated assemblies). Spacing and number of brackets are provided as required.
36. Thresholds are of required size, type, and interlock and are anchored as required.
37. Weather stripping and sound stripping allow proper operation of door.
38. All hardware is complete and with required
39. Keying instructions are understood, and keys are delivered to owner as required. Observe that construction locks are removed and permanent cores are provided.

Continued

Section

11

Drywall, Metal Framing, and Plaster

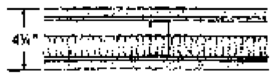
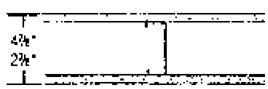
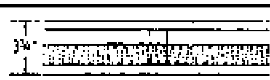
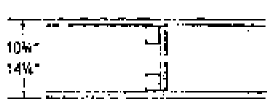
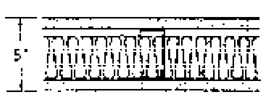
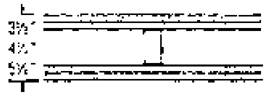
Contents

11.0.0 Drywall Systems

Steel or wood studs, faced with gypsum panels (regular, fire rated or vinyl faced) have dominated the construction industry, representing the most cost-effective light weight, and fire resistant means of creating interior walls. Specialty products, such as ½-inch (12 mm) thick cement board, sometimes referred to as *Wonder board* and *exterior-grade gypsum sheathing panels,* along with the development of heavier-gauge structural metal studs for curtain wall construction, has expanded the number of applications to which these products can be used.

11.0.1 Non-Load-Bearing Partitions

▭ *Sound-deadening material** ■ *RC-1™ Resilient Channel***

Fire rating	Fire-rated construction: Detail & physical data	Fire-rated construction: Description & test no.	Acoustical performance: STC	Acoustical performance: Description & test no.	System reference
1 hr		Steel Stud—⅝" SHEETROCK brand gypsum panels, ULTRACODE core—1⅝" studs 24" o.c.—panels vert appl & screw att with 1⅝" Type S screws 8" o.c. perim, 12" o.c. field—joints stag & fin—**UL Des U419**			A
1 hr		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—2½" studs 24" o.c.—single layer panels ea side appl vert & screw att—1½" THERMAFIBER SAFB—joints fin—perimeter caulked—**UL Des U448** wt 5 width 3¾"	45 48	**TL-69-42** Based on 3⅝" studs & 2" SAFB—**SA-800422**	B
1 hr est		Steel Stud—½" SHEETROCK brand gypsum panels, FIRECODE core—2½" studs 24" o.c.—1½" THERMAFIBER SAFB—2 layers—base layer ¼" SHEETROCK brand gypsum panels screw att—½" facelayer screw att—joints fin—perimeter caulked—est. fire rating based on T-1174-OSU wt 7 width 4¾"	55 53	**CK-684-14** Based on ⅜" thick panels—**CK-684-13**	C
1 hr		Steel Stud—resil partition—⅝" SHEETROCK brand gypsum panels, FIRECODE C Core, or ⅝" SHEETROCK brand gypsum panels, FIRECODE core—3⅝" studs 24" o.c.—3" THERMAFIBER SAFB 25" wide creased to fit cavity—RC-1 chan 24" o.c. screw att one side—panels vert appl & screw att—joints stag & fin—perimeter caulked—**UL Des U451** wt 6 width 5⅜"	55 54	Based on ⅝" SHEETROCK brand gypsum panels, FIRECODE core & 25" wide creased SAFB—**SA-850415** Based on ⅝" SHEETROCK brand gypsum panels, FIRECODE core—**SA-850415**	D
1 hr est		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—2½" studs 24" o.c.—single layer panels one side appl vert & screw att—1½" THERMAFIBER SAFB—2 layers opp side—panels appl vert & screw att—joints stag & fin—perimeter caulked—est. fire rating based on T-3362-OSU wt 7 width 4"	53 41	**SA-800504** Based on same construction without SAFB—**TL-69-148**	E
1 hr		Steel Stud—2 layers ½" SHEETROCK brand gypsum panels ea side—1⅝" studs 24" o.c.—panels appl vert & screw att—joints stag & fin—perimeter caulked—**U of C 5-21-64** wt 9 width 3⅝"	55	Based on SHEETROCK brand gypsum panels FIRECODE C core, & 1½" SAFB—**USG-840824**	F
1 hr		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE core—3⅝" studs 24" o.c.—single layer panels vert or horiz appl & screw att—joints stag & fin—perimeter caulked—**UL Des U465**—based on panels horiz appl—**GA-WP-1200** wt 6 width 4⅞"	40 49 51	**USG-860808** Based on 3" SAFB in cavity—**SA-870717** Based on FIRECODE C core panels and 3" SAFB 25" wide, creased to fit cavity—**TL-90-166**	G
1 hr		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE core—1⅝" studs 24" o.c.—single layer panels vert appl & screw att 12" o.c.—joints fin—perimeter caulked—**U of C 7-31-62** wt 5 width 2⅞"	38	**USG-860809**	H
1 hr		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE core—2½" studs 24" o.c.—1½" THERMAFIBER SAFB—panels apply horiz & screw att—joints opposite—vert joints unfin—horiz joints fin—**CBS 8-11-83**—rating also applies to assembly with ⅝" SHEETROCK brand gypsum panels, FIRECODE C core joints fin—**CBS 5-8-84** wt 6 width 3⅞"	47	**SA-831001**	I
1 hr		Steel Stud Chase Wall—⅝" SHEETROCK brand gypsum panels, FIRECODE core, ea side—1⅝" studs 24" o.c. in 2 rows spaced 6⅛" apart—⅝" gypsum panel gussets or steel run braces spanning chase screw att to studs—panels appl vert & screw att—joints stag & fin—**UL Des U420** wt 6 width 10⅝"	52	Based on 3½" insulation on one side—**TL-76-159**	J
1 hr (truss 2 hr)		Steel Stud—⅝" SHEETROCK brand gypsum panels, FIRECODE C core ea side—fireproofed steel truss—2½" studs 24" o.c. in 2 rows spaced 8" apart—⅝" gypsum panel gussets spanning chase att to stud at qtr & ctr points—panels appl vert & screw att—joints stag & fin—**UL Des U605** wt 6 width 14⅝"	N/A		K
2 hr		Steel Stud—¾" SHEETROCK brand gypsum panels, ULTRACODE core, ea side—3⅝" or 3½" studs 24" o.c.—3" THERMAFIBER SAFB—panels vert appl & screw att 8" o.c. perim, 12" o.c. field—joints stag & fin—perimeter caulked—**UL Des U491**	50	**USG-910617**	L
2 hr		Steel Stud—2 layers ½" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—1⅝", 2½" or 3⅝" studs 24" o.c.—base layer appl vert, face layer appl vert or horiz, joints stag—base layer screw att—face layer strip lamin or screw att—joints fin—perimeter caulked—with or rating based on assembly without sound atten blankets—**UL Des U412** wt 10 width 4⅞"	50 55 52 54	Based on 3⅝" stud assembly without SAFB—**USG-840817** Based on 3⅝" studs and 1½" SAFB—**SA-800421** Based on lamin, face layer, 1½" SAFB and 2½" studs—**SA-860922** Based on 2½" studs, screw att face layer and 1½" SAFB—**CK-654-40**	M
2 hr		Steel Stud—2 layers ⅝" SHEETROCK brand gypsum panels, FIRECODE core, plain or vinyl faced vert appl ea side—2½" studs or 24" o.c.—base layers screw att—face layer lamin or screw att—joints stag & fin or unfin—perimeter caulked—**UL Des U411** wt 12 width 6⅛"	48 56	Based on 2½" studs and ⅝" SHEETROCK brand gypsum panels, FIRECODE C core—**BBN-770408** Based on 3⅝" studs and 3" SAFB—**USG-840818**	N
2 hr		Steel Stud—2 layers ⅝" SHEETROCK brand gypsum panels, FIRECODE core, ea side—2½" studs 24" o.c.—panels appl horiz & joints stag—base and face layers screw att—joints fin—perimeter caulked—**GA-WP-1548** wt 12 width 5"	51 56	Based on 2½" SAFB in cavity—**GA-WP-1548** Based on 2" SAFB in cavity—**USG-840819**	O

*Where thermal insulation is shown in assembly drawings, the specific product is required in the assembly to achieve the stated fire-rating. Fiberglass insulation cannot be substituted for THERMAFIBER insulation.
**Use RC-Resilient Channel or equivalent.

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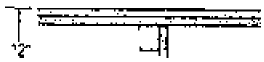
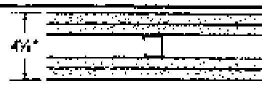
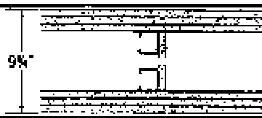
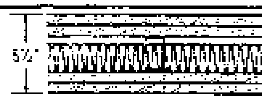
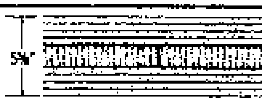
11.0.1 Non-Load-Bearing Partitions—Continued

Fire rating	Fire-rated construction		Acoustical performance		System reference
	Detail & physical data	Description & test no.	STC	Description & test no.	
2 hr		Steel Stud Chase Wall—2 layers 5/8" SHEETROCK brand gypsum panels, FIRECODE core, ea side—1 5/8" studs 24" o.c. in 2 rows spaced 6¼" apart—5/8" gypsum panel gussets or steel run braces spanning chase screw att to studs—panels appl vert & screw att—joints stag & fin—**UL Des U428** wt 13 width 12"	52 57	**TL-76-162** Based on 3½" insulation one side—**TL-76-156**	P
2 hr est		Steel Stud Chase Wall—2 layers 5/8" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—1 5/8" studs 24" o.c. in 2 rows spaced 5⅝" apart—5/8" gypsum panel gussets spanning chase att to studs at qtr points—panels appl vert & screw att—1½" THERMAFIBER SAFB—joints stag & fin—perimeter caulked—est. fire rating based on **UL Des U412** wt 11 width 11"	55	**SA-850907**	O
3 hr		Steel Stud—3 layers ½" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—1 5/8" studs 24" o.c.—base layers appl vert—face layer appl horiz—panels screw att with joints stag and fin—perimeter caulked—rating based on assembly with or without SAFB—**UL Des U435** wt 13 width 4⅝"	59	Based on assembly with 1½" SAFB in cavity—**SA-830112**	R
3 hr		Steel stud—2 layers ¾" SHEETROCK brand gypsum panels, ULTRACODE core, ea side—1 5/8" studs 24" o.c.—base layer app vert and att with 1¼" Type S screws 24" o.c., face layer att vert or horiz with 2¼" Type S screws 12" o.c.—att horiz joints with Type G screws midway betw framing (24" o.c.)—joints fin—perimeter caulked—**UL Des U425**			S
3 hr		Steel Stud—3 layers 5/8" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—1 5/8" studs 24" o.c. in 2 rows spaced 3" apart—steel truss member—gypsum panel gussets or steel run braces spanning chase screw att to studs—panels appl vert & screw att—joints stag & fin—2 hr. rating applies with 2 layers panels ea side—1 hr. rating applies with single layer 5/8" panels ea side—**UL Des U436** wt 13 width 9⅝"	N/A		T
3 hr		Steel stud chase wall—2 layers ¾" SHEETROCK brand gypsum panels, ULTRACODE core, ea side—1 5/8" studs 24" o.c. in two rows spaced 2" apart—steel truss member—gypsum panel gussets or stl run braces spanning chase screw-att to studs—base layer app vert and att with 1¼" Type S screws 24" o.c., face layer att vert or horiz with 2¼" Type S screws 12" o.c.—att horiz joints with Type G screws betw midway framing (24" o.c.)—joints stag & fin—**UL Des U436**			U
4 hr		Steel Stud—2 layers ¾" SHEETROCK brand gypsum panels, ULTRACODE core, ea side—2½" studs 24" o.c.—2" THERMAFIBER SAFB—base layer app vert, joints stag & screw att 24" o.c.—face layer app vert or horiz & screw att 12" o.c.—att along horiz joints with Type G screws midway betw framing (24" o.c.)—joints fin—perimeter caulked—**UL Des U498**	56	**USG-810807**	V
4 hr		Steel Stud—4 layers 5/8" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—1 5/8" studs 24" o.c.—base layers appl vert—face layer appl horiz—panels screw att with joints stag & fin—perimeter caulked—rating based on assembly with or without sound atten fire blankets—**UL Des U435** wt 17 width 5⅝"	62	Based on assembly with 1½" SAFB in cavity—**SA-830113**	W

Steel stud 25 ga. will provide above fire and sound ratings.

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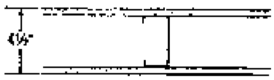
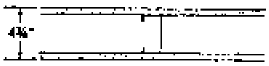
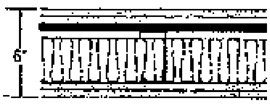
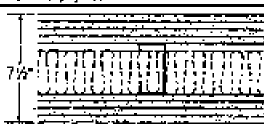
11.0.2 Load-Bearing Partitions

Fire rating	Fire-rated construction: Detail & physical data	Description & test no.	Acoustical performance: STC	Acoustical performance: Description & test no.	System reference
45 min		5/8" SHEETROCK brand gypsum panels, FIRECODE C core—3-5/8" 20 ga. structural studs 24" o.c.—panels appl vert & att with 1" Type S-12 screws 12" o.c.—joints fin—**load bearing up to 100% allowable stud axial—UL Des U425**	47	Based on engineering evaluation using 3" SAFB in cavity	A
1 hr		5/8" SHEETROCK brand gypsum panels, FIRECODE core—3-5/8" 20 ga. structural studs 24" o.c.—panels appl vert & att with 1" Type S-12 Screws 12" o.c.—joints fin—**load bearing up to 100% allowable stud axial load—UL Des U425**	40 41	**USG-810519** Based on 2" SAFB in cavity—**USG-810518**	B
1 hr	 	Dbl layer 5/8" SHEETROCK brand gypsum panels, FIRECODE C core—3-5/8" 20 ga. structural studs 24" o.c.—1", 1-1/2", 2", 3" THERMAFIBER SAFB—RC-1 chan one side spaced 24" o.c. screw-att to studs—panels appl vert with joints stag—base layer att with 1" Type S-12 screws 12" o.c.—face layer att with 1-5/8" Type S-12 screws 12" o.c.—joints fin—rating also applies with IMPERIAL FIRECODE C base and veneer finish surface—**load bearing up to 100% allowable stud axial load—UL Des U440**	61 51	Based on 3-5/8" 16 ga. structural studs, 5/8" thick panels, lateral bracing and 3" SAFB cavity—**SA-830629*** Based on 3-5/8" 16 ga. structural studs and lateral bracing—**SA-840715**	C
1-1/2 hr		Dbl layer 5/8" SHEETROCK brand gypsum panels, FIRECODE C core—3-5/8" 20 ga. structural studs 24" o.c.—panels appl vert—base layer att with 1" Type S-12 screws 12" o.c.—face layer att with 1-5/8" Type S-12 screws 12" o.c.—joints fin—**load bearing up to 100% allowable stud axial load—UL Des U425**	49 49	Based on 2" SAFB—**USG-811009** Based on 2" SAFB and 6" 20 ga structural studs—**USG-810840**	D
2 hr	 	Dbl layer 5/8" SHEETROCK brand gypsum panels, FIRECODE core—3-5/8" 20 ga. structural studs 24" o.c.—panels appl vert—base layer att with 1" Type S-12 screws 12" o.c.—face layer att with 1-5/8" Type S-12 screws 12" o.c.—joints fin—**load bearing up to 60% allowable stud axial load—UL Des U425**	48 49	Based on 2" SAFB in cavity—**USG-811006** Based on 2" SAFB and 6" 20 ga structural studs—**USG-810937**	E

Fire rating	Fire-rated construction: Detail & physical data	Description & test no.	Acoustical performance: STC	Acoustical performance: Description & test no.	System reference
3 hr		Four layers 5/8" SHEETROCK brand gypsum panels, FIRECODE C core, ea side—3-5/8" 20 ga. structural studs 24" o.c.—1", 1-1/2", 2" or 3" THERMAFIBER SAFB optional—base layers appl vert with joints stag—base panels att with Type S-12 screws 48" o.c.—face layer appl vert or horiz with 2-5/8" Type S-12 screws 12" o.c. and 1-1/2" Type G screws in panels—rating also applies with IMPERIAL FIRECODE C base and veneer finish surface—**load bearing up to 100% allowable stud axial load—UL Des U425**			F

*Assemblies with RC-1 Resilient Channel or equivalent require lateral bracing and offer estimated fire rating.

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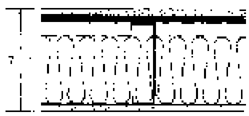
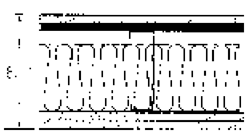
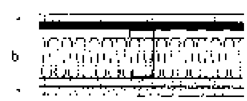
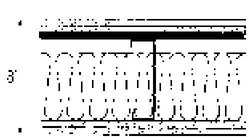
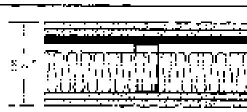
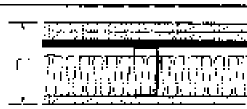
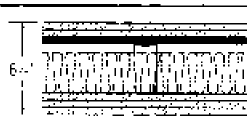
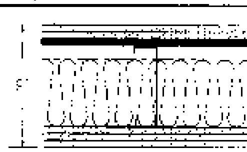
11.0.3 High-Performance Sound Control

High Performance Sound Control

Fire rating	Fire-rated construction: Detail & physical data	Fire-rated construction: Description & test no.	Acoustical performance: STC	Acoustical performance: Description & test no.	System reference
1 hr.	 wt. 6	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—3⅝" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—single-layer gypsum panels screw-att. to studs & RC-1 chan.—panels app. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U451**	50 54	**RAL-TL-87-155** (42 MTC) Based on ⅝" thick panels **RAL-TL-83-216** (47 MTC)	A
1 hr.	 wt. 6	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—6" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—single-layer gypsum panels screw-att. to studs & RC-1 chan.—panels app. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U451**	56 56	**RAL-TL-87-139** (48 MTC) Based on ⅝" thick panels— **RAL-TL-84-141** (50 MTC)	B
1½ hr.	 wt. 8	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—6" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—2 layers gypsum panels screw-att. to studs, 1 layer screw-att. to chan.—panels app. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U452**	59	**RAL-TL-84-140** (54 MTC)	C
1½ hr.	 wt. 8	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—3⅝" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—2 layers gypsum panels screw-att. to studs, 1 layer screw-att. to chan.—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U452**	56	**RAL-TL-83-215** (52 MTC)	D
2 hr.	 wt. 11	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—6" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—chan.—double layer gypsum panels screw-att. to studs & RC-1—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U454**	63 62	**RAL-TL-87-141** (58 MTC) Based on ⅝" thick panels— **RAL-TL-84-138** (58 MTC)	E
2 hr.	 wt. 10	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—3⅝" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—2 layers gypsum panels screw-att. to studs, 2 layers screw-att. to chan.—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U454**	60 61	**RAL-TL-87-154** (54 MTC) Based on ⅝" thick panels— **RAL-TL-83-214** (57 MTC)	F
2 hr.	 wt. 9	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—3⅝" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—single-layer gypsum panels screw-att. to studs, 2 layers screw-att. to chan.—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U453**	56 60 59	Estimated sound test (52 MTC) Based on ⅝" thick panels, 6" 20 ga. structural studs, 3" SAFB—**RAL-TL-87-140** (54 MTC) Based on ⅝" thick panels, 6" 20 ga. structural studs, 3" SAFB—**RAL-TL-84-139** (54 MTC)	G
3 hr.	 wt. 12	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—3⅝" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—3 layers gypsum panels screw-att. to studs, 2 layers screw-att. to chan.—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U455**	61 62	**RAL-TL-87-153** (55 MTC) Based on ⅝" thick panels— **RAL-TL-83-213** (59 MTC)	H
3 hr.	 wt. 12	Resil. Stud Drywall—⅝" SHEETROCK brand gypsum panels, FIRECODE C core—6" 20 ga. structural studs 24" o.c.—3" THERMAFIBER SAFB—RC-1 chan. one side spaced 24" o.c. screw-att. to studs—3 layers gypsum panels screw-att. to stud, 2 layers screw-att. to chan.—panels appl. vert. with joints stag.—joints fin.—perimeter caulked—**UL Des U455**	64 62 65	**RAL-TL-87-142** (59 MTC) Based on ⅝" thick panels— **RAL-TL-84-136** (59 MTC) Based on ⅝" thick panels, acoustical sealant bead between panels and studs, [illegible] between panel layers on stud side—**RAL-TL-84-156** (59 MTC)	I

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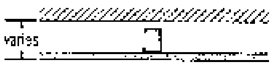
11.0.4 Wall Furring (Partition Details)

Detail & physical data	Description	Comments	System reference
	Metal furring channels 24" o.c., ⅝" SHEETROCK brand gypsum panels, foil-back, screw-attached, joints finished	Provides good vapor resistance, no limiting height	A
	SHEETROCK Z-furring channels applied vertically 24" o.c., THERMAFIBER fire safety FS-15 blankets between channels, ⅝" SHEETROCK brand gypsum panels, foil back, screw-attached to channels, joints finished	Noncombustible system with mineral fiber insulation, suitable for up to 3" thick insulation; good vapor retarder, no limiting height	B
	Steel studs 24" o.c., set in runners, ⅝" SHEETROCK brand gypsum panels, foil-back, screw-attached to studs, joints finished	Free-standing; allows for pipe chase clearance; good vapor retarder	C
	SHEETROCK Z-furring channels applied vertically 24" o.c., rigid plastic foam insulation between channels, ⅝" SHEETROCK brand gypsum panels, foil-back, applied vertically and screw-attached to channels, joints finished	Suitable for up to 3" thick insulation; no limiting height.	D

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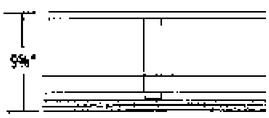
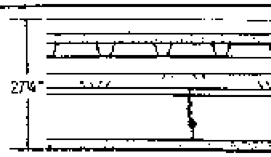
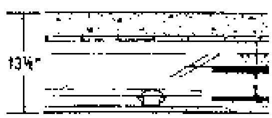
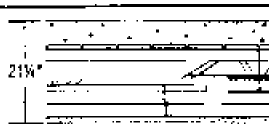
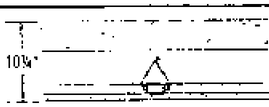
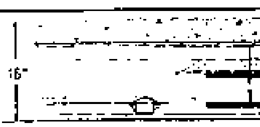
11.0.5 Non-Load-Bearing Ceilings

Fire rating	Fire-rated construction: Detail & physical data	Description & test no.	Acoustical performance: STC	IIC	Description & test no.	System reference
N/A		⅝" SHEETROCK brand gypsum panels, FIRECODE core—1½" chan 4' o.c.—met fur chan 24" o.c.—panels screw att 12" o.c.—joints fin. clg wt 3	N/A			A
1 hr (beam 1 hr)		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—7¼" 18 ga. structural steel joists 24" o.c.—dbl layer gypsum panel clg and ¾" T&G plywd flr att to joists with Type S-12 screws—dbl layer gypsum panels around beam—joints exp—UL Des L524 clg wt 4	39		Based on 9¼" 16 ga. structural joists—USG-760105	B
			43		Based on 9¼" 16 ga. structural joists and 3" SAFB*—USG-760310	
				56	Based on 9¼" 16 ga. structural joists and carpet & pad—USG-760108	
				60	Based on 9¼" 16 ga. structural joists and carpet & pad with 3" SAFB*—USG-760405	
1½ hr		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—susp grid with main run 4' o.c. and cross tees 2' o.c.—gypsum panels screw-att below grid—joints stag and fin—min 1" roof insul and ½" gypsum bd on steel deck over bar joists—1-hr. rating based on assembly with ½" thick panels—UL Des P510 clg wt 4	N/A			C
2 hr (beam 2 hr)		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—furred or susp—met fur chan 24" o.c.—panels att with 1" Type S screws 12" o.c.—joints exp or fin—2½" conc on riblath or corrugated steel deck over bar joist—UL Des G515 clg wt 3	N/A			D
2 hr (beam 3 hr)		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—susp grid with main run 4' o.c. and cross tees 2' o.c.—gypsum panels screw-att below grid—joints fin—2½" conc on riblath over bar joist—UL Des G529 clg wt 3	N/A			E
2 hr		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—met fur chan 24" o.c.—panels att with 1" Type S screws—joints fin—2" prestressed reg or lightwt conc units with 8" deep stems 48" o.c.—UL Des J502—UL Des J503 clg wt 3	N/A			F

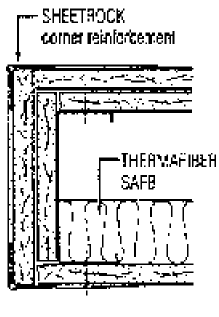
*Insulation may affect fire rating. See SA-905.

Fire rating	Fire-rated construction: Detail & physical data	Description & test no.	Acoustical performance: STC	IIC	Description & test no.	System reference
3 hr (beam 3 hr)		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—susp grid with main run 4' o.c. and cross tees 2' o.c.—gypsum panels screw-att below grid—joints fin—3¼" conc on riblath over bar joist—rating also applies with ½" panels and 2½" conc slab—UL Des G529 clg wt 3	N/A			G
3 hr		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—met fur chan 24" o.c.—panels att with 1" Type S screws—joints fin—prestressed 2½" reg or 2¾" lightwt conc units with 6" deep stems 48" o.c.—UL Des J502—UL Des J503—UL Des J504 clg wt 3		N/A		H
3 hr (beam 3 hr)		⅝" SHEETROCK brand gypsum panels, FIRECODE C core—met fur chan 24" o.c.—panels att with 1" Type S screws 12" o.c.—joints exp or fin—3" conc on corrugated steel deck or on riblath over bar joist—UL Des G512 clg wt 3		N/A		I

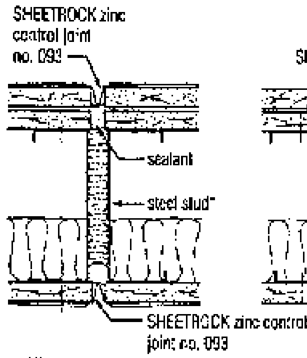
(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.1.0 Partition Construction Details (Illustrated)

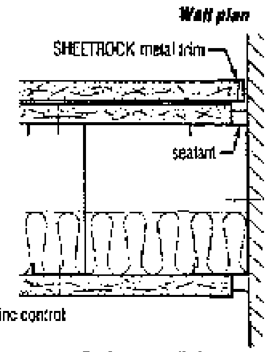
Scale: 3" = 1'-0"



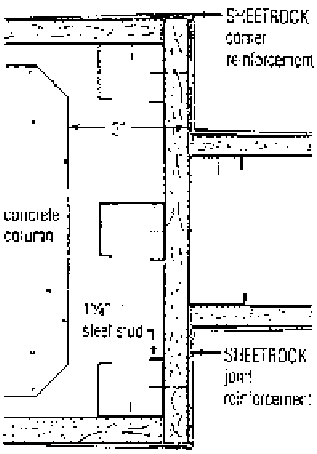
Partition terminal



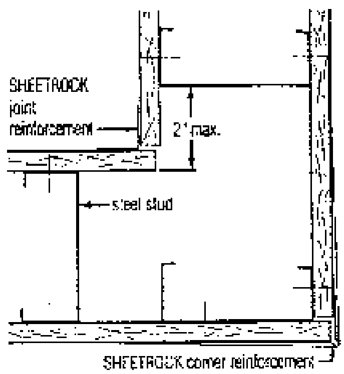
Wall control joint



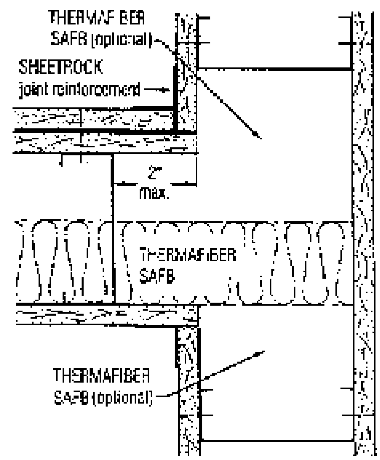
Perimeter relief
wall intersection



Partition relief
column intersection

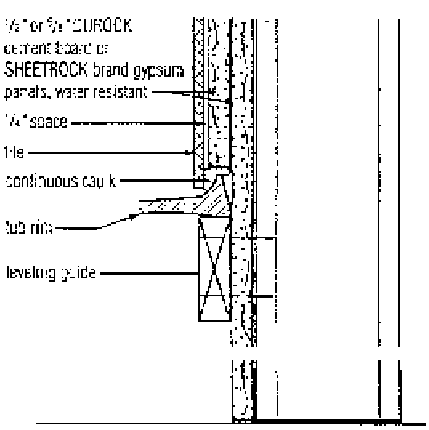


Partition corner

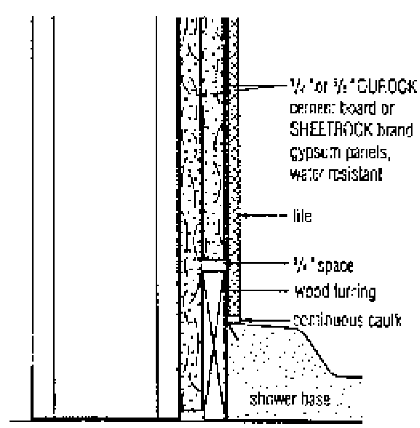


Sound-isolating partition intersection

Double-layer panels



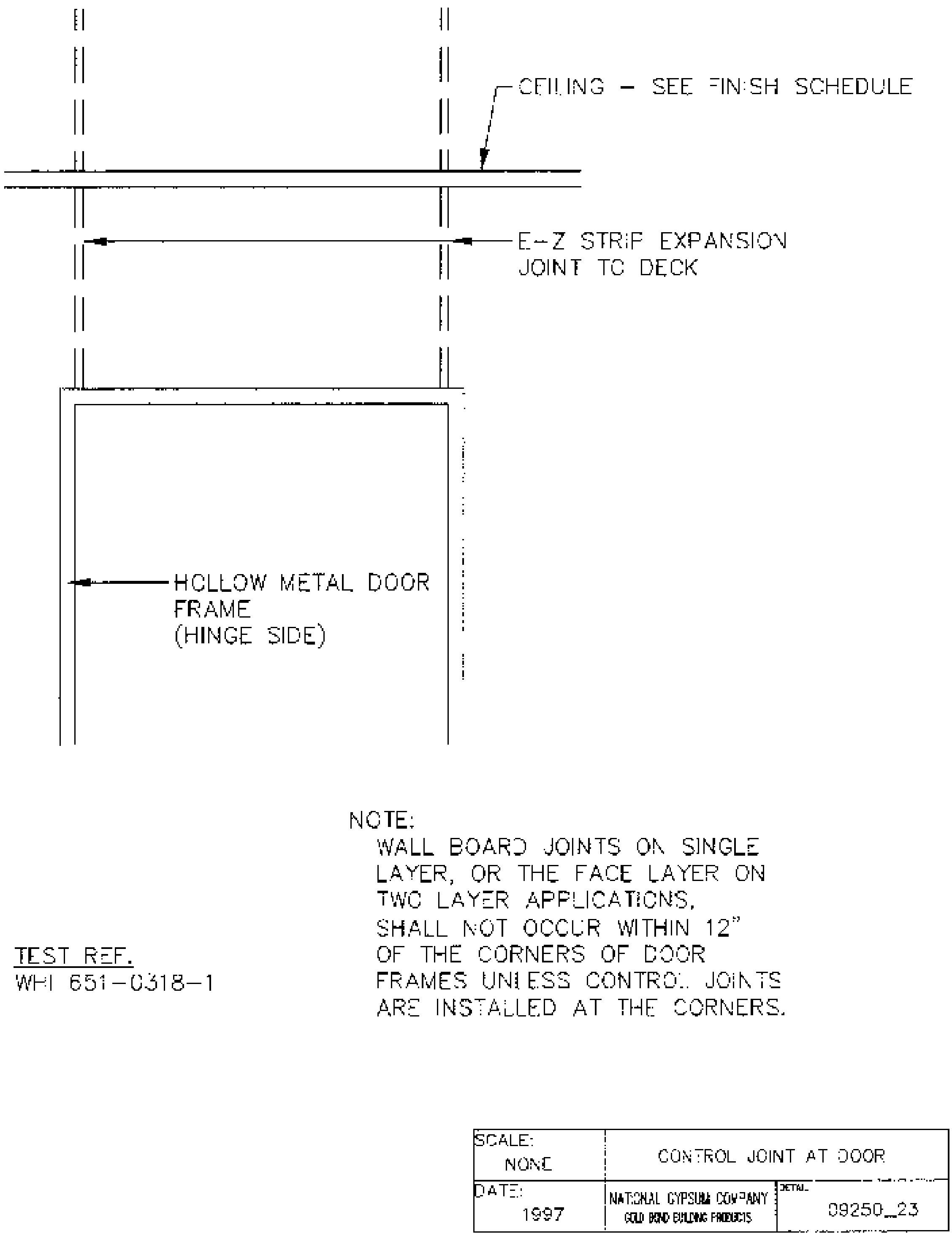
Tub



Shower Receptor

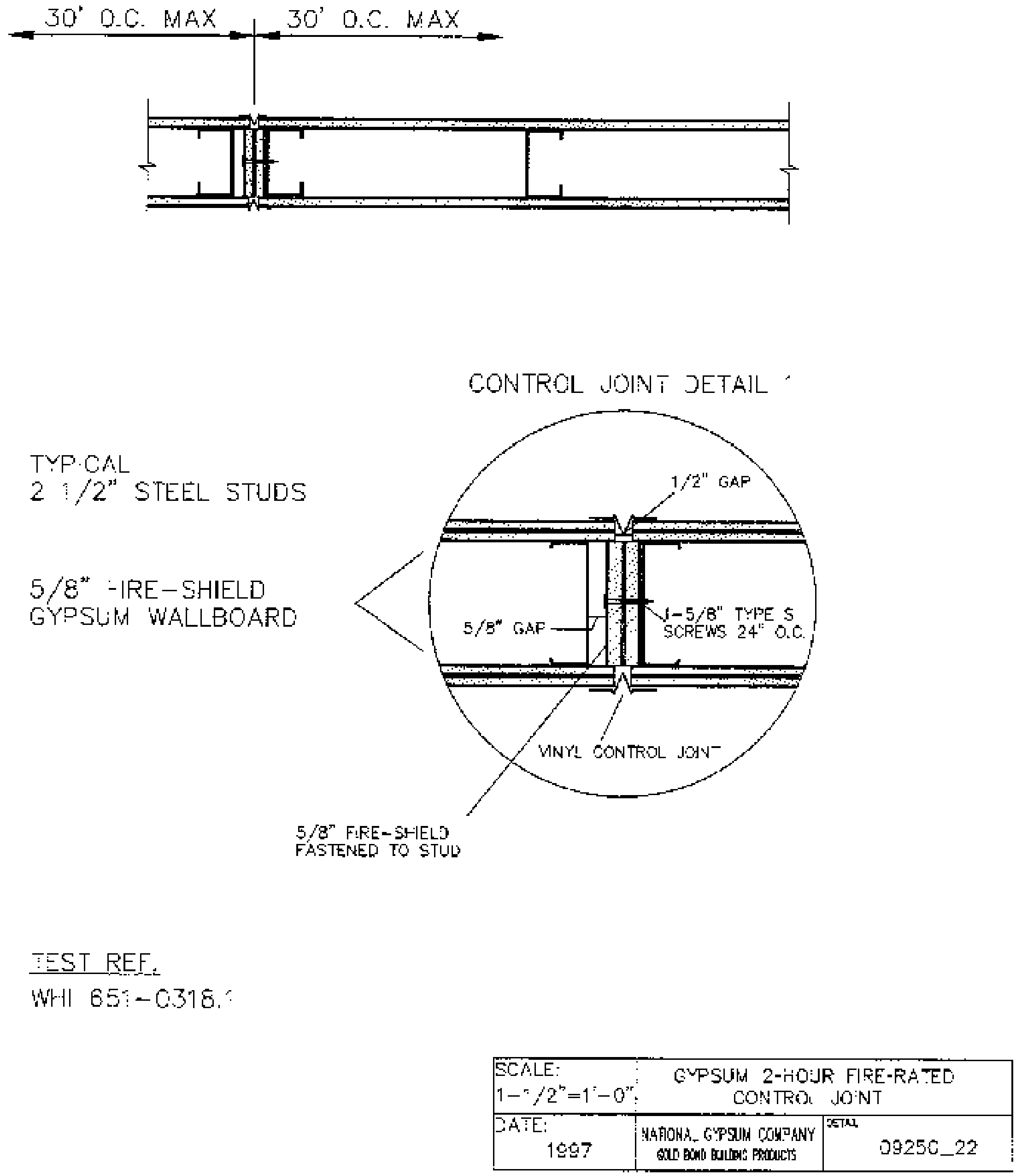
(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.1.1 Control Joint Detail at Door



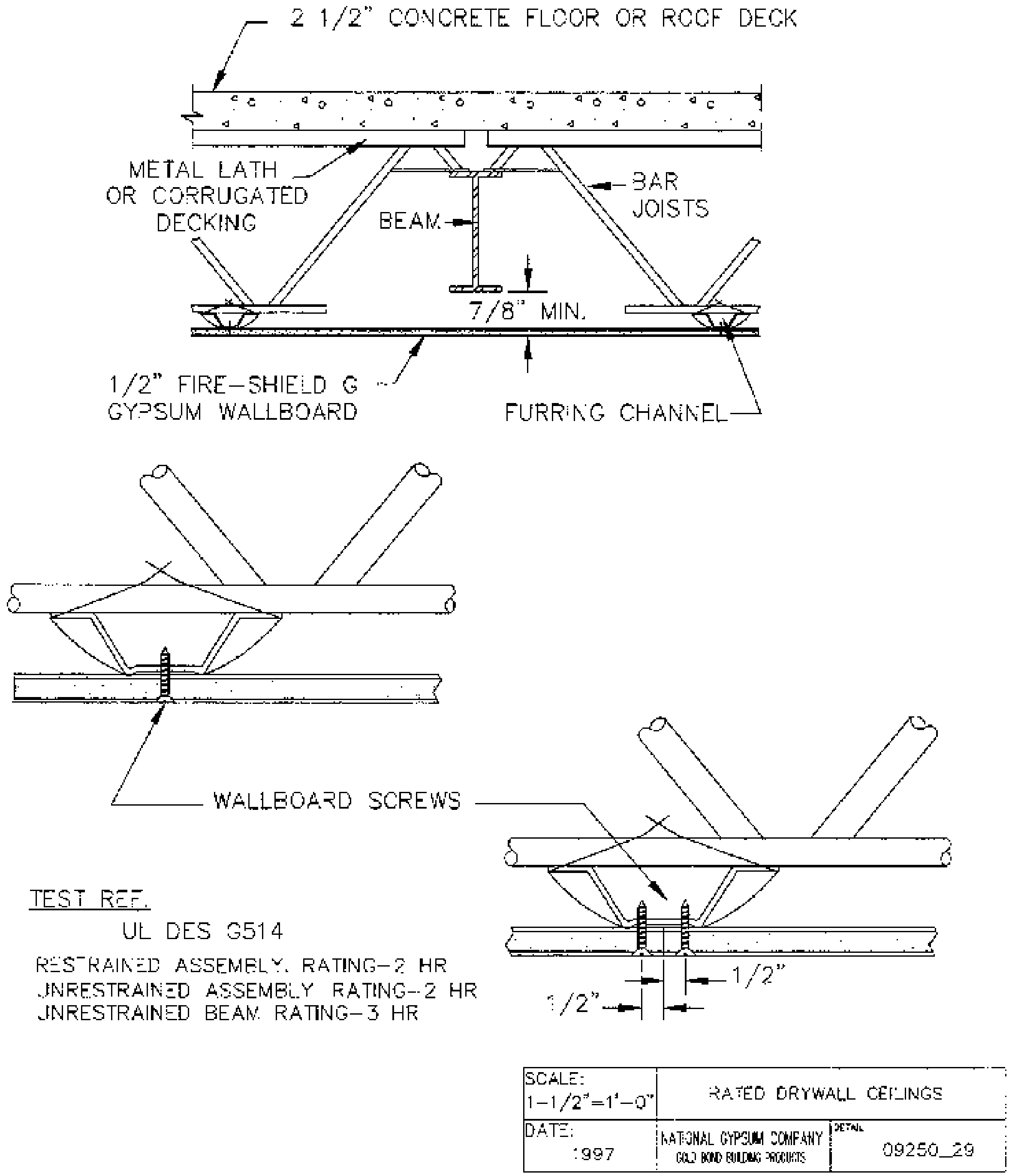
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.2 Two-Hour Rated Control Joint Detail



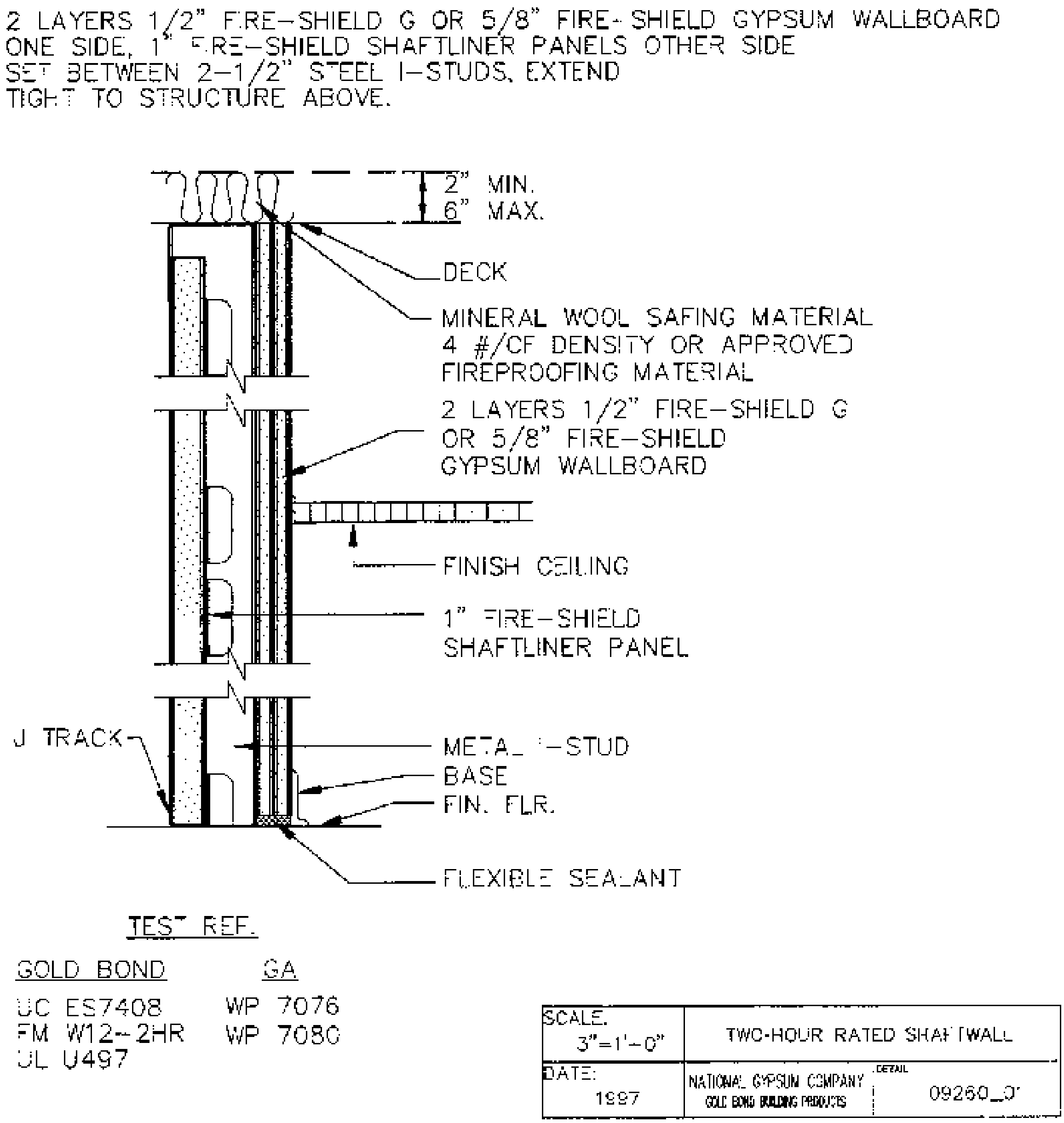
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.3 Rated Drywall Ceilings



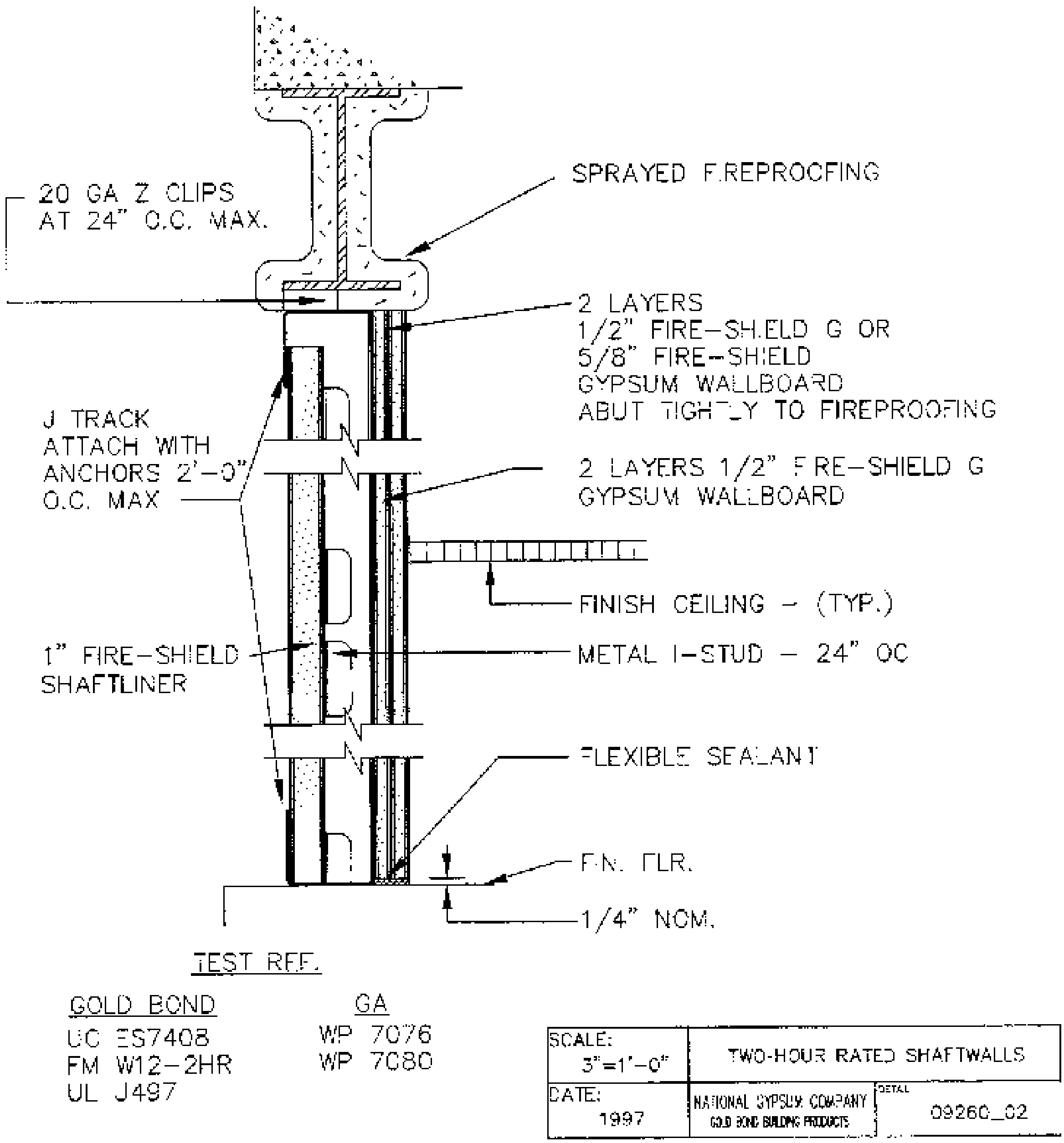
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.4 Rated Shaftwalls (To Structure Above)



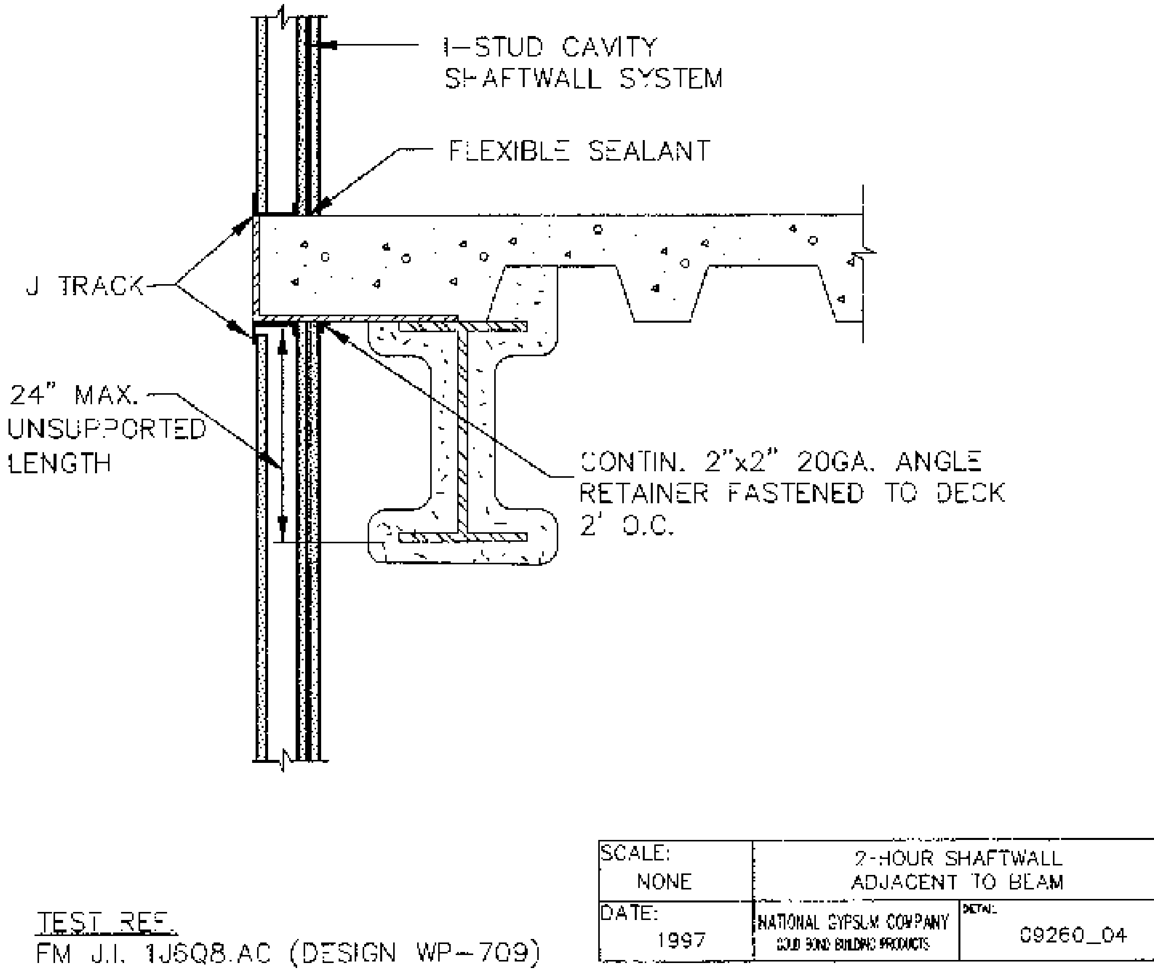
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.5 Rated Shaftwall (To Structural Steel Beam)



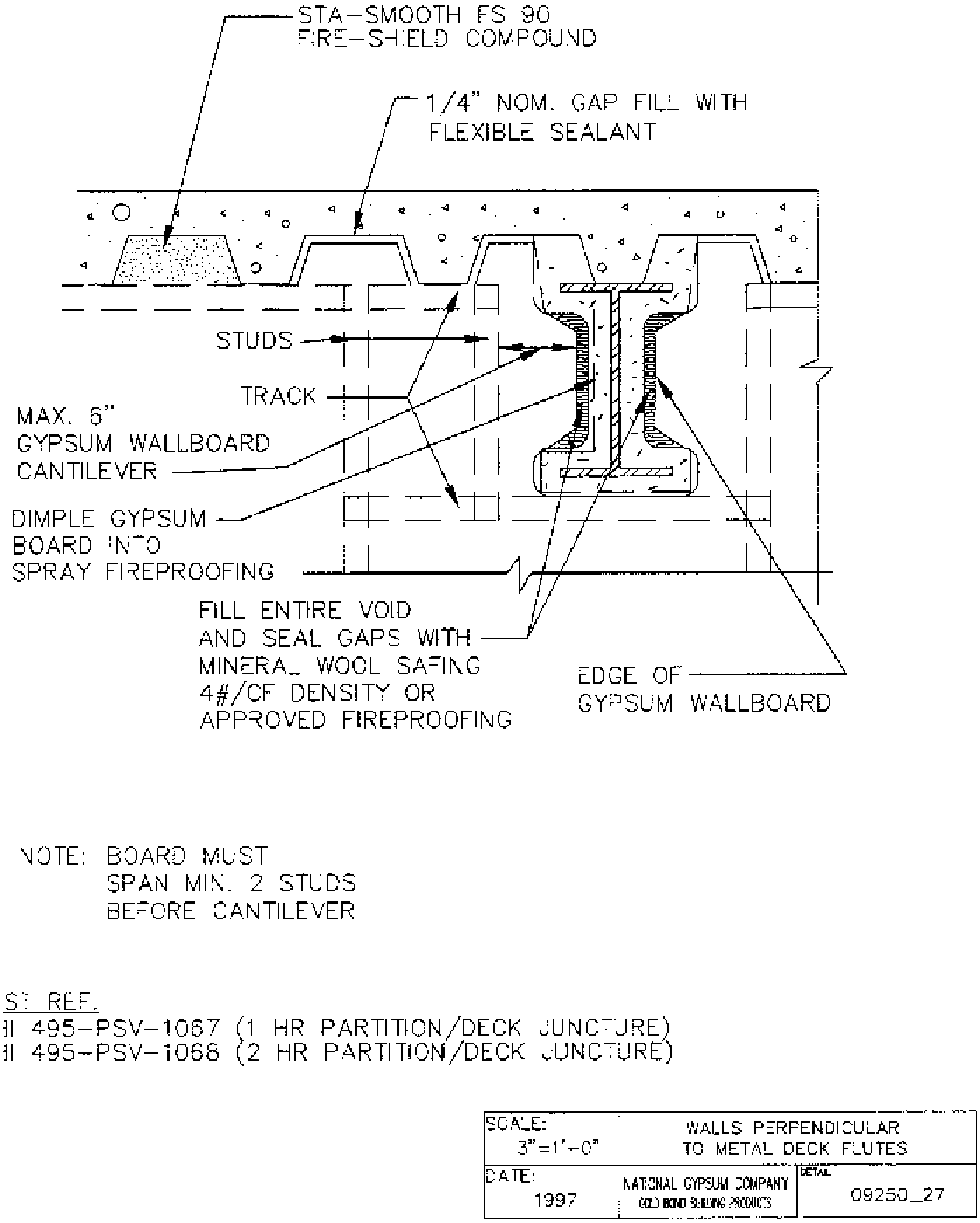
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.6 Rated Shaftwall Adjacent To Beam



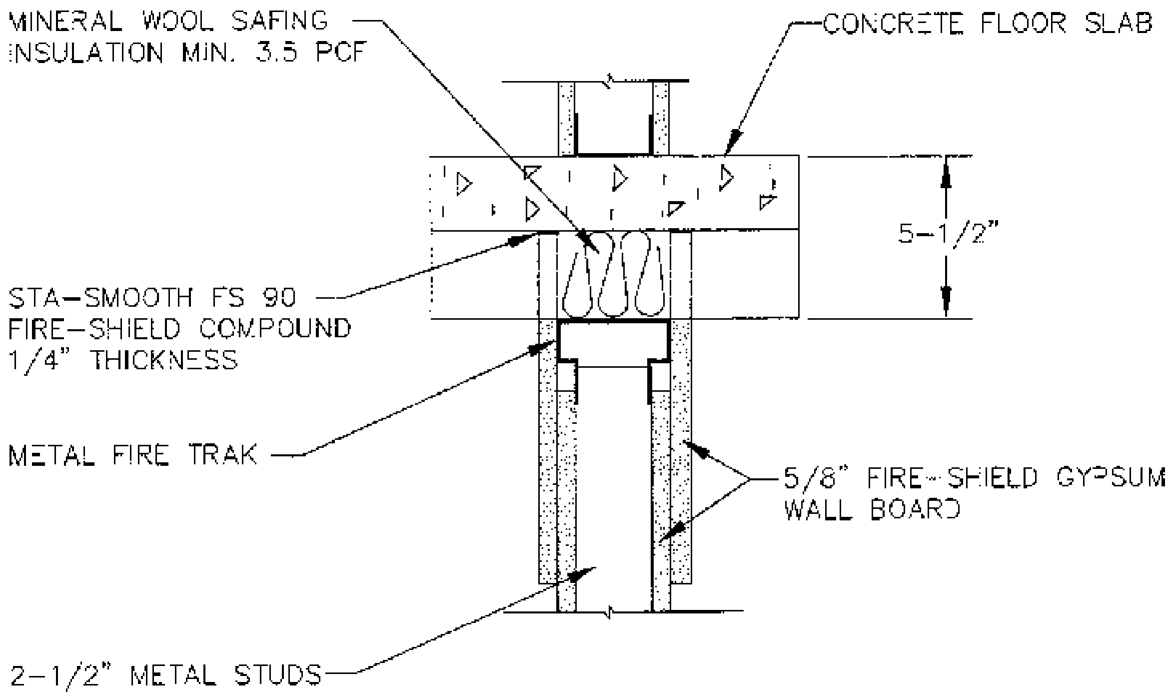
(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.7 Two-Hour Wall Perpendicular To Metal Deck Flutes



(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.8 One-Hour Deflection Track Perpendicular To Flutes



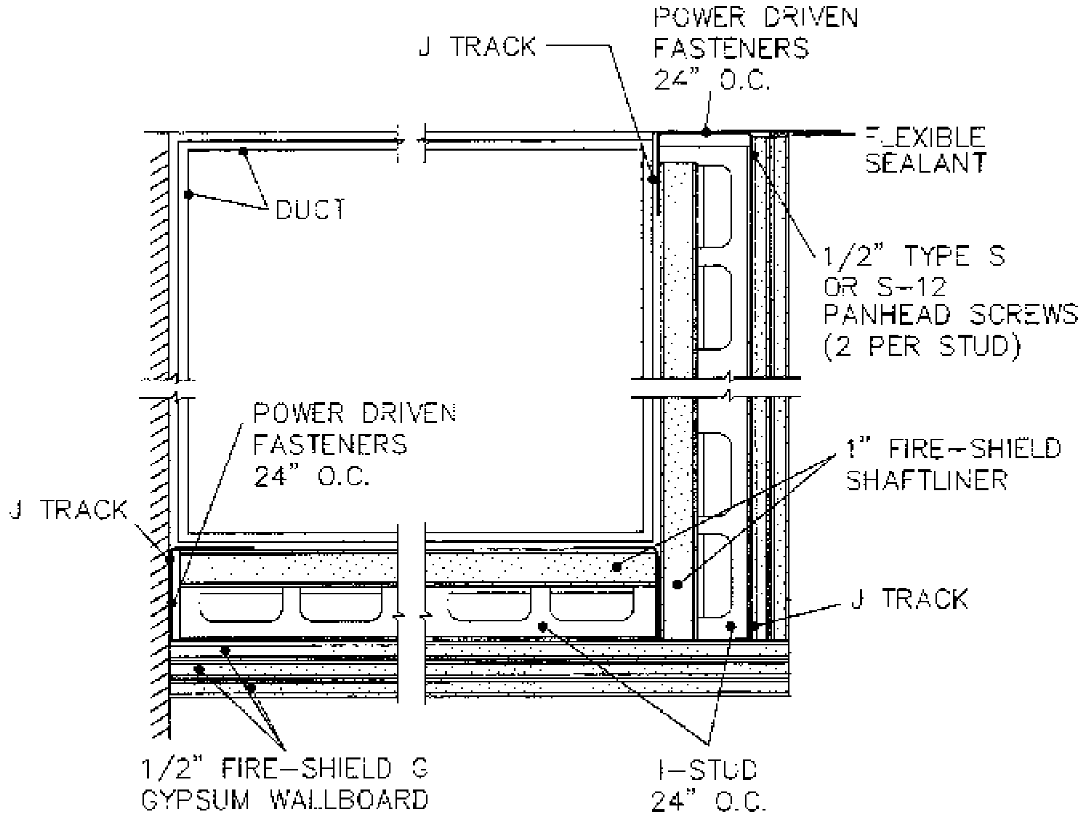
TEST REF.
WHI-495-PSV-1063 (1-HR)
WHI-495-PSV-1064 (2-HR)

NOTE:
USE TWO LAYERS 5/8" FIRE-SHIELD WALL BOARD FOR 2-HR ASSEMBLY.

SCALE: NONE	ONE-HOUR DEFLECTION TRACK PERPENDICULAR TO FLUTES	
DATE: 1997	NATIONAL GYPSUM COMPANY GOLD BOND BUILDING PRODUCTS	DETAIL 09250_24

(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.9 Two-Hour Horizontal Duct Protection



GENERAL NOTES

J TRACK IS FASTENED TO STUD
WITH TWO SCREWS PER STUD END.

AT INTERSECTION OF HORIZ.
AND VERT. WALL SECTIONS FASTENERS
MUST BE APPLIED THROUGH J TRACK
AND INTO I-STUDS.

MAXIMUM HORIZ. SPANS ARE
DEPENDENT ON I-STUD SIZE AND
GAUGE.

TEST REF.
WHI 694.0300.1

SCALE: 3"=1'-0"	TWO-HOUR HORIZONTAL DUCT PROTECTION	
DATE: 1997	NATIONAL GYPSUM COMPANY GOLD BOND BUILDING PRODUCTS	DETAIL 09260_09

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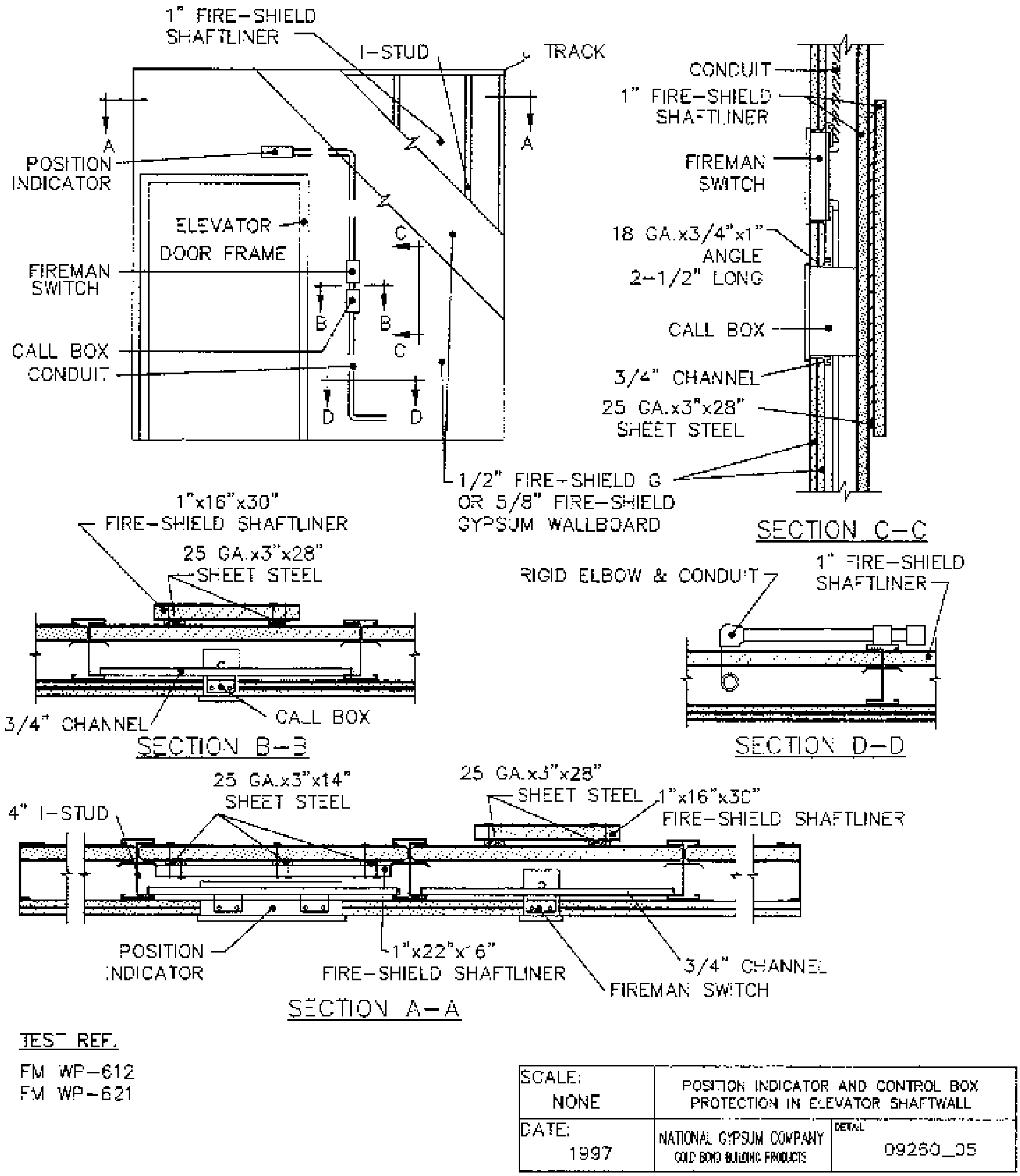
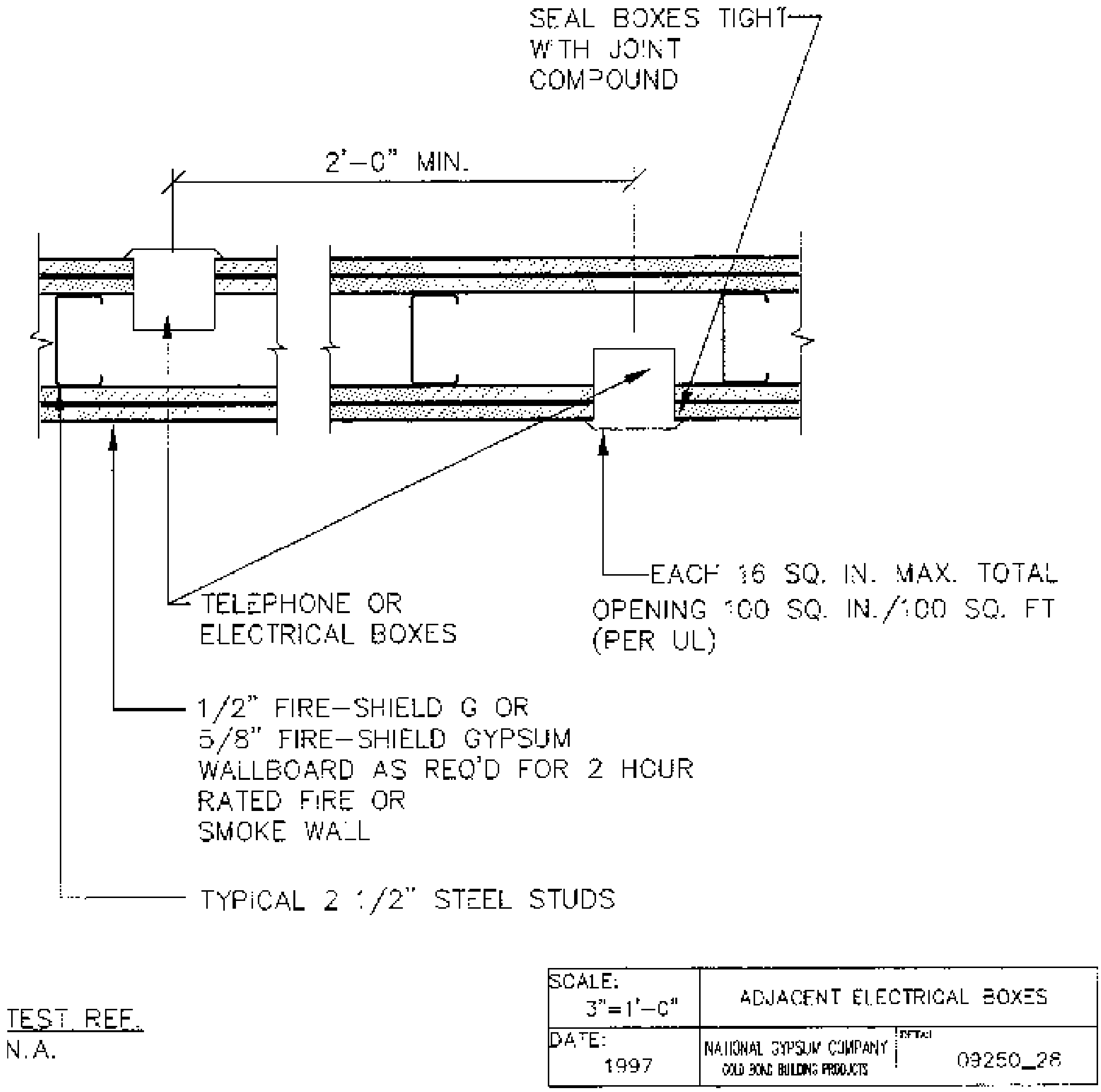
11.1.10 Details at Elevator Entrances



(By permission from the National Gypsum Company, Charlotte, North Carolina.)

11.1.11 Adjacent Electrical Box Installation

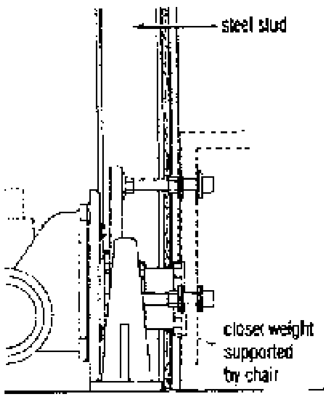


(By permission from the National Gypsum Company, Charlotte, North Carolina.)

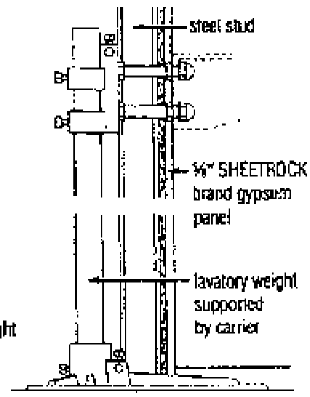
11.2.0 Plumbing Fixture Attachment and Electric Outlet Installation

Fixture Attachment

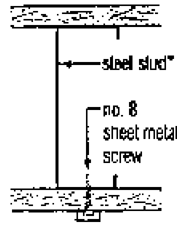
Scale: 3" = 1'-0"



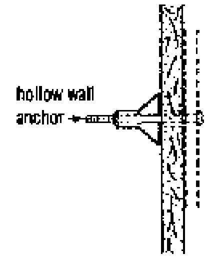
Closet carrier



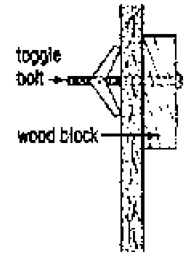
Lavatory carrier



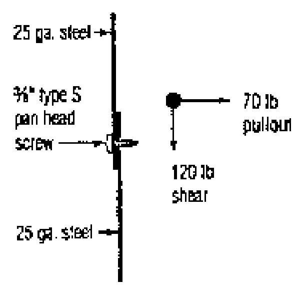
Light



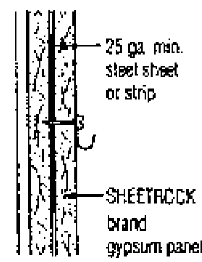
Light



Light



Metal to metal

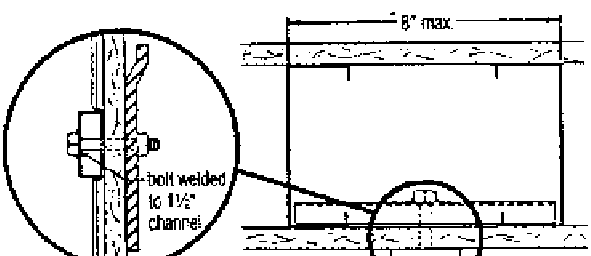


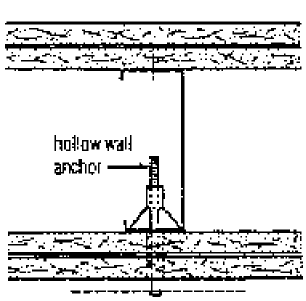
Light

Load table

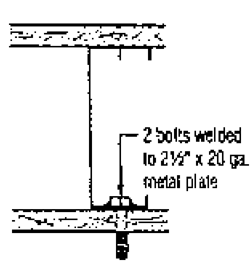
Fastener Type	Size in	Size mm	Base assembly	Allowable withdrawal resistance lb	Allowable withdrawal resistance N[1]	Allowable shear resistance lb	Allowable shear resistance N[1]
toggle bolt or hollow wall anchor	⅛	3.18	½" gypsum panel	20	89	40	178
	3/16	4.76		30	133	50	222
	¼	6.35		40	178	60	267
	⅛	3.18	½" gypsum panel & 25 ga. steel stud	70	311	100	445
	3/16	4.76		80	356	125	556
	¼	6.35		155	689	175	778
no. 8 sheet metal screw			½" gypsum panel & 25 ga. steel stud or 25 ga. steel insert	50	222	80	356
Type S bugle head screw				60	267	100	445
Type S-12 bugle head screw			½" gypsum panel & 20 ga. steel stud or 20 ga. steel insert	65	378	135	600
⅜" Type S pan head screw			25 ga. steel to 25 ga. steel	70	311	120	534
Type S-12			20 ga. steel to 20 ga. steel	53	235	133	591
two bolts welded to steel insert	3/16	4.76	see grab bar attachment below	175	778	200	890
	¼	6.25		200	890	250	1112
bolt welded to 1½" chan	¼	6.35	see plumber's bracket below	200	890	250	1112

(1) Newtons



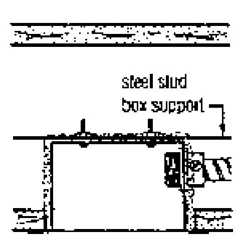


Medium

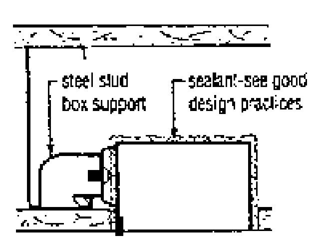


Medium
grab bar attachment

Outlet Boxes



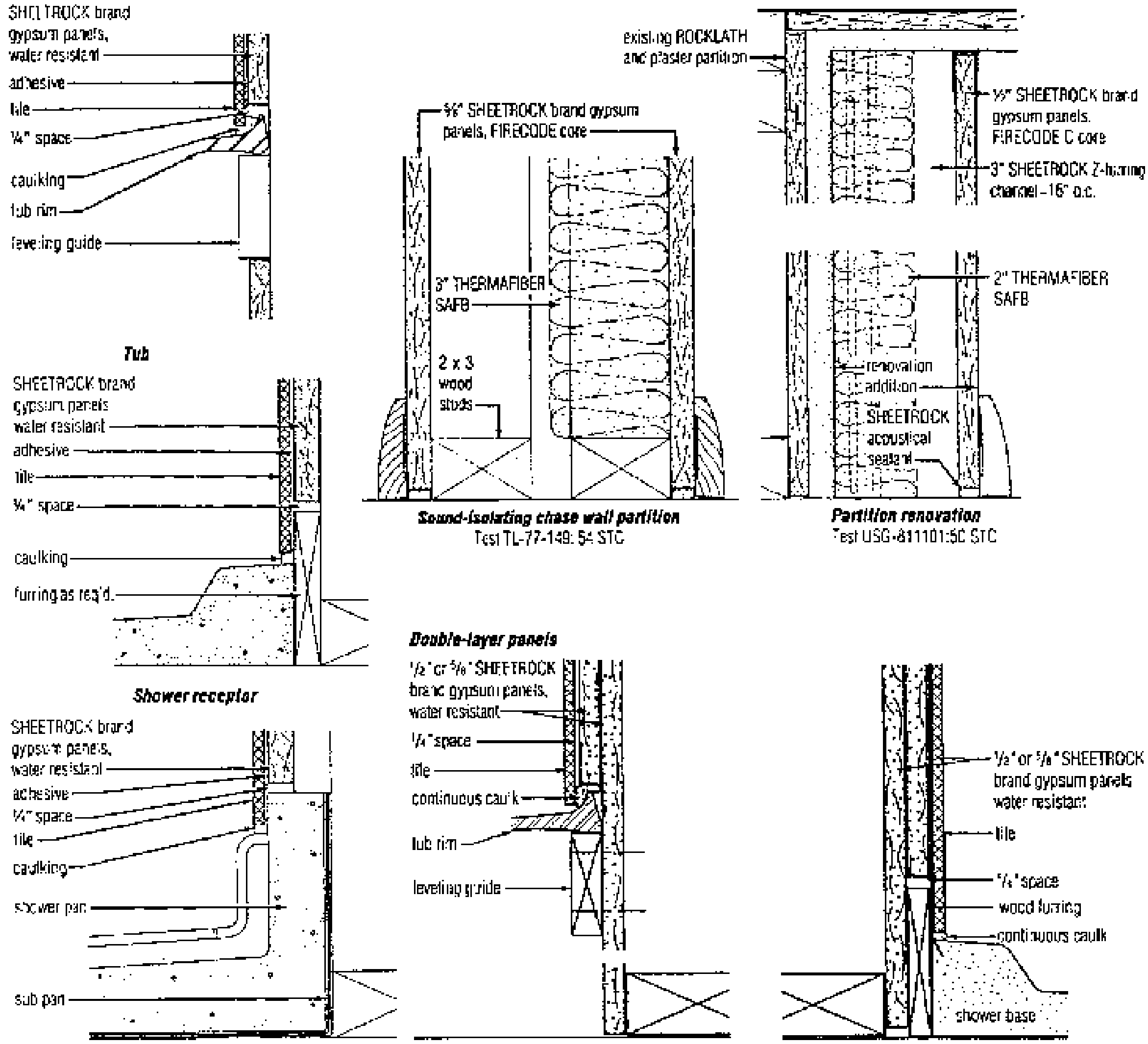
Outlet box



Outlet box
(alternate)

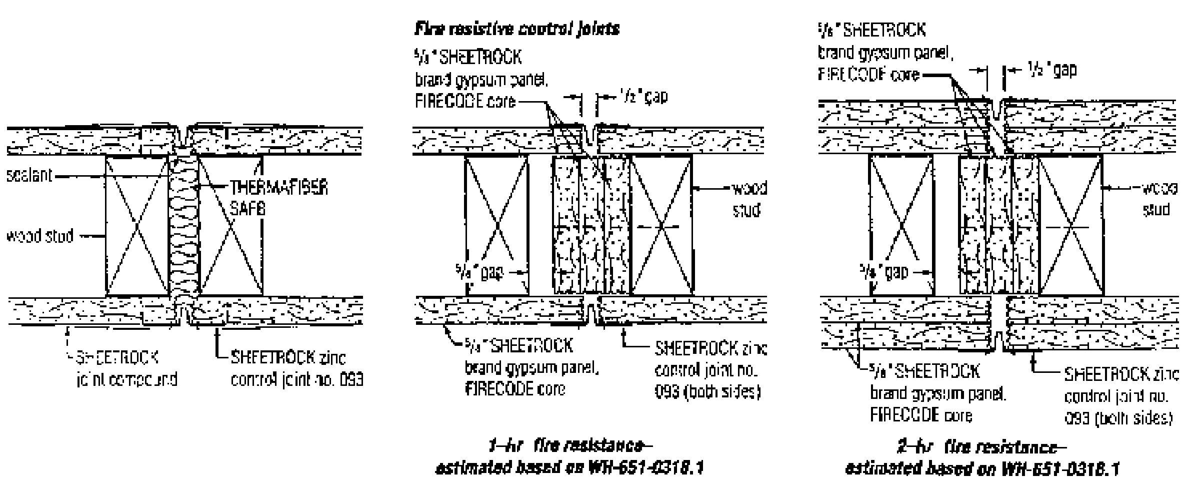
(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.3.0 Tub and Shower Details—Single-Layer Panels



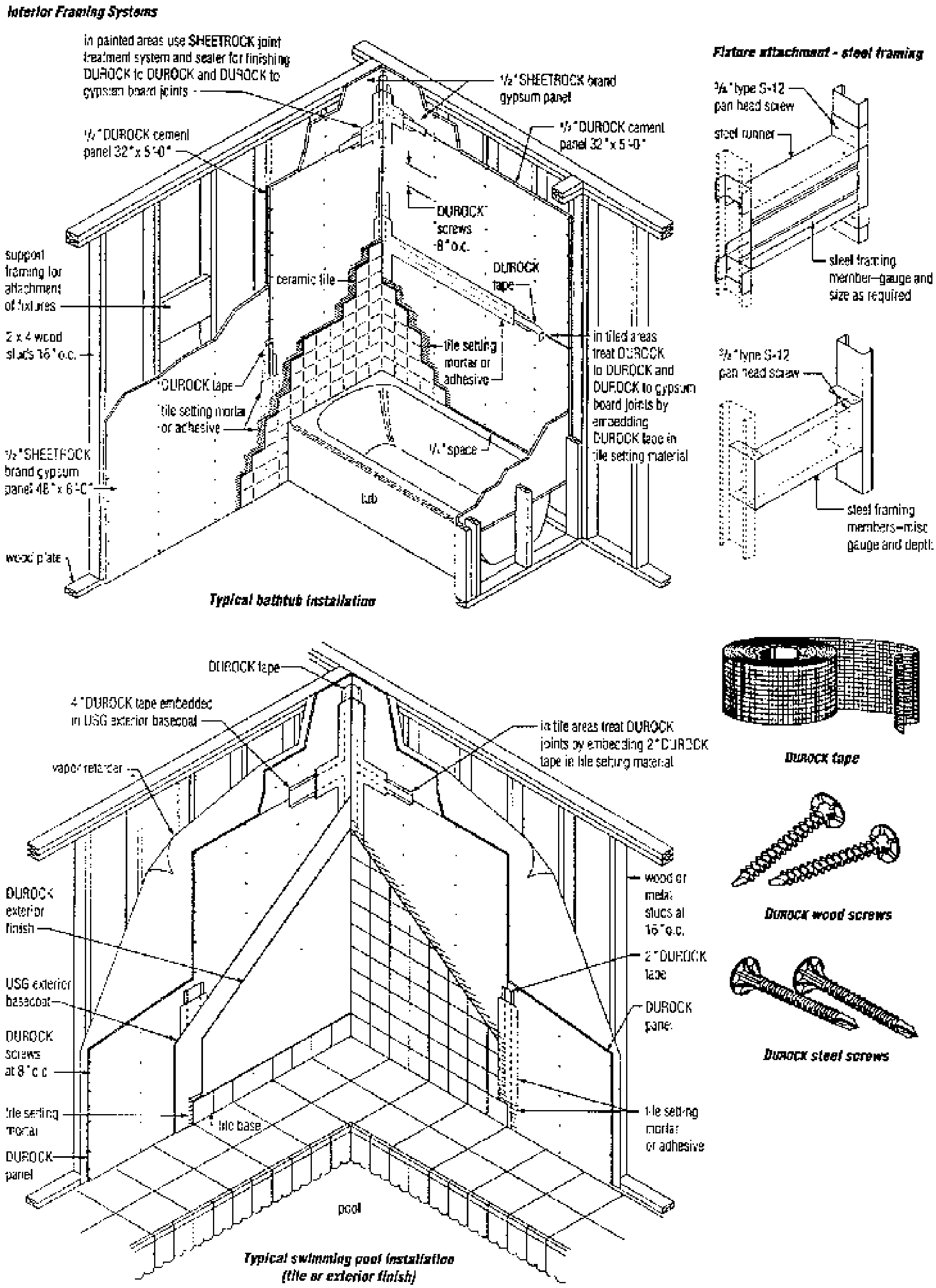
(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.4.0 Wall Control Joint Details (Illustrated)



(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.5.0 Typical Bath Tub and Swimming Pool Wall Details



(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.6.0 Soffit Framing Specifications

This assembly consists of galvanized steel channel runners and studs faced with Sheetrock brand Gypsum Panels, screw attached. It is a lightweight, fast and economical method of filling over cabinets or lockers and of housing overhead ducts, pipes or conduits. The braced system permits constructing soffits with depths of 48" (vertically) and widths to 72" (horizontally). The unbraced system is for soffits up to 24" × 24".

Maximum Width and Depth Dimensions(1)

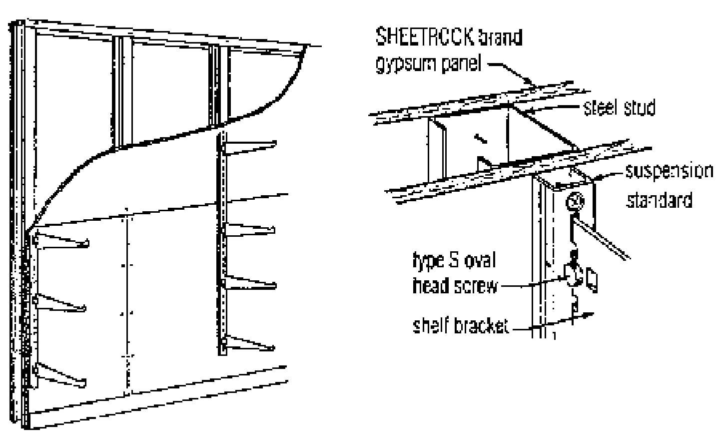
Gypsum board thickness(2)		Steel stud size		Maximum width		Maximum depth for max. width shown	
in.	mm	in.	mm	in.	mm	in.	mm
½	12.7	1⅜	41.3	60	1500	48	1200
½	12.7	2½, 3⅛	63.5, 92.1	72	1800	36	900
⅝	15.9	1⅜	41.3	60	1500	30	800
⅝	15.9	2½, 3⅛	63.5, 92.1	72	1800	18	500

(1) The construction is not designed to support loads other than its own dead weight and should not be used where it may be subjected to excessive abuse.
(2) The double-layer system and ⅛" thick gypsum panels are not recommended for this construction.

11.7.0 Shelf-Wall Specifications and Illustrations

This system provides load-carrying walls for shelving in stores, offices, schools and other applications. Incorporating simple, quickly erected, economical steel stud components with Garcy shelf brackets, standards and accessories, the assembly offers advantages of steel stud-drywall construction plus structural strength to support shelving and merchandise.

In this assembly, 3⅝" steel studs spaced no more than 24" o.c. are securely fastened to floor and ceiling runners and surfaced with either single or double-layer Sheetrock brand Gypsum Panels. Slotted standards are screw-attached through gypsum board to studs or steel reinforcing inserted between layers.



(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

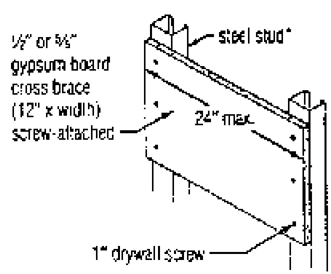
11.8.0 Chase-Wall Specifications and Illustrations

Typical limiting heights—Chase-wall partitions

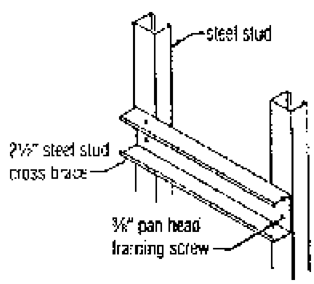
Stud width	Stud ga.	Stud spacing	Allow. defl.	One layer	Two layers
1⅝"	25	16"	L/120	15'3" f	15'3" f
			L/240	13'3" d	14'6" d
			L/360	11'6" d	12'9" d
		24"	L/120	12'6" f	12'6" f
			L/240	11'6" d	12'6" f
			L/360	10'0" d	11'0" d
2½"	25	16"	L/120	19'6" f	19'6" f
			L/240	17'6" d	19'0" d
			L/360	15'6" d	16'6" d
		24"	L/120	16'0" f	16'0" f
			L/240	15'6" d	16'0" f
			L/360	13'6" d	14'6" d
3⅝"	25	16"	L/120	23'6" f	23'6" f
			L/240	22'9" d	23'6" f
			L/360	19'9" d	21'3" d
		24"	L/120	19'3" f	19'3" f
			L/240	19'3" f	19'3" f
			L/360	17'3" d	18'6" d

Limiting height for ½" or ⅝" thick panels and 5 psf uniform load perpendicular to partition. Assemblies require vertical cross braces 4 ft. o.c. max. Use two-layer heights for multilayer assemblies. Limiting criteria: d—deflection, f—bending stress. Consult local code authority for limiting criteria.

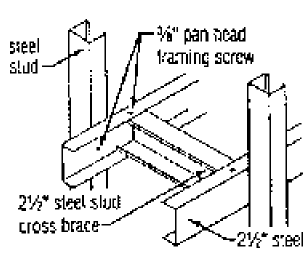
Chase walls provide vertical shafts where greater core widths are needed for pipe chase enclosures and other service installations. They consist of a double row of steel studs with gypsum panel cross braces between rows. Double-layer ⅝" SHEETROCK brand Gypsum



Gypsum brace



Steel stud brace



Steel stud & runner brace

(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.9.0 Resilient Channel Partition Specifications

Resilient attachment of gypsum panels with RC-1 Resilient Channels or equivalent provides low-cost, highly efficient assemblies for increased privacy in corridor and party wall applications. The steel channels float the panels away from the studs and provide a spring action that decouples the board from the framing. When combined with THERMAFIBER SAFB in the framing cavity, highly effective sound attenuation is obtained.

In these thin, lightweight assemblies, horizontal RC-1 Resilient Channels (or equivalent), 24" o.c., are screw-attached one side of 3⅝" steel studs spaced 24" o.c. and set in runners. Gypsum panels are screw-attached to these channels on one side and directly attached to the steel stud flanges on the opposite partition side. THERMAFIBER SAFB, 3" thick and 25" wide, are inserted and creased in the partition cavity. Because the blanket is wider than the cavity, it presses against the panels, thereby damping sound vibrations more effectively and offering 55 STC sound rating. (Use of a filler strip at the base may reduce STC rating.) Limiting heights for these assemblies are shown in the table below.

Limiting heights—resilient channel assemblies[1]

Stud width	Stud ga.	Stud spacing	Allow. defl.	One layer resilient partition
3⅝"	25	16"	L/120 L/240	15'7"f 13'4"d
		24"	L/120 L/240	13'6"f 11'8"d

(1) Limiting height for ⅝" thick gypsum panels and 5-psf uniform load perpendicular to partition. Studs attached to top and bottom runners on resilient side. Limiting criteria: d—deflection; f—bending stress; consult local code authority for limiting criteria.

11.10.0 Tall Wall Specifications and Limiting Heights

Partitions exceeding 30' in height are considered tall. When these taller than normal partition heights are required, consideration must be given to length restrictions for manufacturing and shipping steel studs, scaffolding, stud placement, etc.

Use double structural studs back-to-back 24" o.c. The studs should be the maximum practical length so that the splice of one stud in each pair will occur at outer ⅓ of the span. The splice of the other stud will occur at the opposite end. Attach studs back to back with screws approximately 4' o.c. Attach each stud flange to top and bottom runner with ½" Type S-12 screws so that each pair of studs will have four screw attachments at each end. Attach 1½" 20 ga. V-bracing to stud flanges on each side assembly 12' o.c. for stud alignment and lateral bracing.

For 5 psf wind load, 20 ga. runner track is recommended. The fasteners should have a capacity of 300 lb. in single shear and bearing. For 10 psf wind load, 18 ga. runner track attached with fasteners with 400 lb. single shear and bearing is recommended.

Runner Attachment Spacing

Maximum wall height	Wind load 5 psf	Wind load 10 psf
40'	24"	24"
48'	24"	20"
55'	24"	16"

Required Double Stud Sizes—Structural Studs

Maximum wall height	5 psf L/240 size (in.)	5 psf L/240 ga.	5 psf L/360 Size (in.)	5 psf L/360 ga.	10 psf L/240 Size (in.)	10 psf L/240 ga.	10 psf L/360 Size (in.)	10 psf L/360 ga.
35'	6 7¼	14 or 18	7¼	14 or	8 9¼	14 or 16	9¼ 11½	14 or 16
			8	16				
40'	7¼ 8	14 or 16	8	14	9¼ 11½	14 or 16	11½	16 or
45'	8	14	9¼	14	11½	16	13¼	14
50'	9¼	14	11½	16	11½	14	13¼	14
55'	11½	16	11½	14	13¼	15	—	—

Conforms to 1986 AISI Specification for the Design of Cold-Formed Steel Structural Members.
Narrower flange is 1.552 in.; wider flange is 1.724 in. outside for all structural studs. See note on page 4.

Typical Limiting Heights—Structural Studs

Stud width[1]	Stud gauge	5 psf L/240	5 psf L/360	10 psf L/240	10 psf L/360	15 psf L/240	15 psf L/360
3½"	20	14'9"	13'0"	11'9"	10'3"	10'3"	9'0"
	18	16'3"	14'3"	13'0"	11'3"	11'3"	10'0"
	16	17'6"	15'3"	14'0"	12'3"	12'3"	10'9"
	14	18'9"	16'6"	15'0"	13'3"	13'3"	11'6"
4"	20	15'9"	14'0"	12'9"	11'3"	11'3"	9'9"
	18	17'3"	15'3"	14'0"	12'3"	12'3"	10'9"
	16	18'9"	16'6"	15'0"	13'3"	13'3"	11'6"
	14	20'0"	17'9"	16'3"	14'3"	14'3"	12'6"
6"	20	22'0"	19'3"	17'9"	15'6"	15'6"	13'6"
	18	24'0"	21'3"	19'3"	17'0"	17'0"	14'9"
	16	26'0"	23'0"	21'0"	18'6"	18'6"	16'0"
	14	28'0"	24'9"	22'6"	19'9"	19'9"	17'3"
8"	18	30'6"	26'9"	24'6"	21'6"	21'6"	18'9"
	16	33'0"	29'3"	26'6"	23'3"	23'3"	20'6"
	14	35'6"	31'3"	28'6"	25'0"	25'0"	22'0"

(1) Studs 24" o.c.

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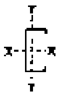
11.10.1 *L* over 120/240/360 Explained

Many of the tables included in this section make reference to *L*/120, *L*/240, and *L*/360. For those unfamiliar with these terms, the following explanation is of assistance in understanding the deflection specification included in these tables. The established rule is that a member should not deflect more than 1/360th of the length of its span, when the span is expressed in inches. To convert inches to centimeters, multiply by 2.54. *L* represents the length of the span, specifically, in the case of *L*/360, a 30-foot (9.144 meter) beam, and this beam should not deflect more than one inch (2.54 centimeters). If the criteria is *L*/240, then this 240-inch (609.6 cm), 20-foot (6.096 meter) beam shall not deflect more than one inch (2.54 cm).

11.10.2 Structural Stud Specifications

Typical Physical and Structural Properties[1]—Structural Studs (FY=40 ksi)

table 5



Size (in.) &	ga.	Weight[2] (lb/ft)	Weight[2] (kg/m)	Net area[3] (in²)	AET (net effective area) (in²)	Allow. Design steel thickness[3] (in)	bending moment about x x axis (K-in)	Lip width (in)	Major axis I_x (in⁴)	Major axis S_x (in³)	Major axis r_x (in)	Minor axis I_y (in⁴)	Minor axis S_y (in³)	Minor axis r_y (in)	Full unreduced section modulus S_1 (in³)	Effective section modulus (M_a/S_1) S_c (in³)	Ω (column factor)	J (in⁴)	C_w (in⁶)	X_o (in)
3-5/8	20	0.97	1.44	0.216	0.2136	0.0359	6.557	0.500	0.541	0.273	1.429	0.085	0.082c	0.621	0.332	0.236	0.752	0.0001	0.300700	1.357
3-5/8	18	1.24	1.85	0.285	0.2713	0.0478	9.247	0.500	0.738	0.385	1.423	0.113	0.106c	0.619	0.395	0.309	0.799	0.0003	0.387	1.345
3-5/8	16	1.59	2.37	0.368	0.3341	0.0598	11.678	0.625	0.893	0.486	1.411	0.147	0.146c	0.629	0.499	0.387	0.804	0.0006	0.5703	1.420
3-5/8	14	2.00	2.98	0.454	0.3917	0.0747	14.293	0.625	1.093	0.596	1.404	0.178	0.176c	0.622	0.611	0.466	0.802	0.0011	0.6833	1.406
4	20	1.02	1.52	0.228	0.1792	0.0359	7.464	0.500	0.673	0.311	1.556	0.091	0.084c	0.617	0.341	0.271	0.721	0.0001	0.3631	1.313
4	18	1.30	1.93	0.301	0.2576	0.0478	10.5	0.500	0.882	0.437	1.550	0.117	0.108c	0.611	0.447	0.355	0.803	0.0003	0.4679	1.301
4	16	1.67	2.48	0.388	0.3571	0.0598	13.302	0.625	1.115	0.554	1.539	0.157	0.150c	0.626	0.566	0.447	0.812	0.0006	0.6616	1.374
4	14	2.09	3.11	0.480	0.4833	0.0747	16.3	0.625	1.366	0.679	1.532	0.189	0.181c	0.619	0.693	0.539	0.811	0.0011	0.6176	1.359
6	20	1.27	1.89	0.300	0.2148	0.0359	12.93	0.500	1.767	0.539	2.253	0.112	0.088c	0.587	0.596	0.495	0.562	0.0002	0.8744	1.111
6	18	1.63	2.43	0.397	0.3107	0.0478	18.561	0.500	2.35	0.773	2.246	0.145	0.118c	0.581	0.785	0.659	0.653	0.0004	1.1309	1.099
6	16	2.08	3.10	0.506	0.4303	0.0598	23.759	0.625	2.99	0.99	2.243	0.195	0.163c	0.598	0.909	0.836	0.710	0.0007	1.5888	1.163
6	14	2.62	3.93	0.629	0.5858	0.0747	29.231	0.625	3.679	1.218	2.234	0.236	0.197c	0.591	1.229	1.017	0.767	0.0014	1.9148	1.148
7-1/4	18	1.84	2.74	0.457	0.2969	0.0478	24.361	0.500	3.732	1.015	2.663	0.157	0.118c	0.562	1.029	0.875	0.583	0.0004	1.7311	1.005
7-1/4	16	2.34	3.48	0.583	0.4304	0.0598	31.269	0.625	4.753	1.303	2.664	0.211	0.166c	0.579	1.311	1.121	0.637	0.0008	2.4067	1.064
7-1/4	14	2.55	4.33	0.720	0.6152	0.0747	35.629	0.625	5.857	1.605	2.654	0.256	0.203c	0.572	1.615	1.366	0.690	0.0015	2.9054	1.050
8	18	1.97	2.93	0.493	0.2937	0.0478	27.874	0.500	4.756	1.161	2.908	0.159	0.118c	0.550	1.187	1.018	0.547	0.0004	2.1644	0.956
8	16	2.50	3.72	0.628	0.456	0.0598	36.132	0.625	6.059	1.505	2.911	0.219	0.166c	0.568	1.513	1.306	0.600	0.0009	2.9966	1.013
8	14	3.15	4.69	0.779	0.6936	0.0747	44.557	0.625	7.473	1.856	2.901	0.265	0.205c	0.561	1.866	1.594	0.652	0.0017	3.6201	0.999
9-1/4	16	2.76	4.11	0.702	0.4146	0.0598	44.630	0.625	8.691	1.868	3.316	0.227	0.166c	0.550	1.875	1.647	0.546	0.0009	4.1512	0.938
9-1/4	14	3.48	5.18	0.872	0.6028	0.0747	55.351	0.625	10.73	2.305	3.306	0.278	0.206c	0.543	2.314	2.015	0.594	0.0018	5.0199	0.925
11-1/2	16	3.23	4.81	0.637	0.4355	0.0598	55.03	0.625	15.03	2.293	4.030	0.229	0.156c	0.521	2.606	2.326	0.470	0.0011	6.7915	0.830
11-1/2	14	4.07	6.06	1.040	0.5366	0.0747	77.138	0.625	18.58	3.214	4.018	0.292	0.207c	0.514	3.221	2.853	0.512	0.0021	8.2221	0.818
13-1/2	14	4.60	6.84	1.189	0.8562	0.0747	90.046	0.625	27.99	3.752	4.639	0.295	0.207c	0.491	4.134	3.704	0.456	0.0024	11.83235	0.743

Conforms to 1986 AISI Specification for the Design of Cold Formed Steel Structural Members.(1) Narrower flange is 1.552 in.; wider flange is 1.724 in outside width for all structural studs. See "Notice" on page 4. (2) Steel with corrosion-resistant coating. (3) Steel without coating.

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11.10.3 Fire-rated Assemblies—One to Three Hour

FIRE RATING

The following table depicts various fire-rated assemblies, incorporating light weight steel framing components. Rather than listing all the specifications (i.e., attachment requirements, assembly constraints, etc.) we ask that the applicable standard is researched through the agency which conducted the test.

Test Reference	Fire Rating	Type of Assembly	Agency	Components
FM24676.4 FC224	2 hr	Floor/Ceiling	FM 1975	* 2½ inches concrete. * 9/16 inch 28 GA deck and mesh * 7 ¼ x 18 GA joists, 24" o.c. * 2 layers ⅝" G.W.B. ceiling
FM29135 FC245	1 hr	Floor/Ceiling	FM 1977	* 2 inches concrete. (Note B) * 1 5/16 inch, 24 GA deck * 6 x 18GA joists, 24" o.c. * 1 layers ½" G.W.B. ceiling
L524	1 hr	Floor/Ceiling	UL 1988	* Min 7¼ x 18 GA, Steel Stud, 24" o.c. * Use any of the floor systems indicated in the UL test.
P511	1 hr	Roof/Ceiling	Ul 1988	* Min 7¼ x 18 GA, Steel Joist, C Shape, 2" Flange Minimum, 24" o.c. * See test for roof/ceiling components.
P512	1 hr	Roof/Ceiling	UL 1988	* Min 7¼ x 18 GA, Steel Joist, C Shape, 24" o.c. * See test for roof/ceiling components.
U418	¾ hr	Bearing Wall	UL 1988	* See test.
U418	1 hr	Bearing Wall	UL 1988	* Two layers ½" thick, G.W.B., one side. * 3½ or 5½ x 18 GA Steel Stud, 24" o.c. * See test for exterior component.
U418	2 hr	Bearing Wall	UL 1988	* Three layers ½" thick G.W.B., one side. * 3½ or 5½ x 18 GA Steel Stud, 24" o.c. * See test for exterior component.
U425	¾, 1 hr	Bearing Wall Interior	UL 1988	* See Test
U425	1½ hr	Bearing Wall Interior	UL 1988	* Two layers ½" thick G.W.B., each side. * 3½ x 20 GA Steel Stud, 24" o.c.
U425	2 hr	Bearing Wall Interior	UL 1988	* Three layers ½" thick G.W.B. * 3½ x 20 GA Steel Stud, 24" o.c.
U425	¾, 1, 1½ hr	Bearing Wall Exterior	UL 1988	* See Test
U425	2 hr	Bearing Wall Exterior	UL 1988	* Three layers ½" thick G.W.B., interior side. * 3½ x 20 GA Steel Stud, 24" o.c. * See test for exterior component.
U426	3 hr	Bearing Wall	UL 1988	* Four layers ½ thick G.W.B., each side. * 3½ x 20 GA Steel Stud, 24" o.c.
U434	1 hr	Bearing Wall	UL 1988	* ⅞" thick Portland Cement Plaster * 3½ x 20 GA Steel Stud, 24" o.c. * One layer ⅝" thick G.W.B. interior.

Note A: UL denotes Underwriters Laboratories, Inc., and FM denotes Factory Mutual Research Corporation.

Note B: Lightweight concrete measured from top flute of deck.

Consult a Fire Resistance Design Manual distributed by the Gypsum Association, 810 Front Street N.E. #510 Washington, D.C. 20002, for additional information. Furthermore, this publication addresses Sound Transmission Characteristics of steel framed assemblies.

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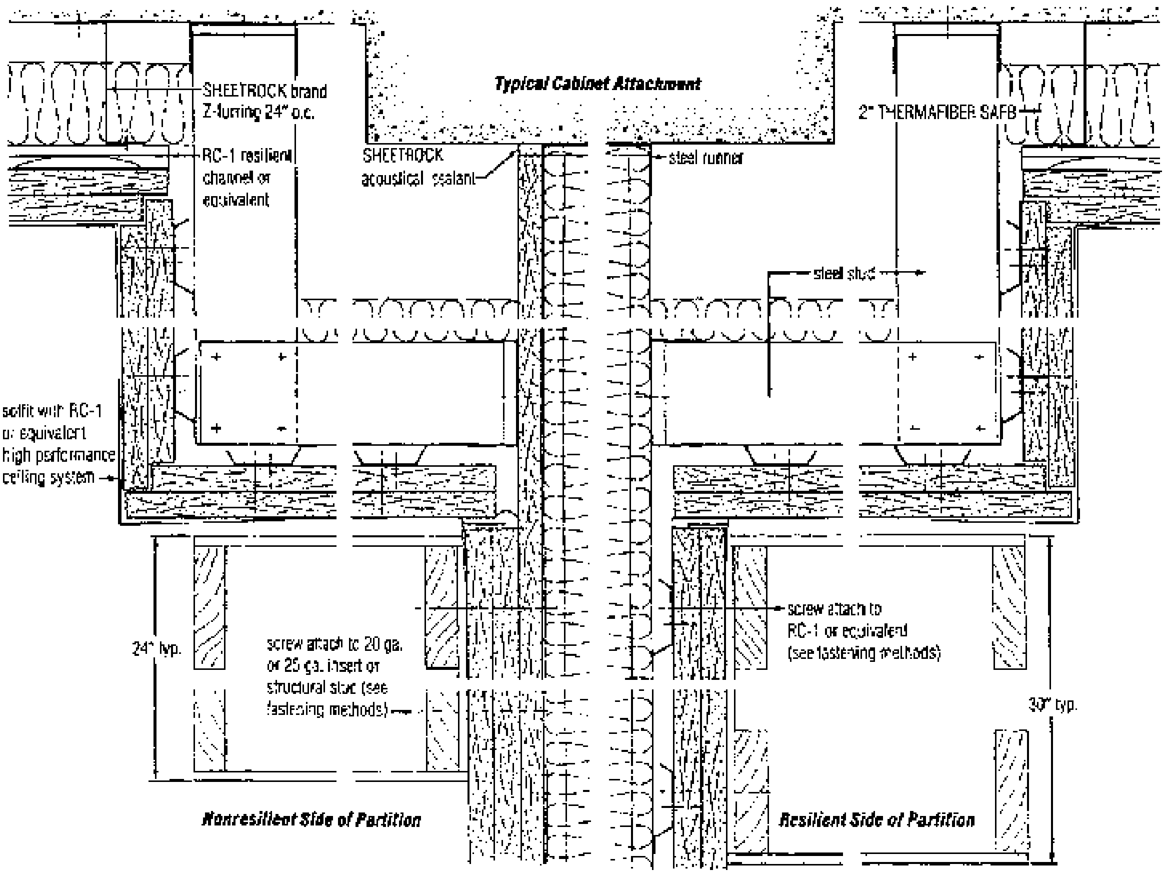
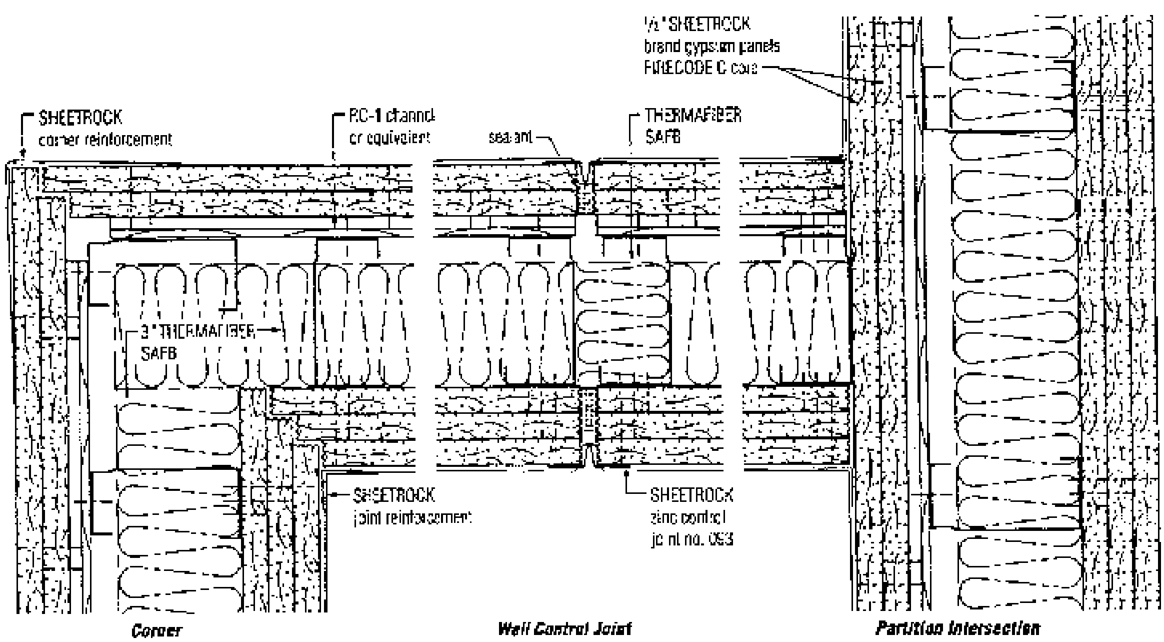
11.11.0 High-Performance Sound-Control Construction (Illustrated)





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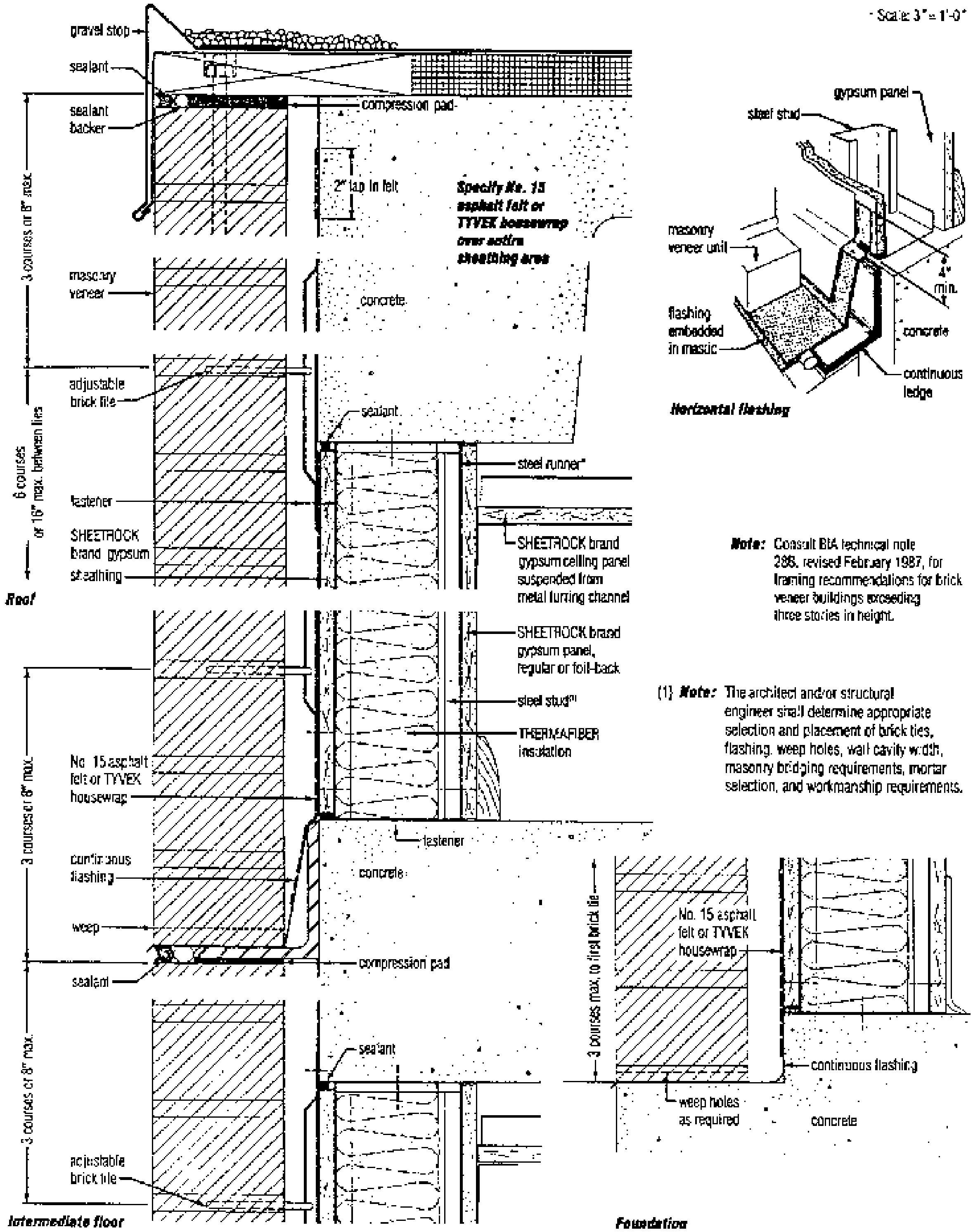
11.12.0 Curtain Wall Construction (Illustrated)



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11.12.1 Typical Curtain-Wall Limiting-Height Specifications

Typical Curtain Wall Limiting Heights—Studs (20-ga.) (F_y = 33 ksi)

Maximum allowable simple span limiting heights calculated using stud properties[1] — **stud properties only**

Design criteria

Wind load (psf)	Stud spacing (in o.c.)	Deflection limitation (L/240) 2½" 20 ga.	3⅝" 20 ga.	4" 20 ga.	6" 20 ga.	Deflection limitation (L/360) 2½" 20 ga.	3⅝" 20 ga.	4" 20 ga.	6" 20 ga.	Deflection limitation (L/600) 2½" 20 ga.	3⅝" 20 ga.	4" 20 ga.	6" 20 ga.
15 (80 mph)	12	9'1"	12'2"	13'2"	18'2"	8'0"	10'7"	11'6"	15'10"	6'8"	9'0"	9'6"	13'4"
	16	8'3"	11'1"	12'0"	16'7"	7'3"	9'8"	10'6"	14'6"	6'1"	8'2"	8'9"	12'2"
	24	7'3"	9'8"	10'6"	14'6"	6'3"	8'6"	9'1"	12'7"	5'3"	7'1"	7'8"	10'8"
20 (90 mph)	12	8'3"	11'1"	12'0"	16'7"	7'3"	9'8"	10'6"	14'6"	6'1"	8'2"	8'9"	12'2"
	16	7'6"	10'1"	10'10"	15'0"	6'7"	8'9"	9'6"	13'1"	5'7"	7'4"	8'0"	11'1"
	24	6'7"	8'9"	9'6"	13'1"	5'9"	7'8"	8'3"	11'6"	4'10"	6'6"	7'0"	9'8"
25 (100 mph)	12	7'8"	10'3"	11'1"	15'4"	6'8"	9'0"	9'8"	13'4"	5'8"	7'7"	8'2"	11'3"
	16	7'0"	9'3"	10'1"	14'0"	6'1"	8'2"	8'9"	12'2"	5'2"	6'10"	7'4"	10'3"
	24	6'1"	8'2"	8'9"	12'2"	5'3"	7'1"	7'8"	10'6"	4'6"	6'0"	6'6"	9'0"
30 (110 mph)	12	7'3"	9'8"	10'6"	14'6"	6'3"	8'6"	9'1"	12'7"	5'3"	7'2"	7'8"	10'8"
	16	6'7"	8'9"	9'6"	13'1"	5'9"	7'8"	8'3"	11'6"	4'10"	6'6"	7'0"	9'8"
	24	5'9"	7'8"	8'3"	11'6"	5'0"	6'8"	7'2"	10'0"	4'2"	5'8"	6'1"	8'6"
35 (120 mph)	12	6'10"	9'2"	9'10"	13'8"	6'0"	8'0"	8'8"	12'0"	5'1"	6'9"	7'3"	10'1"
	16	6'3"	8'3"	9'0"	12'5"	5'6"	7'3"	7'10"	10'10"	4'7"	6'2"	6'7"	9'2"
	24	5'6"	7'3"	7'10"	10'10"	4'9"	6'4"	6'10"	9'6"	4'0"	5'4"	5'8"	8'0"
40 (125 mph)	12	6'7"	8'9"	9'6"	13'1"	5'9"	7'8"	8'3"	11'6"	4'10"	6'5"	7'0"	9'8"
	16	6'0"	8'0"	8'7"	11'10"	5'2"	7'0"	7'6"	10'6"	4'4"	5'10"	6'4"	8'9"
	24	5'2"	7'0"	7'6"	10'4"	4'7"	6'1"	6'7"	9'1"	3'10"	5'1"	5'7"	7'8"

(1) Any independently supported exterior treatment over gypsum sheathing. Based on properties of studs alone with stress increased 33% for intermittent wind loading. Yield strength for studs and runners is 33 ksi.

Typical Curtain Wall Limiting Heights—Studs (F_y = 40 ksi)

Limiting heights calculated using stud properties[1] — **stud properties only**

Design criteria — Simple span limiting heights[1] for steel studs by size and gauge

Wind load	Deflection limitation	Stud spacing (in o.c.)	3⅝" stud 20 ga.	3⅝" 18 ga.	3⅝" 16 ga.	3⅝" 14 ga.	4" stud 20 ga.	4" 18 ga.	4" 16 ga.	4" 14 ga.	6" stud 20 ga.	6" 18 ga.	6" 16 ga.	6" 14 ga.	8" stud 16 ga.	8" 18 ga.	8" 14 ga.
15 psf	L/240	12	13'4"	14'7"	15'9"	16'10"	14'4"	15'8"	16'11"	18'2"	19'10"	21'5"	23'7"	25'3"	27'0"	28'10"	32'0"
		16	12'1"	13'3"	14'4"	15'4"	13'0"	14'3"	15'5"	16'6"	18'0"	19'9"	21'5"	22'11"	25'0"	27'1"	29'1"
		24	10'7"	11'7"	12'6"	13'4"	11'4"	12'5"	13'5"	14'5"	15'9"	17'3"	18'8"	20'0"	21'10"	23'6"	25'4"
	L/360	12	11'8"	12'9"	13'9"	14'9"	12'6"	13'8"	14'10"	15'10"	17'4"	19'0"	20'7"	22'1"	24'0"	26'0"	27'11"
		16	10'7"	11'7"	12'6"	13'4"	11'4"	12'5"	13'5"	14'5"	15'9"	17'3"	18'8"	20'0"	21'10"	23'8"	25'4"
		24	9'3"	10'1"	10'11"	11'8"	9'11"	10'10"	11'9"	12'7"	13'9"	15'1"	16'4"	17'6"	19'1"	20'8"	22'2"
	L/600	12	9'10"	10'9"	11'7"	12'5"	10'7"	11'7"	12'6"	13'4"	14'7"	16'0"	17'4"	18'7"	20'3"	22'0"	23'7"
		16	8'11"	9'9"	10'6"	11'3"	9'7"	10'6"	11'4"	12'2"	13'3"	14'7"	15'9"	16'11"	18'5"	19'11"	21'5"
		24	7'9"	8'6"	9'2"	9'10"	8'5"	9'2"	9'11"	10'7"	11'7"	12'9"	13'9"	14'9"	16'1"	17'5"	18'8"
20 psf	L/240	12	12'1"	13'3"	14'4"	15'4"	13'0"	14'3"	15'5"	16'6"	18'0"	19'9"	21'5"	22'11"	25'0"	27'1"	29'0"
		16	11'0"	12'0"	13'0"	13'11"	11'10"	12'11"	14'0"	15'0"	16'5"	17'11"	19'5"	20'10"	22'8"	24'7"	26'5"
		24	9'7"	10'6"	11'4"	12'2"	10'4"	11'4"	12'3"	13'1"	14'4"	15'8"	17'0"	18'2"	19'10"	21'6"	23'1"
	L/360	12	10'7"	11'7"	12'7"	13'4"	11'4"	12'5"	13'5"	14'5"	15'9"	17'3"	18'8"	20'0"	21'10"	23'8"	25'4"
		16	9'7"	10'6"	11'4"	12'2"	10'4"	11'4"	12'3"	13'1"	14'4"	15'8"	17'0"	18'2"	19'10"	21'6"	23'1"
		24	8'5"	9'2"	9'11"	10'7"	9'0"	9'11"	10'8"	11'5"	12'6"	13'8"	14'10"	15'11"	17'4"	18'9"	20'2"
	L/600	12	8'11"	9'9"	10'6"	11'3"	9'7"	10'5"	11'4"	12'2"	13'3"	14'7"	15'9"	16'11"	18'5"	19'11"	21'5"
		16	8'1"	8'10"	9'7"	10'3"	8'9"	9'6"	10'4"	11'0"	12'1"	13'2"	14'4"	15'4"	16'9"	18'2"	19'5"
		24	7'1"	7'9"	8'4"	8'11"	7'7"	8'4"	9'0"	9'8"	10'7"	11'7"	12'6"	13'5"	14'7"	15'10"	17'0"
25 psf	L/240	12	11'3"	12'3"	13'3"	14'2"	12'1"	13'3"	14'4"	15'4"	16'8"	18'4"	19'10"	21'3"	23'2"	25'2"	26'11"
		16	10'2"	11'2"	12'1"	12'11"	11'0"	12'0"	13'0"	13'11"	15'2"	16'5"	18'0"	19'4"	21'1"	22'10"	24'6"
		24	8'11"	9'9"	10'6"	11'3"	9'7"	10'6"	11'4"	12'2"	13'3"	14'7"	15'9"	16'11"	18'5"	19'11"	21'5"
	L/360	12	9'10"	10'9"	11'7"	12'5"	10'7"	11'7"	12'6"	13'4"	14'7"	16'0"	17'4"	18'7"	20'3"	22'0"	23'7"
		16	8'11"	9'9"	10'6"	11'3"	9'7"	10'6"	11'4"	12'2"	13'3"	14'7"	15'9"	16'11"	18'5"	19'11"	21'5"
		24	7'9"	8'6"	9'2"	9'10"	8'5"	9'2"	9'11"	10'7"	11'7"	12'9"	13'9"	14'9"	16'1"	17'5"	18'8"
	L/600	12	8'3"	9'1"	9'9"	10'6"	8'11"	9'9"	10'6"	11'3"	12'4"	13'6"	14'8"	15'8"	17'1"	18'6"	19'10"
		16	7'6"	8'3"	8'11"	9'6"	8'1"	8'10"	9'7"	10'3"	11'2"	12'3"	13'4"	14'3"	15'6"	16'10"	18'1"
		24	6'7"	7'2"	7'9"	8'4"	7'1"	7'9"	8'4"	8'11"	9'9"	10'9"	11'7"	12'5"	13'7"	14'8"	15'9"
30 psf	L/240	12	10'7"	11'7"	12'8"	13'4"	11'4"	12'5"	13'5"	14'5"	15'9"	17'4"	18'8"	20'0"	21'10"	23'8"	25'4"
		16	9'7"	10'6"	11'4"	12'2"	10'4"	11'4"	12'3"	13'1"	14'5"	15'8"	17'0"	18'2"	19'10"	21'6"	23'1"
		24	8'5"	9'2"	9'11"	10'7"	9'0"	9'11"	10'8"	11'5"	12'6"	13'8"	14'10"	15'11"	17'4"	18'9"	20'2"
	L/360	12	9'3"	10'1"	10'11"	11'8"	9'11"	10'10"	11'9"	12'7"	13'9"	15'1"	16'4"	17'6"	19'1"	20'8"	22'2"
		16	8'5"	9'2"	9'11"	10'7"	9'0"	9'11"	10'8"	11'5"	12'6"	13'8"	14'10"	15'11"	17'4"	18'9"	20'2"
		24	7'4"	8'0"	8'8"	9'3"	7'11"	8'8"	9'4"	10'0"	10'11"	12'0"	13'0"	13'11"	15'2"	16'5"	17'7"
	L/600	12	7'9"	8'6"	9'2"	9'10"	8'5"	9'2"	9'11"	10'7"	11'7"	12'9"	13'9"	14'9"	16'1"	17'5"	18'8"
		16	7'1"	7'9"	8'4"	8'11"	7'7"	8'4"	9'0"	9'8"	10'7"	11'7"	12'6"	13'5"	14'7"	15'10"	17'0"
		24	6'2"	6'9"	7'4"	7'10"	6'9"	7'3"	7'10"	8'5"	9'3"	10'1"	10'11"	11'9"	12'9"	13'10"	14'10"
35 psf	L/240	12	10'1"	11'0"	11'10"	12'8"	10'10"	11'10"	12'9"	13'8"	15'0"	16'5"	17'9"	19'0"	20'8"	22'6"	24'1"
		16	9'1"	10'0"	10'9"	11'6"	9'10"	10'9"	11'7"	12'5"	13'7"	14'11"	16'2"	17'3"	18'10"	20'5"	21'11"
		24	8'0"	8'9"	9'5"	10'1"	8'7"	9'5"	10'2"	10'10"	11'10"	13'0"	14'1"	15'1"	16'5"	17'10"	19'2"
	L/360	12	8'9"	9'7"	10'4"	11'1"	9'5"	10'4"	11'2"	11'11"	13'1"	14'4"	15'6"	16'7"	18'1"	19'6"	21'1"
		16	8'0"	8'9"	9'5"	10'1"	8'7"	9'5"	10'2"	10'10"	11'10"	13'0"	14'1"	15'1"	16'5"	17'10"	19'2"
		24	7'0"	7'7"	8'3"	8'10"	7'6"	8'2"	8'10"	9'6"	10'4"	11'4"	12'4"	13'2"	14'4"	15'7"	16'9"
	L/600	12	7'5"	8'1"	8'9"	9'4"	8'0"	8'9"	9'5"	10'1"	11'0"	12'1"	13'1"	14'0"	15'3"	16'7"	17'9"
		16	6'9"	7'4"	7'11"	8'6"	7'3"	7'11"	8'7"	9'2"	10'0"	11'0"	11'11"	12'9"	13'11"	15'1"	16'2"
		24	5'10"	6'5"	6'11"	7'5"	6'4"	6'11"	7'6"	8'0"	8'9"	9'7"	10'5"	11'2"	12'1"	13'2"	14'1"
40 psf	L/240	12	9'7"	10'6"	11'4"	12'2"	10'4"	11'4"	12'3"	13'1"	14'4"	15'8"	17'0"	18'2"	19'10"	21'6"	23'1"
		16	8'9"	9'7"	10'4"	11'0"	9'5"	10'3"	11'1"	11'11"	13'0"	14'3"	15'5"	16'6"	18'0"	19'6"	20'11"
		24	7'7"	8'4"	9'0"	9'8"	8'2"	9'0"	9'8"	10'5"	11'4"	12'5"	13'6"	14'5"	15'9"	17'1"	18'4"
	L/360	12	8'5"	9'2"	9'11"	10'7"	9'0"	9'11"	10'8"	11'5"	12'6"	13'8"	14'10"	15'11"	17'4"	18'9"	20'2"
		16	7'7"	8'4"	9'0"	9'8"	8'2"	9'0"	9'8"	10'5"	11'4"	12'5"	13'6"	14'5"	15'9"	17'1"	18'4"
		24	6'8"	7'3"	7'10"	8'5"	7'2"	7'10"	8'6"	9'1"	9'11"	10'10"	11'9"	12'7"	13'9"	14'11"	16'0"
	L/600	12	7'1"	7'9"	8'4"	8'11"	7'7"	8'4"	9'0"	9'8"	10'7"	11'7"	12'6"	13'5"	14'7"	15'10"	17'0"
		16	6'5"	7'0"	7'7"	8'2"	6'11"	7'7"	8'2"	8'9"	9'7"	10'6"	11'4"	12'2"	13'3"	14'5"	15'5"
		24	5'7"	6'2"	6'8"	7'1"	6'1"	6'7"	7'2"	7'8"	8'4"	9'2"	9'11"	10'8"	11'7"	12'7"	13'6"

Conforms to 1986 AISI Specification for the Design of Cold-Formed Steel Structural Members.

(1) Any independently supported exterior treatment over gypsum sheathing. Based on properties of studs alone with stress increased 33% for wind loading. Yield strength for runners is 33 ksi.

IMPORTANT NOTE: U.S. Gypsum Company does not manufacture these steel framing members. The table above shows maximum limiting heights for "typical" curtain wall construction based on the typical physical and structural properties published in Tables 1 through 5 on pages 4 and 5. The physical and structural values that govern this table are suggested minimums and may vary by region and by manufacturer. Table is meant as a general guideline only. Request actual physical and structural property data from our local United States Gypsum Company representative or framing manufacturer.

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11.13.0 Wind Load Tables—Height Limitations (12" on Center)

WIND LOAD	WEB SIZE	DEFLECTION	CH 20GA	CH 18GA	CH 16GA	CH 14GA	CEE 20GA	CEE 18GA	CEE 16GA	CEE 14GA	CEE 12GA	JW 20GA	JW 18GA	JW 16GA	JW 14GA	JW 12GA	JWE 18GA	JWE 16GA	JWE 14GA	JWE 12GA
5PSF	2 1/2	L/240	13.9	15.1	16.1	17.2	14.6	15.8	16.9	18.1	19.9	15.3	16.7	17.9	19.2	21.2	17.7	19.0	20.3	22.5
		L/360	12.2	13.2	14.1	15.0	12.8	13.8	14.8	15.8	17.4	13.4	14.6	15.7	16.7	18.5	15.5	16.6	17.8	19.7
		L/600	10.3	11.1	11.9	12.6	10.8	11.7	12.5	13.3	14.7	11.3	12.3	13.2	14.1	15.6	13.0	14.0	15.0	16.6
	3 5/8	L/240	18.5	20.1	21.5	22.9	19.4	21.0	22.5	24.1	26.7	20.3	22.2	23.8	25.5	28.3	23.4	25.1	26.9	29.9
		L/360	16.2	17.5	18.7	20.0	16.9	18.4	19.7	21.0	23.3	17.7	19.4	20.8	22.3	24.7	20.4	21.9	23.5	26.1
		L/600	13.6	14.8	15.8	16.9	14.3	15.5	16.6	17.7	19.7	15.0	16.4	17.5	18.8	20.8	17.2	18.5	19.8	22.0
	4	L/240	20.0	21.7	23.2	24.8	20.9	22.7	24.3	26.0	28.8	21.9	23.9	25.7	27.5	30.5	25.1	27.0	29.0	32.2
		L/360	17.4	18.9	20.3	21.7	18.3	19.8	21.2	22.7	25.2	19.1	20.9	22.4	24.0	26.7	22.0	23.6	25.3	28.1
		L/600	14.7	16.0	17.1	18.3	15.4	16.7	17.9	19.2	21.2	16.1	17.6	18.9	20.3	22.5	18.5	19.9	21.4	23.7
	6	L/240	27.5	29.9	32.0	34.3	28.7	31.2	33.4	35.8	39.8	29.9	32.7	35.1	37.7	41.9	34.2	36.8	39.5	44.0
		L/360	24.0	26.1	28.0	30.0	25.1	27.2	29.2	31.3	34.8	26.1	28.6	30.7	32.9	36.6	29.9	32.2	34.5	38.5
		L/600	20.3	22.0	23.6	25.3	21.1	23.0	24.6	26.4	29.4	22.0	24.1	25.9	27.8	30.9	25.2	27.1	29.1	32.4
	8	L/240	34.7	37.8	40.5	43.5	36.1	39.3	42.1	45.2	50.4	37.6	41.1	44.1	47.4	52.8	42.7	46.0	49.4	55.1
		L/360	30.3	33.0	35.4	38.0	31.5	34.3	36.8	39.5	44.0	32.8	35.9	38.5	41.4	46.1	37.3	40.2	43.2	48.2
		L/600	25.6	27.9	29.9	32.0	26.6	28.9	31.1	33.3	37.1	27.7	30.3	32.5	34.9	38.9	31.5	33.9	36.4	40.6
15PSF	2 1/2	L/240	9.6	10.4	11.2	11.9	10.1	11.0	11.7	12.5	13.8	10.6	11.6	12.4	13.3	14.7	12.3	13.2	14.1	15.6
		L/360	8.4	9.1	9.7	10.4	8.8	9.6	10.2	10.9	12.1	9.3	10.1	10.9	11.6	12.8	10.7	11.5	12.3	13.6
		L/600	7.1	7.7	8.2	8.8	7.5	8.1	8.6	9.2	10.2	7.8	8.6	9.2	9.8	10.8	9.0	9.7	10.4	11.5
	3 5/8	L/240	12.8	13.9	14.9	15.9	13.4	14.6	15.6	16.7	18.5	14.1	15.4	16.5	17.7	19.6	16.2	17.4	18.7	20.7
		L/360	11.2	12.2	13.0	13.9	11.7	12.7	13.6	14.8	16.2	12.3	13.5	14.4	15.4	17.1	14.2	15.2	16.3	18.1
		L/600	9.5	10.3	11.0	11.7	9.9	10.7	11.5	12.3	13.6	10.4	11.3	12.2	13.0	14.4	11.9	12.8	13.8	15.3
	4	L/240	13.8	15.0	16.1	17.2	14.5	15.7	16.9	18.0	20.0	15.2	16.6	17.8	19.1	21.2	17.4	18.7	20.1	22.3
		L/360	12.1	13.1	14.0	15.0	12.7	13.7	14.7	15.9	17.5	13.3	14.5	15.5	16.7	18.5	15.2	16.4	17.6	19.5
		L/600	10.2	11.1	11.9	12.7	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.1	15.6	12.9	13.8	14.8	16.5
	6	L/240	19.1	20.7	22.2	23.8	19.9	21.6	23.2	24.9	27.6	20.7	22.7	24.4	26.1	29.1	23.7	25.5	27.4	30.5
		L/360	16.7	18.1	19.4	20.8	17.4	18.9	20.3	21.7	24.1	18.1	19.8	21.3	22.8	25.4	20.7	22.3	23.9	26.7
		L/600	14.1	15.3	16.4	17.5	14.7	15.9	17.1	18.3	20.4	15.3	16.7	18.0	19.3	21.4	17.5	18.8	20.2	22.5
	8	L/240	24.1	26.2	28.1	30.2	25.0	27.2	29.2	31.4	34.9	26.1	28.5	30.6	32.8	36.6	29.7	31.9	34.3	38.3
		L/360	21.1	22.9	24.6	26.4	21.9	23.8	25.5	27.4	30.5	22.8	24.9	26.7	28.7	32.0	25.9	27.9	30.0	33.4
		L/600	17.9	19.3	20.7	22.2	18.4	20.1	21.5	23.1	25.7	19.2	21.0	22.5	24.2	27.0	21.9	23.5	25.3	28.2
20PSF	2 1/2	L/240	8.8	9.5	10.1	10.8	9.2	10.0	10.7	11.4	12.6	9.7	10.6	11.3	12.1	13.3	11.2	12.0	12.8	14.2
		L/360	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/600	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
	3 5/8	L/240	11.7	12.6	13.5	14.5	12.2	13.2	14.2	15.2	16.8	12.8	14.0	15.0	16.1	17.8	14.7	15.8	17.0	18.8
		L/360	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
	4	L/240	12.6	13.7	14.6	15.6	13.2	14.3	15.3	16.4	18.2	13.8	15.1	16.2	17.3	19.2	15.8	17.0	18.3	20.3
		L/360	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/600	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
	6	L/240	17.3	18.8	20.2	21.6	18.1	19.6	21.1	22.6	25.1	18.9	20.6	22.1	23.8	26.4	21.6	23.2	24.9	27.7
		L/360	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/600	12.8	13.9	14.9	15.9	13.3	14.5	15.5	16.6	18.5	13.9	15.2	16.3	17.5	19.5	15.9	17.1	18.4	20.4
	8	L/240	21.9	23.8	25.6	27.4	22.7	24.7	26.5	28.5	31.7	23.7	25.9	27.8	29.8	33.3	26.9	29.0	31.2	34.8
		L/360	19.1	20.6	22.3	23.9	19.9	21.6	23.7	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/600	16.1	17.6	18.8	20.2	16.8	18.2	19.6	21.0	23.4	17.5	19.1	20.5	22.0	24.5	19.9	21.4	23.0	25.6
25PSF	2 1/2	L/240	8.1	8.8	9.4	10.0	8.5	9.3	9.9	10.6	11.7	9.0	9.8	10.5	11.2	12.4	10.4	11.1	11.9	13.2
		L/360	7.1	7.7	8.2	8.8	7.5	8.1	8.6	9.2	10.2	7.8	8.6	9.2	9.8	10.8	9.0	9.7	10.4	11.5
		L/600	6.0	6.5	6.9	7.4	6.3	6.8	7.3	7.8	8.6	6.6	7.2	7.7	8.3	9.1	7.6	8.2	8.8	9.7
	3 5/8	L/240	10.8	11.7	12.6	13.4	11.3	12.3	13.2	14.1	15.6	11.9	13.0	13.9	14.9	16.5	13.7	14.7	15.7	17.5
		L/360	9.5	10.3	11.0	11.7	9.9	10.7	11.5	12.3	13.6	10.4	11.3	12.2	13.0	14.4	11.9	12.8	13.8	15.3
		L/600	8.0	8.6	9.3	9.9	8.4	9.1	9.7	10.4	11.5	8.8	9.6	10.3	11.0	12.2	10.1	10.8	11.6	12.9
	4	L/240	11.7	12.7	13.6	14.5	12.2	13.3	14.2	15.2	16.9	12.8	14.0	15.0	16.1	17.9	14.7	15.8	17.0	18.9
		L/360	10.2	11.1	11.9	12.7	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.1	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.1	11.9	13.2	10.8	11.7	12.5	13.9

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WIND LOAD	WEB SIZE	DEFLECTION	CN 20GA	CN 18GA	CN 16GA	CN 14GA	CEE 20GA	CEE 18GA	CEE 16GA	CEE 14GA	CEE 12GA	JW 20GA	JW 18GA	JW 16GA	JW 14GA	JW 12GA	JWE 18GA	JWE 16GA	JWE 14GA	JWE 12GA
5PSF	2 1/2	L/240	13.9	15.1	16.1	17.2	14.6	15.8	16.9	18.1	19.9	15.3	16.7	17.9	19.2	21.2	17.7	19.0	20.3	22.5
		L/360	12.2	13.2	14.1	15.0	12.8	13.8	14.8	15.8	17.4	13.4	14.6	15.7	16.7	18.5	15.5	16.6	17.8	19.7
		L/600	10.3	11.1	11.9	12.6	10.8	11.7	12.5	13.3	14.7	11.3	12.3	13.2	14.1	15.6	13.0	14.0	15.0	16.6
	3 5/8	L/240	18.5	20.1	21.5	22.9	19.4	21.0	22.5	24.1	26.7	20.3	22.2	23.8	25.5	28.3	23.4	25.1	26.9	29.9
		L/360	16.2	17.5	18.7	20.0	16.9	18.4	19.7	21.0	23.3	17.7	19.4	20.8	22.3	24.7	20.4	21.9	23.5	26.1
		L/600	13.6	14.8	15.8	16.9	14.3	15.5	16.6	17.7	19.7	15.0	16.4	17.5	18.8	20.8	17.2	18.5	19.8	22.0
	4	L/240	20.0	21.7	23.2	24.8	20.9	22.7	24.3	26.0	28.8	21.9	23.9	25.7	27.5	30.5	25.1	27.0	29.0	32.2
		L/360	17.4	18.9	20.3	21.7	18.3	19.8	21.2	22.7	25.2	19.1	20.9	22.4	24.0	26.7	22.0	23.6	25.3	28.1
		L/600	14.7	16.0	17.1	18.3	15.4	16.7	17.9	19.2	21.2	16.1	17.6	18.9	20.3	22.5	18.5	19.9	21.4	23.7
	6	L/240	27.5	29.9	32.0	34.3	28.7	31.2	33.4	35.8	39.8	29.9	32.7	35.1	37.7	41.9	34.2	36.8	39.5	44.0
		L/360	24.0	26.1	28.0	30.0	25.1	27.2	29.2	31.3	34.8	26.1	28.6	30.7	32.9	36.6	29.9	32.2	34.5	38.5
		L/600	20.3	22.0	23.6	25.3	21.1	23.0	24.6	26.4	29.4	22.0	24.1	25.9	27.8	30.9	25.2	27.1	29.1	32.4
	8	L/240	34.7	37.8	40.5	43.5	36.1	39.3	42.1	45.2	50.4	37.6	41.1	44.1	47.4	52.8	42.7	46.0	49.4	55.1
		L/360	30.3	33.0	35.4	38.0	31.5	34.3	36.8	39.5	44.0	32.8	35.9	38.5	41.4	46.1	37.3	40.2	43.2	48.2
		L/600	25.6	27.9	29.9	32.0	26.6	28.9	31.1	33.3	37.1	27.7	30.3	32.5	34.9	38.9	31.5	33.9	36.4	40.6
15PSF	2 1/2	L/240	9.6	10.4	11.2	11.9	10.1	11.0	11.7	12.5	13.8	10.6	11.6	12.4	13.3	14.7	12.3	13.2	14.1	15.6
		L/360	8.4	9.1	9.7	10.4	8.8	9.6	10.2	10.9	12.1	9.3	10.1	10.9	11.6	12.8	10.7	11.5	12.3	13.6
		L/600	7.1	7.7	8.2	8.8	7.5	8.1	8.6	9.2	10.2	7.8	8.6	9.2	9.8	10.8	9.0	9.7	10.4	11.5
	3 5/8	L/240	12.8	13.9	14.9	15.9	13.4	14.6	15.6	16.7	18.5	14.1	15.4	16.5	17.7	19.6	16.2	17.4	18.7	20.7
		L/360	11.2	12.2	13.0	13.9	11.7	12.7	13.6	14.8	16.2	12.3	13.5	14.4	15.4	17.1	14.2	15.2	16.3	18.1
		L/600	9.5	10.3	11.0	11.7	9.9	10.7	11.5	12.3	13.6	10.4	11.3	12.2	13.0	14.4	11.9	12.8	13.8	15.3
	4	L/240	13.8	15.0	16.1	17.2	14.5	15.7	16.9	18.0	20.0	15.2	16.6	17.8	19.1	21.2	17.4	18.7	20.1	22.3
		L/360	12.1	13.1	14.0	15.0	12.7	13.7	14.7	15.8	17.5	13.3	14.5	15.6	16.7	18.5	15.2	16.4	17.6	19.5
		L/600	10.2	11.1	11.9	12.7	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.1	15.6	12.9	13.8	14.8	16.5
	6	L/240	19.1	20.7	22.2	23.8	19.9	21.6	23.2	24.8	27.6	20.7	22.7	24.4	26.1	29.1	23.7	25.5	27.4	30.5
		L/360	16.7	18.1	19.4	20.8	17.4	18.9	20.3	21.7	24.1	18.1	19.8	21.3	22.8	25.4	20.7	22.3	23.9	26.7
		L/600	14.1	15.3	16.4	17.5	14.7	15.9	17.1	18.3	20.4	15.3	16.7	18.0	19.3	21.4	17.5	18.8	20.2	22.5
	8	L/240	24.1	26.2	28.1	30.2	25.0	27.2	29.2	31.4	34.9	26.1	28.5	30.6	32.8	36.6	29.7	31.9	34.3	36.3
		L/360	21.1	22.9	24.6	26.4	21.9	23.8	25.5	27.4	30.5	22.8	24.9	26.7	28.7	32.0	25.9	27.9	30.0	33.4
		L/600	17.9	19.3	20.7	22.2	18.4	20.1	21.5	23.1	25.7	19.2	21.0	22.5	24.2	27.0	21.9	23.5	25.3	28.2
20PSF	2 1/2	L/240	8.8	9.5	10.1	10.8	9.2	10.0	10.7	11.4	12.6	9.7	10.6	11.3	12.1	13.3	11.2	12.0	12.8	14.2
		L/360	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/600	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
	3 5/8	L/240	11.7	12.6	13.5	14.5	12.2	13.2	14.2	15.2	16.8	12.8	14.0	15.0	16.1	17.8	14.7	15.8	17.0	18.8
		L/360	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
	4	L/240	12.6	13.7	14.6	15.6	13.2	14.3	15.3	16.4	18.2	13.8	15.1	16.2	17.3	19.2	15.8	17.0	18.3	20.3
		L/360	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/600	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
	6	L/240	17.3	18.8	20.2	21.6	18.1	19.6	21.1	22.6	25.1	18.9	20.6	22.1	23.8	26.4	21.6	23.2	24.9	27.7
		L/360	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/600	12.8	13.9	14.9	15.9	13.3	14.5	15.5	16.6	18.5	13.9	15.2	16.3	17.5	19.5	15.9	17.1	18.4	20.4
	8	L/240	21.9	23.8	25.6	27.4	22.7	24.7	26.5	28.5	31.7	23.7	25.9	27.8	29.8	33.3	26.9	29.0	31.2	34.8
		L/360	19.1	20.6	22.3	23.9	19.9	21.6	23.2	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/600	16.1	17.6	18.8	20.2	16.8	18.2	19.6	21.0	23.4	17.5	19.1	20.5	22.0	24.5	19.9	21.4	23.0	25.6
25PSF	2 1/2	L/240	8.1	8.8	9.4	10.0	8.5	9.3	9.9	10.6	11.7	9.0	9.8	10.5	11.2	12.4	10.4	11.1	11.9	13.2
		L/360	7.1	7.7	8.2	8.8	7.5	8.1	8.6	9.2	10.2	7.8	8.6	9.2	9.8	10.8	9.0	9.7	10.4	11.5
		L/600	6.0	6.5	6.9	7.4	6.3	6.8	7.3	7.8	8.6	6.6	7.2	7.7	8.3	9.1	7.6	8.2	8.8	9.7
	3 5/8	L/240	10.8	11.7	12.6	13.4	11.3	12.3	13.2	14.1	15.6	11.9	13.0	13.9	14.9	16.5	13.7	14.7	15.7	17.5
		L/360	9.5	10.5	11.0	11.7	9.9	10.7	11.5	12.3	13.6	10.4	11.3	12.2	13.0	14.4	11.9	12.8	13.8	15.3
		L/600	8.0	8.6	9.3	9.9	8.4	9.1	9.7	10.4	11.5	8.8	9.6	10.3	11.0	12.2	10.1	10.8	11.6	12.9
	4	L/240	11.7	12.7	13.6	14.5	12.2	13.3	14.2	15.2	16.9	12.8	14.0	15.0	16.1	17.9	14.7	15.8	17.0	18.9
		L/360	10.2	11.1	11.9	12.7	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.1	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.1	11.9	13.2	10.8	11.7	12.5	13.9

Continued

11.14.0 Wind Load Tables—Height Limitations (16" on Center)

WIND LOAD	WEB SIZE	DEFLEC TION	GN				CEE					JW					JWS			
			20GA	18GA	16GA	14GA	20GA	18GA	16GA	14GA	12GA	20GA	18GA	16GA	14GA	12GA	18GA	16GA	14GA	12GA
5PSF	2 1/2	L/240	12.6	13.7	14.6	15.6	13.3	14.4	15.4	16.4	18.1	13.9	15.2	16.3	17.4	19.2	16.1	17.3	18.5	20.5
		L/360	11.0	12.0	12.8	13.6	11.6	12.6	13.4	14.3	15.8	12.2	13.3	14.2	15.2	16.8	14.0	15.1	16.1	17.9
		L/600	9.3	10.1	10.8	11.5	9.8	10.6	11.3	12.1	13.3	10.3	11.2	12.0	12.8	14.2	11.9	12.7	13.6	15.1
	3 5/8	L/240	16.8	18.2	19.5	20.8	17.6	19.1	20.5	21.9	24.2	18.4	20.2	21.6	23.1	25.7	21.2	22.8	24.4	27.3
		L/360	14.7	15.9	17.0	18.2	15.4	16.7	17.9	19.1	21.2	16.1	17.6	18.9	20.2	22.4	18.5	19.9	21.4	23.7
		L/600	12.4	13.4	14.4	15.4	13.0	14.1	15.1	16.1	17.9	13.6	14.9	15.9	17.1	18.9	15.6	16.8	18.0	20.0
	4	L240	18.1	19.7	21.1	22.5	19.0	20.6	22.1	23.6	26.2	19.9	21.7	23.3	25.0	27.7	22.9	24.6	26.3	29.3
		L/360	15.9	17.2	18.4	19.7	16.6	18.0	19.3	20.6	22.9	17.4	19.0	20.4	21.8	24.2	20.0	21.5	23.0	25.6
		L/600	13.4	14.5	15.5	16.6	14.0	15.2	16.3	17.4	19.3	14.6	16.0	17.2	18.4	20.4	16.8	18.1	19.4	21.6
	6	L/240	25.0	27.2	29.1	31.2	26.1	28.3	30.4	32.6	36.2	27.2	29.7	31.9	34.2	38.1	31.1	33.4	35.9	40.0
		L/360	21.8	23.7	25.4	27.2	22.8	24.7	26.5	28.4	31.6	23.7	26.0	27.9	29.9	33.3	27.2	29.2	31.4	34.9
		L/600	18.4	20.0	21.5	23.0	19.2	20.9	22.4	24.0	26.7	20.0	21.9	23.5	25.2	28.1	22.9	24.6	26.5	29.5
	8	L/240	31.6	34.3	36.8	39.5	32.8	35.7	38.3	41.1	45.6	34.1	37.3	40.1	43.0	48.0	38.8	41.9	44.9	50.1
		L/360	27.6	30.0	32.2	34.5	28.6	31.2	33.5	35.9	40.0	29.8	32.6	35.0	37.6	41.9	33.9	36.5	39.2	43.8
		L/600	23.3	25.3	27.2	29.1	24.2	26.3	28.2	30.3	33.7	25.2	27.5	29.5	31.7	35.4	28.6	30.9	33.1	36.9
15PSF	2 1/2	L/240	8.9	9.5	10.1	10.8	9.2	10.0	10.7	11.4	12.6	9.7	10.6	11.3	12.1	13.3	11.2	12.0	12.8	14.2
		L/360	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/600	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.9	8.2	8.8	9.4	10.5
	3 5/8	L/240	11.7	12.6	13.5	14.5	12.2	13.2	14.2	15.2	16.8	12.8	14.0	15.0	16.1	17.8	14.7	15.8	17.0	18.8
		L/360	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
	4	L/240	12.6	13.7	14.6	15.6	13.2	14.3	15.3	16.4	18.2	13.8	15.1	16.2	17.3	19.2	15.8	17.0	18.3	20.3
		L/360	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/600	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.5	13.5	15.0
	6	L/240	17.3	18.8	20.2	21.6	18.1	19.6	21.1	22.6	25.1	18.9	20.6	22.1	23.8	26.4	21.6	23.2	24.9	27.7
		L/360	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/600	12.8	13.9	14.9	15.9	13.3	14.5	15.5	16.6	18.5	13.9	15.2	16.3	17.5	19.5	15.9	17.1	18.4	20.4
	8	L/240	21.9	23.8	25.6	27.4	22.7	24.7	26.6	28.5	31.7	23.7	25.9	27.8	29.8	33.3	26.9	29.0	31.2	34.8
		L/360	19.1	20.8	22.3	23.9	19.9	21.6	23.2	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/600	16.1	17.6	18.8	20.2	16.8	18.2	19.6	21.0	23.4	17.5	19.1	20.5	22.0	24.5	19.9	21.4	23.0	25.6
20PSF	2 1/2	L/240	8.0	8.6	9.2	9.8	8.4	9.1	9.7	10.3	11.4	8.8	9.6	10.3	11.0	12.1	10.1	10.9	11.6	12.9
		L/360	7.0	7.5	8.0	8.6	7.3	7.9	8.5	9.0	10.0	7.7	8.4	9.0	9.6	10.6	8.9	9.5	10.2	11.3
		L/600	5.9	6.4	6.8	7.2	6.2	6.7	7.1	7.6	8.4	6.5	7.1	7.6	8.1	8.9	7.5	8.0	8.6	9.5
	3 5/8	L/240	10.6	11.5	12.3	13.1	11.1	12.0	12.9	13.8	15.3	11.6	12.7	13.6	14.6	16.2	13.4	14.4	15.4	17.1
		L/360	9.3	10.0	10.7	11.5	9.7	10.5	11.3	12.0	13.3	10.2	11.1	11.9	12.7	14.1	11.7	12.6	13.5	15.0
		L/600	7.8	8.5	9.1	9.7	8.2	8.9	9.5	10.2	11.3	8.6	9.4	10.0	10.8	11.9	9.9	10.6	11.4	12.6
	4	L/240	11.4	12.4	13.3	14.2	12.0	13.0	13.9	14.9	16.5	12.5	13.7	14.7	15.7	17.5	14.4	15.5	16.6	18.4
		L/360	10.0	10.8	11.6	12.4	10.5	11.3	12.2	13.0	14.4	10.9	12.0	12.8	13.8	15.3	12.6	13.5	14.5	16.1
		L/600	8.4	9.1	9.8	10.5	8.9	9.6	10.3	11.0	12.2	9.2	10.1	10.8	11.6	12.9	10.6	11.4	12.2	13.6
	6	L/240	15.8	17.1	18.3	19.6	16.4	17.8	19.1	20.5	22.8	17.1	18.7	20.1	21.6	24.0	19.6	21.1	22.6	25.2
		L/360	13.8	15.0	16.0	17.2	14.3	15.6	16.7	17.9	19.9	15.0	16.4	17.6	18.9	21.0	17.1	18.4	19.8	22.0
		L/600	11.6	12.6	13.5	14.5	12.1	13.2	14.1	15.1	16.8	12.6	13.8	14.8	15.9	17.7	14.4	15.5	16.7	18.6
	8	L/240	19.9	21.6	23.2	24.9	20.7	22.5	24.1	25.9	28.8	21.5	23.5	25.3	27.1	30.2	24.5	26.3	28.3	31.6
		L/360	17.4	18.9	20.3	21.8	18.0	19.6	21.1	22.6	25.2	18.8	20.5	22.1	23.7	26.4	21.4	23.0	24.7	27.6
		L/600	14.7	16.0	17.1	18.4	15.2	16.6	17.8	19.1	21.3	15.9	17.3	18.6	20.0	22.3	18.0	19.4	20.9	23.3
25PSF	2 1/2	L/240	7.4	8.0	8.6	9.1	7.8	8.4	9.0	9.6	10.6	8.1	8.9	9.5	10.2	11.3	9.4	10.1	10.8	12.0
		L/360	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
		L/600	5.5	5.9	6.3	6.7	5.7	6.2	6.6	7.1	7.8	6.0	6.6	7.0	7.5	8.3	6.9	7.4	8.0	8.8
	3 5/8	L/240	9.8	10.7	11.4	12.2	10.3	11.2	12.0	12.8	14.2	10.8	11.8	12.6	13.5	15.0	12.4	13.3	14.3	15.9
		L/360	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
		L/600	7.2	7.9	8.4	9.0	7.6	8.2	8.8	9.4	10.4	8.0	8.7	9.3	10.0	11.1	9.2	9.8	10.5	11.7
	4	L/240	10.6	11.5	12.3	13.2	11.1	12.1	12.9	13.8	15.3	11.6	12.7	13.6	14.6	16.2	13.4	14.4	15.4	17.1
		L/360	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
		L/600	7.8	8.5	9.1	9.7	8.2	8.9	9.5	10.2	11.3	8.6	9.4	10.1	10.8	12.0	9.9	10.6	11.4	12.6

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WIND LOAD	WEB SIZE	DEFLECTION	CN 20GA	CN 18GA	CN 16GA	CN 14GA	CSE 20GA	CSE 18GA	CSE 16GA	CSE 14GA	CSE 12GA	JW 20GA	JW 18GA	JW 16GA	JW 14GA	JW 12GA	JWS 18GA	JWS 16GA	JWS 14GA	JWS 12GA
5PSF	2 1/2	L/240	12.6	13.7	14.6	15.6	13.3	14.4	15.4	16.4	18.1	13.9	15.2	16.3	17.4	19.2	16.1	17.3	18.5	20.5
		L/360	11.0	12.0	12.8	13.6	11.6	12.6	13.4	14.3	15.8	12.2	13.3	14.2	15.2	16.8	14.0	15.1	16.1	17.9
		L/600	9.3	10.1	10.8	11.5	9.8	10.6	11.3	12.1	13.3	10.3	11.2	12.0	12.8	14.2	11.8	12.7	13.6	15.1
	3 5/8	L/240	16.8	18.2	19.5	20.8	17.6	19.1	20.5	21.9	24.2	18.4	20.2	21.6	23.1	25.7	21.2	22.8	24.4	27.3
		L/360	14.7	15.9	17.0	18.2	15.4	16.7	17.9	19.1	21.2	16.1	17.6	18.9	20.2	22.4	18.5	19.9	21.4	23.7
		L/600	12.4	13.4	14.4	15.4	13.0	14.1	15.1	16.1	17.9	13.6	14.9	15.9	17.1	18.9	15.6	16.8	18.0	20.0
	4	L240	18.1	19.7	21.1	22.5	19.0	20.6	22.1	23.6	26.2	19.9	21.7	23.3	25.0	27.7	22.9	24.6	26.3	29.3
		L/360	15.9	17.2	18.4	19.7	16.6	18.0	19.3	20.6	22.9	17.4	19.0	20.4	21.8	24.2	20.0	21.5	23.0	25.6
		L/600	13.4	14.5	15.5	16.6	14.0	15.2	16.3	17.4	19.3	14.5	16.0	17.2	18.4	20.4	16.8	18.1	19.4	21.6
	6	L/240	25.0	27.2	29.1	31.2	26.1	28.3	30.4	32.6	36.2	27.2	29.7	31.9	34.2	38.1	31.1	33.4	35.9	40.0
		L/360	21.8	23.7	25.4	27.2	22.8	24.7	26.5	28.4	31.6	23.7	26.0	27.9	29.9	33.3	27.2	29.2	31.4	34.9
		L/600	18.4	20.0	21.5	23.0	19.2	20.9	22.4	24.0	26.7	20.0	21.9	23.5	25.2	28.1	22.9	24.6	26.5	29.5
	8	L/240	31.6	34.3	36.8	39.5	32.8	35.7	38.3	41.1	45.8	34.1	37.3	40.1	43.0	48.0	38.8	41.8	44.9	50.1
		L/360	27.6	30.0	32.2	34.5	28.6	31.2	33.5	35.9	40.0	29.8	32.6	35.0	37.6	41.9	33.9	36.5	39.2	43.8
		L/600	23.3	25.3	27.2	29.1	24.2	26.3	28.2	30.3	33.7	25.2	27.5	29.5	31.7	35.4	28.6	30.9	33.1	36.9
15PSF	2 1/2	L/240	8.9	9.5	10.1	10.8	9.2	10.0	10.7	11.4	12.8	9.7	10.6	11.3	12.1	13.3	11.2	12.0	12.8	14.2
		L/360	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/600	6.5	7.0	7.5	8.0	6.8	7.3	7.8	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
	3 5/8	L/240	11.7	12.6	13.5	14.5	12.2	13.2	14.2	15.2	16.8	12.9	14.0	15.0	16.1	17.8	14.7	15.8	17.0	18.8
		L/360	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/600	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
	4	L/240	12.6	13.7	14.6	15.6	13.2	14.3	15.3	16.4	18.2	13.8	15.1	16.2	17.3	19.2	15.8	17.0	18.3	20.3
		L/360	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/600	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.5	13.5	15.0
	6	L/240	17.3	18.8	20.2	21.6	18.1	19.6	21.1	22.6	25.1	18.9	20.6	22.1	23.8	26.4	21.6	23.2	24.9	27.7
		L/360	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/600	12.8	13.9	14.9	15.9	13.3	14.5	15.5	16.6	18.5	13.9	15.2	16.3	17.5	19.5	15.9	17.1	18.4	20.4
	8	L/240	21.9	23.8	25.6	27.4	22.7	24.7	26.6	28.5	31.7	23.7	25.9	27.8	29.8	33.3	26.9	29.0	31.2	34.8
		L/360	19.1	20.8	22.3	23.9	19.9	21.6	23.2	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/600	16.1	17.6	18.8	20.2	16.8	18.2	19.6	21.0	23.4	17.5	19.1	20.5	22.0	24.5	19.9	21.4	23.0	25.6
20PSF	2 1/2	L/240	8.0	8.6	9.2	9.8	8.4	9.1	9.7	10.3	11.4	8.8	9.6	10.3	11.0	12.1	10.1	10.9	11.6	12.9
		L/360	7.0	7.5	8.0	8.6	7.3	7.9	8.5	9.0	10.0	7.7	8.4	9.0	9.6	10.6	8.9	9.5	10.2	11.3
		L/600	5.9	6.4	6.8	7.2	6.2	6.7	7.1	7.6	8.4	6.5	7.1	7.6	8.1	8.9	7.5	8.0	8.6	9.5
	3 5/8	L/240	10.6	11.5	12.3	13.1	11.1	12.0	12.9	13.8	15.3	11.6	12.7	13.6	14.6	16.2	10.4	14.4	15.4	17.1
		L/360	9.3	10.0	10.7	11.5	9.7	10.5	11.3	12.0	13.3	10.2	11.1	11.9	12.7	14.1	11.7	12.6	13.5	15.0
		L/600	7.8	8.5	9.1	9.7	8.2	8.9	9.5	10.2	11.3	8.6	9.4	10.0	10.8	11.9	9.9	10.6	11.4	12.6
	4	L/240	11.4	12.4	13.3	14.2	12.0	13.0	13.9	14.9	16.5	12.5	13.7	14.7	15.7	17.5	14.4	15.5	16.6	18.4
		L/360	10.0	10.8	11.6	12.4	10.5	11.3	12.2	13.0	14.4	10.9	12.0	12.8	13.6	15.3	12.6	13.5	14.5	16.1
		L/600	8.4	9.1	9.8	10.5	8.9	9.6	10.3	11.0	12.2	9.2	10.1	10.8	11.6	12.9	10.6	11.4	12.2	13.6
	6	L/240	15.8	17.1	18.3	19.6	16.4	17.8	19.1	20.5	22.8	17.1	18.7	20.1	21.6	24.0	19.6	21.1	22.6	25.2
		L/360	13.8	15.0	16.0	17.2	14.3	15.6	16.7	17.9	19.9	15.0	16.4	17.6	18.9	21.0	17.1	18.4	19.8	22.0
		L/600	11.6	12.6	13.5	14.5	12.1	13.2	14.1	15.1	16.8	12.8	13.8	14.8	15.9	17.7	14.4	15.5	16.7	18.6
	8	L/240	19.9	21.6	23.2	24.9	20.7	22.5	24.1	25.9	28.8	21.5	23.5	25.3	27.1	30.2	24.5	26.3	28.3	31.6
		L/360	17.4	18.9	20.3	21.8	18.0	19.6	21.1	22.6	25.2	18.8	20.5	22.1	23.7	26.4	21.4	23.0	24.7	27.6
		L/600	14.7	16.0	17.1	18.4	15.2	16.6	17.8	19.1	21.3	15.9	17.3	18.6	20.0	22.3	18.0	19.4	20.9	23.3
25PSF	2 1/2	L/240	7.4	8.0	8.6	9.1	7.8	8.4	9.0	9.6	10.6	8.1	8.9	9.5	10.2	11.3	9.4	10.1	10.8	12.0
		L/360	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
		L/600	5.5	5.9	6.3	6.7	5.7	6.2	6.6	7.1	7.8	6.0	6.6	7.0	7.5	8.3	6.9	7.4	8.0	8.8
	3 5/8	L/240	9.8	10.7	11.4	12.2	10.3	11.2	12.0	12.8	14.2	10.8	11.8	12.6	13.5	15.0	12.4	13.3	14.3	15.9
		L/360	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
		L/600	7.2	7.9	8.4	9.0	7.6	8.2	8.8	9.4	10.4	8.0	8.7	9.3	10.0	11.1	9.2	9.8	10.5	11.7
	4	L/240	10.6	11.5	12.3	13.2	11.1	12.1	12.9	13.8	15.5	11.6	12.7	13.6	14.6	16.2	13.4	14.4	15.4	17.1
		L/360	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
		L/600	7.8	8.5	9.1	9.7	8.2	8.9	9.5	10.2	11.3	8.6	9.4	10.1	10.8	12.0	9.9	10.6	11.4	12.6

Continued

11.15.0 Wind Load Tables—Height Limitations (24" on Center)

WIND LOAD	WEB SIZE	DEFLEC-TION	CH 20GA	CH 18GA	CH 16GA	CH 14GA	CEE 20GA	CEE 18GA	CEE 16GA	CEE 14GA	CEE 12GA	JW 20GA	JW 18GA	JW 16GA	JW 14GA	JW 12GA	JWB 18GA	JWB 16GA	JWB 14GA	JWB 12GA
5PSF	2 1/2	L/240	11.0	12.0	12.6	13.6	11.6	12.6	13.4	14.3	15.8	12.2	13.3	14.2	15.2	16.8	14.0	15.1	16.1	17.9
		L/360	9.6	10.4	11.2	11.9	10.1	11.0	11.7	12.5	13.8	10.6	11.6	12.4	13.3	14.7	12.3	13.2	14.1	15.6
		L/600	8.1	8.8	9.4	10.0	8.5	9.3	9.9	10.6	11.7	9.0	9.8	10.5	11.2	12.4	10.4	11.1	11.9	13.2
	3 5/8	L/240	14.7	15.9	17.0	18.2	15.4	16.7	17.9	19.1	21.2	16.1	17.6	18.9	20.2	22.4	18.5	19.9	21.4	23.7
		L/360	12.8	13.9	14.9	15.9	13.4	14.6	15.6	16.7	18.5	14.1	15.4	16.5	17.7	19.6	16.2	17.4	18.7	20.7
		L/600	12.8	11.7	12.6	13.4	11.3	12.3	13.2	14.1	15.6	11.9	13.0	13.9	14.9	16.5	13.7	14.7	15.7	17.5
	4	L/240	15.9	17.2	18.4	19.7	16.6	18.0	19.3	20.6	22.9	17.4	19.0	20.4	21.8	24.2	20.0	21.5	23.0	25.6
		L/360	13.8	15.0	16.1	17.2	14.5	15.7	16.9	18.0	20.0	15.2	16.6	17.8	19.1	21.2	17.4	18.7	20.1	22.3
		L/600	11.7	12.7	13.6	14.5	12.2	13.3	14.2	15.2	16.9	12.8	14.0	15.0	16.1	17.9	14.7	15.8	17.0	18.9
	6	L/240	21.8	23.7	25.4	27.2	22.8	24.7	26.5	28.4	31.6	23.7	26.0	27.9	29.9	33.3	27.2	29.2	31.4	34.9
		L/360	19.1	20.7	22.2	23.8	19.9	21.6	23.2	24.9	27.6	20.7	22.7	24.4	26.1	29.1	23.7	25.5	27.4	30.5
		L/600	16.1	17.5	18.7	20.1	16.8	18.2	19.6	21.0	23.3	17.5	19.1	20.6	22.0	24.5	20.0	21.5	23.1	25.8
	8	L/240	27.6	30.0	32.2	34.5	28.6	31.2	33.5	35.9	40.0	29.8	32.6	35.0	37.6	41.9	33.9	36.5	39.2	43.8
		L/360	24.1	26.2	28.1	30.2	25.0	27.2	29.2	31.4	34.9	26.1	28.5	30.6	32.8	36.6	29.7	31.9	34.3	38.3
		L/600	20.3	22.1	23.7	25.4	21.1	23.0	24.7	26.5	29.5	22.0	24.0	25.8	27.7	30.9	25.0	26.9	28.9	32.3
15PSF	2 1/2	L/240	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/360	6.7	7.2	7.7	8.3	7.0	7.6	8.1	8.7	9.6	7.4	8.1	8.6	9.2	10.2	8.5	9.1	9.8	10.8
		L/600	5.6	6.1	6.5	7.0	5.9	6.4	6.9	7.3	8.1	6.2	6.8	7.3	7.8	8.6	7.2	7.7	8.3	9.1
	3 5/8	L/240	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/360	8.9	9.6	10.3	11.0	9.3	10.1	10.8	11.6	12.8	9.8	10.7	11.4	12.3	13.6	11.2	12.1	12.9	14.4
		L/600	7.5	8.1	8.7	9.3	7.9	8.5	9.1	9.8	10.8	8.2	9.0	9.7	10.3	11.5	9.5	10.2	10.9	12.1
	4	L/240	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/360	9.6	10.4	11.2	11.9	10.1	10.9	11.7	12.5	13.9	10.5	11.5	12.3	13.2	14.7	12.1	13.0	13.9	15.5
		L/600	8.1	8.8	9.4	10.1	8.5	9.2	9.9	10.6	11.7	8.9	9.7	10.4	11.2	12.4	10.2	11.0	11.8	13.1
	6	L/240	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/360	13.2	14.4	15.4	16.5	13.8	15.0	16.1	17.2	19.2	14.4	15.7	16.9	18.1	20.2	16.5	17.7	19.0	21.2
		L/600	11.2	12.1	13.0	13.9	11.6	12.6	13.6	14.5	16.2	12.1	13.3	14.3	15.3	17.0	13.9	14.9	16.0	17.9
	8	L/240	19.1	20.8	22.3	23.9	19.9	21.6	23.2	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/360	16.7	18.2	19.6	20.9	17.4	18.9	20.3	21.8	24.2	18.1	19.8	21.2	22.8	25.4	20.6	22.1	23.8	26.5
		L/600	14.1	15.3	16.5	17.6	14.6	15.9	17.1	18.4	20.4	15.2	16.7	17.9	19.2	21.4	17.3	18.7	20.1	22.4
20PSF	2 1/2	L/240	7.0	7.5	8.0	8.6	7.3	7.9	8.5	9.0	10.0	7.7	8.4	9.0	9.6	10.6	8.9	9.5	10.2	11.3
		L/360	6.1	6.6	7.0	7.5	6.4	6.9	7.4	7.9	8.7	6.7	7.3	7.8	8.4	9.3	7.7	8.3	8.9	9.8
		L/600	5.1	5.6	5.9	6.3	5.4	5.8	6.2	6.7	7.3	5.6	6.2	6.6	7.1	7.8	6.5	7.0	7.5	8.3
	3 5/8	L/240	9.3	10.0	10.7	11.5	9.7	10.5	11.3	12.0	13.3	10.2	11.1	11.9	12.7	14.1	11.7	12.6	13.5	15.0
		L/360	8.1	8.8	9.4	10.0	8.5	9.2	9.8	10.5	11.7	8.9	9.7	10.4	11.1	12.4	10.2	11.0	11.8	13.1
		L/600	6.8	7.4	7.9	8.5	7.1	7.8	8.3	8.9	9.8	7.5	8.2	8.8	9.4	10.4	8.6	9.3	9.9	11.0
	4	L/240	10.0	10.8	11.6	12.4	10.5	11.3	12.2	13.0	14.4	10.9	12.0	12.8	13.8	15.3	12.6	13.5	14.5	16.1
		L/360	8.7	9.5	10.1	10.8	9.1	9.9	10.6	11.4	12.6	9.6	10.5	11.2	12.0	13.3	11.0	11.8	12.7	14.1
		L/600	7.4	8.0	8.5	9.1	7.7	8.4	9.0	9.6	10.6	8.1	8.8	9.5	10.1	11.3	9.3	10.0	10.7	11.9
	6	L/240	13.8	15.0	16.0	17.2	14.3	15.6	16.7	17.9	19.9	15.0	16.4	17.6	18.9	21.0	17.1	18.4	19.8	22.0
		L/360	12.0	13.1	14.0	15.0	12.5	13.6	14.6	15.7	17.4	13.1	14.3	15.4	16.5	18.3	15.0	16.1	17.3	19.2
		L/600	10.1	11.0	11.8	12.7	10.6	11.5	12.3	13.2	14.7	11.0	12.1	13.0	13.9	15.5	12.6	13.6	14.6	16.2
	8	L/240	17.3	18.9	20.3	21.8	18.0	19.6	21.1	22.6	25.2	18.8	20.5	22.1	23.7	26.4	21.4	23.0	24.7	27.6
		L/360	15.2	16.5	17.7	19.0	15.8	17.2	18.4	19.8	22.0	16.4	17.9	19.3	20.7	23.1	18.7	20.1	21.6	24.1
		L/600	12.8	13.9	15.0	16.0	13.3	14.5	15.5	16.7	18.6	13.9	15.1	16.3	17.5	19.5	15.8	17.0	18.2	20.3
25PSF	2 1/2	L/240	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
		L/360	5.6	6.1	6.5	7.0	5.9	6.4	6.9	7.3	8.1	6.2	6.8	7.3	7.8	8.6	7.2	7.7	8.3	9.1
		L/600	4.8	5.2	5.5	5.9	5.0	5.4	5.8	6.2	6.8	5.2	5.7	6.1	6.6	7.2	6.1	6.5	7.0	7.7
	3 5/8	L/240	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
		L/360	7.5	8.1	8.7	9.3	7.8	8.5	9.1	9.8	10.8	8.2	9.0	9.7	10.3	11.5	9.5	10.2	10.9	12.1
		L/600	6.3	6.9	7.3	7.9	6.6	7.2	7.7	8.2	9.1	6.9	7.6	8.1	8.7	9.7	8.0	8.6	9.2	10.2
	4	L/240	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
		L/360	8.1	8.8	9.4	10.1	8.5	9.2	9.9	10.6	11.7	8.9	9.7	10.4	11.2	12.4	10.2	11.0	11.8	13.1
		L/600	6.8	7.4	7.9	8.5	7.2	7.8	8.3	8.9	9.9	7.5	8.2	8.8	9.4	10.4	8.6	9.3	9.9	11.0

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WIND LOAD	WEB SIZE	DEFLECTION	CH				CEE					[illegible]					[illegible]			
			20GA	18GA	16GA	14GA	20GA	18GA	16GA	14GA	12GA	20GA	18GA	16GA	14GA	12GA	18GA	16GA	14GA	12GA
5PSF	2 1/2	L/240	11.0	12.0	12.6	13.6	11.6	12.6	13.4	14.3	15.8	12.2	13.3	14.2	15.2	16.8	14.0	15.1	16.1	17.9
		L/360	9.6	10.4	11.2	11.9	10.1	11.0	11.7	12.5	13.8	10.6	11.6	12.4	13.3	14.7	12.3	13.2	14.1	15.6
		L/600	8.1	8.8	9.4	10.0	8.5	9.3	9.9	10.6	11.7	9.0	9.8	10.5	11.2	12.4	10.4	11.1	11.9	13.2
	3 5/8	L/240	14.7	15.9	17.0	18.2	15.4	16.7	17.9	19.1	21.2	16.1	17.6	18.9	20.2	22.4	18.5	19.9	21.4	23.7
		L/360	12.8	13.9	14.9	15.9	13.4	14.6	15.6	16.7	18.5	14.1	15.4	16.5	17.7	19.6	16.2	17.4	18.7	20.7
		L/600	12.8	11.7	12.6	13.4	11.3	12.2	13.2	14.1	15.6	11.9	13.0	13.9	14.9	16.5	13.7	14.7	15.7	17.5
	4	L/240	15.9	17.2	18.4	19.7	16.6	18.0	19.3	20.6	22.9	17.4	19.0	20.4	21.8	24.2	20.0	21.5	23.0	25.6
		L/360	13.8	15.0	16.1	17.2	14.5	15.7	16.9	18.0	20.0	15.2	16.6	17.8	19.1	21.2	17.4	18.7	20.1	22.3
		L/600	11.7	12.7	13.6	14.5	12.2	13.3	14.2	15.2	16.9	12.8	14.0	15.0	16.1	17.9	14.7	15.8	17.0	18.9
	6	L/240	21.8	23.7	25.4	27.2	22.8	24.7	26.5	28.4	31.6	23.7	26.0	27.9	29.9	33.3	27.2	29.2	31.4	34.9
		L/360	19.1	20.7	22.2	23.8	19.9	21.6	23.2	24.9	27.6	20.7	22.7	24.4	26.1	29.1	23.7	25.5	27.4	30.5
		L/600	16.1	17.5	18.7	20.1	16.8	18.2	19.6	21.0	23.3	17.5	19.1	20.6	22.0	24.5	20.0	21.5	23.1	25.8
	8	L/240	27.6	30.0	32.2	34.5	28.6	31.2	33.5	35.9	40.0	29.8	32.6	35.0	37.6	41.9	33.9	36.5	39.2	43.8
		L/360	24.1	26.2	28.1	30.2	25.0	27.2	29.2	31.4	34.9	26.1	28.5	30.6	32.8	36.6	29.7	31.9	34.3	38.3
		L/600	20.3	22.1	23.7	25.4	21.1	23.0	24.7	26.5	29.5	22.0	24.0	25.8	27.7	30.9	25.0	26.9	28.9	32.3
15PSF	2 1/2	L/240	7.7	8.3	8.9	9.4	8.0	8.7	9.3	9.9	11.0	8.4	9.2	9.9	10.5	11.7	9.7	10.5	11.2	12.4
		L/360	6.7	7.2	7.7	8.3	7.0	7.6	8.1	8.7	9.6	7.4	8.1	8.6	9.2	10.2	8.5	9.1	9.8	10.8
		L/600	5.6	6.1	6.5	7.0	5.9	6.4	6.9	7.3	8.1	6.2	6.8	7.3	7.8	8.6	7.2	7.7	8.3	9.1
	3 5/8	L/240	10.2	11.0	11.8	12.6	10.7	11.6	12.4	13.3	14.7	11.2	12.2	13.1	14.0	15.6	12.9	13.8	14.8	16.5
		L/360	8.9	9.6	10.3	11.0	9.3	10.1	10.8	11.6	12.8	9.8	10.7	11.4	12.3	13.6	11.2	12.1	12.9	14.4
		L/600	7.5	8.1	8.7	9.3	7.9	8.5	9.1	9.8	10.8	8.2	9.0	9.7	10.3	11.5	9.5	10.2	10.9	12.1
	4	L/240	11.0	11.9	12.8	13.6	11.5	12.5	13.4	14.3	15.9	12.0	13.2	14.1	15.1	16.8	13.8	14.9	16.0	17.7
		L/360	9.6	10.4	11.2	11.9	10.1	10.9	11.7	12.5	13.9	10.5	11.5	12.3	13.2	14.7	12.1	13.0	13.9	15.5
		L/600	8.1	8.8	9.4	10.1	8.5	9.2	9.9	10.6	11.7	8.9	9.7	10.4	11.2	12.4	10.2	11.0	11.8	13.1
	6	L/240	15.2	16.5	17.6	18.9	15.8	17.2	18.4	19.7	21.9	16.5	18.0	19.3	20.8	23.1	18.8	20.3	21.8	24.2
		L/360	13.2	14.4	15.4	16.5	13.8	15.0	16.1	17.2	19.2	14.4	15.7	16.9	18.1	20.2	16.5	17.7	19.0	21.2
		L/600	11.2	12.1	13.0	13.9	11.6	12.6	13.6	14.5	16.2	12.1	13.3	14.3	15.3	17.0	13.9	14.9	16.0	17.9
	8	L/240	19.1	20.8	22.3	23.9	19.9	21.6	23.2	24.9	27.7	20.7	22.6	24.3	26.1	29.1	23.5	25.3	27.2	30.4
		L/360	16.7	18.2	19.5	20.9	17.4	18.9	20.3	21.8	24.2	18.1	19.8	21.2	22.8	25.4	20.6	22.1	23.8	26.5
		L/600	14.1	15.3	16.5	17.6	14.6	15.9	17.1	18.4	20.4	15.2	16.7	17.9	19.2	21.4	17.3	18.7	20.1	22.4
20PSF	2 1/2	L/240	7.0	7.5	8.0	8.6	7.3	7.9	8.5	9.0	10.0	7.7	8.4	9.0	9.6	10.6	8.9	9.5	10.2	11.3
		L/360	6.1	6.6	7.0	7.5	6.4	6.9	7.4	7.9	8.7	6.7	7.3	7.8	8.4	9.3	7.7	8.3	8.9	9.8
		L/600	5.1	5.6	5.9	6.3	5.4	5.8	6.2	6.7	7.3	5.6	6.2	6.6	7.1	7.8	6.5	7.0	7.5	8.3
	3 5/8	L/240	9.3	10.0	10.7	11.5	9.7	10.5	11.3	12.0	13.3	10.2	11.1	11.9	12.7	14.1	11.7	12.6	13.5	15.0
		L/360	8.1	8.8	9.4	10.0	8.5	9.2	9.8	10.5	11.7	8.9	9.7	10.4	11.1	12.4	10.2	11.0	11.8	13.1
		L/600	6.8	7.4	7.9	8.5	7.1	7.8	8.3	8.9	9.8	7.5	8.2	8.8	9.4	10.4	8.6	9.3	9.9	11.0
	4	L/240	10.0	10.8	11.6	12.4	10.5	11.3	12.2	13.0	14.4	10.9	12.0	12.8	13.8	15.3	12.6	13.5	14.5	16.1
		L/360	8.7	9.5	10.1	10.8	9.1	9.9	10.6	11.4	12.6	9.6	10.5	11.2	12.0	13.3	11.0	11.8	12.7	14.1
		L/600	7.4	8.0	8.5	9.1	7.7	8.4	9.0	9.6	10.6	8.1	8.8	9.5	10.1	11.3	9.3	10.0	10.7	11.9
	6	L/240	13.8	15.0	16.0	17.2	14.3	15.6	16.7	17.9	19.9	15.0	16.4	17.6	18.9	21.0	17.1	18.4	19.8	22.0
		L/360	12.0	13.1	14.0	15.0	12.5	13.6	14.6	15.7	17.4	13.1	14.3	15.4	16.5	18.3	15.0	16.1	17.3	19.2
		L/600	10.1	11.0	11.8	12.7	10.6	11.5	12.3	13.2	14.7	11.0	12.1	13.0	13.9	15.5	12.6	13.6	14.6	16.2
	8	L/240	17.3	18.9	20.3	21.8	18.0	19.6	21.1	22.6	25.2	18.8	20.5	22.1	23.7	26.4	21.4	23.0	24.7	27.6
		L/360	15.2	16.5	17.7	19.0	15.8	17.2	18.4	19.8	22.0	16.4	17.9	19.3	20.7	23.1	18.7	20.1	21.6	24.1
		L/600	12.8	13.9	15.0	16.0	13.3	14.5	15.5	16.7	18.6	13.9	15.1	16.3	17.5	19.5	15.8	17.0	18.2	20.3
25PSF	2 1/2	L/240	6.5	7.0	7.5	8.0	6.8	7.3	7.9	8.4	9.3	7.1	7.8	8.3	8.9	9.8	8.2	8.8	9.4	10.5
		L/360	5.6	6.1	6.5	7.0	5.9	6.4	6.9	7.3	8.1	6.2	6.8	7.3	7.8	8.6	7.2	7.7	8.3	9.1
		L/600	4.8	5.2	5.5	5.9	5.0	5.4	5.8	6.2	6.8	5.2	5.7	6.1	6.6	7.2	6.1	6.5	7.0	7.7
	3 5/8	L/240	8.6	9.3	10.0	10.7	9.0	9.8	10.5	11.2	12.4	9.4	10.3	11.0	11.8	13.1	10.8	11.7	12.5	13.9
		L/360	7.5	8.1	8.7	9.3	7.8	8.5	9.1	9.8	10.8	8.2	9.0	9.7	10.3	11.5	9.5	10.2	10.9	12.1
		L/600	6.3	6.9	7.3	7.9	6.6	7.2	7.7	8.2	9.1	6.9	7.6	8.1	8.7	9.7	8.0	8.6	9.2	10.2
	4	L/240	9.3	10.1	10.8	11.5	9.7	10.5	11.3	12.1	13.4	10.2	11.1	11.9	12.8	14.2	11.7	12.6	13.5	15.0
		L/360	8.1	8.8	9.4	10.1	8.5	9.2	9.9	10.6	11.7	8.9	9.7	10.4	11.2	12.4	10.2	11.0	11.8	13.1
		L/600	6.8	7.4	7.9	8.5	7.2	7.8	8.3	8.9	9.9	7.5	8.2	8.8	9.4	10.4	8.6	9.3	9.9	11.0

Continued

11.16.0 Axial Load Tables—5 psf Wind Loads

HEIGHT			8 FT			9 FT			10 FT			12 FT			14 FT			16 FT		
SPACING			12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"
WEB	SECT	GA																		
3 5/8	CN	20	2.10	2.10	2.10	2.05	2.05	2.05	1.98	1.98	1.86	1.61	1.63	1.36	1.35	1.20	0.90	1.01	0.83	
		18	2.94	2.94	2.94	2.87	2.87	2.87	2.77	2.77	2.77	2.52	2.45	2.12	2.04	1.84	1.49	1.53	1.33	
		16	4.35	4.35	4.35	4.14	4.14	4.14	3.91	3.91	3.91	3.41	3.41	3.41	2.93	2.90	2.58	2.38	2.18	1.88
		14	5.89	5.89	5.89	5.58	5.58	5.58	5.21	5.21	5.21	4.39	4.39	4.39	3.63	3.63	3.53	2.99	2.94	2.82
	CEE	20	2.54	2.54	2.54	2.47	2.47	2.47	2.38	2.38	2.33	2.16	2.03	1.73	1.69	1.52	1.19	1.24	1.06	
		18	3.50	3.50	3.50	3.40	3.40	3.40	3.28	3.28	3.28	2.96	2.96	2.69	2.51	2.29	1.94	1.90	1.70	1.35
		16	5.36	5.36	5.35	5.04	5.04	5.04	4.69	4.69	4.69	4.00	4.00	4.00	3.38	3.38	3.13	2.83	2.63	2.31
		14	7.06	7.06	7.06	6.64	6.64	6.64	6.15	6.15	6.15	5.10	5.10	5.10	4.18	4.18	4.15	3.43	3.43	3.11
		12	10.40	10.40	10.40	9.52	9.52	9.52	8.69	8.69	8.69	7.05	7.05	7.05	5.70	5.70	5.70	4.64	4.64	4.64
	JW	20	2.87	2.87	2.87	2.80	2.80	2.80	2.72	2.72	2.72	2.50	2.48	2.13	2.09	1.89	1.52	1.56	1.36	1.01
		18	4.18	4.18	4.18	4.05	4.05	4.05	3.90	3.90	3.90	3.52	3.52	3.30	3.05	2.82	2.40	2.31	2.09	1.69
		16	6.55	6.55	6.55	6.16	6.16	6.16	5.70	5.70	5.70	4.77	4.77	4.77	3.98	3.98	3.86	3.33	3.26	2.88
		14	8.49	8.49	8.49	7.97	7.97	7.97	7.36	7.36	7.36	6.04	6.04	6.04	4.92	4.92	4.92	4.03	4.03	3.75
		12	12.24	12.24	12.24	11.28	11.28	11.28	10.18	10.18	10.18	8.22	8.22	8.22	6.64	6.64	6.64	5.41	5.41	5.41
	JWE	18	4.53	4.53	4.53	4.42	4.42	4.42	4.30	4.30	4.30	3.99	3.99	3.91	3.51	3.41	2.99	2.81	2.56	2.13
		16	6.81	6.81	6.81	6.61	6.61	6.61	6.35	6.35	6.35	5.48	5.48	5.48	4.57	4.57	4.54	3.83	3.83	3.43
		14	9.40	9.40	9.40	8.97	8.97	8.97	8.40	8.40	8.40	6.92	6.92	6.92	5.64	5.64	5.64	4.64	4.64	4.51
		12	13.79	13.79	13.79	12.73	12.73	12.73	11.53	11.53	11.53	9.35	9.35	9.35	7.60	7.60	7.60	6.23	6.23	6.23
		10	16.61	16.61	16.61	15.30	15.30	15.30	13.80	13.80	13.80	11.14	11.14	11.14	9.01	9.01	9.01	7.36	7.36	7.36
6	CN	20	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.26	2.30	2.30	1.98
		18	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.27	3.10
		16	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94
		14	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.56	6.58
	CEE	20	2.93	2.93	2.93	2.93	2.93	2.93	2.92	2.92	2.92	2.88	2.89	2.88	2.82	2.92	2.82	2.73	2.73	2.45
		18	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.10	4.10	4.10	4.00	4.00	4.00	3.85	3.85	3.83
		16	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	6.91	6.91	6.91	6.61	6.61	6.61	6.17	6.17	6.17
		14	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.42	9.42	9.42	9.00	9.00	9.00	8.40	8.40	8.40
		12	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.22	14.22	14.22	13.22	13.22	13.22
	JW	20	3.27	3.27	3.27	3.25	3.25	3.25	3.24	3.24	3.24	3.18	3.18	3.18	3.11	3.11	3.11	3.01	3.01	2.86
		18	5.03	5.03	5.03	5.00	5.00	5.00	4.97	4.97	4.97	4.88	4.88	4.88	4.73	4.73	4.73	4.53	4.53	4.53
		16	8.74	8.74	8.74	8.68	8.68	8.68	8.61	8.61	8.61	8.38	8.38	8.38	7.94	7.94	7.94	7.37	7.37	7.37
		14	11.97	11.97	11.97	11.85	11.85	11.85	11.70	11.70	11.70	11.28	11.28	11.28	10.69	10.69	10.69	9.91	9.91	9.91
		12	18.58	18.58	18.58	18.39	18.39	18.39	18.15	18.15	18.15	17.49	17.49	17.49	16.55	16.55	16.55	15.32	15.32	15.32
	JWE	18	5.28	5.28	5.28	5.25	5.25	5.25	5.22	5.22	5.22	5.13	5.13	5.13	5.01	5.01	5.01	4.86	4.86	4.86
		16	8.82	8.82	8.82	8.75	8.75	8.75	8.65	8.65	8.65	8.40	8.40	8.40	8.06	8.06	8.06	7.63	7.63	7.63
		14	12.50	12.50	12.50	12.42	12.42	12.42	12.31	12.31	12.31	12.04	12.04	12.04	11.61	11.61	11.61	10.91	10.91	10.91
		12	20.82	20.82	20.82	20.64	20.64	20.64	20.42	20.42	20.42	19.80	19.80	19.80	18.70	18.70	18.70	17.33	17.33	17.33
		10	26.83	26.83	26.83	26.50	26.50	26.50	26.09	26.09	26.09	26.09	25.03	25.03	25.03	23.61	23.61	23.61	21.84	21.84
8	CN	20	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
		18	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16
		16	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
		14	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12
	CEE	20	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
		18	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
		16	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84
		14	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24
		12	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
	JW	20	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.30	3.30	3.26	3.26	3.26
		18	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.10	5.10	5.10	5.02	5.02	5.02
		16	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.88	8.88	8.88	8.72	8.72	8.72
		14	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.24	12.24	12.24	11.90	11.90	11.90
		12	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.14	19.14	19.14
	JWE	18	5.45	5.45	5.45	5.44	5.44	5.44	5.43	5.43	5.43	5.39	5.39	5.39	5.34	5.34	5.34	5.27	5.27	5.27
		16	9.26	9.26	9.26	9.23	9.23	9.23	9.20	9.20	9.20	9.10	9.10	9.10	8.95	8.95	8.95	8.74	8.74	8.74
		14	13.06	13.06	13.06	13.03	13.03	13.03	12.99	12.99	12.99	12.88	12.88	12.88	12.72	12.72	12.72	12.50	12.50	12.50
		12	22.78	22.78	22.78	22.70	22.70	22.70	22.61	22.61	22.61	22.35	22.35	22.35	21.97	21.97	21.97	21.46	21.46	21.46
		10	30.01	30.01	30.01	29.89	29.89	29.89	29.74	29.74	29.74	29.29	29.29	29.29	28.63	28.63	28.63	27.71	27.71	27.71

Foot Notes: Axial Load Tables (Pages 18-21)

Braced C-Studs Subject to Axial and Lateral Loads

- Allowable axial loads in kips (K)
- For use in selection of load bearing wall components subjected to axial and uniform lateral loads.
- Select a stud in terms of height (feet), spacing (inches O.C.) and lateral load (PSF), which provides an allowable axial capacity equal to or greater than the applied axial load.
- Numbers in regular type do not exceed L/360 Deflection.
- Numbers in bold type do not exceed L/240 Deflection.
- Must check for Web Crippling.

(By permission from Dale/Incor division of Dale Industries, Dearborn, Michigan.)

11.17.0 Axial Load Tables—25 psf Wind Loads

HEIGHT			8 FT			9 FT			10 FT			12 FT			14 FT			16 FT		
SPACING			12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	20"	12"	16"	24"
WEB	SECT.	GA																		
3 5/8	CN	20	1.65	1.33	0.73	1.32	0.95		0.98											
		18	2.64	2.26	1.53	2.22	1.79	1.02	1.77	1.80										
		16	4.35	4.27	3.25	4.04	3.64	2.91	3.46	3.01		2.86								
		14	5.89	5.89	5.62	5.58	5.48	4.71	5.11	4.64	3.79	3.59	3.09							
	CEE	20	2.16	1.81	1.16	1.77	1.37	0.64	1.38	0.93										
		18	3.35	2.97	2.27	2.90	2.45	1.65	2.40	1.90		1.49								
		16	5.35	5.35	4.75	5.04	4.67	3.87	4.34	3.87	3.02	3.00								
		14	7.06	7.06	6.99	6.64	6.64	5.79	6.15	5.63	4.68	4.32	3.77		2.95					
		12	10.40	10.40	10.40	9.52	9.52	9.42	8.69	8.69	7.84	6.80	6.20	5.15	4.83	4.23				
	JW	20	2.59	2.22	1.57	2.18	1.78	1.00	1.77	1.29										
		18	4.13	3.73	2.98	3.60	3.10	2.20	3.03	2.48	1.90	1.85								
		16	6.55	6.55	6.17	6.16	5.98	5.11	5.55	5.02	4.10	3.87	3.32							
		14	8.49	8.49	8.49	7.97	7.97	7.17	7.36	6.91	5.86	5.32	4.09		3.64					
		12	12.24	12.24	12.24	11.28	11.28	11.28	10.18	10.18	9.68	8.22	7.64	6.62	5.97	5.34		4.29		
	JWE	18	4.53	4.30	3.53	4.23	3.72	2.85	3.65	3.10	2.12	2.54	1.91							
		16	6.81	6.81	6.68	6.61	6.61	5.76	6.35	5.82	4.92	4.63	4.03		3.17					
		14	9.40	9.40	9.40	8.97	8.97	6.57	6.40	8.30	7.20	6.44	5.79	4.67	4.62	3.89				
		12	13.79	13.79	13.79	12.73	12.73	12.73	11.53	11.53	11.18	9.35	8.88	7.63	6.98	6.26		5.05		
		10	16.61	16.61	16.61	15.30	15.30	15.30	13.80	13.80	13.80	11.14	11.09	9.76	8.71	7.96	6.66	6.41	5.71	
6	CN	20	2.31	2.31	1.96	2.31	2.11	1.66	2.16	1.86	1.31	1.74	1.34	0.61	1.26	0.76		0.79		
		18	3.27	3.27	3.12	3.27	3.27	2.77	3.27	3.02	2.40	2.85	2.40	1.57	2.27	1.72		1.67		
		16	4.94	4.94	4.04	4.94	4.04	4.04	4.94	4.94	4.97	4.94	4.82	4.04	4.64	4.09	3.09	3.94	3.27	
		14	6.58	6.58	6.58	6.56	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.26	6.58	6.23	5.21	6.01	5.31	
	CEE	20	2.93	2.93	2.93	2.93	2.81	2.28	2.85	2.52	1.90	2.33	1.68	1.06	1.74	1.19		1.13		
		18	4.17	4.17	4.17	4.17	4.17	3.84	4.17	4.09	3.42	3.63	3.33	2.43	3.10	2.50	1.40	2.35	1.85	
		16	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	6.91	6.89	5.89	6.33	5.66	4.46	5.14	4.37	
		14	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.42	9.42	8.95	9.00	8.50	7.15	7.67	6.82	5.35
		12	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.22	14.22	13.07	13.19	12.14	10.32
	JW	20	3.27	3.27	3.09	3.25	3.25	2.73	3.24	2.96	2.34	2.73	2.31	1.46	2.13	1.58		1.51		
		18	5.03	5.03	5.03	5.00	5.00	4.75	4.97	4.97	4.25	4.68	4.13	3.13	3.83	3.15	1.93	2.96	2.18	
		16	8.74	8.74	8.74	8.68	8.68	8.68	8.61	8.61	8.61	8.38	8.38	7.61	7.94	7.22	5.69	6.49	5.67	4.24
		14	11.97	11.97	11.97	11.85	11.85	11.85	11.70	11.70	11.70	11.28	11.28	10.93	10.69	10.31	8.76	9.26	8.29	6.61
		12	18.58	18.58	18.58	18.39	18.39	18.39	18.15	18.15	18.15	17.49	17.49	17.49	16.55	16.55	15.87	15.82	14.67	12.72
	JWE	18	5.28	5.28	5.28	5.25	5.25	5.23	5.22	5.22	4.77	5.13	4.66	3.71	4.39	3.74	2.54	3.54	2.76	
		16	8.82	8.82	8.82	8.75	8.75	8.75	8.65	8.65	8.65	8.40	8.40	7.90	8.06	7.61	6.34	7.03	6.20	4.75
		14	12.50	12.50	12.50	12.42	12.42	12.42	12.31	12.31	12.31	12.04	12.04	12.04	11.61	11.61	10.19	10.68	9.71	7.96
		12	20.82	20.82	20.82	20.64	20.64	20.64	20.42	20.42	20.42	19.80	19.80	19.80	18.70	18.70	18.08	17.33	16.73	14.53
		10	26.83	26.83	26.83	26.50	26.50	26.50	26.09	26.09	26.09	25.03	25.03	25.03	23.61	23.61	23.61	21.84	21.84	19.36
8	CN	20	2.22	2.22	2.15	2.22	2.22	1.92	2.22	2.10	1.87	2.00	1.70	1.10	1.65	1.25	0.47	1.25	0.75	
		18	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.01	3.16	3.01	2.46	2.96	2.58	1.61	2.56	2.06	1.13
		16	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.10	4.55	4.25	3.45
		14	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	5.57
	CEE	20	2.90	2.90	2.90	2.90	2.90	2.65	2.90	2.85	2.37	2.75	2.40	1.72	2.32	1.87	0.97	1.65	1.27	0.25
		18	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	3.74	4.12	3.84	3.07	3.82	3.29	2.34
		16	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.34	6.84	6.54	5.41
		14	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.21	8.39
		12	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
	JW	20	3.33	3.33	3.33	3.33	3.33	3.31	3.33	3.33	3.03	3.33	3.06	2.40	2.95	2.53	1.66	2.49	1.91	0.69
		18	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	4.52	5.10	4.62	3.62	4.52	3.87	2.65
		16	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.88	8.88	8.56	8.72	8.64	7.34
		14	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.24	12.24	12.24	11.90	11.90	10.83
		12	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.27	19.67	19.67	19.67	19.14	19.14	19.14
	JWE	18	5.45	5.45	5.45	5.44	5.44	5.44	5.43	5.43	5.43	5.39	5.39	5.02	5.34	5.03	4.16	4.99	4.97	3.22
		16	9.26	9.26	9.26	9.23	9.23	9.23	9.20	9.20	9.20	9.10	9.10	9.10	8.95	8.95	8.67	8.74	8.74	7.66
		14	13.06	13.06	13.06	13.03	13.03	13.03	12.99	12.99	12.99	12.88	12.88	12.88	12.72	12.72	12.72	12.50	12.50	12.02
		12	22.78	22.78	22.78	22.70	22.70	22.70	22.61	22.61	22.61	22.35	22.35	22.35	21.97	21.97	21.97	21.46	21.46	21.46
		10	30.01	30.01	30.01	29.89	29.89	29.89	29.74	29.74	29.74	29.29	29.29	29.29	28.63	28.63	28.63	27.71	27.71	27.71

Notes:

1. Values shown assume concentric loading of the members.
2. In load-bearing (axial) wall construction, mechanical bridging shall be used in all cases. Installation of bridging must be completed before any loads are applied to the system. V-Bar Bridging, as shown on page 17, is the most effective and efficient method of installation to prevent rotation of flanges.
3. Studs shall be braced against rotation. Install mechanical bridging spaced at intervals not exceeding 4'-0" on center, maximum. Refer to page 17 for bridging types and installation methods.
4. Stud ends shall be securely attached to track components at the top and bottom of the wall assembly. Stud ends must be seated as tightly as possible into tracks in all compression and bearing applications.
5. For components subjected to 5 PSF and greater lateral wind loads, the actual bending and axial stresses were multiplied by 0.75 in accordance with AISI Section A4.4.
6. Deflections and stresses were calculated without regard to the composite contribution of facing materials.
7. Contact DALE/INCOR for allowable axial capacities of framing components not shown in the table.

(By permission from Dale/Incor division of Dale Industries, Dearborn, Michigan.)

11.18.0 Axial Load Tables—30 psf Wind Loads

HEIGHT			8 FT			9 FT			10 FT			12 FT			14 FT			16 FT		
SPACING			12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"
WEB	SECT	GA																		
3 5/8	CN	20	1.45	1.08	0.40	1.10	0.67		0.73											
		18	2.41	1.90	1.21	1.94	1.47		1.50	0.97										
		16	4.35	4.02	3.30	3.61	3.34	2.51	3.19	2.69										
		14	5.89	5.89	5.24	5.58	5.16	4.28	4.81	4.29	3.31	3.29								
	CEE	20	1.94	1.54	0.79	1.59	1.07		1.10											
		18	3.12	2.70	1.87	2.62	2.12	1.20	2.10	1.55										
		16	5.35	5.17	4.35	4.84	4.34	3.42	4.07	3.52		2.70								
		14	7.06	7.06	6.46	6.64	6.29	5.29	5.83	5.23	4.18	4.00	3.37							
		12	10.40	10.40	10.40	9.52	9.52	8.90	8.69	8.44	7.27	6.43	5.75		4.48					
	JW	20	2.37	1.94	1.19	1.93	1.45		1.49	0.97										
		18	3.88	3.41	2.51	3.30	2.73	1.73	2.70	2.08		1.67								
		16	6.55	6.55	5.75	6.16	5.63	4.63	5.22	4.62	3.57	3.56								
		14	8.49	8.49	8.02	7.97	7.75	6.65	7.16	6.48	5.28	4.92	4.24		3.29					
		12	12.24	12.24	12.24	11.28	11.26	11.05	10.18	10.16	9.06	7.89	7.17	5.92	5.59	4.89				
	JWE	18	4.40	4.00	3.15	3.90	3.35	2.35	3.32	2.70	1.60	2.16								
		16	6.81	6.81	6.26	6.61	6.28	5.28	6.02	5.40	4.27	4.25	3.58							
		14	9.40	9.40	9.38	8.97	8.97	8.02	8.40	7.35	6.62	6.04	5.32		4.14					
		12	13.79	13.79	13.79	12.73	12.73	12.68	11.53	11.53	10.50	9.15	8.35	6.95	6.52	5.75		4.65		
		10	16.61	16.61	16.61	15.30	15.30	15.30	13.80	13.80	13.32	11.14	10.54	9.04	8.24	7.41		5.98		
6	CN	20	2.31	2.16	1.74	2.21	1.91	1.39	1.99	1.64	1.01	1.49	1.04	0.24	0.96					
		18	3.27	3.27	2.90	3.27	3.10	2.50	3.15	2.77	2.05	2.57	2.07	1.10	1.92	1.30		1.27		
		16	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.94	4.54	4.94	4.49	3.59	4.28	3.67	2.54	3.54	2.79	
		14	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	5.81	6.46	5.81	4.83	5.58	4.61	
	CEE	20	2.93	2.88	2.38	2.81	2.58	1.98	2.05	2.27	1.55	2.06	1.53	0.58	1.39	0.79				
		18	4.17	4.17	3.94	4.17	4.17	3.52	4.17	3.82	3.02	3.53	2.95	1.90	2.73	2.03		1.99		
		16	7.04	7.04	7.04	7.04	7.04	7.04	7.04	7.04	6.71	6.91	6.49	5.34	5.93	5.16	3.78	4.67	3.82	
		14	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.42	9.42	8.32	8.85	7.95	6.40	7.15	6.20	
		12	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.22	14.02	12.17	12.54	11.37	9.37
	JW	20	3.27	3.27	2.84	3.25	3.23	2.43	3.09	2.71	1.98	2.48	1.38	0.98	1.91	1.18		1.11		
		18	5.03	5.03	4.90	5.00	5.00	4.38	4.97	4.70	3.80	4.35	3.73	2.53	3.43	2.65	1.25	2.48	1.61	
		16	8.74	8.74	8.74	8.68	8.68	8.68	8.61	8.61	8.61	8.38	8.23	6.98	7.49	6.67	5.17	5.99	5.07	
		14	11.97	11.97	11.97	11.85	11.85	11.85	11.70	11.70	11.70	11.28	11.28	10.23	10.04	9.66	7.94	8.66	7.59	5.74
		12	18.58	18.58	18.58	18.39	18.39	18.39	18.15	18.15	18.15	17.49	17.49	17.49	16.55	16.55	14.92	15.09	13.84	11.67
	JWE	18	5.28	5.28	5.28	5.25	5.25	4.90	5.22	5.20	4.35	4.86	4.26	3.16	3.99	3.24	1.89	3.06	2.21	
		16	8.82	8.82	8.82	8.75	8.75	8.75	8.65	8.65	8.65	8.40	8.40	7.33	7.89	7.09	5.64	6.53	5.60	
		14	12.50	12.50	12.50	12.42	12.42	12.42	12.31	12.31	12.31	12.04	12.04	11.54	11.61	11.09	9.34	10.08	8.98	7.08
		12	20.82	20.82	20.82	20.64	20.64	20.64	20.42	20.42	20.42	19.80	19.80	19.80	18.70	18.70	17.00	17.23	15.80	13.35
		10	26.83	26.83	26.83	26.50	26.50	26.50	26.09	26.09	26.09	25.03	25.03	25.03	23.61	23.61	22.58	21.64	20.79	19.04
8	CN	20	2.22	2.22	1.97	2.22	2.12	1.72	2.17	1.92	1.42	1.82	1.47	0.77	1.40	0.95	0.05	0.95	0.44	
		18	3.16	3.16	3.16	3.16	3.16	3.03	3.16	3.16	2.76	3.13	2.78	2.13	2.73	2.26	1.38	2.26	1.68	0.61
		16	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.37	4.55	4.47	3.72	4.42	3.92	3.00
		14	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	5.87	6.12	6.04	5.12
	CEE	20	2.90	2.90	2.72	2.90	2.90	2.42	2.90	2.65	2.10	2.55	2.12	1.32	2.35	1.50	0.55	1.50	0.82	
		18	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.07	4.12	4.07	3.39	3.99	3.52	2.64	3.49	2.92	1.79
		16	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.76	6.84	6.84	5.84	6.76	5.09	4.73
		14	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	8.89	9.24	9.09	7.69
		12	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.29
	JW	20	3.33	3.33	3.33	3.33	3.33	3.08	3.33	3.31	2.76	3.18	2.78	2.03	2.73	2.18	1.16	2.14	1.49	0.87
		18	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	4.97	5.14	4.97	4.09	4.82	4.22	3.07	4.12	3.37	1.96
		16	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.88	8.88	8.01	8.72	8.12	6.62
		14	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.24	12.24	11.86	11.86	11.77	10.05
		12	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.14	19.14	18.94
	JWE	18	5.45	5.45	5.45	5.44	5.44	5.44	5.43	5.43	5.43	5.39	5.39	4.62	5.29	4.71	3.61	4.62	3.89	2.57
		16	9.26	9.26	9.26	9.23	9.23	9.23	9.20	9.20	9.20	9.10	9.10	9.10	8.95	8.95	8.32	8.74	8.39	6.96
		14	13.06	13.06	13.06	13.03	13.03	13.03	12.99	12.99	12.99	12.88	12.88	12.88	12.72	12.72	12.72	12.50	12.50	11.22
		12	22.78	22.78	22.78	22.70	22.70	22.70	22.61	22.61	22.61	22.35	22.35	22.35	21.97	21.97	21.97	21.46	21.46	21.26
		10	30.01	30.01	30.01	29.89	29.89	29.89	29.74	29.74	29.74	29.29	29.29	29.29	28.63	28.63	28.63	27.71	27.71	27.71

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11.19.0 Axial Load Tables—40 psf Wind Loads

HEIGHT			8 FT			9 FT			10 FT			12 FT			14 FT			16 FT		
SPACING			12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"	12"	16"	24"
WEB	SECT	GA																		
3 5/8	CN	20	1.38	0.63		0.67														
		18	1.99	1.46		1.47	0.87		0.97											
		16	4.02	3.52	2.82	3.34	2.79		2.69											
		14	5.89	5.49	4.57	5.16	4.56	3.48	4.29	3.64										
	CEE	20	1.54	1.04		1.07														
		18	2.70	2.15	1.15	2.12	1.50		1.55											
		16	5.17	4.62	3.62	4.34	3.72		3.52	2.94										
		14	7.06	6.76	5.66	6.29	5.61	4.41	5.23	4.53		3.37								
		12	10.40	10.40	9.78	9.52	9.25	7.92	8.44	7.64	6.27	5.75	4.96							
	JW	20	1.94	1.44	0.49	1.45	0.85		0.97											
		18	3.41	2.81	1.68	2.73	2.05		2.06	1.33										
		16	6.55	6.02	4.95	5.63	4.96	3.76	4.62	3.92										
		14	8.49	8.34	7.12	7.75	7.00	5.65	6.48	5.66	4.26	4.24								
		12	12.24	12.24	12.09	11.28	11.28	10.00	10.18	9.48	8.01	7.17	8.32		4.89					
	JWE	18	4.00	3.43	2.35	3.35	2.67	1.45	2.70	1.95										
		16	6.81	6.53	5.46	6.28	5.61	4.36	5.40	4.62		3.58								
		14	9.40	9.40	6.48	8.97	8.39	6.99	7.85	7.00	5.52	5.32	4.44							
		12	13.79	13.79	13.79	12.73	12.73	11.53	11.53	10.95	9.30	8.35	7.38		5.75					
		10	16.61	16.61	16.61	15.30	15.30	14.70	13.80	13.77	12.02	10.54	9.51	7.74	7.41	6.44				
6	CN	20	2.16	1.89	1.31	1.91	1.56	0.86	1.64	1.21	0.48	1.04	0.48							
		18	3.27	3.05	2.42	3.10	2.67	1.90	2.77	2.30	1.36	2.07	1.40		1.30					
		16	4.94	4.94	4.92	4.94	4.94	4.44	4.94	4.77	3.92	4.49	3.89	2.74	3.67	2.82		2.79		
		14	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.18	6.58	6.11	4.90	5.81	5.03		4.81		
	CEE	20	2.89	2.56	1.91	2.58	2.18	1.41	2.27	1.77	0.85	1.53	0.91		0.79					
		18	4.17	4.12	3.44	4.17	3.72	2.87	3.82	3.27	2.24	2.95	2.25	0.93	2.03	1.18				
		16	7.04	7.04	7.04	7.04	7.04	6.61	7.04	6.99	5.91	6.49	5.71	4.26	5.16	4.21		3.82		
		14	9.46	9.46	9.46	9.46	9.46	9.46	9.46	9.46	8.96	9.42	8.75	7.17	7.95	6.90	5.05	6.20	5.07	
		12	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	14.51	13.24	14.02	12.77	10.52	11.37	9.99	
	JW	20	3.27	2.99	2.37	3.03	2.63	1.83	2.71	2.21	1.26	1.96	1.31		1.16					
		18	5.03	5.03	4.33	5.00	4.63	3.68	4.70	4.10	2.97	3.73	2.93	1.45	2.65	1.70		1.61		
		16	8.74	8.74	8.74	8.68	8.66	8.58	8.61	8.61	7.74	8.23	7.38	5.83	6.67	5.64		5.07		
		14	11.97	11.97	11.97	11.85	11.85	11.85	11.70	11.70	11.32	11.26	10.71	8.91	9.66	8.49	6.39	7.59	6.31	
		12	18.58	18.58	18.58	18.39	18.39	18.39	18.15	18.15	18.15	17.49	17.49	16.64	16.55	15.55	13.15	13.84	12.37	8.70
	JWE	18	5.28	5.28	4.86	5.25	5.13	4.25	5.20	4.62	3.57	4.26	3.51	2.11	3.24	2.31		2.24		
		16	8.82	8.82	8.82	8.75	8.75	8.75	8.65	8.65	8.05	8.40	7.70	6.23	7.09	6.11	4.31	5.60	4.50	
		14	12.50	12.50	12.50	12.42	12.42	12.42	12.31	12.31	12.31	12.04	11.99	10.27	11.09	9.91	7.79	8.98	7.56	
		12	20.82	20.82	20.82	20.64	20.64	20.64	20.42	20.42	20.42	19.80	19.80	18.95	18.70	17.70	15.03	15.80	14.13	11.23
		10	26.83	26.83	26.83	26.50	26.50	26.50	26.09	26.09	26.09	25.03	25.03	25.03	23.61	23.36	20.34	20.79	18.91	15.64
8	CN	20	2.22	2.07	1.65	2.12	1.85	1.32	1.92	1.60	0.95	1.47	1.02	0.12	0.55	0.38		0.44		
		18	3.16	3.16	2.98	3.16	3.16	2.66	3.16	2.91	2.31	2.78	2.33	1.48	2.26	1.68	0.56	1.68	0.96	
		16	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.52	4.55	4.55	3.82	4.47	3.97	3.00	3.92	3.30	2.10
		14	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	6.12	5.99	6.12	6.12	5.17	6.04	5.42	4.22
	CEE	20	2.90	2.85	2.37	2.90	2.57	1.97	2.65	2.27	1.52	2.12	1.57	0.55	1.50	0.80		0.02		
		18	4.12	4.12	4.12	4.12	4.12	3.97	4.12	4.12	3.59	4.07	3.62	2.74	3.52	2.94	1.79	2.92	2.17	
		16	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.64	6.04	6.64	6.16	4.86	6.09	5.21	3.59
		14	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.24	9.12	9.24	9.24	7.84	9.09	8.14	6.42
		12	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.59	14.74	14.74	12.76
	JW	20	3.33	3.33	3.03	3.33	3.23	2.66	3.31	2.93	2.23	2.78	2.28	1.28	2.18	1.50	0.29	1.49	0.69	
		18	5.14	5.14	5.14	5.14	5.14	4.84	5.14	5.14	4.34	4.97	4.37	3.24	4.22	3.45	1.97	3.37	2.42	0.62
		16	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.34	8.88	8.38	6.86	8.12	7.09	5.24
		14	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.35	12.32	12.24	12.24	10.54	11.77	10.62	8.47
		12	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.14	19.14	17.12
	JWE	18	5.45	5.45	5.45	5.44	5.44	5.37	5.43	5.43	4.88	5.39	4.89	3.79	4.71	3.99	2.59	3.89	2.99	1.32
		16	9.26	9.26	9.26	9.23	9.23	9.23	9.20	9.20	9.20	9.10	9.10	8.67	8.95	8.67	7.22	8.39	7.41	5.64
		14	13.06	13.06	13.06	13.03	13.03	13.03	12.99	12.99	12.99	12.88	12.88	12.88	12.72	12.72	11.62	12.50	11.75	9.67
		12	22.78	22.78	22.78	22.70	22.70	22.70	22.61	22.61	22.61	22.35	22.35	22.35	21.97	21.97	21.97	21.46	21.46	19.2
		10	30.01	30.01	30.01	29.89	29.89	29.89	29.74	29.74	29.74	29.29	29.29	29.29	28.63	28.63	28.63	27.71	27.71	26.29

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11.20.0 Weld and Fastener Tables

Suggested design loads for screw connections (pounds)

Steel Thickness (Gauge)	No. 12-14 (D = .160"; T = .177") Shear or Bearing	No. 12-14 Pullout	NO. 10-16 (D = .138"; T = .153") Shear or Bearing	NO. 10-16 Pullout	NO. 8-18 (D = .120"; T = .125") Shear or Bearing	NO. 8-18 Pullout	No. 6, S-12 (D = .100"; T = .106") Shear or Bearing	No. 6, S-12 Pullout
12	890	280	780	245	675	210	560	175
14	555	195	520	170	470	145	395	125
16	390	155	370	135	340	115	310	95
18	280	120	260	105	240	90	220	75
20	185	95	175	80	165	70	150	60

Type of Loading

NOTES:
1. Design values are based on CCFSS Technical Bulletin Vol. 2, No. 1 which outlines the proposed AISI specification provisions for screw connections
2. Minimum screw spacing and distance from edge shall not be less than 1 1/2 D nor less than P/Fyt where D is the screw shank diameter and P is the shear load.
3. When connecting materials of different gage, use loads shown for the lighter gage.
4. Screw capabilities are based on a minimum connected material strength of Fy = 33,000 PSI.

Suggested design loads for Powder driven fasteners in concrete

TABLE A

suggested capacity in stone aggregate concrete (pounds)

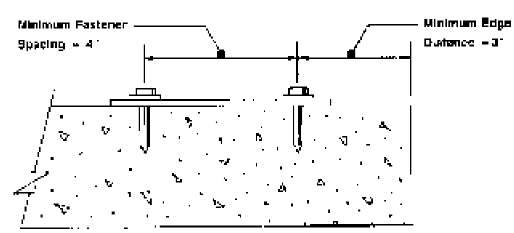
Shank Diameter	Minimum Penetration	Type of Loading	Concrete Compression Strength (PSI) 2000	3000	4000
0.145"	1⅛"	Pullout	90	115	145
		Shear	160	225	265
0.177"	1⁷⁄₁₆"	Pullout	150	150	150
		Shear	250	285	330
0.205"	1¼"	Pullout	150	150	150
		Shear	390	445	500

TABLE B

suggested bearing capacity when used to connect gage thickness steel (pounds)

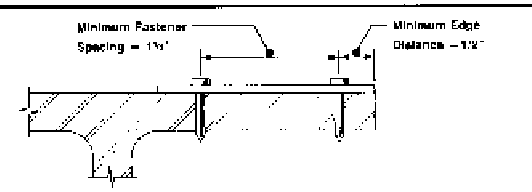
Shank Diameter	Steel Gage Thickness 16 Gage	18 Gage	20 Gage
0.145"	—	—	—
		—	198
0.177"	—	—	—
	—	321	241
0.205"	—	—	—
	465	372	279

NOTES:
1. Capacities shown are for stone aggregate concrete and are based on a low velocity shot.
2. Minimum fastener spacing — 4"; minimum fastener edge distance — 3".
3. Shear values are per Hilti ICBO Research Report #2388.
4. Bearing capacity is based on Bearing Area x 1.15 x 33,000 psi. Allowable bearing capacity per Section 4.5.6 of the 1986 A.I.S.I. "Specification for the Design of Cold Formed Steel Structural Members."
5. Pullout values per DALE / INCOR recommendations.



Suggested design loads in pull-out or shear for Powder driven fasteners in structural steel (pounds)

Cold Rolled Steel Gage	0.145" Shank Diameter Hot Rolled Steel Thickness ½"	⅜"	¼"	0.177" Shank Diameter Hot Rolled Steel Thickness ¼"	⅜"	0.205" Shank Diameter Hot Rolled Steel Thickness ½"	¼"	⅜"	½"
12	210	210	210	335	395	395	465	525	660
14	210	210	210	335	395	395	465	525	561
16	210	210	210	335	395	395	465	465	465
18	210	210	210	321	321	321	372	372	372
20	197	197	197	241	241	241	279	279	279



NOTES:
1. Tests were conducted with the fastener point driver completely through the back side of the hot rolled steel member. This was necessary to obtain proper gripping force.
2. Bearing strength is based on Bearing Area x 1.15 x 33,000 psi for cold formed steel.
3. Shear values are per Hilti ICBO Research Report #2388.

Suggested design loads for fillet and flare-bevel groove welds

Steel Gage	Design Thickness (inches)	Weld Size (inches)	Allowable Load (lb/in.)
12	.1017	5/32	1370
14	.0713	1/8	960
16	.0566	1/8	760
18	.0451	1/8	605

NOTES:
1. Values listed may be increased by 1/3 for wind or seismic loading (check codes for application).
2. Welds may be positioned so they are subject to either shear or tensile stress.
3. When joining materials of different gage, use loads shown for the lighter gage.
4. Flare-bevel groove welds are welds that occur between the out side radius of one member and the flat of an adjacent member radius of one member and the flat of an adjacent member.

Technical Assistance - Welding

A wire feed type welder is recommended for fastest and most uniform welding in the shop. Good welds are also obtained with a ³⁄₃₂" or ⅛" AWS type 6013 or 7014 rod with a welding heat of 60-110 amperes depending on the gage of material and the fit of the parts.

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11.21.0 Shaftwall and Stairwall Structural Properties

SERIES 620 J TRACK AND SLOTTED C-T STUDS are manufactured from hot-dipped galvanized steel meeting ASTM A 924 AND ASTM A653.

The 2 1/2" steel-framing system retains the popular 3 1/2" wall thickness with a 2-hour fire rating to accommodate standard door-framing dimensions. A unique feature of the Series 620 stud is its slotting in the web of the stud. Tests have demonstrated that these slots effectively improve resistance to thermal and noise transmissions.

The 2 1/2" stud provides a 1 1/2" air cavity for services. Studs are friction fitted between top and bottom J Tracks.

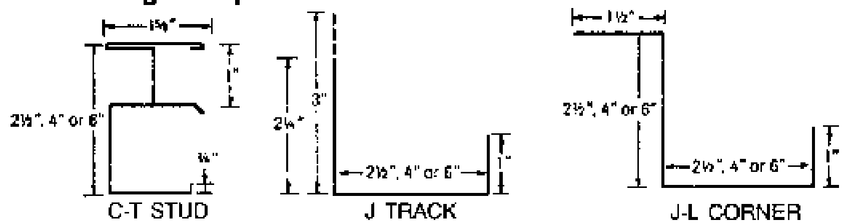
Use J Tracks for all closure details, including duct and door openings, abutments, intersections, etc. No other special metal components are required.

However, an alternate vertical J-L corner member is available in 10' and 12' lengths for use in lieu of two J Tracks to form certain outside corner configurations. See detail. Studs are automatically spaced 24" o.c. maximum with the special Shaftliner panels.

Helpful Hints

- Use a fastening plate to secure the J Track whenever fasteners are closer than 4" to the edge. Setting the plate at the time of concrete construction will avoid spalling by mechanical fasteners.
- Pre-cut C-T studs 3/4" less than the opening's height.
- Pre-cut 1" Type X Shaftliner 3/4" less than the opening's height.
- In structural steel-frame construction, install J Track sections before applying spray-on fire proofing.
- Items to be anchored to the wall (cabinets, sinks, handrails, etc.) should be fastened to the C-T studs or to plates secured behind or between layers of 1/2" Fireguard® C. Joint compounds should be applied at ambient temperatures above 50°F (10°C) with adequate ventilation.
- For acoustical sealing and prevention of air leakage, use a bead of flexible sealant at the perimeter of each wall under each face layer and under the 2 1/2" flange of J Track for shaftwall finished on one side.
- Use Type S screws for 25-gauge steel framing. Use Type S-12 screws for 20-gauge (or heavier) steel framing.
- It is important that the job structural engineer approve the type, size and maximum spacing of track fasteners to meet the design load requirements.

Stud Design Properties



Minimum C-T Stud Section Properties

Based on AISIA "Specifications For The Design of Cold-Formed Steel Structural Members."

T = Minimum uncoated base steel thickness (inches)
W = Weight (pounds per linear foot)
A = Section area (inches²)
I_x = Moment of Inertia (inches⁴)
S_x (C) = Section modulus "C" flange (inches³)
S_x (T) = Section modulus "T" flange (inches³)

Stud Size	T	W	A	I_x	S_x (C)	S_x (T)
2 1/2" x 25 ga	0.0179	0.470	0.118	0.132	0.095	0.118
2 1/2" x 20 ga	0.0329	0.820	0.218	0.242	0.175	0.217
4" x 25 ga	0.0179	0.580	0.145	0.374	0.171	0.207
4" x 20 ga	0.0329	1.020	0.267	0.687	0.341	0.380
6" x 25 ga	0.0179	0.715	0.181	0.957	0.299	0.347
6" x 20 Ba	0.0329	1.260	0.333	1.759	0.543	0.637

Limiting Heights – Studs 24"

1 Hr. Rated Series 622

Stud Depth (in.)	Stud & Track Gauge	Design Deflection Limit	Uniform Load (PSF) 5	7.5	10	15
2.5	25	L/120	14'-2"	12'-5"	11'-3"	9'-4"
		L/180	12'-5"	10'-10"	9'-10"	8'-7"
		L/240	11'-2"	9'-10"	8'-11"	7'-10"
		L/360	9'-10"	8'-7"	7'-10"	6'-10"
2.5	20	L/120	15'-10"	13'-10"	12'-6"	10'-11"
		L/180	13'-10"	12'-1"	10'-11"	9'-7"
		L/240	12'-8"	10'-11"	9'11"	8'-8"
		L/360	10'-11"	9'-7"	8'-8"	7'-7"
4	25	L/120	19'-1"	15'-11"	13'-10"	11'-3"
		L/180	16'-8"	14'-6"	13'-2"	11'-3"
		L/240	15'-1"	13'-2"	12'-0"	10'-8"
		L/360	13'-2"	11'-6"	10'-6"	9'-2"
4	20	L/120	21'-8"	18'-11"	17'-2"	15'-0"
		L/180	18'-11"	16'-6"	15'-0"	13'-1"
		L/240	17'-2"	15'-0"	13'-8"	11'-11"
		L/360	15'-0"	13'-1"	11'-11"	12'-5"
6	25	L/120	22'-7"	18'-9"	16'-3"	12'-0"
		L/180	19'-9"	17'-3"	15'-6"	12'-0"
		L/240	17'-11"	15'-8"	14'-3"	12'-0"
		L/360	15'-8"	13'-8"	12'-5"	10'-10"
6	20	L/120	27'-4"	23'-11"	21'-9"	19'-0"
		L/180	23'-11"	21'-11"	19'-0"	16'-7"
		L/240	21'-8"	19'-0"	17'-3"	15'-1"
		L/360	19'-0"	16'-7"	15'-1"	13'-2"

2 Hr. Rated Series 620 or 621 and 3 Hr. Rated Series 630 or 631

Stud Depth (in.)	Stud Track Gauge	Design Deflection Limit	Uniform Load (PSF) 5	7.5	10	15
2.5	25	L/120	15'-6"	13'-3"	11'-6"	9'-5"
		L/180	13'-7"	11'-10"	10'-9"	9'-5"
		L/240	12'-4"	10'-9"	9'-9"	8'-6"
		L/360	10'-9"	9'-5"	8'-5"	7'-6"
2.5	20	L/120	17'-4"	15'-1"	13'-9"	12'-0"
		L/180	15'-1"	13'-2"	12'-0"	10'-6"
		L/240	13'-9"	12'-0"	10'-11"	9'-6"
		L/360	12'-0"	10'-5"	9'-6"	8'-4"
4	25	L/120	18'-7"	15'-11"	13'-10"	11'-3"
		L/180	16'-3"	15'-1"	13'-10"	11'-3"
		L/240	16'-7"	14'-5"	13'-2"	11'-3"
		L/360	14'-5"	12'-9"	11'-6"	11'-3"
4	20	L/120	23'-6"	20'-8"	18'-9"	15'-6"
		L/180	20'-6"	18'-1"	16'-5"	14'-4"
		L/240	18'-9"	16'-5"	14'-11"	13'-0"
		L/360	16'-5"	14'-4"	13'-7"	11'-5"
6	25	L/120	22'-11"	18'-9"	16'-3"	12'-0"
		L/180	21'-6"	19'-9"	16'-3"	12'-0"
		L/240	18'-8"	17'-2"	15'-7"	12'-0"
		L/360	17'-2"	15'-0"	13'-9"	19'-3"
6	20	L/120	30'-0"	26'-2"	23'-7"	19'-3"
		L/180	26'-2"	22'-11"	20'-9"	18'-2"
		L/240	23'-9"	20'-9"	18'-11"	16'-6"
		L/360	20'-5"	18'-2"	15'-5"	14'-5"

Test Ref: WHI-495-0206/0225, issued August 4, 1995. C-T studs and J track are same gauge. Based on deflection limits with adjustment to conform to conform to minimum safety factor of 1.5 for ultimate bending strength and end reation.

Track Fastener Shear Loads

Comprehensive design data on this subject may be found in ACWI *Steel Framing Systems Manual.*

For shear-bearing capacity considerations of the perimeter steel-wall track, the following Table is an expanded version of the ACWI table—to include 22- and 25-gauge-thick steel with ⅛" and ⅜₄" diameter fasteners.

For example, an 18' high wall under a design pressure load of 15 psf would require ⅛" diameter fasteners to be spaced 16" o.c. maximum to avoid exceeding the design shear stress of 25-gauge steel track. In addition, those same ⅛" diameters, driven ¾" deep in 3000 psi concrete, must be spaced 14" o.c. maximum to avoid exceeding the design shear stress of the concrete.

ALLOWABLE SHEAR LOAD (LB)

Shank Diameter	Steel Thickness 16-Ga.	18-Ga.	20-Ga	22-Ga	25-Ga.
⅛"	—	—	310	259	181
9/64"	—	—	349	291	203
5/32"	·	...	388	323	226
11/64"	—	517	427	356	248
3/16"	777	621	460	388	271

Note: It is important the job engineer approve the type, size, and maximum spacing of perimeter fasteners to meet the design load requirements.

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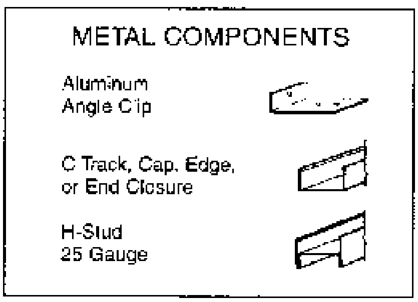
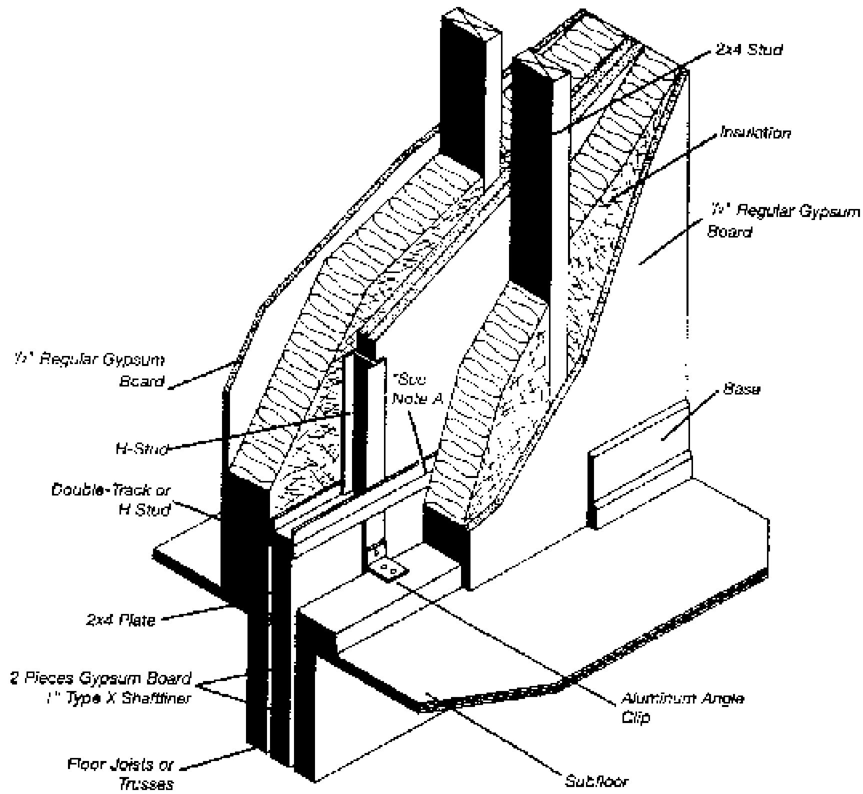
11.22.0 Area Separation Walls—Fire and Sound Test References

Designed for maximum flexibility as Area Separation Walls, the Series 600 is the most cost-efficient, performance-oriented system.





Fire and Sound Test References

The design file numbers and the references appearing in this brochure may be cross referenced in the Fire Resistance Design Manual published by the Gypsum Association of the UL and ULC Fire Resistance Directories published by Underwriters Laboratories. The Fire Resistance Design Manual is referenced in the BOCA Basic/National Building Code, the Standard Building Code by SBCCI, and the uniform Building Code by ICBO.

The data relating to fire and sound-tested assemblies contained herein is based on the characteristics, properties and performance of materials and systems obtained under controlled test conditions as set forth under the appropriate ASTM standard such as E119 (Fire), E90 (Sound) or E72 (Structural).

Prior to installation, the specifier or user should determine that the local Building and Fire Code Authority permits the installation of gypsum Area Separation Walls and that the insuring group will not penalize the owner.

Installation Instructions

When the wood framed walls of one unit are complete, the Area Separation Walls are constructed before the next unit's interior framing is started. Allow a ¾" space between the Area Separation Wall and the wood framing.

Bottom track is secured to the slab using suitable fasteners at a maximum of 24" o.c. Begin at one end or side with a vertical section of 2" x 10' track. Insert two pieces of 1" Type X Shaftliner. Plumb and secure with a 2" x 2" x 10' H-Stud member. Install gypsum board panels and H-Stud members progressively across the wall and secure to the wood framing with aluminum angle clips.

Aluminum angle clips should be screw-attached to the web of the H-Studs and nailed or screwed to the wood top plates (48" o.c. max.). Attach angle clips to the same H-stud on both sides of the Area Separation Wall. Cap the assembly with either and H-Stud member placed horizontally or two pieces of track fastened back to back. Repeat the process for the next course of gypsum panels and metal framing up to or through the roofline per plan details. Cap the top of the assembly with 2" track.

Cover all exposed edges or web faces of the metal with 6" wide strips of ½" Type X board secured to the metal with 1" Type S drywall screws approximately 12" o.c.

NOTE A:

As tested, all exposed track and H-Stud members should be covered with 6" wide strips of either ¾" C or ⅝" Type X, screw-attached 12" o.c.

Some authorities, however, consider the insulation and interior finish as sufficient protection. Please check with your local Building Official or Fire Marshal's office.

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11.23.0 Plaster Systems

For years, the three-coat plaster system installed on expanded metal lath, attached to either wood or metal furring or studs, provided the ultimate in interior wall and ceiling construction. The smooth monolithic system created by plastering provided a relatively abuse-resistant surface; when decorative cornice or ceiling moldings were applied, an elegant room took shape.

However, the skills required to properly apply a three-coat plaster wall and their associated costs brought forth the development of veneer plaster systems in the 1960s. These systems took advantage of the large gypsum panels available to provide a smooth, stable foundation for a 1⁄16 inch (3 mm) to 1⁄8 inch (6 mm) application of plaster. The overall cost of this system is considerably lower than the conventional scratch-brown finish coat. With a drying tie of 48 hours versus 5 days for the regular three-coat system, production is greatly increased.

11.23.1 Comparing Conventional Plaster, Veneer Plaster, and Drywall Systems

Selecting a Plaster System

Because plaster systems provide more options in component selection than conventional drywall or masonry construction, plaster systems provide a much greater range of performance levels. The charts below compare conventional plaster, veneer plaster and drywall systems and list the distinctive characteristics of each.

Product Compatibility Selector

	Substrate						Finish Plaster								
Basecoat Plaster	**CMU**	**Mono. Conc.[1]**	**ML CH-FMG.**	**ML C-Studs**	**ROCKLATH Plaster Base**	**IMPERIAL Veneer Base**	**RED TOP Finish**	**STRUCTO-Gauge Lime**	**Keenes/ Lime**	**Gauging/ Lime**	**Keenes/ Lime/Sand**	**Gauging/ Lime/Sand**	**IMPERIAL Finish**	**DIAMOND Interior Finish**	**ORIENTAL Exterior Finish**
RED TOP & RED TOP Two Purpose (Sand)	✓	✓	✓	○	✓	○	✓	✓	✓	✓	✓	✓	✓	✓	○
RED TOP & RED TOP Two Purpose (Lightweight)	✓	✓	✓	○	✓	○	○	○	○	✓[3]	✓	✓	○	○	○
RED TOP Wood Fiber (Sand)	✓	✓	✓	○	✓	○	✓	✓	✓	✓	✓	✓	✓	✓	○
STRUCTO-BASE (Sand)	✓	✓	✓	✓	✓	○	✓	✓	✓	✓	✓	✓	✓	✓	○
STRUCTO-LITE	✓	✓	✓	○	✓	○	○	○	○	✓[3]	✓	✓	○	○	○
IMPERIAL Basecoat	✓	✓	○	○	○	✓	✓	✓	✓	✓	✓	✓	✓	✓	○
DIAMOND Veneer Basecoat	✓	✓	○	○	○	✓	✓	✓	✓	✓	✓	✓	✓	✓	○
IMPERIAL Finish	○	○	○	○	○	✓	—	—	—	—	—	—	—	—	—
DIAMOND Interior Finish	○	✓[1]	○	○	○	✓	—	—	—	—	—	—	—	—	—
DIAMOND Interior Finish (Electric Cable)	○	✓[1]	○	○	○	✓	—	—	—	—	—	—	—	—	—
Portland Cement/Lime/Sand (Stucco)	✓	✓	✓	○	○	○	○	○	○	○	○	○	○	○	✓

Notes: (1) A bonding agent must first be applied. (2) Job sanded. (3) Quality Gauging/not over metal lath.

Monolithic concrete to be treated with top quality bonding agent
✓ = Acceptable
○ = Not Acceptable
— = Not Applicable

Comparing Conventional Plaster, Veneer Plaster and Drywall Systems*

System	**Characteristics**	**Comments**			
1. **Conventional Plaster**	Best system to attain a uniform, monolithic, blemish-free, smooth surface with good to excellent wear resistance based on the type of finish plaster. Ability to achieve intricate architectural details and ornamental shapes. High cost.				
2. **Two Coat Veneer Plaster Systems** IMPERIAL Basecoat Plaster (commercial application) or DIAMOND Veneer Basecoat Plaster (residential and light commercial applications) with finish plasters A-E below	Provide distinct advantages over single coat veneer plaster and drywall systems. More monolithic surface with improved appearance under oblique lighting conditions. Ability to obtain truer wall surfaces, greater resistance to nail pops, joint ridging and joint shadowing/banding. Wider choice of finishing materials and texture options.	FINISH PLASTER RATING (No. 1 Best—No. 5 Acceptable) Productivity	Hardness	Workability	Ease to achieve smooth surface
A. IMPERIAL Finish	Ultimate in surface hardness and abrasion resistance. Easily textured. Low productivity and more difficult to achieve a smooth finish.	5	1	4	4
B. DIAMOND Interior Finish	Single bag, ready-to-use finish. Moderate strength. Acceptable workability extremely adaptable to textured finishes with or without the addition of aggregate. Satisfactory smooth finish.	2	3	3	3
C. STRUCTO-GAUGE Gauging Lime putty (1:1) or RED TOP Finish	Hardest dense putty finish. Moderate workability and ease of application. Excellent finish appearance	2	4	2	2
D. Regular Gauging Lime Putty	Highest productivity. Best workability. Jointable, easiest to achieve a monolithic finish. Only moderate surface hardness	1	5	1	1
E. RED TOP Keenes Cement Lime Putty and Sand	Ultimate choice for texturing. Unique, only retemperable material, allows extended time period for floating. Provides the ability for pigment addition to achieve colored textured surface also.	Due to unique nature Keenes is not rated with above finishes.			
3. **One Coat IMPERIAL Finish Plaster**	Monolithic, smooth or textured appearance. Ultimate in surface hardness. Direct to plaster base in a single coat veneer plaster system. Achieves high productivity due to compatibility with absorbent surface plaster base. Ready for further decoration in as little as 24 hours if completely dry.	Fast completion shortens construction time, brings in paying tenants faster, thus reducing interest paid on project construction loan.			
4. **One Coat DIAMOND Interior Finish Plaster**	Monolithic appearance. Moderate wear-resistant surface. Provides a wide range of texture types with or without the addition of aggregate. Ready for further decoration in as little as 24 hours if completely dry. Greatest coverage for single coat application over veneer plaster base. Lowest cost single coat veneer plaster system	See comment IMPERIAL Finish.			
5. **Gypsum Drywall**	Relatively smooth surface with acceptable monolithic appearing surface under most conditions. Lowest cost. Resistant to light abrasion. Most susceptible to nail pops and joint photographing				

*This table is meant to serve as a general guide to the selection of plaster systems. The information should not be construed as limiting materials or systems to specific types of construction.

(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.23.2 Lath and Plaster Installation Procedures

Installation

Steel Studs—Space steel studs a maximum of 16" o.c.

Metal Lath—Place Self-Furring Diamond Mesh Lath against studs and with end joints staggered in adjacent rows. Screw studs *through dimples only*, spacing screws 6" o.c. Lap ends of lath at least 1" between supports. Lap side (horizontal) joints at least ½". Wire tie all side laps and end joints between supports together at intervals not exceeding 6".

Basecoat—Mix STRUCTO-BASE Gypsum Plaster in a mechanical mixer to a uniform consistency. Scratch and brown coats shall be proportioned 2 cu. ft. of sand per 100 lbs. of plaster. Determine optimum batch material fluidity at the mixer by adjusting water usage to achieve the following slumps:

Machine application ....1½" maximum, 1" preferred.
Hand application.......................½" maximum, ½" preferred.

Slump Determination Procedure—Place a wetted 2" IDx4" high cylinder on base plate. Gradually fill cylinder with material, puddling occasionally. When full, strike-off flush with top of cylinder. Slowly raise cylinder and allow material to slump. Position empty cylinder beside material on the base plate (do not disturb) and place a rule on cylinder top to overhang material. Measurement from rule to material indicates slump.

Scratch Coat—For hand application, apply scratch coat with sufficient material and pressure to form good full keys and then cross rake.

For machine application, maintain sufficient angle in the spray pattern to develop full keys on the back of the lath and to prevent excessive material blow-through. Where leveling by trowel is necessary to remove high spots, cross rake for sufficient bond with subsequent brown coat.

Allow scratch coat to set and *partially* dry before application of brown coat.

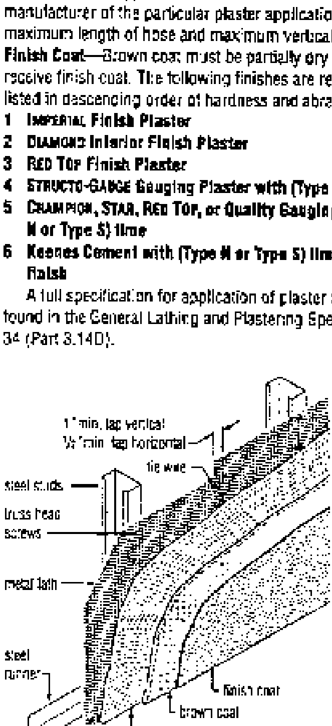
Brown Coat—Apply brown coat after scratch coat has set firm and hard (maintaining proper "green state" or dampness). When applying the brown coat by hand application, use sufficient pressure to ensure proper bonding to the scratch coat application. Bring out to grounds (allow $\frac{1}{16}$" for finish coat) and straighten to a true surface with rod and darby with only limited use of additional water. Leave surface rough and open to receive finish coat. Minimum thickness of scratch and brown coats (basecoat plaster) shall be ⅝" measured from the face of the lath.

For machine application of scratch and brown coats, consult the manufacturer of the particular plaster application machine for maximum length of hose and maximum vertical lift.

Finish Coat—Brown coat must be partially dry (green state) to receive finish coat. The following finishes are recommended and listed in descending order of hardness and abrasion resistance:

1. **IMPERIAL Finish Plaster**
2. **DIAMOND Interior Finish Plaster**
3. **RED TOP Finish Plaster**
4. **STRUCTO-GAUGE Gauging Plaster with (Type N or Type S) lime**
5. **CHAMPION, STAR, RED TOP, or Quality Gauging Plaster with (Type N or Type S) lime**
6. **Keenes Cement with (Type N or Type S) lime for a sand float finish**

A full specification for application of plaster finish coats can be found in the General Lathing and Plastering Specifications on page 34 (Part 3.14D).



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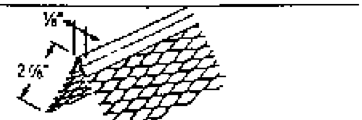
11.23.3 Lath, Framing, and Furring Accessories

Lath Accessories

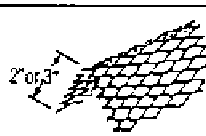
1-A Expanded Corner Bead
Easily flexed for irregular corners. Reinforces close to nose of bead, made with 2¼" wide expanded flanges, of galvanized steel or zinc alloy for exterior use.



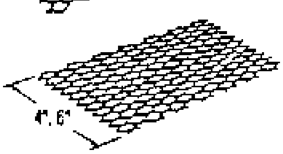
Double-X Corner Bead
Ideal for structural tile and rough masonry, adjusts easily for plaster depth on columns. Perforated stiffening ribs along expanded flange.

4-A Flexible Corner Bead
Ideal for curved edges (archways, telephone niches, etc.). Versatile and economical as an "all-purpose" corner bead. Snipping flanges lets you bend this bead to any curvature radius.

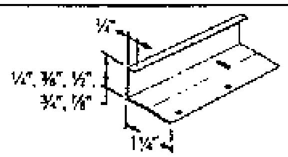
Cornerite
Strips of Diamond Mesh Lath for reinforcement. Available as painted or galvanized steel. Cornerite, bent in the center to a 100° angle, reinforces interior angles between unlapped metal lath, and between masonry constructions (to reduce plaster cracking) and nonferrous lath. Sizes 2"x2"x96", 3"x3"x96".

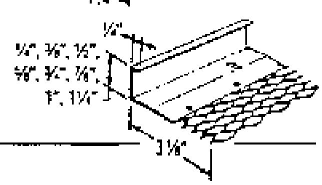


Striplath, a flat strip, reinforces joints of nonmetallic and/or dissimilar plaster lathing/bases, also spans pipe chases. Sizes: 4"x96", 6"x96".

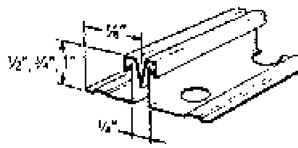


Casing Beads
Use ⅝" casing beads with metal lath, ¾" beads with all masonry units. When flange is applied under ROCKLATH Plaster Base, use ⅜" beads, over ROCKLATH Base, ⅞" beads. Made from corrosion-resistant galvanized steel or zinc alloy for exterior applications. #66 Square Edge Sizes with 1⅛" short, solid flange: ½", ⅝", ¾", ⅞", 1". #66 Square Edge Sizes with 3¼" long, expanded flange: ¼", ⅜", ½", ⅝", ¾", ⅞", 1", 1¼". Length: 10'.

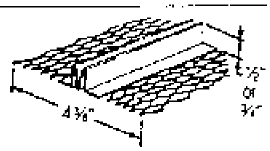




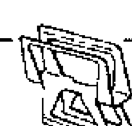
SHEETROCK Zinc Control Joints Nos. 50, 75, 100
Relieves plaster expansion/contraction stresses in large areas. Used from floor to ceiling in long partition runs, and from header to ceiling above door frames. Plastic tape, removed after plastering, protects a ¼" x ½" deep slot. Roll-formed from zinc, it is corrosion-resistant for both interior and exterior use with gypsum or portland cement plaster. Sizes, grounds: No. 50, ½"; No. 75, ¾"; No. 100, 1" (for exterior stucco curtain walls). Length: 10'. Limitations: adequate protection must be provided behind the control joint to maintain sound and/or fire ratings. Zinc control joint should not be used with magnesium oxychloride cement stuccos or stuccos containing calcium chloride additives.



Double V Expansion Joint
Provides stress relief to control cracking in large plastered areas. Made with expanded flanges of corrosion-resistant galvanized steel, or zinc for exterior use. Grounds: ½", ¾". Lengths: 10'.

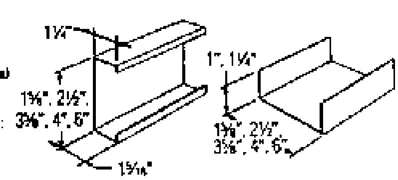


ROCKLATH Field Clip S-1
Supports and aligns ⅜" thick ROCKLATH base ends where joints do not fall directly over 16" o.c. max. framing members; designed for use with ⅜" ROCKLATH Plaster Base.

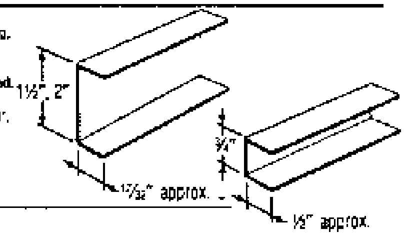


Framing and Furring Accessories

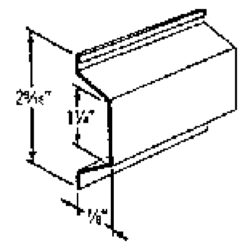
Steel ST-Studs and CR-Runners
Channel-shaped, roll-formed, with corrosion-resistant coating. Secure, rigid screw or clip attachment of the gypsum base utilizes the full structural contribution of the lath and plaster membrane. Stud widths: 1⅝" (for 25 ga. only), 2½", 3⅝", 4", 6"; stud styles: 25 ga., 22 ga., 20 ga. Stud lengths: 8' to 16'. Runners come in stud widths, 10' length only.



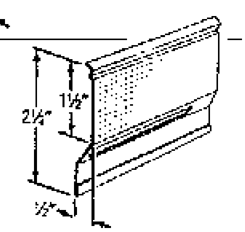
Cold-Rolled Channels
Made of 16 ga. steel. Used for furring, suspended ceilings, partitions, ornamental lathing. Available either galvanized or black asphaltum painted. Sizes, ¾", with ½" flange; 1½" and 2" with ¹⁷⁄₃₂" flange. Lengths: 16' and 20'.



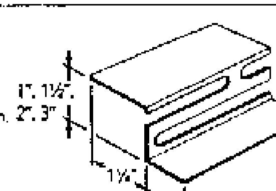
Metal Furring Channels
Hat-shaped channels for ceiling and wall furring. Roll-formed from two gauges of corrosion-resistant steel. DWC-25 for screw attachment of ROCKLATH Base. DWC-20 for greater spans, load-carrying capacity and exterior furring. Products comply with ASTM C645. Face width: 1¼", depth: ⅞", length: 12'.



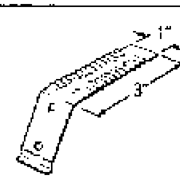
RC-1™ Resilient Channel
Part of the family of SHEETROCK Metal Products. Corrosion-resistant steel channel for resilient attachment of ROCKLATH Base to wood and steel framing. Prepunched holes in the flange facilitate screw fastening to framing members with 1¼" Type W or S screws. Not suitable for use with more than 2 layers of ⅝" thick gypsum panels.



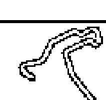
SHEETROCK Z-Furring Channels
Mechanically attach THERMAFIBER insulation and rigid foam insulations and ROCKLATH Base to interior of masonry walls. Made of corrosion-resistant, hot-dip galvanized steel. Furring depths: 1", 1½", 2", 3"; length: 8'6".



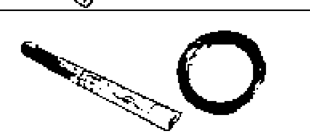
Adjustable Wall Furring Brackets
Used in braced furring systems for interior or exterior masonry walls. Made of 20 ga. galvanized steel and attached to steel studs. Furring depth: up to 2¼" plus stud width.



Metal Furring Channel Clip
Galvanized 1⅛" wire used to attach metal furring channels to 1½" cold-rolled channel ceiling gridwork.



Tie Wire and Hanger Wire
Tie wire is 18 ga. galvanized steel wire used in drywall/plaster to tie furring channel to runners and in plaster to tie metal lath to channel. Hanger wire is 8 ga. galvanized steel for hanging 1½" runner channels in drywall/plaster suspended ceilings.



(By permission from the United States Gypsum Corporation, Chicago, Illinois.)

11.24.0 Five Levels of Drywall-Taping Systems

- *Level 1* All joints and interior angles shall have tape embedded in joint compound. The surface shall be free of excess joint compound. Tool marks and ridges are acceptable. Suggested location of Level 1 taping: fire- and smoke-taped baffles above suspended ceilings and elsewhere where gypsum board is concealed from public view.
- *Level 2* All joints and interior angles shall have tape embedded in the joint compound and shall receive one separate coat of joint compound applied over all joints, angles, and fastener heads and accessories. The surface shall be free of excess joint compound. Tool marks and ridges are acceptable. Suggested location of Level 2 taping: Substrates that receive tile or paneling in excess of ¼ inch (8 mm) thickness.
- *Level 3* All joints and interior angles shall have tape embedded in the joint compound and shall receive two separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. The surface shall be free of excess joint compound and all surfaces shall be smooth and free of tool marks and ridges. Suggested location of Level 3 taping: Areas scheduled to receive heavy-textured finishes (hand or spray applied), paneling less than ¼ inch (8 mm) thickness, or Class III vinyl wall coverings.
- *Level 4* All joints and interior angles shall have tape embedded in the joint compound and shall receive three separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. Surfaces shall be free of excess joint compound and all surfaces shall be free of tool marks and ridges. Suggested location of Level 4 taping: Areas to receive paint coatings, paneling less than ¼ inch (8 mm) thickness, and where vinyl or wall fabric wall coverings will be applied.
- *Level 5* All joints and interior angles shall have tape embedded in the joint compound and shall receive three separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. Provide a thin skim coat of joint compound (or other material manufactured expressly for this purpose) over the entire surface. The finished surface shall be free of excess joint compound and all surfaces shall be smooth of tool marks and ridges. Suggested location of Level 5 taping: Areas scheduled to be lit by cove- and washing-type light fixtures.

11.25.0 Gypsum Drywall—Quality Control Checklist

Quality Control Checklist

Project no.

Section: **Gypsum Drywall**

No. **09251**

Date

GYPSUM DRYWALL - FRAMING

1. All submittals concluding samples are approved and on site.
2. Material is stored in dry location.
3. Materials galvanized where exposed damp conditions.
4. Studs are doubled-up at jambs, unless otherwise required.
5. Reinforced and heavy gauge studs as required.
6. Studs allow for movement: slab deflection.
7. Studs securely anchored to walls, columns and floors.
8. Sound-proofing provided at floors and walls as required.
9. Observe locations, layout and plumbness.
10. Channel stiffeners are provided as required.
11. Special fastening and connection are observed.
12. Anchor blocking, plates, other equip. provided.
13. Cut studs for openings are properly framed.
14. Observe size, gauge of runner and furring channels.
15. Hangers are saddletied, bolted or clipped as required.
16. Tie wire for channels to runners properly tied.
17. Elevation and layout of furring is understood.
18. Observe that surfaces are plumb or level.
19. Observe that long single lengths are used.
20. Control joints are installed per contract documents.
21. Requirements for adjoining surfaces of different materials are accommodated.
22. Sealing provided for sound or thermal isolation.
23. Spacing and construction are as specified.
24. Observe location of required blocking, bracing, nailers

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

12

Exterior Insulation and Finish Systems (EIFS) and Vinyl Siding

Contents

12.0.0 Introduction to EIFS

Developed in Europe in the 1950s, its introduction in the United States provided builders with another durable, relatively maintenance-free exterior wall finish that was aesthetically pleasing and cost-effective.

This multicomponent system consists of:

- An insulation board, generally expanded polystyrene (EPS)
- A strong adhesive and/or a mechanical fastening system
- A durable base coat reinforced with a glass fiber mesh
- A finish coat that protects the substrate and is available in a variety of factory prepared colors. Various textures can be created during the application process.
- Architectural shapes such as cornices, fascias, quoins articulation, keystones, and arches can be created in the facade by the use of additions to the base EPS board and/or routing of various portions of the EPS board.

EIFS with drainage is an exterior cladding system that incorporates all of the above components and includes mesh or another medium placed directly over the building paper to create an opening between the sheathing and the backside of the insulation board through which any trapped water can drain to the outside.

12.1.0 Class PB and PM Systems

There are two classes of EIFS systems:

Class PB

1. The base coat thickness varies depending upon the number of layers or thickness of reinforcing mesh. This reinforcing mesh is embedded into the base coat per EIFS manufacturer recommendations and with no mesh color visible.
2. Protective finish coats, of various thicknesses, and available in a variety of colors and textures created by the applicator, are applied over the base coat.

Class PM

1. The base coat is applied to a uniform thickness which can range from ¼ inch (6 mm) nominal to ⅜ inch (9 mm) nominal. The base coat thickness is not dependent upon the number of layers or thickness of reinforcing mesh. The reinforcing mesh is installed over the surface of the insulation board. The base coat is applied over the reinforcing mesh.
2. Protective finish coats, of various thickness, in a variety of colors and textures created by the applicator, are applied over the base coat.

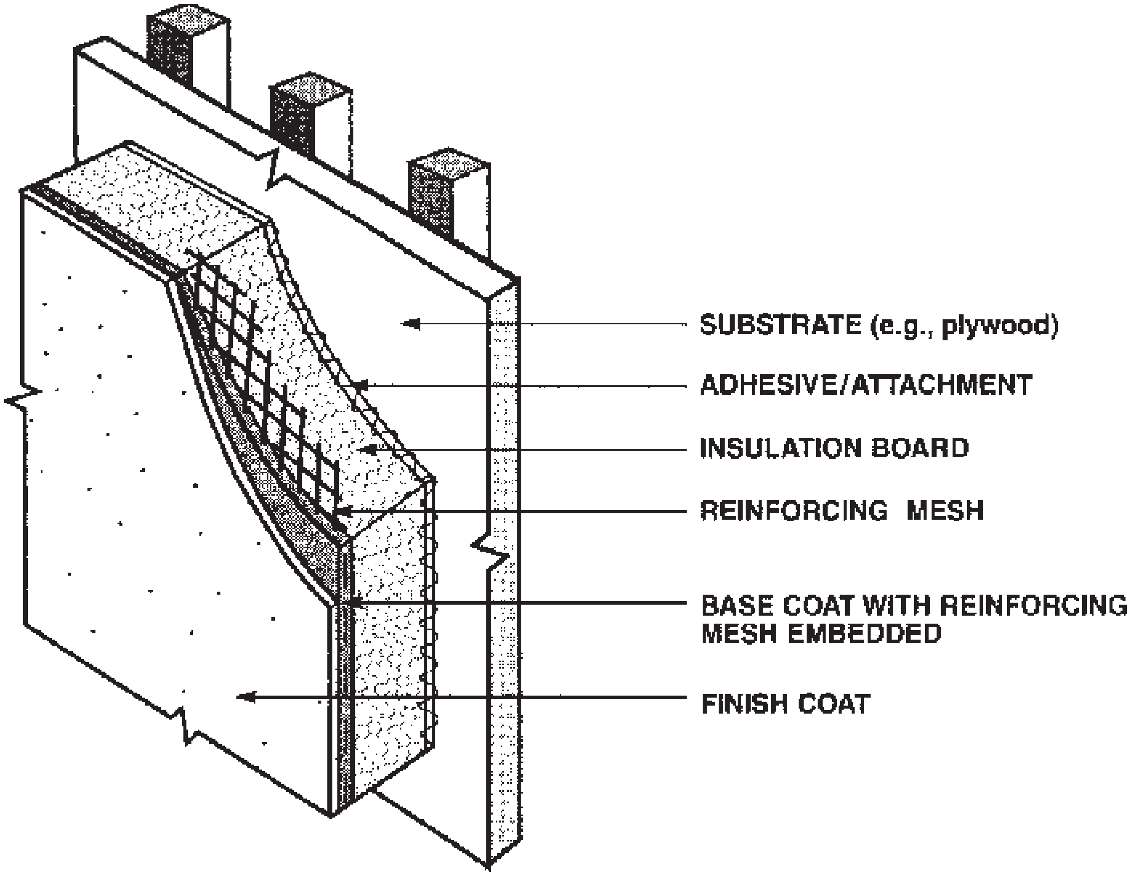
EIFS has been widely accepted in both the residential and commercial construction fields and provides an energy-efficient, cost-effective exterior wall surface.

According to EIFS Industry Members Association, the following sheathing substrates can be used for Class PB EIFS.

Sheathing Type	Allowable Weather Exposure
Gypsum board-paper faced, water resistant	One month without severe weather
Glass mat faced sheathing	Six months (typical)
Exterior grade plywood	Permanent
Exposure 1 plywood	OK for “long” construction delays
Oriented Strand Board (OSB)	OK for “long” construction delays
Cementitious	OK for sun, rain, or snow

To ensure a quality product, each of the components of an EIFS system requires strict compliance with established procedures and methods of application. Application tips and typical details are set forth in the following illustrations and text.

12.2.0 Components of EIFS for Residential Use—Cutaway Sections



(Courtesy of EIMA (EIFS Industry Members Association.)

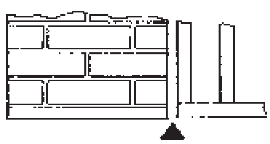
12.3.0 Substrate, Backwrapping, and EPS Board Installation

SUBSTRATE PREPARATION

- Remove surface contaminants.
- Replace weather-damaged sheathing and repair damaged or cracked surfaces.
- Correct surfaces to comply with required tolerances.

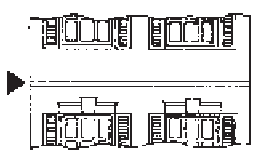
Expansion Joints

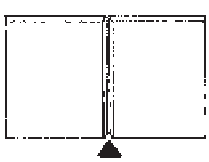
Expansion joints are required in EIFS systems at the following locations:



1. Where dissimilar materials or construction meet.

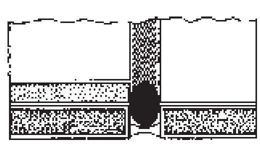
2. Floor lines in multi-level wood frame construction.





3. Where joints already exist in the substrate.

4. Detail of a typical expansion joint.



5. Other areas where significant movement is expected in the supporting construction or the substrate.

Note: Use appropriate sealant/primer and backer rod following sealant manufacturer's recommendations to prevent water from getting into or behind the EIFS system. Do not apply base coat/mesh or finish over the expansion joint sealant.

BACKWRAPPING

Prior to applying the insulation boards on the wall, a strip of reinforcing mesh is applied to the substrate. This mesh will eventually wrap around the edge of the insulation. We refer to this procedure as "backwrapping."

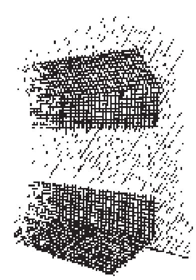
The two main purposes of backwrapping are

1. to ensure the edges of insulation boards will be protected and
2. to ensure the entire edge of the insulation system will be well adhered.

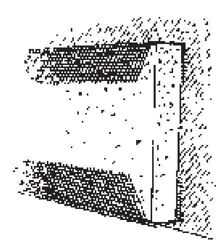
Procedure

Using the proper adhesive and strips of mesh, apply a minimum 2 1/2" (64mm) of mesh to the base of the wall. Allow the remaining mesh to hang down; this will be "wrapped" around the insulation board at a later time with a minimum of 2 1/2" (64mm) on the face of the board. Care should be taken to prevent the adhesive from collecting on the portion of mesh which will be used to wrap the insulation.

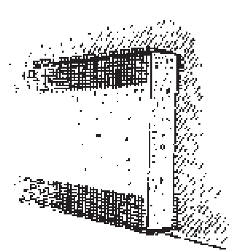
This "backwrapping" procedure must be used wherever the insulation system starts or stops, i.e., the base of the system or when meeting door/window frames, etc.



1. Adhere the strips of reinforcing mesh to the substrate



2. Adhere the insulation board to the substrate between the mesh.



3. Wrap and embed the mesh on the face of the insulation board.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

INSULATION

The insulation boards used for above-grade applications are expanded polystyrene or "EPS" boards. Various thicknesses are available (minimum 3/4" [19mm])*. The maximum size board allowable is 2' x 4' (610 x 1219mm).

*Note: Most building codes restrict EPS insulation to a maximum of 4" (102mm) thickness.

Expanded Polystyrene Quality Test

Prior to applying any EPS boards, they must be checked to ensure they meet EIFS manufacturer specifications. EPS boards must be produced by an approved and licensed manufacturer and checked in the field as follows:

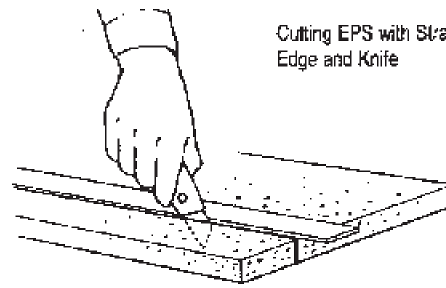
1. Upon Delivery
   - A. EPS boards are to be delivered in labeled plastic bags.
   - B. Each bag should identify physical properties of the board.
   - C. Each board shall be clearly marked with the brand name and the manufacturer's applicable code report number.
   - D. All boards are to be wire cut (not cast formed), and the edges are to be square cut.
   - E. Make sure the EPS boards have not been damaged in handling.
2. Storage
   - A. Protect from direct sunlight during storage and after application.
   - B. Store flat in a dry area (not on edge).

CUTTING EPS BOARDS

Commonly, EPS boards are cut with a hot knife using a square to guide the cut.

Always keep the knife sharp and use a low angle when cutting the board. The low angle allows the knife to "slice" through the insulation.

Other popular methods for cutting include the following power tools: circular saw, router, table saw, band saw or hot wire machine.



Cutting EPS with Straight Edge and Knife

ADHESIVE APPLICATION

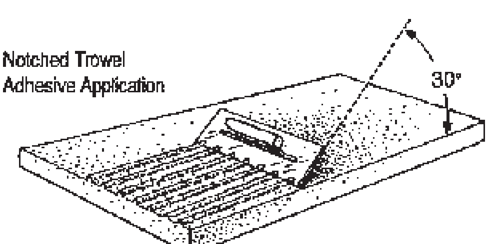
Apply the adhesive to the insulation board by trowel using the ribbon and dab method or the notched trowel method.

When using the notched trowel method, always hold the notched trowel at a minimum 30° angle to produce the correct size ribbons. When forming the ribbons, press the trowel firmly (this will prevent excess adhesive from collecting between the ribbons). Keep the trowel clean to prevent any adhesive buildup in the notches.

The ribbons typically run horizontally when the boards are applied to the wall.

Note: The notched trowel method may be required by code in some regions of the country in lieu of the ribbon and dab method. Check the manufacturer's code report.

Notched Trowel Adhesive Application



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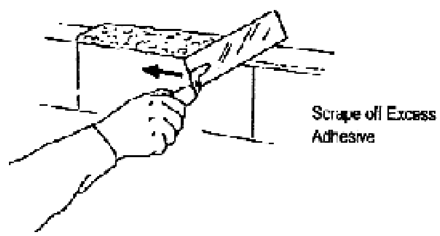
EPS BOARD APPLICATION

Always start from a level baseline. Prior to placing the EPS boards on the wall, care should

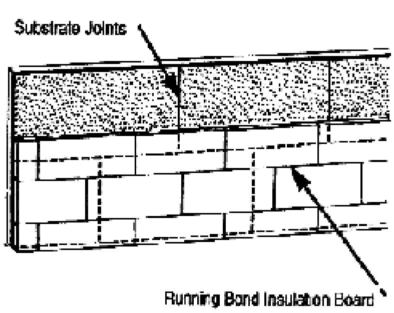


be taken to wipe or scrape any excess adhesive from the edges of the boards. If the adhesive collects between the boards, this will cause unwanted "thermal bridges" causing future problems. When applying the boards, butt them tightly together. This will prevent any "thermal breaks" in the system.

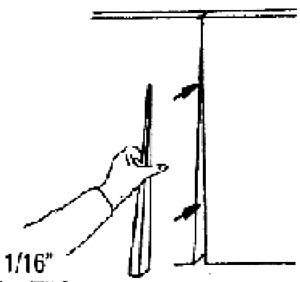
When placing the boards on the wall, always apply the correct amount of pressure for the adhesive to "grab." Press hard or "tamp" the boards to ensure a good "grab." To apply uniform pressure over the entire board, use a large block or "rasping board."

Always place the boards so all vertical joints are staggered and bridge sheathing substrate joints.

Insulation boards are applied in a running bond pattern, with staggered vertical joints and interlocking insulation boards at the inside and outside corners. Insulation board joints must be offset from sheathing joints. Insulation board must be fit around (not aligned) with corners of openings.



FILLING EPS VOIDS



As mentioned, the EPS boards are to be applied butted tightly together. A thorough inspection should be made for any voids or spaces larger than 1/16" (1.6mm) between the EPS boards. Any gaps between boards Must be filled with insulation. Gaps must not be filled with adhesive or any other noninsulating material.

By insulating all open joints between the boards the wall will be properly insulated. Flow of base coat material into these gaps can result in future cracks.

RASPING

The entire surface of the EPS wall must be level and uniform. Rasp the surface.

EPS boards are very easy to level and shape using a "rasping board."

When rasping the insulation boards even, it is important that you rasp the entire surface of the boards, not just the edges. If you rasp just the edges, then the wall will appear to have waves in it during "critical" light.

BASE COAT AND MESH

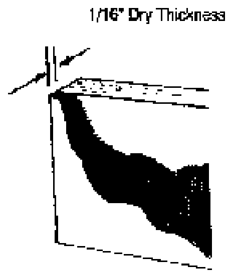
Once the wall has been prepared, it must be protected from sun/water damage.

Reinforcement is then added to all the boards for impact protection. To achieve this, apply the base coat and embed appropriate mesh. This procedure is known as the "base coat application."

Continued

12.4.0 Base Coat Application

BASE COAT APPLICATION

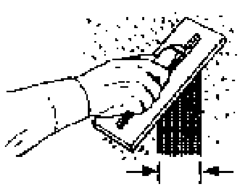


Apply the base coat on the insulation boards. Immediately embed the mesh in the base coat by troweling from the center to the edges of the mesh, to avoid wrinkles. Trowel off any excess base coat from the surface. The mesh shall be embedded so that no mesh color is visible.

Application at Detail Work
Additional protection at doors and windows is achieved by applying "butterflies" or small strips of mesh diagonally at the sills and headers prior to application of field mesh.

Application at Corners
All inside and outside corners must have two layers of mesh applied (double wrapped).

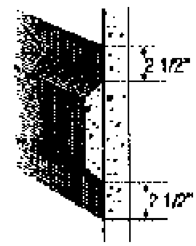
Application at Wall Areas
When embedding the mesh into the base coat, work vertically or horizontally in 40" (1016mm) strips (the approximate width of the mesh). Overlap the strip edges a minimum of 2 1/2" (64mm), or butt edges together, in accordance with EIFS manufacturer's recommendations.



Note: All EPS boards are to be covered with the base coat and mesh application and allowed to dry prior to applying any finish.

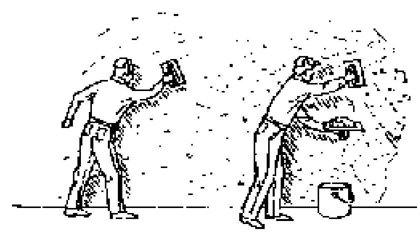
High Impact Areas
A second layer of high impact mesh (14 oz/yd^2 minimum) may be detailed on the drawings, or specifically described in the contract documents, for areas susceptible to high impact. Apply this layer of mesh first, in a similar manner as described above, however with the edges butted; no mesh color visible. After this layer has dried, apply the standard mesh (4 oz/yd^2), with the mesh overlapped as described above, and with no mesh color visible.

EPS Shapes
EPS shapes installed over EIFS on noncombustible construction must have reinforcing mesh fully embedded into the base coat.



PRIMER APPLICATION (OPTIONAL SYSTEM COMPONENT)

Priming is sometimes recommended as a color base. In addition, priming provides uniform substrate absorption, improves weather resistance, enhances finish color and inhibits efflorescence in cementitious substrates. The primer is applied with a paint roller or brush to the substrate.



Floating Finish — Applying Finish

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.5.0 Finish Coat Application

FINISH APPLICATION

Plan the finish application so enough workers are available to finish entire sections of wall area at one time, uninterrupted.

Mix the finish with a clear, rust-free mixer. Small amounts of clean water may be added to aid workability. Use only stainless steel trowels to apply the finish. Work in pairs with the first person applying the finish to the wall and the second person floating the finish to the desired texture.

1. Apply finish directly over the base coat (or primed base coat as specified) ONLY AFTER THE BASE COAT/PRIMER HAS THOROUGHLY DRIED.
2. Avoid application in direct sunlight.
3. Apply finish in a continuous application, always working to a wet edge.
4. Aesthetic V-grooves may be designed into the system to accommodate workability on multilevel buildings (a minimum of 3/4" [19mm] insulation board must be left after any grooves are cut).
5. Texture finishes must be floated with a specific trowel to achieve proper textures and avoid inconsistencies of the finish. Check with EIFS manufacturer for recommended tools.
6. Avoid installing separate batches of finish side by side.
7. Interrupt application at natural breaks in construction, i.e., expansion joints, changes of plane, system terminations, etc.

Note: Weather conditions affect application and drying time. Follow or precede sun around building, Hot or dry conditions limit working time and accelerate drying and may require adjustments in the scheduling of work to achieve desired results; cool or damp conditions extend working time and slow down drying and may require added measures of protection against wind, dust, dirt, rain and freezing.

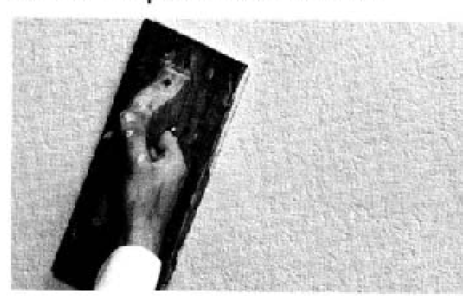
FLOATING TEXTURES

There are basically two different textures that can be achieved.

1. Pebbled Texture - This finish is applied to the wall to approximately the thickness of the aggregate in the finish. Float the finish to disperse the aggregates evenly.

Note: A plastic trowel may be used to float the finish, but the appearance may vary from the texture achieved by using a stainless steel trowel.

2. Random Texture - This finish is applied to the wall to approximately the thickness of the largest stone in the finish. The finish is then scraped down to ensure it is no thicker than the largest stone size. Float the finish to produce the random texture. When floating, you can either float it immediately (wet float) or allow the finish to set a short time and float it (dry float). By allowing the finish to set and dry float, the finish will produce more flat areas.

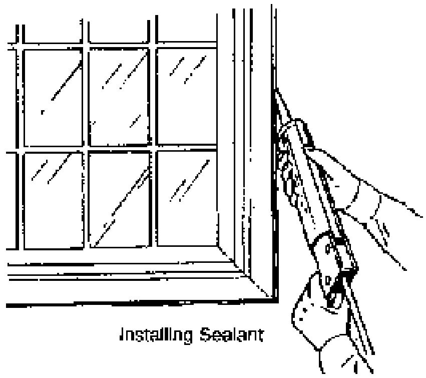


Note: The finish coating should not be allowed to set too long or "burn" marks will be produced in the texture.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.6.0 Sealants

SEALANTS



Installing Sealant

Whenever the insulation system or the EPS boards meet another material, i.e., door/window frame, roof, pipes or wires, meter boxes, exterior faucets, etc., a sealant joint must be provided.

THEORY

The sealant prevents water penetration behind the system. If water is allowed to enter behind the system, it can do damage to the substrate and framing.

To properly install sealant, you need to provide a joint between two materials. Sealants work like a rubber band or a shock absorber bonded between two surfaces, stretching back and forth as the two surfaces move.

There are two important factors to remember when installing sealants:

First, the sealant must bond to only two surfaces such as the coated EPS board edge and a window frame. It should never bond to a third surface like the substrate. If you bond the third surface, the "rubber band" will not be able to stretch back and forth, and the sealant will fail.

Second, minimum perimeter sealant joint width shall be 1/2" (13mm) or 4 times the anticipated movement, whichever is greater. Minimum expansion sealant joint width shall be 3/4" (19mm) or 4 times the anticipated movement, whichever is greater. Joint depth shall be in accordance with sealant manufacturer's requirements.

There is an easy way to solve both of the above problems: use a "backer rod" material that can be pushed in the joint. Backer rod must be closed-cell polyethylene type. This will provide a backing to hold the size of the joint correctly and provide a third surface that the caulk will NOT bond to.

Note: In some cases the two surfaces to be sealed are not deep enough to allow a backer rod to be installed. In such cases "bondbreaker" tapes are available that may be used in place of a backer rod.

Therefore, as you apply the EPS board, whenever you meet a dissimilar material as mentioned above, you should leave a space between the EPS and dissimilar material.

Edges of the insulation board, which will receive sealant, must be coated with base coat.

Some EIFS manufacturers require a primer over the base coat.

Whenever possible, the finish coat should not be returned into the sealant joint, and sealant should be applied against the base coat.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.7.0 Protecting the System

PROTECTING THE SYSTEM

- Protect surrounding areas and surfaces to prevent damage during application of the system.
- Protect the system when work ceases for the day or when an area is completed to prevent wash-off of installed materials and water infiltration into or behind the system.
- Provide protection of installed EIFS from dust, dirt, precipitation, freezing and continuous high humidity during installation.
- Tops of walls must immediately be covered with the final trim or temporarily protected to prevent water infiltration behind the system. Cap flashing must be installed as soon as possible after the finish coat has been installed.
- All sealants must be installed in a timely manner. Protect open joints from water intrusion during construction with backer rod or temporary covering until permanently sealed.

JOB-SITE CLEANUP

- All excess wall system materials shall be removed from the job site by the contractor in accordance with contract provisions.
- All surrounding areas, where the EIFS has been applied, shall be left free of debris and foreign substances.

CLASS PB EIFS PROBLEM PREVENTION

Following is a list of NEVERS which was prepared from historic field experience and testing.

General

1. Never deviate from published specification.
2. Never store or apply EIFS materials below 40°F (4°C).
3. Never mix additives such as rapid binders, antifreeze, accelerators, etc., To any materials under any circumstances.
4. Never use any material that has not been specified.
5. Never use products that have frozen.
6. Never apply adhesive directly on the substrate. Always apply adhesive to the back of the insulation boards.
7. Never use accessories with Class PB EIFS unless specified by the manufacturer.
8. Never apply EIFS on horizontal or inadequately sloped weather-exposed surfaces.

Insulation

9. Never allow adhesives or base coats to fill joints between EPS boards. Always fill joints with slivers of insulation.
10. Never allow any open joints in the insulated wall system. Always fill voids with slivers of insulation.
11. Never use EPS board larger than 2' x 4'. (610 x 1219mm) or less than 3/4" (19mm) thick.
12. Never use insulation board other than manufacturer-specified board.
13. Never store EPS board on edge or in sunlight.
14. Never apply any products over loose EPS boards.
15. Never leave any areas of the insulation system open to penetration of water or moisture.
16. Never rasp just the EPS board joints. Always rasp the entire wall surface, removing high spots from the surface.
17. Never allow EPS board joints to be in line with sheathing joints. Always bridge joints by a minimum of 8" (203mm).
18. Never have less than 3/4" (19mm) of EPS on the wall, especially at aesthetic grooves.

Mesh

19. Never leave any areas of EPS boards unprotected without mesh.
20. Never butt standard mesh. Always overlap it a minimum of 2 1/2" (64mm).

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

21. Never overlap high impact mesh. Butt the edges together.
22. Never allow mesh to protrude through base coat or finish.
23. Never apply materials over a damp or frozen surface.
24. Never place mesh on wall before area is covered with base coat. Always "embed" the mesh into the wet base coat.
25. Never use only a single wrap of mesh on inside and outside corners. Always double wrap these areas.

Finish

26. Never apply finishes thinner or heavier than recommended.
27. Never apply finishes in direct sunlight.
28. Never use steel trowels. Always use stainless steel or plastic.
29. Never put finish over sealants.
30. Never apply finish until base coat is dry.

DO YOU WANT TO MAKE MONEY ON THIS JOB?

What to Do Before You Start

1. Be sure applicators are familiar and confident with the materials they will work with.
   a. Attend and participate in a product seminar.
   b. Practice, learn and improve your skills.
2. Organize for efficiency.
   a. Who will do what?
   b. Confident, skilled, experienced leaders should train their crews.

What to Do Prior to Day One on the Job

1. Is the scaffolding set back far enough to provide good clearance and little interference?
2. Is the substrate prepared to the specified tolerance?
3. Is the EPS board acceptable?
4. Is precutting the EPS or mesh possible?
5. Are the areas for storage and working with the materials set up for efficient operation?

Continued

12.8.0 Tips on Applying EPS Boards

Tips on Applying the EPS Boards

1. Be sure layout provides for bridging sheathing joints.
2. Place the boards tightly together.
3. Fill any gaps between the board with EPS slivers.
4. Always allow extra board on outside corners for rasping.

Temporary Protection

1. Protect from water and other trades.
2. Tenting for freeze protection - use propane or natural gas heaters with proper ventilation.
3. Install backer rod in sealant joints.

Permanent Protection

1. Flashing, high-impact mesh and correct sealant.
2. Be sure the general contractor is aware of your needs in advance,

Final Notes

1. Keep work area clean, especially during the finish application.
2. If spraying finish, turn over or clean scaffolding boards first.
3. Know how the materials will react under adverse weather conditions and how to compensate.

   a. Warm, dry, sun, wind - fast drying.

   b. Cool, humid, no air circulation - longer drying time will be required.
4. Call for help if you think you need it.

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12.9.0 EIFS Glossary

EIFS GLOSSARY

Adhesive: A material used to attach the insulation board to the substrate.

Aesthetic Joints: A groove cut into EPS board for appearance purposes. It also may provide a place for the applicator to stop and start the application process.

Applicator: An independent contractor who installs EIF systems. They are instructed by specific EIFS manufacturers in the handling and use of their products but have no contractual relationship with the manufacturer.

ASTM: American Society for Testing and Materials. An independent organization that is involved with setting standards and practices for all materials, including those used in EIFS. ASTM standards are currently being developed specifically for EIFS construction.

Backer Rod: Closed-cell, flexible, polyethylene foam rod. It is sized for specific joint widths and is inserted into a joint cavity to a specific depth from the face of the joint. The rod limits the depth of the sealant joint and helps produce an hourglass sealant shape which helps to distribute stresses in the sealant.

Backwrapping: The practice of attaching a strip of reinforcing mesh to the wall substrate, adhesively attaching EPS insulation board to the substrate, then wrapping the mesh around to the face of the EPS board and embedding it in the base coat. When the base coat is applied in this manner and totally encapsulates the system, the system is resistant to water penetration.

Base Coat: A material applied to the face of the insulation board that functions as the weather barrier.

Class PB System: A class of EIFS where the base coat varies in thickness depending upon the number of layers, or thickness, of reinforcing mesh.

The reinforcing material is glass fiber mesh, which is embedded into the base coat per EIFS manufacturer's recommendations and with no mesh color visible. Protective finish coats, of various thickness, in a variety of textures and colors, are applied over the base coat.

Class PM System: A class of EIFS where the base coat is applied to a uniform thickness which can range from a nominal 1/4" (6mm) to 3/8" (9mm). The base coat thickness is not dependent upon the number of layers or thickness of reinforcing mesh. The reinforcing mesh is installed over the surface of the insulation board. The base coat is applied over the reinforcing mesh.

Cracks: Breaks in the surface lamina of an EIFS. They can be caused by internal stresses in the wall system greater than the strength of the lamina. Some common causes are unlapped mesh, gaps between insulation boards, adhesive between insulation boards, design errors (no expansion joint where one belongs) and concentrated stresses at unreinforced corners of openings and projections through the system.

Deflection: The amount of movement in a wall as a result of the loads applied to it. Most Class PB EIFS are designed to be applied to substrates that meet L/240 (height of unsupported wall span/240) maximum allowable deflection. Note: Meeting design criteria and calculation of deflection are the responsibility of the building designer.

EIFS: Exterior Insulation and Finish System.

EIMA: EIFS Industry Members Association.

EPS: Expanded Polystyrene. Type I rigid EPS insulation board is typically used in Class PB EIFS. Thicknesses range from 3/4" to 4" (19-100mm) and density is usually 1.0 lb/cu ft (16 kg/m2)

Expansion Joints: Gaps that extend through the entire depth of the EIFS and allow movement of the wall system without damage to the EIFS. They are usually coincidental with expansion joints in the substrate and are sealed with the proper sealant to prevent water intrusion into or behind the system.

Finish: A decorative and protective textured coating applied over the base coat.

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Flashings: Metal or plastic accessories used to deflect water away from EIFS terminations in the event of water infiltration. They are used at parapet tops, window and door heads, window sills and the like.

Gypsum Sheathing: In EIFS construction, the most common type of sheathing that has been used is exterior grade gypsum sheathing, conforming to ASTM C-79. Glass mat-faced gypsum sheathing conforming to ASTM C-1177 is the preferred type of gypsum sheathing.

Inspection: On-site examination of components and installation of an EIFS. Inspection may include review of plans and details; observation and critique of all phases of EIFS construction, quality control testing of components and the system itself; and a complete record of operations, which may be kept on a daily basis and reported as part of the project acceptance process by the owner of the project.

Installation: The application of an EIFS to a substrate.

Insulation: A preformed insulating material of a specific type and density that functions to reduce heat flow through the wall and provides the surface to receive the base coat.

Isolation Joint: A joint provided around penetrations through the EIF system such as window and door openings, scuppers, etc. It may or may not incorporate flashings and is sealed with the appropriate backer rod and sealant.

Lamina: The combination of the base coat, embedded mesh and finish. The lamina provides strength and resistance to damage and gives the system its appearance, durability and resistance to water penetration.

Mechanical Fasteners: A device sometimes used to attach the insulation board to the substrate.

Model Building Codes: Three major code groups exist in the United States. The western states are represented by ICBO (International Congress of Building Officials). In the midwest and northeast, the group is BOCA (Building Officials Code Administrators). SBCCI (Southern Building Code Congress International) is referred to in the southeast.

Permeability: The relative ability of a specific material to allow the flow of water vapor. EIFS generally have a low resistance to the flow of vapor, so they are considered to have low vapor permeability.

Primer: A Material that may be used to prepare surfaces prior to application of another system component.

Quality Control: The inspection and testing of components of a system, as well as the system itself, on a program basis,

Reinforcing Mesh: Balanced, open weave fabric, treated for compatibility with other materials of the system, which functions to strengthen the system.

Sealant: A specially designed sealant, used with backer rod, to fill joints and make them waterproof. The sealant used must be flexible enough to expand and contract with the wall system while maintaining its bond to both sides of the sealant joint. Low modulus sealants are generally preferred for use with EIFS because of their ability to elongate without imposing high stress at the EIFS/sealant interface.

Substrate: The surface to which an EIFS is attached.

Terminations: Any place an EIFS ends. Terminations can be window or door openings, the bottom or top of a wall or both sides of an expansion joint. In any case, all terminations must be totally encapsulated with base coat and mesh and a sealant or flashing with appropriate backer rod installed to prevent water infiltration.

Texture: The appearance of the finish. It is affected by the aggregate sizes used in the finish as well as the troweling technique used.

Continued

12.10.0 Checklists

CHECKLIST PRIOR TO EIFS INSTALLATION

Job conditions

- Ambient temperatures above 40°F (4°C) (or as recommended by manufacturer) and maintained through minimum 24 hours following completion of installation.
- Protect surrounding areas and surfaces. Protect finished work from water penetration and run-off.
- Cap flashing and sealants to be installed immediately after the completion of the installation of EIFS.
- Use only manufacturer-recommended sealants.

Weather conditions affect application and drying time. Hot or dry conditions limit working time and accelerate drying and may require adjustments in the scheduling of work to achieve desired results; cool or damp conditions extend working time and retard drying and may require added measures of protection against wind, dust, dirt, rain and freezing.

Substrate Conditions

- Free from defects, paints, coatings, sealers or other foreign materials.
- Free of hot spots and releasing agents.
- No planar irregularities greater than 1/4" (6mm in 2.4m) radius.
- Approved substrate and conditions.

Materials Typically Needed for Completing Installation

Portland Cement
Adhesive and/or Base Coat
Insulation Board
Reinforcing Meshes
Finish Coat
Clean Potable Water
Trowels
Rasping Board
Utility Knife
Router or Hot Gun
Primer

Delivery, Storage, and Handling of EIFs Materials

- Deliver all EIFS Materials in their original sealed containers bearing manufacturer's name and identification of product.
- Protect all products from freezing and temperatures in excess of 90°F (32°C); store away from direct sunlight.
- Protect bag products from moisture and humidity. Store under cover off the ground in a dry location.

Examination of Surfaces

A. Inspect surfaces for:

- Contamination - algae, chalkiness, dirt, dust, efflorescence, form oil, fungus, grease, mildew or other foreign substances.
- Surface absorption and chalkiness.
- Cracks - measure crack width and record location of cracks.
- Damage and deterioration.
- Moisture content and moisture damage-use a moisture meter to determine if the surface is dry enough to receive the EIFS and record any areas of moisture damage.
- Compliance with specification tolerances—record areas that are out of tolerance (greater than 1/4" in 8'-O" [6mm in 2.4m]) deviation in plane.

B. Inspect sheathing application for compliance with applicable requirement.

- Exterior gypsum sheathing - see Gypsum Association Publication GA-253.
- Exterior Grade and Exposure I wood-based sheathing - see American Plywood Association Publication APA J20G.
- Glass mat-faced gypsum sheathing - refer to manufacturer's literature.
- Cementitious sheathing - consult manufacturer's published recommendations,

C. Report deviations from the requirements of project specifications or other conditions that might adversely affect the EIFS installation to the general contractor.

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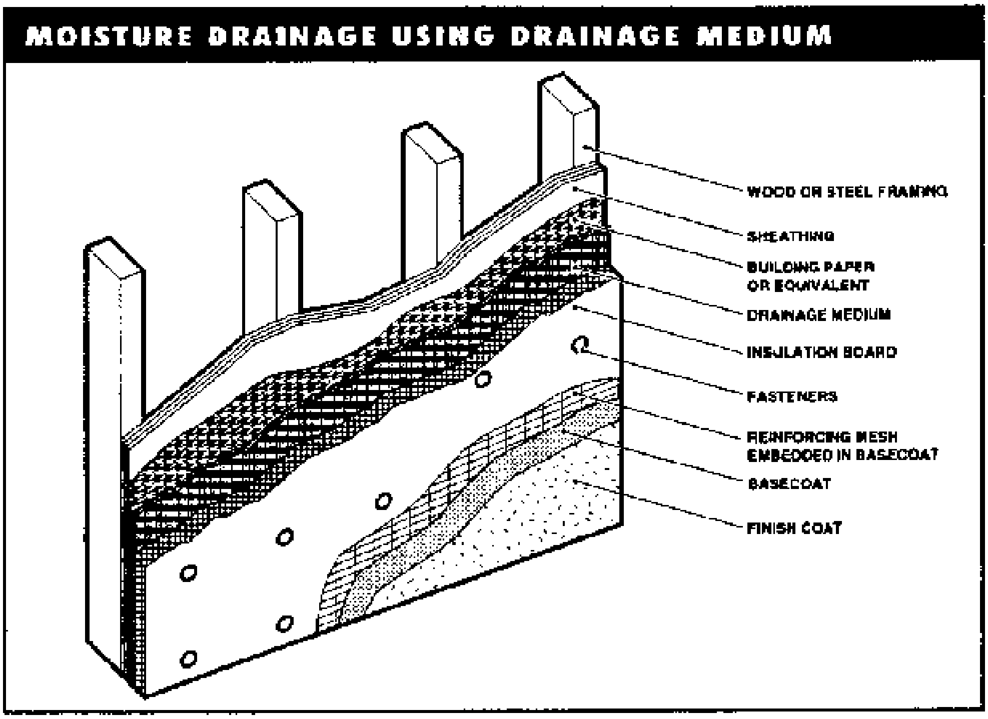
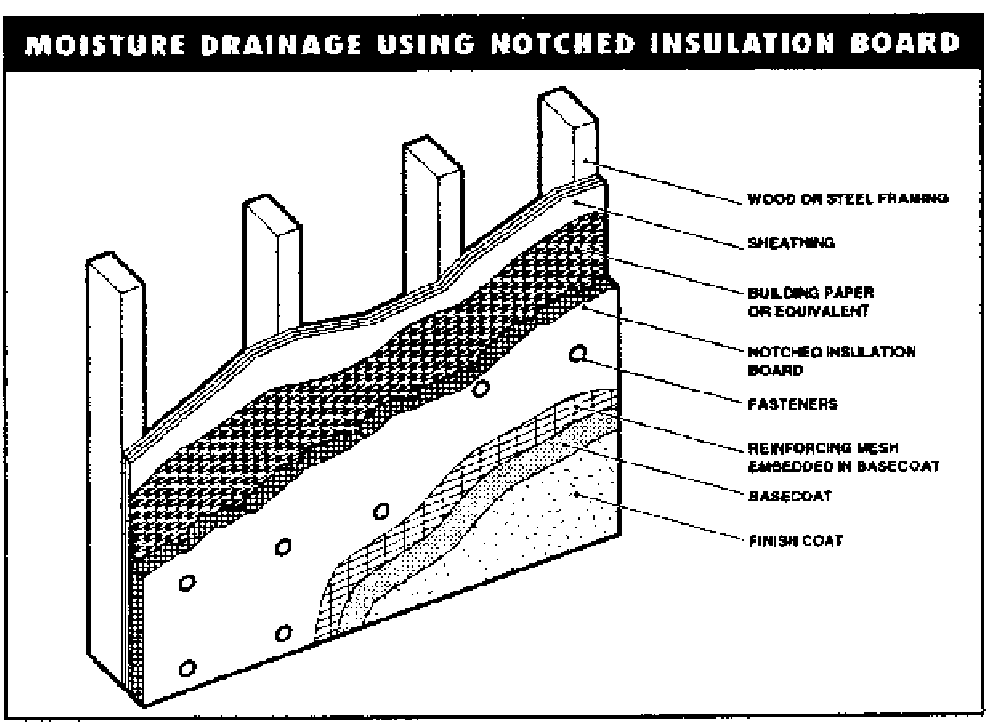
12.11.0 Diagram of Moisture Drainage Systems

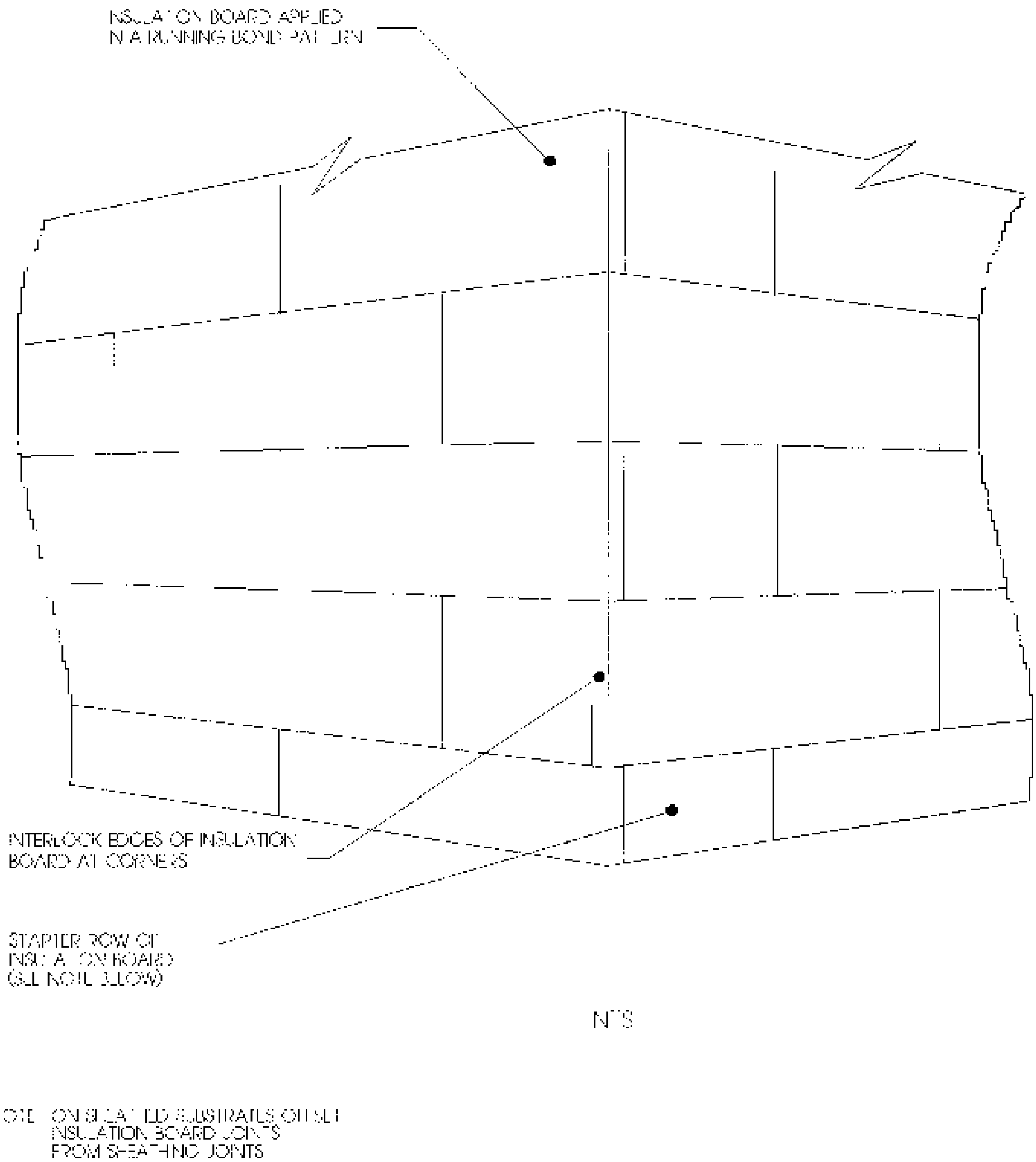


A mesh or other medium placed directly over the building paper creates an opening between the sheathing and backside of the insulation board through which water can escape to the outside.



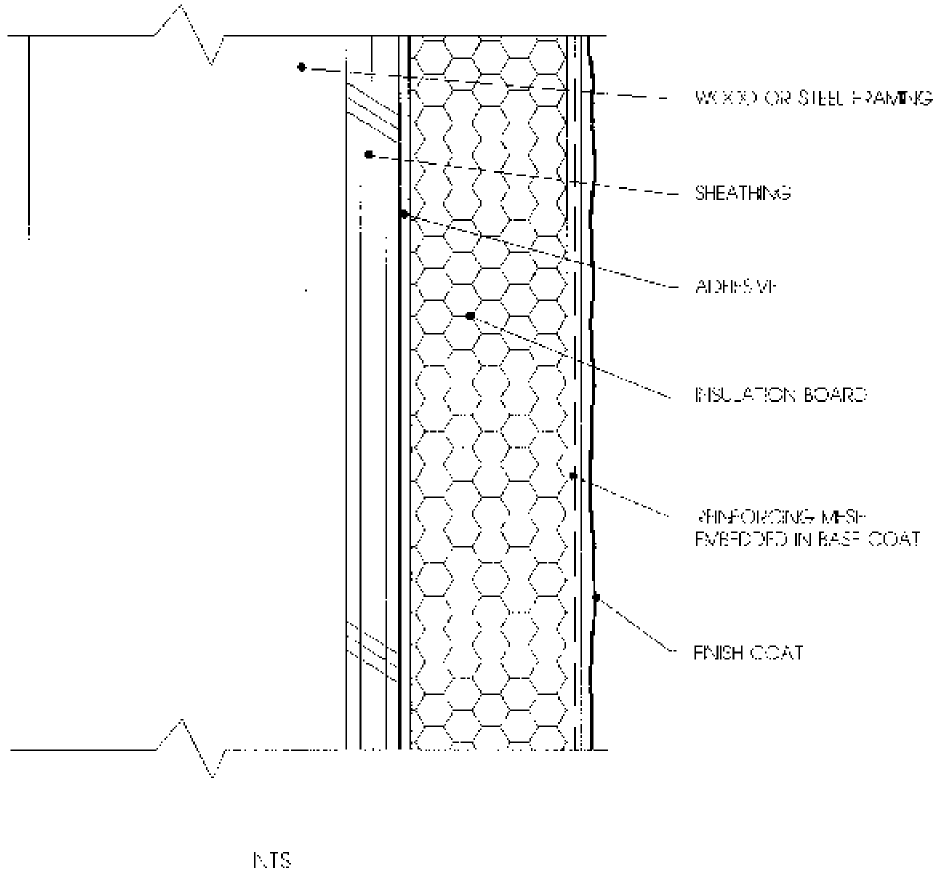
(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.12.0 Typical Board Layout



(By permission from EIFS Industry Members Association, Morrow, Georgia.)

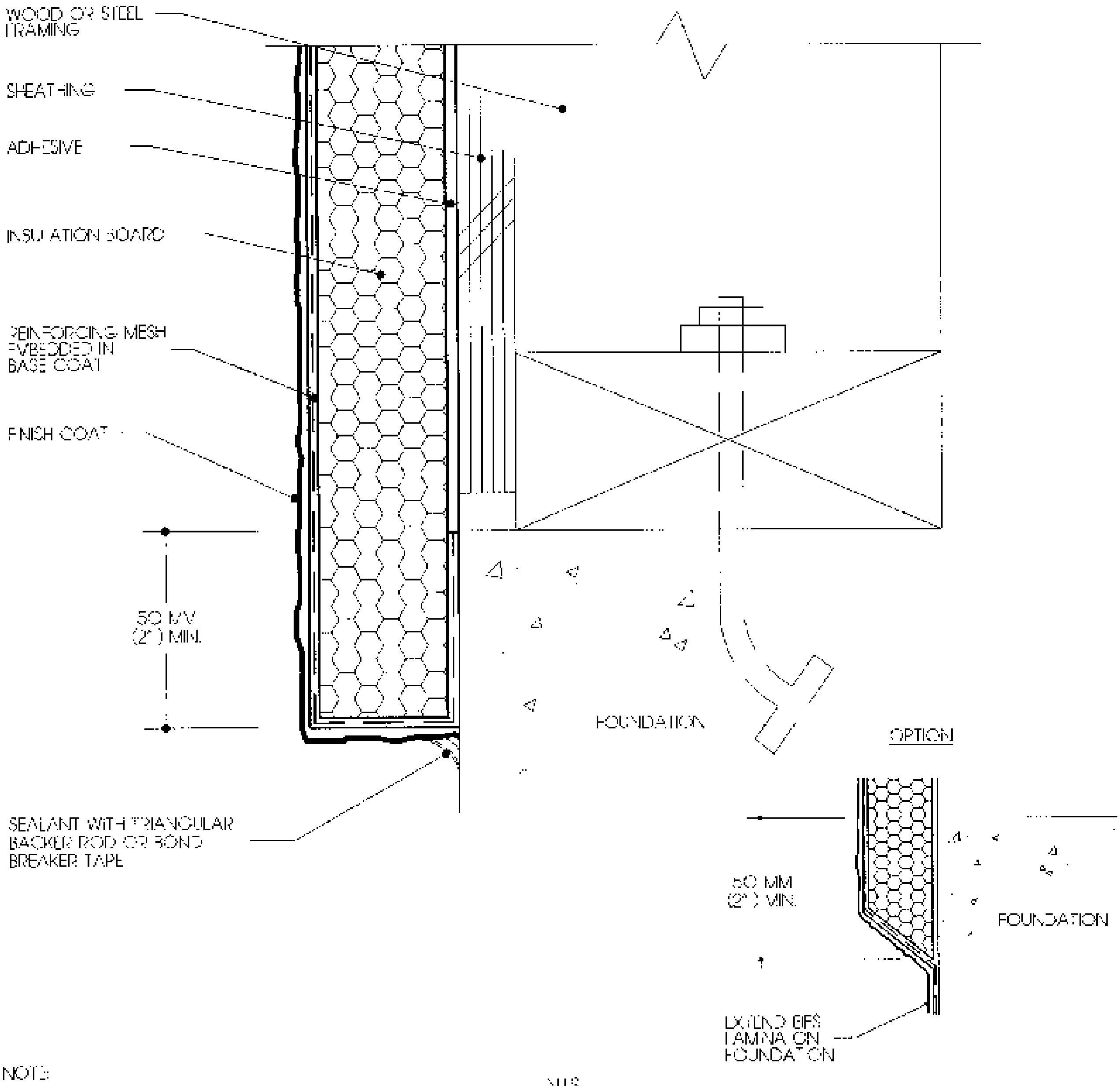
12.13.0 Typical System Cross Section



NOTE:
APPLICATION OF EIFS TO MASONRY
SUBSTRATES IS SIMILAR

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.14.0 Typical Termination at Foundation

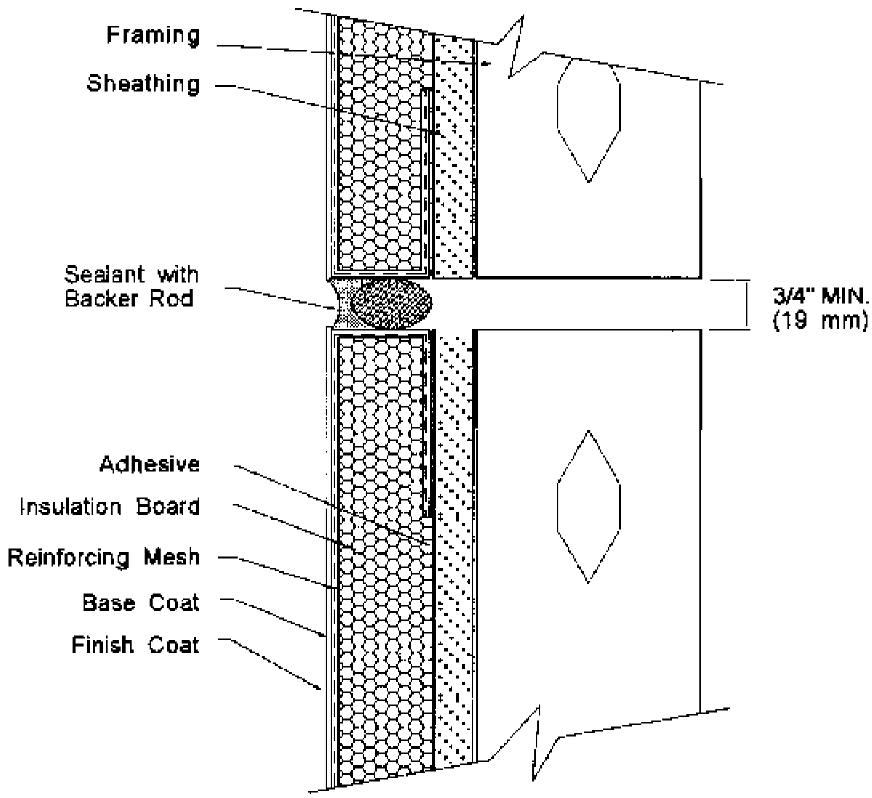


NOTE:

1. EIFS MUST TERMINATE A MINIMUM OF 200 MM (8") ABOVE FINISHED GRADE
2. APPLICATION OF EIFS TO MASONRY SUBSTRATES IS SIMILAR.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.15.0 Typical Expansion Joint Detail



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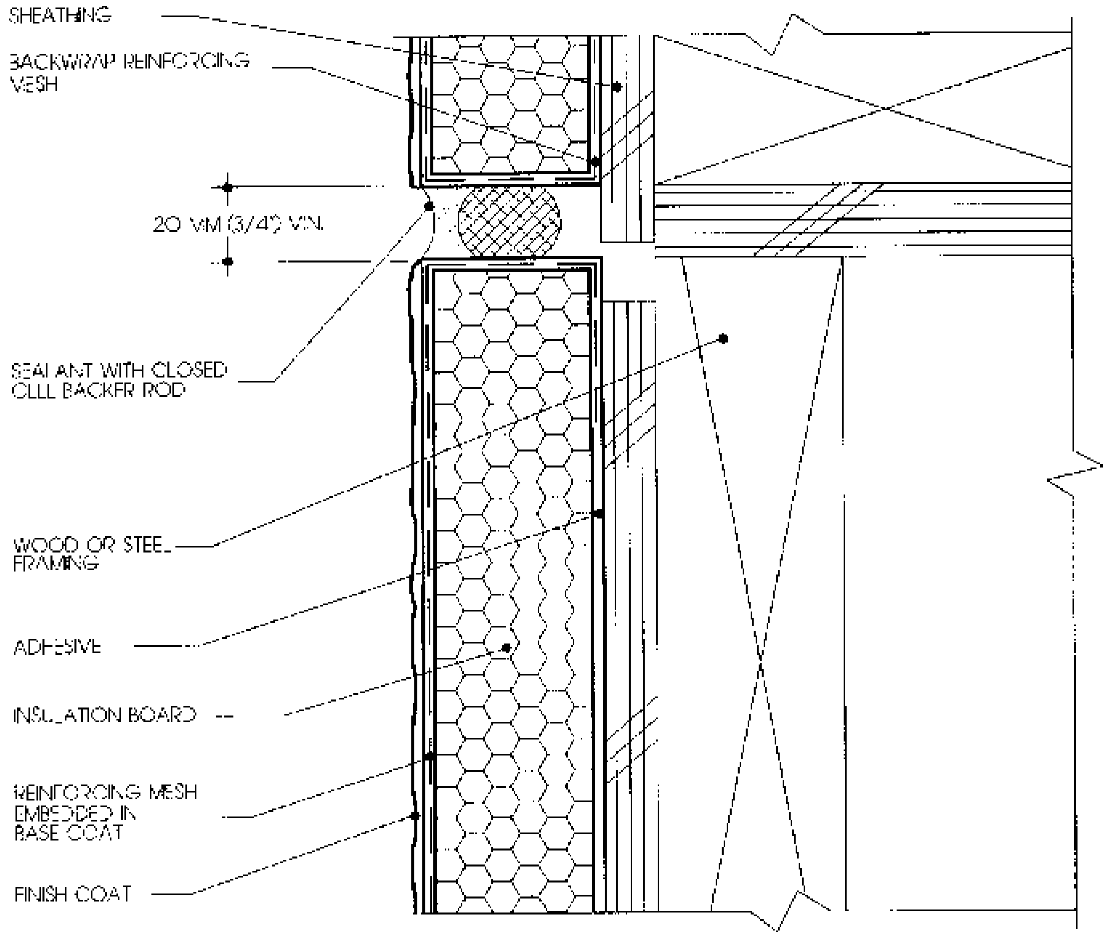
12.15.1 Typical Expansion Joint Detail at Floorline



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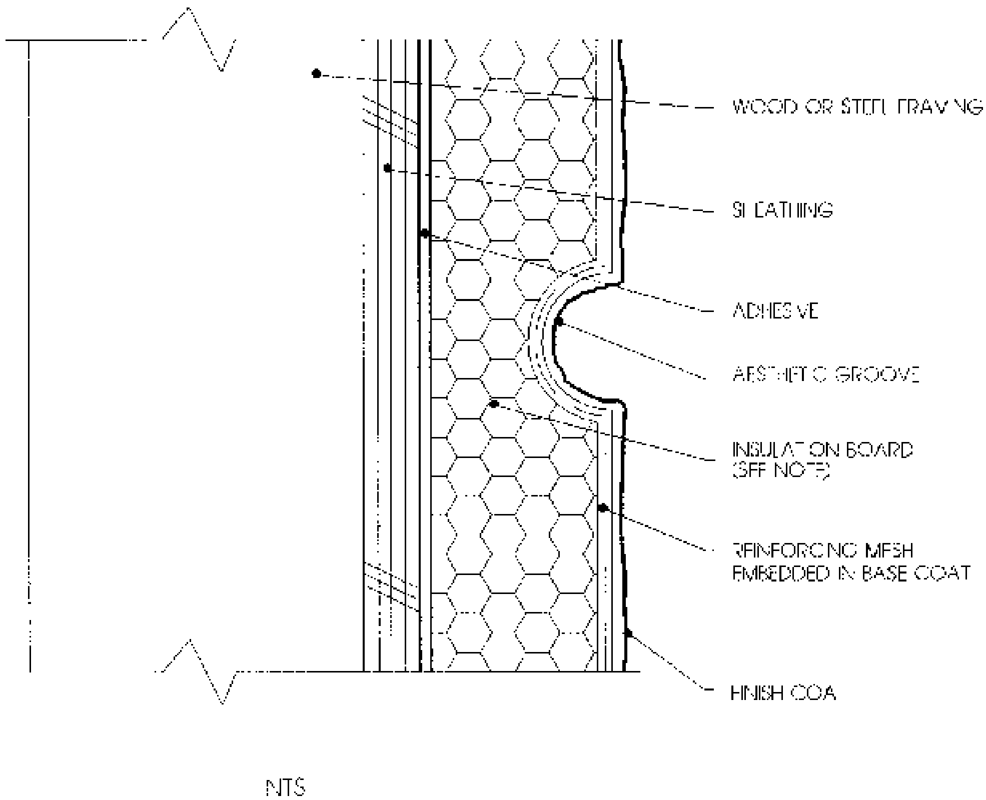
12.16.0 Typical Aesthetic Groove

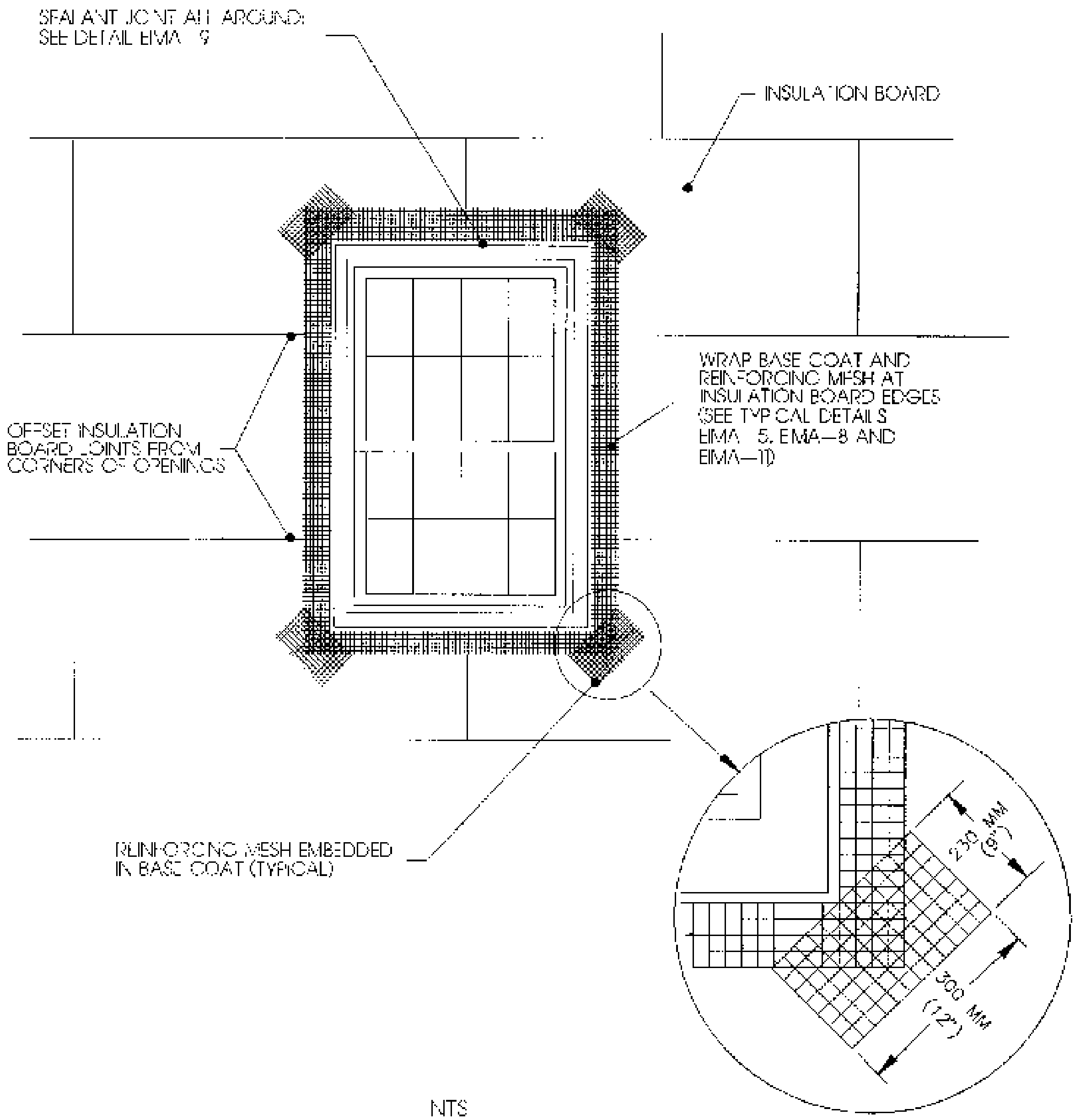


NOTE:

1. APPLICATION OF EIFS TO MASONRY SUBSTRATES IS SIMILAR.
2. OFFSET INSULATION BOARD JOINTS FROM AESTHETIC GROOVE

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

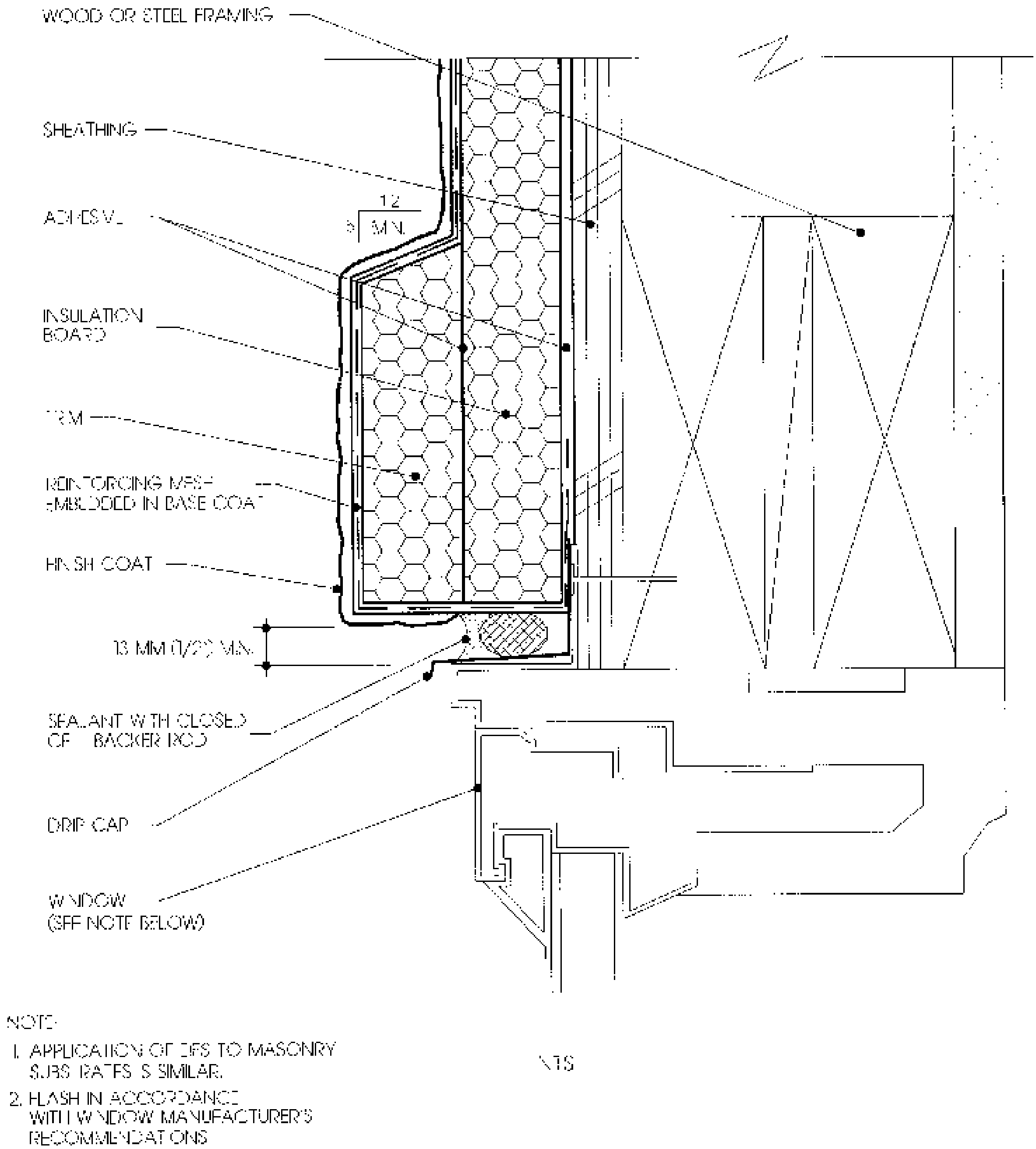
12.17.0 Typical Window Opening Reinforcement



NOTE: TYPICAL AT WINDOWS,
DOORS, ETC.

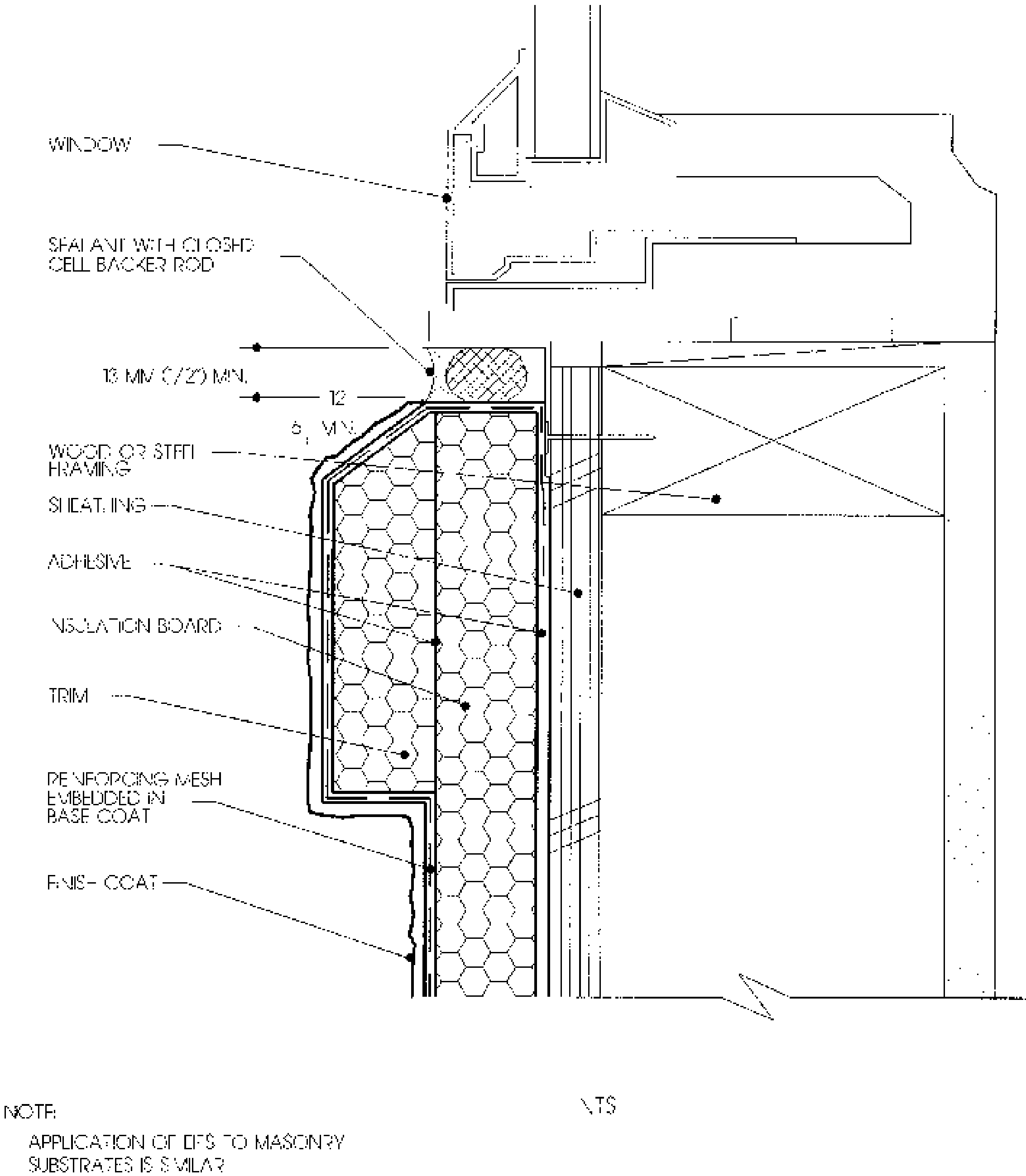
(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.17.1 Typical EIFS Termination at Window Head (With Trim)



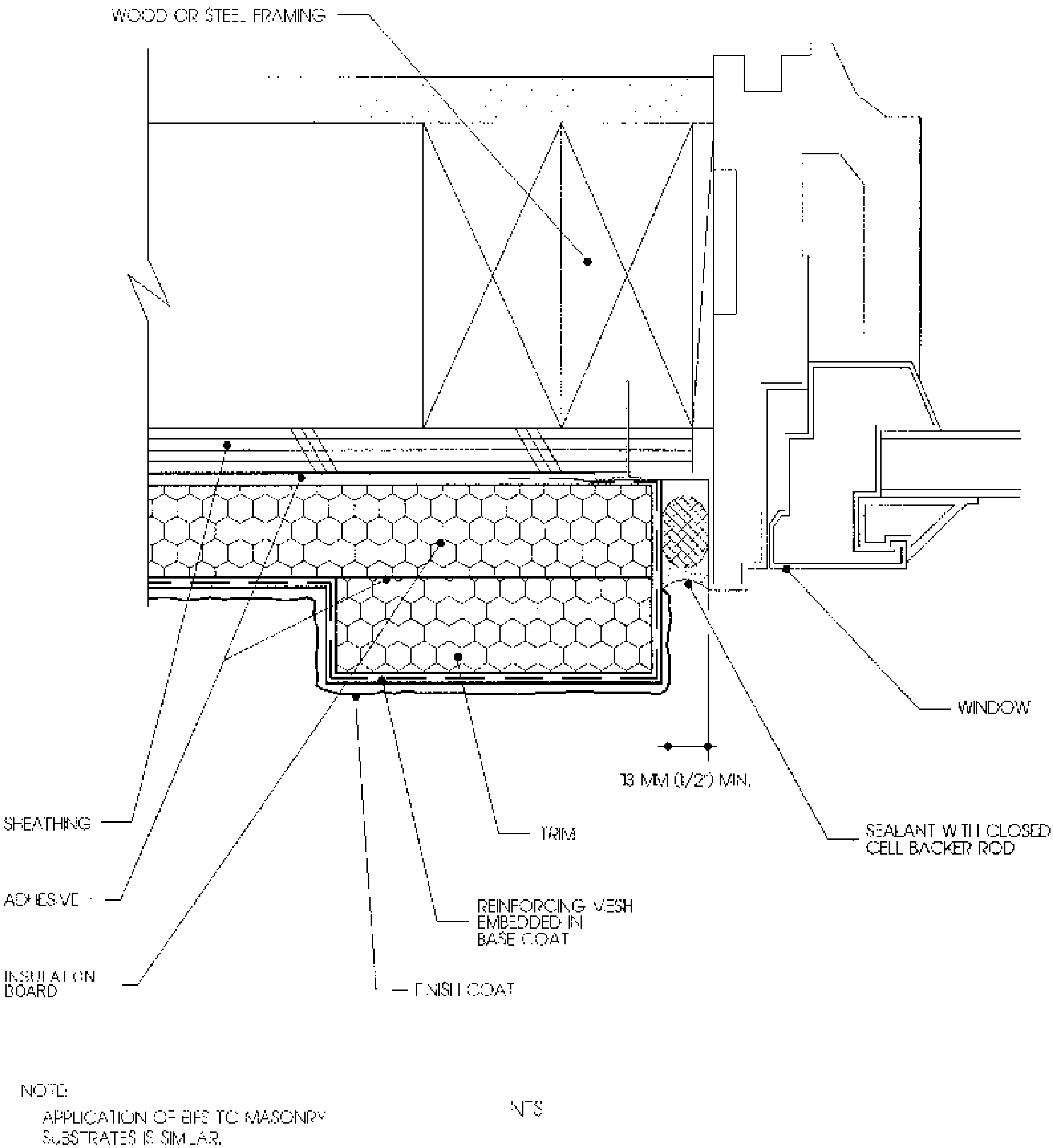
(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.17.2 Typical EIFS Termination at Window Sill (With Trim)



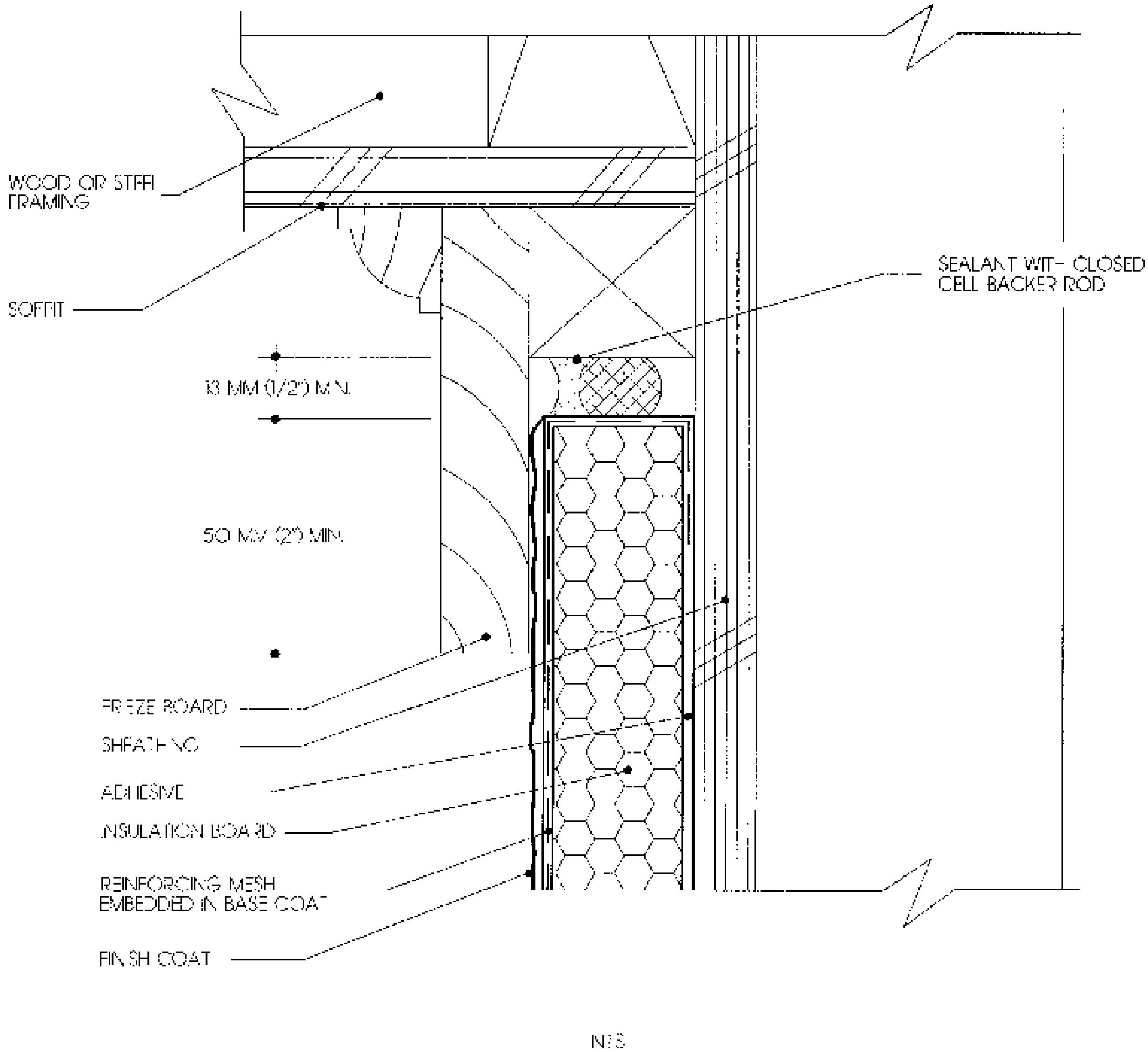
(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.17.3 Typical EIFS Termination at Window Jamb (With Trim)



(By permission from EIFS Industry Members Association, Morrow, Georgia.)

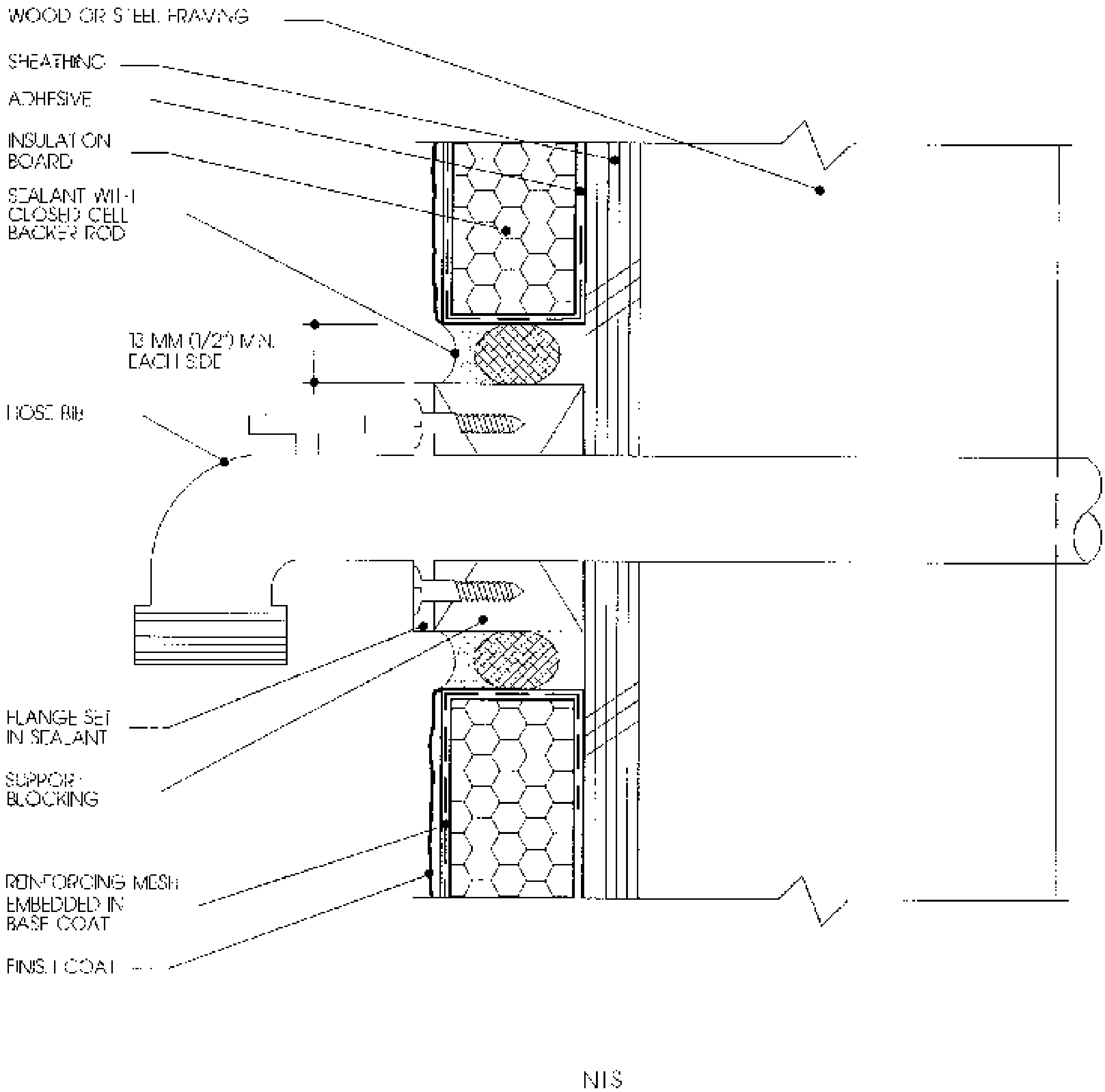
12.18.0 Termination at Soffit/Gable End



NOTE:
APPLICATION OF EIFS TO MASONRY
SUBSTRATES IS SIMILAR.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

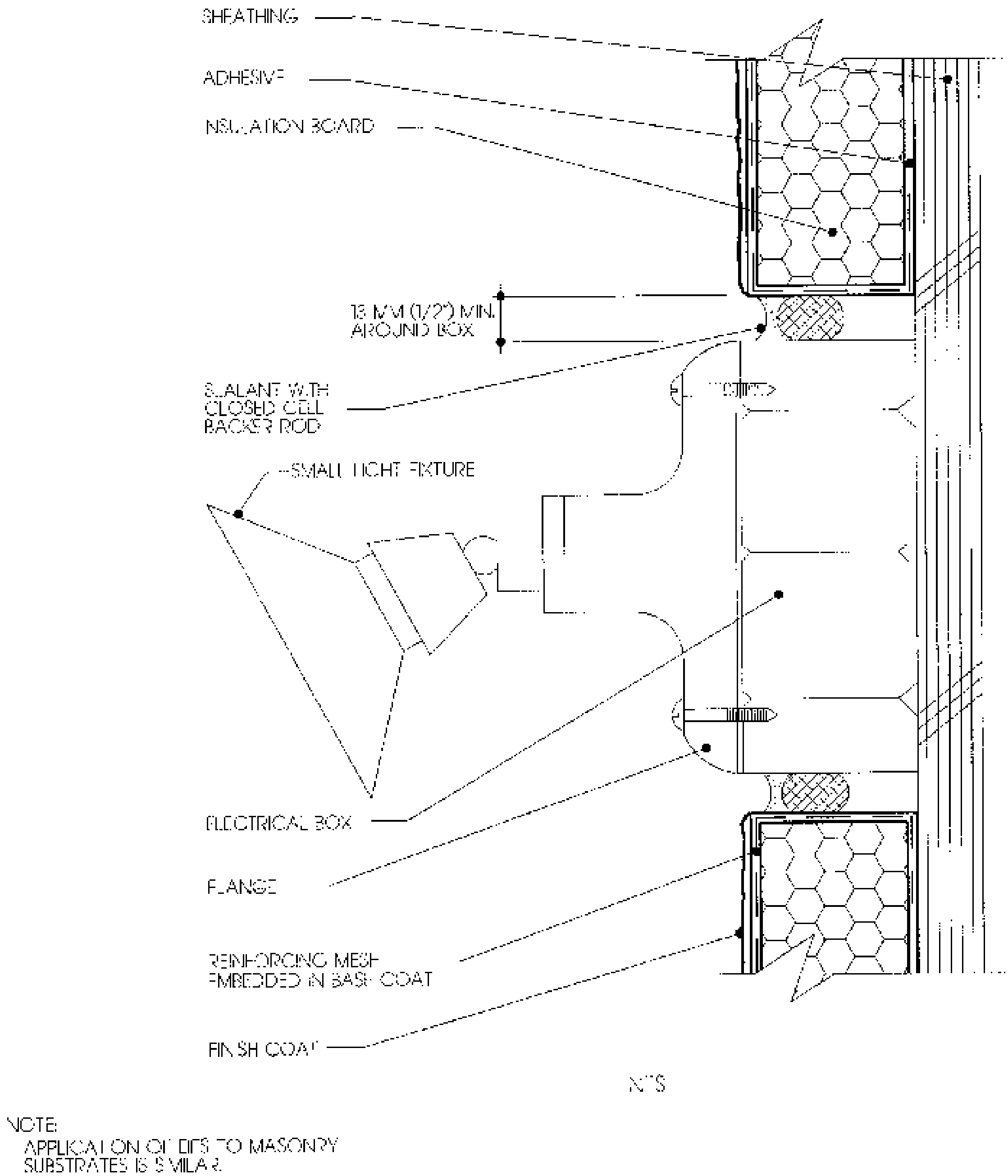
12.19.0 Typical Nose Bib Penetration



NOTE:
APPLICATION OF EIFS TO MASONRY SUBSTRATES IS SIMILAR.

(By permission from EIFS Industry Members Association, Morrow, Georgia.)

12.20.0 Typical Outdoor Light Fixture Installation



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12.21.0 Introduction to Vinyl Siding Installations Made Easy

There are various substitutes for conventional wood siding on the market: solid polyvinyl chloride (PVC) siding, PVC-coated steel siding, and rigid polypropylene siding. All share one common property—less maintenance and upkeep than their wood replacements.

Vinyl siding has been tested by ASTM and compliance with ASTM D3679 ensures quality in the following areas:

Length and width check three places along a piece of siding to ensure that is meets the advertised length and width.

Thickness siding is measured in thousandths of an inch along five or more places on the siding to ensure compliance with manufacturer's specifications.

Color reflected light off a piece of siding "reads" the color for uniformity.

Gloss measure reflectivity of several pieces of the same brand.

Camber measures the straightness of the siding which cannot vary by more than ⅛ inch.

Heat shrinkage when placed in a hot air oven or water bath of 160°F, siding will not shrink more than 3 percent.

Linear expansion freeze and then heat a small piece of siding (−22°F to +54°F) to measure expansion and contraction.

Surface distortion (oil canning) heat a piece of siding to 120°F and inspect.

Impact resistance drop an eight-pound weight on a piece of siding with a force equal to 60 foot pounds and siding should not crack or tear at point of impact.

Windload resistance subject siding to 80-mph winds to ensure that it stays on the wall.

Weathering performance test pieces for two years to ensure that it will not chip, crack, peel, or flake.

The proper installation of vinyl siding begins with a few basic installation rules set forth on the following pages. Vinyl siding terminology will be familiar to anyone in the trade. Fastener selection and fastener options range from corrosion resistant nails to screws or staples, but the method of installing these fasteners is peculiar to the product.

As the Fastening Procedure illustrated sheet (Figure 12.25.0) reveals, vinyl siding can expand or contract ½ inch (1.25 cm) or more over a standard 12'6" (3.8 meters) length, therefore fasteners cannot be "driven home" to hold the siding tight to the substrate. A space about the thickness of a die is to be left between the back of the fastener and the face of the siding nailing slot.

12.22.0 Basic Installation Rules

Before getting started, it is important to review several rules of thumb for vinyl siding application. The following rules, which come up throughout this guide, are critical for proper vinyl siding installation:

1. Installed panels must move freely from side to side.
2. When installing a siding panel, push up from the bottom until the lock is fully engaged with the piece below it. Without stretching the panel, reach up and nail it into place.
3. Fasten nails or other fasteners in the center of the nailing slot.
4. Do not force the panels up or down when fastening in position. Allow them to hang without strain.
5. Do not drive the head of the nail tightly against the siding nail hem. Allow 1/32" (about the thickness of a dime) clearance between the fastener head and the siding panel. Drive nails straight and level to prevent distortion and buckling of the panel.
6. Leave a minimum of 1/4" clearance at all openings and stops to allow for normal expansion and contraction. When installing in temperatures below 40°F, increase minimum clearance to 3/8".
7. Do not caulk the panels where they meet the receiver of inside corners, outside corners, or J-trim. Do not caulk the overlap joints.
8. Do not face-nail or staple through siding. Vinyl siding expands and contracts with outside temperature changes. Face-nailing can result in ripples in the siding.
9. In residing, strapping or removal of uneven original siding may be necessary.
10. In new construction, avoid the use of green lumber as the underlayment. Keep in mind that siding can only be as straight and stable as what lies under it.

(By permission from Vinyl Siding Institute, Washington, D.C. Website: www.vinylsiding.org.)

12.23.0 Terms To Know

Backerboard—a flat material used on the face of the house, between the studs and the siding, to provide a nailable surface for the siding.

Buttlock—the bottom edge of a siding or soffit panel, or accessory piece, opposite the nailing slots, which locks onto to the preceding panel.

Channel—the area of the accessory trim or corner post where siding or soffit panels are inserted. Channels also refer to the trim itself, and are named for the letters of the alphabet they resemble (e.g., J-channel, F-channel, etc.).

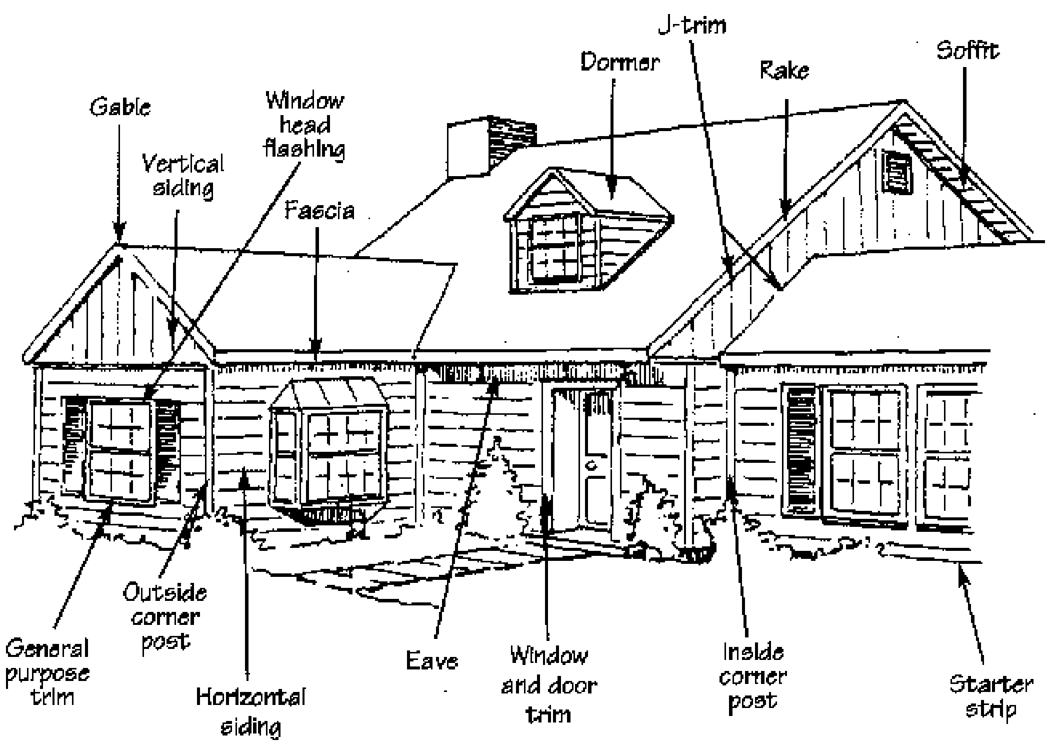
Course—a row of panels, one panel wide, running the length of the house from one side to the other, or, in the case of vertical siding, from top to bottom.

Drip Cap/Head Flashing—an accessory installed with vertical siding to ensure that water drips away from panels and does not infiltrate them; it is also used as a vertical base.

Double Channel Lineal—a siding accessory that joins two soffit panels.

Face—refers to the side of a siding or soffit panel that is showing once the panel has been installed.

Face-nailing—the action of fastening directly onto the "face" side of a panel (instead of using the nail hem slot). This practice is generally not used in siding installation.



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Fascia Board—a board attached to the ends of the rafters between the roofing material and the soffit overhang. Fascia cap is the covering around that board.

Flashing—a thin, flat material, usually aluminum, positioned under or behind J-channels, corner posts, windows, etc., to keep draining water from penetrating the home.

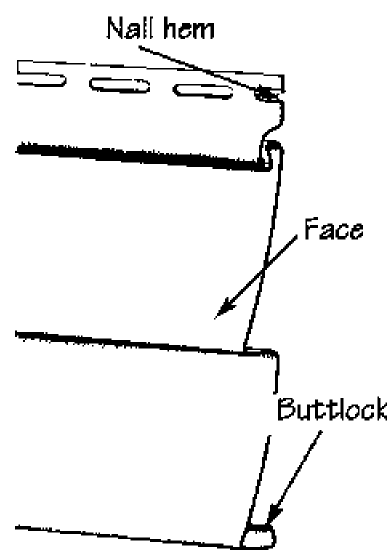
Furring/Furring Strip—a wooden or steel framing material, usually 1" x 3", used to provide an even nailing base. To "fur" a surface means to apply these strips.

Lap—to overlap the ends of two siding panels or accessory pieces to allow for expansion and contraction of the vinyl product.

Lug/Crimp—the raised "ears" or tabs on a siding panel, created by a snaplock punch, which can be used to lock a siding panel into place when the nailing hem has been removed.

Miter—to make a diagonal cut, beveled to a specific angle (usually 45°). Sometimes miter cuts are made into an overlapping siding or soffit panel surface, to provide a neater appearance.

Nailing Hem (or Flange)—the section of siding or accessories where the nailing slots are located.



Plumb—a position or measurement that is truly and exactly vertical, 90° from a level surface.

Scoring—running a utility knife blade, a sharpened awl, scoring tool, or other sharp implement across a soffit or siding panel face without cutting all the way through the panel. This weakens the vinyl surface in a specific area and allows the panel to be bent and broken off cleanly.

Soffit—material used to enclose the horizontal underside of an eave, cornice, or overhang.

Strapping—a flexible framing material used to even a surface prior to installation.

Starter Strip—an accessory applied directly to the surface of the building and used to secure the first course of siding to the home.

Underlayment—weather-resistant material placed under vinyl siding panels.

Weep Holes—openings cut into siding or accessories to allow for water runoff.

Continued

12.24.0 Fastener Choices

Use aluminum, galvanized steel, or other corrosion-resistant nails, staples, or screws when installing vinyl siding. Aluminum trim pieces require aluminum or stainless steel fasteners.

Nails

Nail heads should be 5/16" minimum in diameter. Shank should be 1/8" in diameter (Fig. 13). Minimum nail lengths are as follows:

- 1 1/2" for general use
- 2" for residing
- 2 1/2" minimum for going through siding with backerboard
- 1" to 1 1/2" for trim

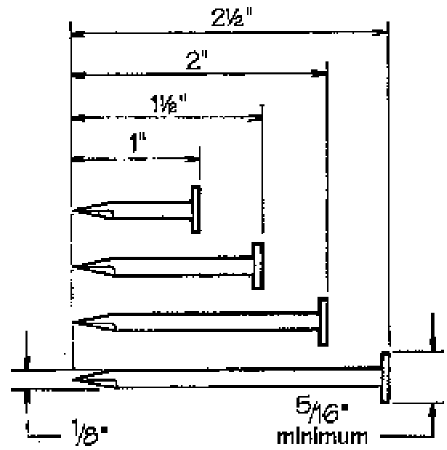


Figure 13.

Screw Fasteners

Screw fasteners can be used if the screws do not restrict the normal expansion and contraction movement of the vinyl siding panel on the wall. Screws must be centered in the slot with a minimum 1/32" space between the screw head and the vinyl. Screws should be:

- Size #8, truss head or pan head.
- Corrosion-resistant, self-tapping sheet metal type.

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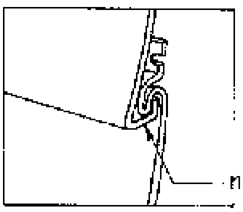
12.25.0 Fastening Procedures

Vinyl siding can expand and contract 1/2" or more over a 12' 6" length with changes in temperature. Whether using a nail, screw, or staple to fasten the siding, the following basic rules must be followed:



- Make sure the panels are fully locked along the length of the bottom, but do not force them up tight when fastening.
- Do not drive the head of the fastener tightly against the siding nail hem. Leave a minimum of 1/32" (the thickness of a dime) between the fastener head and the vinyl. **Tight nailing, screwing, or stapling will cause the vinyl siding to buckle with changes in temperature (Fig. 14).**
- When fastening, start in the center of the panel and work toward the ends.
- Center the fasteners in the center of the slots to permit expansion and contraction of the siding (Fig. 15).
- Drive fasteners straight and level to prevent distortion and buckling of the panel (Fig. 16).
- Space the fasteners a maximum of 16" apart for the horizontal siding panels, every 12' for the vertical siding panels, and every 8" to 10" for the accessories. Start fastening vertical siding and corner posts in the top of the uppermost slots to hold them in position. Place all other fasteners in the center of the slots (Fig. 17).

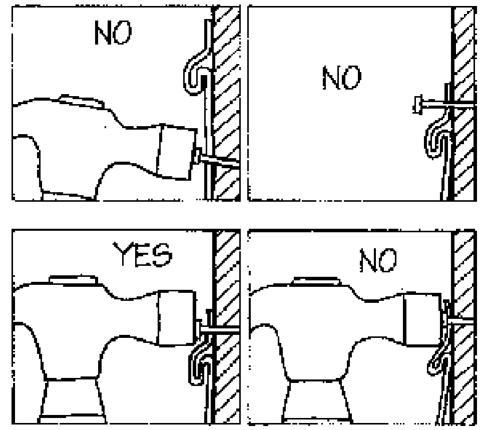


Figure 14.

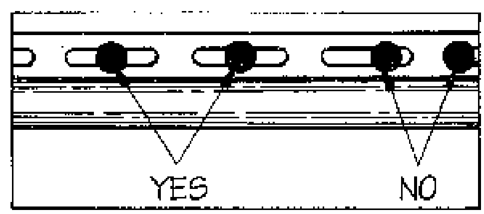


Figure 15.

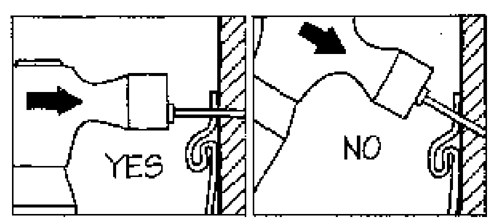


Figure 16.

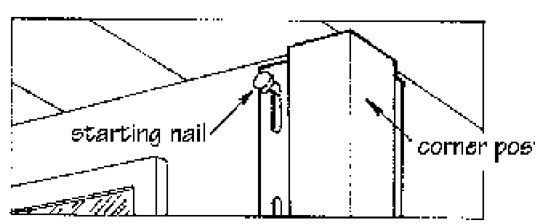
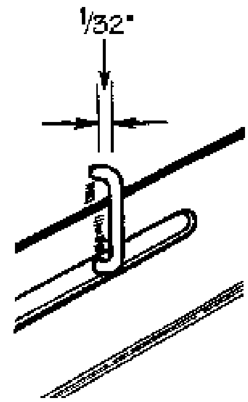


Figure 17.

(By permission from Vinyl Siding Institute, Washington, D.C. Website: www.vinylsiding.org.)

Staples

If staples are being used instead of nails or screws, they must be (Fig. 18):



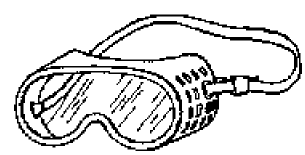
- Not less than 16-gauge semiflattened to an elliptical cross section.
- A minimum of 1" long.
- Wide enough in the crown to allow free movement of the siding (1/32" away from the nailing hem).

Continued

12.26.0 Cutting the Siding

When cutting vinyl siding, follow these guidelines:

- Safety goggles are always recommended for all cutting and nailing operations. As on any construction job, use proper safety equipment and follow safe construction practices.



- With a circular saw, install the fine-toothed (plywood) blade backwards on the saw for a smoother, cleaner cut, especially in cold weather. (Fig. 19.) Cut slowly. Do not attempt to cut materials other than vinyl with a reversed direction saw blade.

  Caution! Use of a backwards blade on any other materials could be unsafe.

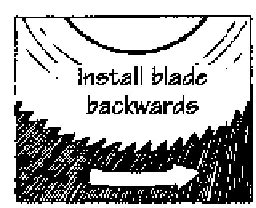


Figure 19.

- With tin snips, avoid closing the blades completely at the end of a stroke for a neater, cleaner cut (Fig. 20).
- With a utility knife or scoring tool, score the vinyl face up with medium pressure and snap it in half. It is not necessary to cut all the way through the vinyl (Fig. 21).

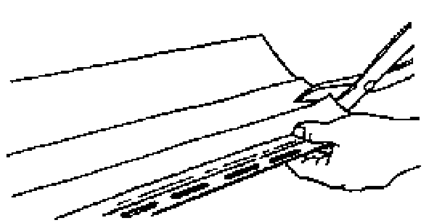


Figure 20.

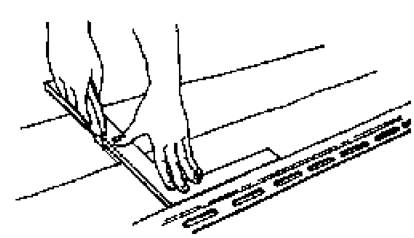


Figure 21.

(By permission from Vinyl Siding Institute, Washington, D.C. Website: www.vinylsiding.org.)

12.27.0 Installing Accessories

Before the siding itself can be hung, a number of accessories must be installed first, including starter strips, corner posts, window flashing, trim, and J-channels over the roof lines.

Starter Strip

In order for the siding to be installed properly in a level fashion, the starter strip at the bottom of the wall must be level.

- Determine the lowest point of the wall that will be sided; from that point, measure up 1/4" less than the width of the starter strip and partially drive a nail at one corner.
- Attach a chalkline; go to the next corner and pull the line taut.
- Make sure the line is level by using a line level or a 4' level.
- Snap the chalkline and repeat the procedure around the entire house.
- Using the chalkline as a guide, install the top edge of the starter strip along the bottom of the chalkline, nailing at 10" intervals. Allow space for the corner posts, J-channels, etc.
- Keep the ends of starter strips at least 1/4" apart to allow for expansion (Fig. 24).
- Nail in the center of the starter strip nailing slots.

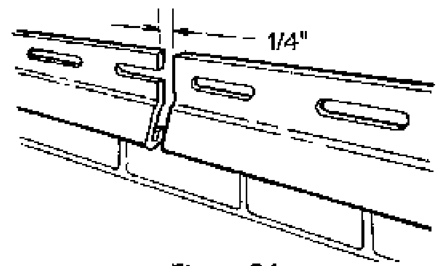


Figure 24.

NOTE: When insulation or backerboard is used, fur the starter strip, if necessary, to accommodate thickness. For a vertical siding starter strip, see the section on vertical siding.

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12.28.0 Outside and Inside Corner Posts

- A water resistant material should be used to flash the inside and outside corners a minimum of 10" on each side before installation of the corner posts (Fig. 25).

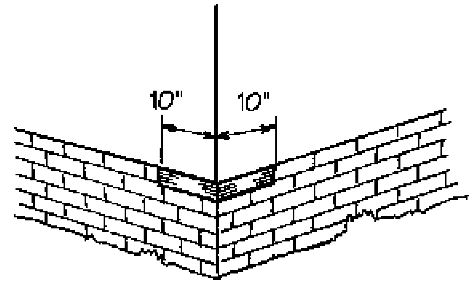

Figure 25.

> NOTE: Install vinyl soffit and fascia before installing outside and inside corner posts.

- Place the corner post in position, allowing a 1/4" gap between the top of the post and the eave or soffit. Position a nail at the top of the upper slot on both sides of the corner post, leaving a 1/32"gap between the nail heads and the corner posts. The corner post hangs from these nails. The balance of the nailing should be in the center of the slot, 8" to 12" apart, again leaving 1/32" between the nail head and the corner post. This allows for the expansion and contraction to occur at the bottom. The corner post should extend 3/4" below the starter strip. Make sure the posts are plumb (i.e., vertically straight) (Fig. 26 and 27).

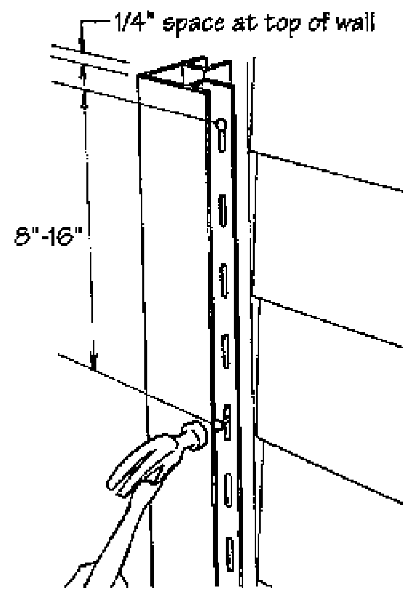

Figure 26.

- If more than one length of corner post is required, overlap the upper piece over the lower piece by cutting away 1" of the nailing flange on the top piece. Overlap 3/4", allowing 1/4" for expansion. This method will produce a visible joint between the two posts, but will allow water to flow over the joint, reducing the chance of water infiltration.

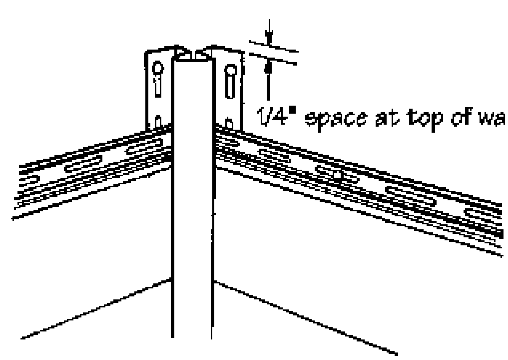

Figure 27.

(By permission from Vinyl Siding Institute, Washington, D.C. Website: www.vinylsiding.org.)

12.29.0 Windows, Doors, and Roof Lines

Window Flashing

The following instructions should be followed when applying window flashing:

- Apply the flashing on the underside of the window first (Fig. 28).
- Follow this application with flashing on the sides of the window. Make sure to overlap the bottom flashing (Fig. 29).
- Finally, apply the flashing at the top of the window.

The flashing should extend past the nail flanges of any accessory to prevent water infiltration through the opening. The flashing should be long enough to direct water over the nail flange of the last course of siding (Fig. 30). Use this example as a model for applying flashing to other openings such as electrical outlets and doors.

Trim

J-channel is used around windows and doors to receive the siding. Follow the steps below when applying trim.

- Cut and bend the tab of the top piece of J-channel down to provide flashing over the side J-channel.
- Fold the bottom end of the side piece of J-channel inward at the bottom of the window, to fit over the existing J-channel to prevent water from entering under the sill.

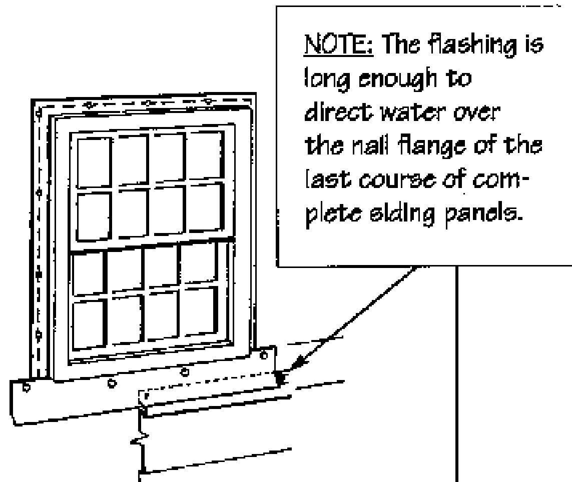

Figure 28.

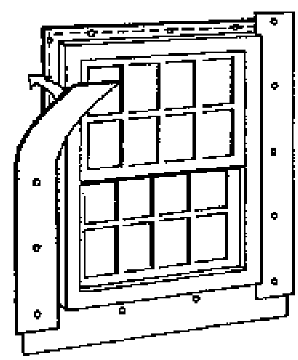

Figure 29.

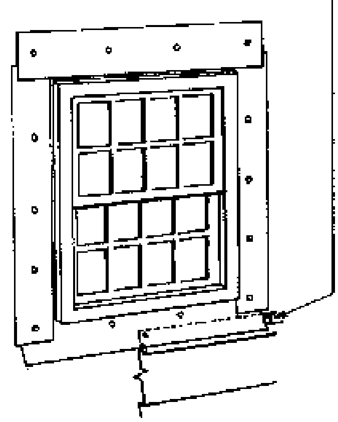

Figure 30.

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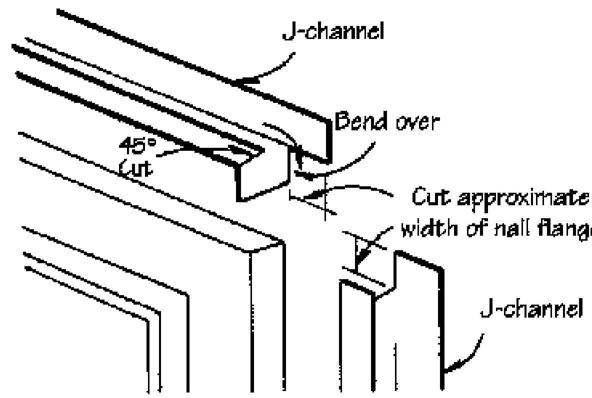

Figure 31.

- Cut the side J-channel members longer than the height of the window or door, and notch the channel at the top.

- Miter cut the free flange at a 45° angle and bend the tab down to provide flashing over the side members (Fig. 31). A similar miter and tab may be provided at the bottom of the window, depending on the sill's condition. The J-channel should fit snug to the window.

J-Channel Over Roof Lines

- Install the flashing before the J-channel to prevent water infiltration along the intersection of a roof and wall.

- Keep the J-channel approximately 1/2" from the roof line. Chalk a straight line up the roof flashing to guide J-channel installation.

- Overlap the J-channel (lapping the upper piece over the lower piece) if it is necessary to use more than one piece.

- Extend the J-channel past the edge of the roof, channeling water into the gutter, in order to ensure proper runoff.

NOTE: Vinyl J-channels should not be in direct contact with roofing shingles, since the shingles may transfer enough heat to the vinyl J-channel to cause its distortion.

- With dark shingles, or a south or west exposure, it is recommended to either use a metal J-channel or to install the vinyl J-channel as far away from the roofing as is aesthetically acceptable, having first ensured that there is sufficient flashing behind the J-channel to prevent water infiltration.

Continued

- Fasten the nail, screw, or staple that is closest to the roof line at the far end of the nail hem slot, to ensure that siding will expand away from the J-channel (Fig. 32).

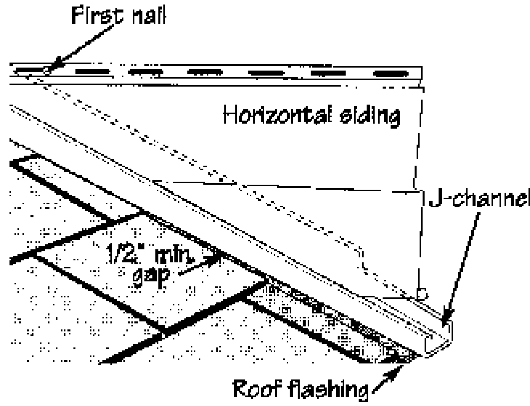

Figure 32.

Figure 12.29.0—*Continued*

12.30.0 Gable and Trim

Before applying siding to the gables, the J-channel should be installed to receive the siding at the gable ends (Fig. 33):

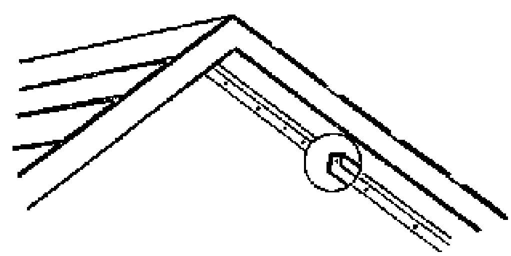

Figure 33.

- Where the left and right sections meet at the gable peak, let one of the sections butt into the peak with the other section overlapping.
- A miter cut should be made on the face flange of this piece for better appearance.
- Fasten the J-channel every 8" to 12".
- If more than one length of J-channel is required to span a wall surface, be sure to overlap the J-channels by 3/4".

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12.31.0 Installation Tips

1. Special tools will come in handy:
   - A nail hole punch, sometimes called a slot punch which can be used to create a nailing slot in a piece of siding where the top edge has been ripped off.
   - A snap lock punch can also be used to create a tab along the edge of a panel that has been rip cut to fit under a window or at the top of a wall.
   - An unlocking tool, also called a zip tool, to be used to free an installed panel so it can be relocated door removed from the wall.
2. The straighter the substrate whether it by plywood, OSB, cement board, etc., the better the finished installation. Since the quality of the sheathing is dependent upon the quality of the framing, it is important to check for warped, bowed, out of plumb, or levelness of the framing *prior* to installing sheathing.
3. Siding manufacturers do not all recommend installing vinyl siding over felt paper since over time the felt can deteriorate. When that occurs, particles from the felt paper will fall into the siding butts and laps and may eventually bleed through the siding's weep holes or joints.
4. When applying vinyl siding over masonry use 1" × 3" (2.5 cm × 7.5 cm) furring strips.
5. When installing a starter strip at sills above brick surfaces or garage doors or porches, nail a "J" channel to the substrate or furring strip nd place the siding in the "J" strip.
6. To obtain greater rigidity when installing outside corner posts, use a product called E-Z Post (registered trademark). This item is a wire cut foam insert that fits into corner posts making them easier to handle and more rigid once installed.
7. Follow the window manufacturer's recommendations for creating a watertight installation. Some installers bend the bottom tabs up behind the side channel to provide a more watertight seal.
8. When a span requires more than one length of "J" channel, overlap the channels by a minimum of ¾ inches (1.87 cm) to allow room for expansion and contraction.
9. When encountering an outside hose bib installation or an exterior electrical receptacle, the vinyl siding supplier can usually provide an injection-molded "J" block to make a quality enclosure around this obstacle.
10. When installing panels on a gable end, check the slope angle of the template from time to time to ensure that there is not too much variation in the slope angle from one course to the next.
11. To estimate the number of vented panels needed for soffit venting, determine the square footage of attic floor and divide by 2—this equals the total free net area required in square inches. Total free area is divided between intake vents located in the eaves and exhaust vents generally located at or near the roof peak—so divide this number in half. That is how much soffit venting you will need. This is a rough estimate, so check with the local building code before ordering soffit panels.
12. When joining two lengths of soffit panel over a long run, either use a piece of "H" trim to span the joint or overlap panels a minimum of 1 inch (2.5 cm).

12.32.0 Cleaning Mildew from Vinyl Siding

Eaves, porch ceilings, and wall areas just below the eave line are susceptible to mildew forming in their surfaces. To remove mildew prepare the following solution:

⅓ cup of laundry detergent

⅔ cup trisodium phosphate

1 quarter of 5% sodium hypochlorite solution (bleach)

3 quarts of water

Apply this solution to the mildew areas, allow it to remain for several minutes and the rinse off. Always wear eye protection and rubber gloves because the trisodium phosphate and bleach should be kept away from eyes and bare skin.

Section

13

Flooring

Contents

13.0.0 Most Frequently Encountered Flooring Materials

Materials for floor coverings range from painted concrete to custom-made ceramic tiles or carpeting. This section deals primarily with those materials most frequently encountered on construction projects: wood flooring, resilient flooring, and carpet, and secondarily, with less frequently used materials (stone veneer, seamless flooring, and terrazzo).

13.1.0 Wood Flooring (Types)

The species of wood most commonly used for flooring are oak (red and white) and maple. Yellow birch and sweet birch are used on occasion, as are more exotic and costly species (such as pecan, walnut, cherry, ash, hickory, and teak).

- *Oak* Available in two grades of quartered sawed and five grades of plain sawed, generally milled as tongue-and-groove, oak flooring is sold in plank, strip, block, or parquet form.
- *Maple* Obtained from the sugar maple or rock maple trees, this wood is exceptionally hard and finds wide usage in gymnasium floors. Its resistance to abrasion and ability to take an excellent finish makes it desirable for all wood floor applications where heavy wear will be anticipated.
- *Acrylic-impregnated hardwood* Radiation polymerization of hardwood flooring replaces the air in the wood cells with a liquid polymer using a vacuum and pressure process. The liquid polymer can be colored or clear. The resultant finish will greatly improve the wood's resistance to wear.

13.2.0 Resilient Flooring

Vinyl Composition Tile (VCT)

The two types of vinyl composition tile are available in several thicknesses:

- *Type 1* Smooth surface
- *Type 2* Embossed surface

A thoroughly blended composition of thermoplastic binders, fillers, and pigment is used. The thermoplastic binder is polyvinyl chloride resin or a copolymer resin made by copolymerizing vinyl chloride with other monomeric materials. The size is usually 12" × 12" (304.8 mm). The difference between length and width shall be no greater than 0.020" (0.51 mm) for any size of square tile. Thickness will be either ⅛" (3.18 mm), 3⁄32" (2.38 mm), 0.080" (2.03 mm), 1⁄16" (1.59 mm).

Solid Vinyl Tile

Solid vinyl tiles are available in two types and three classes:

- *Type 1* Smooth surface
  Class A Monolithic
  Class B Multilayered
- *Type 2* Embossed surface
  Class A Monolithic
  Class B Multilayered
- *Class C* Class A or B with a permanently bonded coating.

Materials of Construction

- *Class A* Contains a constant composition through the tile thickness.
- *Class B* Contains layers of either Material I or Material II or combinations thereof.
- *Class C* Any construction of Class A or Class B that has a permanently bonded protective coating of Material III.

- *Material I* Vinyl plastic composed a binder stabilized against heat and polyvinyl chloride or a copolymer of vinyl chloride (not less than 85% of which shall be polyvinyl chloride). The vinyl resin must be at least 60%, by weight, of the binder.
- *Material II (Translucent)* A transparent vinyl plastic containing resins, each one of which shall be polyvinyl chloride or a copolymer of vinyl chloride, not less than 85% of which is vinyl chloride. The vinyl resin must be at least 60%, by weight, of the binder.
- *Material III* A clear or transparent layer specifically formulated to function as a top coat to enhance the flooring material. This coating is composed of, but to restricted to, conventional vinyl resins of plasticizers. The size is generally 12" × 12" (304.8 mm) × (304.8 mm) with the same tolerances as VCT.

The nominal thicknesses can be ⅛" (3.18 mm), 0.100" (2.54 mm), 0.080" (2.03 mm), 0.0625" (1.59 mm), 0.050" (1.27 mm), 0.039" (1.00 mm).

Rubber floor tiles are made of 100% virgin synthetic rubber with a slip-retardant additive. This type of flooring has high strength as a result of its elasticity and resilience. Base thickness for heavy-duty wear is 0.130" (3.38 mm) and 0.100" (2.54 mm) for light-duty use.

13.2.1 Specifications for Solid Vinyl Floor Tile

There are two basic types of solid vinyl flooring:

Type 1 Smooth surface, subdivided into Class A—Monolithic, and Class B—multilayered.

Type II Embossed surface, subdivided into Class A—Monolithic, Class B—Multilayered, and Class C—Class A or Class B with a permanently bonded coating. Construction of solid vinyl flooring employs one of three types of materials:

Material I Contains a binder stabilized against heat and light deterioration and fillers and pigments as required. The binder consists of one or more vinyl resins, plasticizers, and modifying resins not less than 34% by weight of the composition. Each vinyl resin, polyvinyl chloride (PVC), or copolymer of vinyl chloride is to be not less than 85% vinyl chloride. The vinyl resin is to be not less than 60% of the weight of the binder.

Material II This is a translucent material stabilized against heat and light deterioration and may contain one or more vinyl resins and plasticizers. Each resin shall be PVC or a copolymer of vinyl chloride not less than 85% of which is vinyl chloride. The vinyl resin is to be not less than 60% by weight of the binder.

Material III This is a clear or translucent layer specifically formulated to function as a top coat. It can be formulated from conventional vinyl resins and plasticizers.

Nominal thickness of solid vinyl tile is available in the following gauges:

⅛" (.125) (3.18 mm)	.0625 inch (1.58 mm)
.100 inch (2.54 mm)	.050 inch (1.27 mm)
.080 inch (2.03 mm)	.039 inch (1.00 mm)

13.2.2 Specifications for Vinyl Composition Tile

Vinyl composition tile (VCT) is classified into two types:

- *Type 1* Smooth surface
- *Type 2* Embossed surface

The composition of both types consists of a thoroughly blended composition of thermoplastic binders, fillers, and pigments. The thermoplastic binder can be either a polyvinyl chloride (PVC) resin or a copolymer resin made by copolymerizing vinyl chloride with other monomeric materials.

VCT is available in 12 inch × 12 inch squares (304.8 mm × 304.8 mm) and is manufactured to a tolerance of ±0.016 inches (.41 mm) in 12 inches (304.8 mm). Thickness availability is

⅛ inch (3.18 mm)

3⁄32 inch (2.38 mm)

1⁄16 inch (1.59 mm)

13.2.3 Specifications for Resilient Flooring with a Plastic Wearlayer and Backing

Sheet vinyl flooring is classified as to wear type, backing type, minimum wear layer thickness and minimum overall thickness.

Wear layer types:

- *Type I* Material I (see designations previously described in Section 13.2.1—solid vinyl floor tile specifications) with or without Material # with integral decoration and with or without depressed areas.
- *Type II* Material II with or without Material III and/or translucent Material I or II with integral and/or printed decoration.
- *Type III* Translucent Material II and/or Material III with decoration visible through the wear layer.

Backing Groups:

Group I nonfoam plastic backing

Group II fibrous backing

Group III foam plastic backing

Grades, wearlayer types, overall thickness

Grade	Wearlayer Type	Wearlayer thickness	Overall thickness
A	I	.050" (1.270 mm)	.080" (2.032 mm)
A	II and III	.020" (.508 mm)	.060" (1.524 mm)
B	I and II	.030" (.762 mm)	.060" (1.524 mm)
B	II	.014" (.356 mm)	.050" (1.270 mm)
C	I and II	.020" (.508 mm)	.050" (1.270 mm)
C	II and III	.010" (.254 mm)	.050" (1.270 mm)

13.2.4 Addressing Moisture Related Problems When Installing Tile on Concrete Slabs

When the proper steps are not taken when installing resilient flooring over concrete slabs adhesion failure will occur, the alkali in the concrete can create efflorescence at the tile joints, mold mildew and bacteria will have fertile fields for growth and color changes in the tile may take place.

Precautions to Be Taken When the Concrete Slab Is Placed

A moisture barrier with a permanence of less than 0.3 perms (0.2 metric perms), as measured by ASTM E-96—Test Methods for Water Vapor Transmission of Materials needs to be installed below grade. Placement of a one-inch (25 mm) layer of sand over the porous fill under the slab will help in preventing puncturing of the moisture barrier.

The concrete surface to receive the resilient flooring must be troweled smooth with a surface tolerance of 5⁄16" (8 mm) in 120 inches (3050 mm) per American Concrete Institute (ACI) standards.

Any joints in the slab should be patched with a latex patching compound. The finished slab should be allowed to properly cure for a minimum of 6 weeks.

Testing for Moisture

Several tests are used to check for moisture in the slab. Rubber mats can be place on the concrete slab for a 24-hour period after which the floor beneath the mat is inspected for dampness. The Delmhorst Moisture Detector and the Protimeter Concrete-master electrical resistance meters can also be employed to detect the presence of moisture. The RMA Moisture Test Unit will measure moisture when an effective moisture barrier has been placed under the slab. A widely accepted method of checking for moisture, the RMA method dictates that the emission of moisture vapor from the floor shall not be more than 3 pounds (1.3608 kg) per 1000 square feet (1.465 kg per 100 square meters) per 24 hours. Failure to meet these criteria may require another test in a week or two.

Subfloor Preparation Prior to Installing Resilient Flooring

1. The concrete slab must be properly cured and acceptable moisture content verified.
2. The surface must be swept clean and free from dust, paint, wax, grease, and oil.
3. The presence of curing compounds, hardeners, or sealants in the concrete or surface applied may affect adherence.
4. If a scaly or powdery surface has formed on all or a portion of the slab, some form of contamination may be present. A pH meter can be used to determine whether a reading higher than 9 is obtained which may indicate a potential moisture problem.
5. Cracks, joints, depressions, minor bumps, and other irregularities in the surface of the slab should be corrected by grinding or flash patching.
6. A room temperature of 70°F (21°C) to 80°F (27°C) should be maintained for at least 48 hours prior to, during, and after the resilient floor installation.

13.3.0 Carpet Construction and Materials

Construction is the amount of pile packed into a given volume of carpet and is translated into ounces of yarn for unit volume and depends upon the following:

- *Pitch* The number of warp lines of yarn in a 27" width. The higher the "pitch," the more dense the carpet.
- *Stitch* The number of lengthwise yarn tufts contained in a 1" area. More stitches per inch results in a more-dense carpet face.
- *Pile height* A measurement from the back of the pile to the front or top of the pile. High pile does not wear well; low pile does not wear well. Medium pile is the better service pile.

Weight per yard, expressed in ounces per yard, is the total weight of the pile yard, plus backings and coatings.

Materials of Construction

- *Wool* Soft, good serviceability, and resilient. The highest priced of the carpet materials.
- *Acrylics* Wool-like appearance; average durability, abrasion resistance, and stain resistance.
- *Polyester* Good abrasion resistance; feels like wool; susceptible to oil-based stains.
- *Olefin* Also referred to as *polypropylene,* often is used for indoor–outdoor carpet. Resistant to fading and staining; good abrasion resistance, resilience not good.
- *Nylon* Excellent abrasion resistance; easy to clean; and very good crush and stain resistance.

The backing material on all types of carpet can be:

- *Primary backing* The material to which surface yarns are attached and constructed of jute cotton, or a synthetic.

- *Secondary backing* A material laminated to the primary backing to improve resiliency and add stability. It can be either jute or a woven or nonwoven synthetic material.
- *Separate padding* A cushioning material, separate from the carpet, that can be constructed of jute, foam rubber, plastic, or felted cattle hair.

13.3.1 Carpet—Factors Affecting Wearability

Wearability is characterized by a carpet's tight gauge, low pile, and high-stitch rate. A dense low pile of a specific weight will usually provide better service than a high pile and low density of the same weight.

Density refers to the amount of pile (the upright ends of yarn, either cut or looped) packed into a given volume of carpet. This is measured in ounces of pile yarn per unit volume.

Gauge is the distance between two needle points, expressed in a fraction of an inch. This applies to both knitted and tufted carpet; the tighter the gauge the more dense the carpet.

Resiliency of the carpet is the ability of the yarn to spring back after being crushed or walked upon. Resiliency will vary according to the method of carpet manufacture and its texture.

13.3.2 Methods of Carpet Manufacture and Textures Produced

Methods of carpet manufacturing include:

Tufted A high-speed method by which the yarns are inserted through a prewoven backing fabric leaving the stitches long enough to be either cut off or left as loops.

Woven An in-and-out method of interlacing both surface and backing yarns in one operation.

Knitted The surface and backing loops are woven together with a stitching yarn on a machine with three sets of needles. As in weaving, this type of carpet is manufactured in one operation.

Fusion bonded Two backing fabrics that run parallel with a space in between are used and the backing has an adhesive on its face side. Implanting a multifold fiber web between the backings creates a sandwich. When a blade slices through the middle of the sandwich, two identical sections of carpet are created.

Textures produced by carpet manufacturers:

Cut pile Made from unset yarns to create an even, velvety texture; can also be created from firm-ended yarns. Cut pile carpets look luxurious, but show foot steps easily.

Level loop pile Loops are all of the same height and are created by a tufting, weaving, or knitting action. There is some variation in the height of the loops and while suitable for heavily trafficked areas, the space between loops easily collects dirt.

Cut and loop By creating different loop heights, a variety of textures can be created.

Static resistance This can be achieved during manufacturer through choice of material, special fibers, metallic wires, or chemicals used to dissipate the static electricity generated as people walk on the carpet.

13.3.3 Computing Square Yards and Square Meters of Carpet

LENGTH	9 FEET			12 FEET			15 FEET		
FT IN	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
6-00	54.0	6.00	5.02	72.0	8.00	6.69	90.0	10.00	8.36
6-01	54.8	6.08	5.09	73.0	8.11	6.78	91.3	10.14	8.48
6-02	55.5	6.17	5.16	74.0	8.22	6.87	92.5	10.28	8.59
6-03	56.3	6.25	5.23	75.0	8.33	6.97	93.8	10.42	8.71
6-04	57.0	6.33	5.30	76.0	8.44	7.06	95.0	10.56	8.83
6-05	57.8	6.42	5.37	77.0	8.56	7.15	96.3	10.69	8.94
6-06	58.5	6.50	5.43	78.0	8.67	7.25	97.5	10.83	9.06
6-07	59.3	6.58	5.50	79.0	8.78	7.34	98.8	10.97	9.17
6-08	60.0	6.67	5.57	80.0	8.89	7.43	100.0	11.11	9.29
6-09	60.8	6.75	5.64	81.0	9.00	7.52	101.3	11.25	9.41
6-10	61.5	6.83	5.71	82.0	9.11	7.62	102.5	11.39	9.52
6-11	62.3	6.92	5.78	83.0	9.22	7.71	103.8	11.53	9.64
7-00	63.0	7.00	5.85	84.0	9.33	7.80	105.0	11.67	9.76
7-01	63.8	7.08	5.92	85.0	9.44	7.90	106.3	11.81	9.87
7-02	64.5	7.17	5.99	86.0	9.56	7.99	107.5	11.94	9.99
7-03	65.3	7.25	6.06	87.0	9.67	8.08	108.8	12.08	10.10
7-04	66.0	7.33	6.13	88.0	9.78	8.17	110.0	12.22	10.22
7-05	66.8	7.42	6.20	89.0	9.89	8.27	111.3	12.36	10.33
7-06	67.5	7.50	6.27	90.0	10.00	8.36	112.5	12.50	10.45
7-07	68.3	7.58	6.34	91.0	10.11	8.45	113.8	12.64	10.57
7-08	69.0	7.67	6.41	92.0	10.22	8.55	115.0	12.78	10.68
7-09	69.8	7.75	6.48	93.0	10.33	8.64	116.3	12.92	10.80
7-10	70.5	7.83	6.55	94.0	10.44	8.73	117.5	13.06	10.92
7-11	71.3	7.92	6.62	95.0	10.56	8.83	118.8	13.19	11.03
8-00	72.0	8.00	6.69	96.0	10.67	8.92	120.0	13.33	11.15
8-01	72.8	8.08	6.76	97.0	10.78	9.01	121.3	13.47	11.26
8-02	73.5	8.17	6.83	98.0	10.89	9.10	122.5	13.61	11.38
8-03	74.3	8.25	6.90	99.0	11.00	9.20	123.8	13.75	11.50
8-04	75.0	8.33	6.97	100.0	11.11	9.29	125.0	13.89	11.61
8-05	75.8	8.42	7.04	101.0	11.22	9.38	126.3	14.03	11.73
8-06	76.5	8.50	7.11	102.0	11.33	9.48	127.5	14.17	11.84
8-07	77.3	8.58	7.18	103.0	11.44	9.57	128.8	14.31	11.96
8-08	78.0	8.67	7.25	104.0	11.56	9.66	130.0	14.44	12.08
8-09	78.8	8.75	7.32	105.0	11.67	9.75	131.3	14.58	12.19
8-10	79.5	8.83	7.39	106.0	11.78	9.85	132.5	14.72	12.31
8-11	80.3	8.92	7.46	107.0	11.89	9.94	133.8	14.86	12.43
9-00	81.0	9.00	7.52	108.0	12.00	10.03	135.0	15.00	12.54
9-01	81.8	9.08	7.60	109.0	12.11	10.13	136.3	15.14	12.66
9-02	82.5	9.17	7.66	110.0	12.22	10.22	137.5	15.28	12.77
9-03	83.3	9.25	7.73	111.0	12.33	10.31	138.8	15.42	12.89
9-04	84.0	9.33	7.80	112.0	12.44	10.40	140.0	15.56	13.01
9-05	84.8	9.42	7.87	113.0	12.56	10.50	141.3	15.69	13.12
9-06	85.5	9.50	7.94	114.0	12.67	10.59	142.5	15.83	13.24
9-07	86.3	9.58	8.01	115.0	12.78	10.68	143.8	15.97	13.35
9-08	87.0	9.67	8.08	116.0	12.89	10.78	145.0	16.11	13.47
9-09	87.8	9.75	8.15	117.0	13.00	10.87	146.3	16.25	13.59
9-10	88.5	9.83	8.22	118.0	13.11	10.96	147.5	16.39	13.70
9-11	89.3	9.92	8.29	119.0	13.22	11.05	148.8	16.53	13.82

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT IN	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
10-00	90.0	10.00	8.36	120.0	13.33	11.15	150.0	16.67	13.94
10-01	90.8	10.08	8.43	121.0	13.44	11.24	151.3	16.81	14.05
10-02	91.5	10.17	8.50	122.0	13.56	11.33	152.5	16.94	14.17
10-03	92.3	10.25	8.57	123.0	13.67	11.43	153.8	17.08	14.28
10-04	93.0	10.33	8.64	124.0	13.78	11.52	155.0	17.22	14.40
10-05	93.8	10.42	8.71	125.0	13.89	11.61	156.3	17.36	14.52
10-06	94.5	10.50	8.78	126.0	14.00	11.71	157.5	17.50	14.63
10-07	95.3	10.58	8.85	127.0	14.11	11.80	158.8	17.64	14.75
10-08	96.0	10.67	8.92	128.0	14.22	11.89	160.0	17.78	14.86
10-09	96.8	10.75	8.99	129.0	14.33	11.98	161.3	17.92	14.98
10-10	97.5	10.83	9.06	130.0	14.44	12.08	162.5	18.06	15.10
10-11	98.3	10.92	9.13	131.0	14.56	12.17	163.8	18.19	15.21
11-00	99.0	11.00	9.20	132.0	14.67	12.26	165.0	18.33	15.33
11-01	99.8	11.08	9.27	133.0	14.78	12.36	166.3	18.47	15.44
11-02	100.5	11.17	9.34	134.0	14.89	12.45	167.5	18.61	15.56
11-03	101.3	11.25	9.41	135.0	15.00	12.54	168.8	18.75	15.68
11-04	102.0	11.33	9.48	136.0	15.11	12.63	170.0	18.89	15.79
11-05	102.8	11.42	9.55	137.0	15.22	12.73	171.3	19.03	15.91
11-06	103.5	11.50	9.62	138.0	15.33	12.82	172.5	19.17	16.03
11-07	104.3	11.58	9.69	139.0	15.44	12.91	173.8	19.31	16.14
11-08	105.0	11.67	9.76	140.0	15.56	13.01	175.0	19.44	16.26
11-09	105.8	11.75	9.82	141.0	15.67	13.10	176.3	19.58	16.37
11-10	106.5	11.83	9.89	142.0	15.78	13.19	177.5	19.72	16.49
11-11	107.3	11.92	9.96	143.0	15.89	13.28	178.8	19.86	16.61
12-00	108.0	12.00	10.03	144.0	16.00	13.38	180.0	20.00	16.72
12-01	108.8	12.08	10.10	145.0	16.11	13.47	181.3	20.14	16.84
12-02	109.5	12.17	10.17	146.0	16.22	13.56	182.5	20.28	16.95
12-03	110.3	12.25	10.24	147.0	16.33	13.66	183.8	20.42	17.07
12-04	111.0	12.33	10.31	148.0	16.44	13.75	185.0	20.56	17.19
12-05	111.8	12.42	10.38	149.0	16.56	13.84	186.3	20.69	17.30
12-06	112.5	12.50	10.45	150.0	16.67	13.93	187.5	20.83	17.42
12-07	113.3	12.58	10.52	151.0	16.78	14.03	188.8	20.97	17.53
12-08	114.0	12.67	10.59	152.0	16.89	14.12	190.0	21.11	17.65
12-09	114.8	12.75	10.66	153.0	17.00	14.21	191.3	21.25	17.77
12-10	115.5	12.83	10.73	154.0	17.11	14.31	192.5	21.39	17.88
12-11	116.3	12.92	10.80	155.0	17.22	14.40	193.8	21.53	18.00
13-00	117.0	13.00	10.87	156.0	17.33	14.49	195.0	21.67	18.12
13-01	117.8	13.08	10.94	157.0	17.44	14.59	196.3	21.81	18.23
13-02	118.5	13.17	11.01	158.0	17.56	14.68	197.5	21.94	18.35
13-03	119.3	13.25	11.08	159.0	17.67	14.77	198.8	22.08	18.46
13-04	120.0	13.33	11.15	160.0	17.78	14.86	200.0	22.22	18.58
13-05	120.8	13.42	11.22	161.0	17.89	14.96	201.3	22.36	18.70
13-06	121.5	13.50	11.29	162.0	18.00	15.05	202.5	22.50	18.81
13-07	122.3	13.58	11.36	163.0	18.11	15.14	203.8	22.64	18.93
13-08	123.0	13.67	11.43	164.0	18.22	15.24	205.0	22.78	19.04
13-09	123.8	13.75	11.50	165.0	18.33	15.33	206.3	22.92	19.16
13-10	124.5	13.83	11.57	166.0	18.44	15.42	207.5	23.06	19.28
13-11	125.3	13.92	11.64	167.0	18.56	15.52	208.8	23.19	19.39

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
14-00	126.0	14.00	11.71	168.0	18.67	15.61	210.0	23.33	19.51
14-01	126.8	14.08	11.78	169.0	18.78	15.70	211.3	23.47	19.63
14-02	127.5	14.17	11.84	170.0	18.89	15.79	212.5	23.61	19.74
14-03	128.3	14.25	11.91	171.0	19.00	15.89	213.8	23.75	19.86
14-04	129.0	14.33	11.98	172.0	19.11	15.98	215.0	23.89	19.97
14-05	129.8	14.42	12.05	173.0	19.22	16.07	216.3	24.03	20.09
14-06	130.5	14.50	12.12	174.0	19.33	16.16	217.5	24.17	20.21
14-07	131.3	14.58	12.19	175.0	19.44	16.26	218.8	24.31	20.32
14-08	132.0	14.67	12.26	176.0	19.56	16.35	220.0	24.44	20.44
14-09	132.8	14.75	12.33	177.0	19.67	16.44	221.3	24.58	20.55
14-10	133.5	14.83	12.40	178.0	19.78	16.54	222.5	24.72	20.67
14-11	134.3	14.92	12.47	179.0	19.89	16.63	223.8	24.86	20.79
15-00	135.0	15.00	12.54	180.0	20.00	16.72	225.0	25.00	20.90
15-01	135.8	15.08	12.61	181.0	20.11	16.81	226.3	25.14	21.02
15-02	136.5	15.17	12.68	182.0	20.22	16.91	227.5	25.28	21.13
15-03	137.3	15.25	12.75	183.0	20.33	17.00	228.8	25.42	21.25
15-04	138.0	15.33	12.82	184.0	20.44	17.09	230.0	25.56	21.37
15-05	138.8	15.42	12.89	185.0	20.56	17.19	231.3	25.69	21.48
15-06	139.5	15.50	12.96	186.0	20.67	17.28	232.5	25.83	21.60
15-07	140.3	15.58	13.03	187.0	20.78	17.37	233.8	25.97	21.72
15-08	141.0	15.67	13.10	188.0	20.89	17.47	235.0	26.11	21.83
15-09	141.8	15.75	13.17	189.0	21.00	17.56	236.3	26.25	21.95
15-10	142.5	15.83	13.24	190.0	21.11	17.65	237.5	26.39	22.06
15-11	143.3	15.92	13.31	191.0	21.22	17.74	238.8	26.53	22.18
16-00	144.0	16.00	13.38	192.0	21.33	17.84	240.0	26.67	22.30
16-01	144.8	16.08	13.45	193.0	21.44	17.93	241.3	26.81	22.41
16-02	145.5	16.17	13.52	194.0	21.56	18.02	242.5	26.94	22.53
16-03	146.3	16.25	13.59	195.0	21.67	18.12	243.8	27.08	22.64
16-04	147.0	16.33	13.66	196.0	21.78	18.21	245.0	27.22	22.76
16-05	147.8	16.42	13.73	197.0	21.89	18.30	246.3	27.36	22.88
16-06	148.5	16.50	13.80	198.0	22.00	18.39	247.5	27.50	22.99
16-07	149.3	16.58	13.87	199.0	22.11	18.49	248.8	27.64	23.11
16-08	150.0	16.67	13.94	200.0	22.22	18.58	250.0	27.78	23.23
16-09	150.8	16.75	14.00	201.0	22.33	18.67	251.3	27.92	23.34
16-10	151.5	16.83	14.07	202.0	22.44	18.77	252.5	28.06	23.46
16-11	152.3	16.92	14.14	203.0	22.56	18.86	253.8	28.19	23.57
17-00	153.0	17.00	14.21	204.0	22.67	18.95	255.0	28.33	23.69
17-01	153.8	17.08	14.28	205.0	22.78	19.04	256.3	28.47	23.81
17-02	154.5	17.17	14.35	206.0	22.89	19.14	257.5	28.61	23.92
17-03	155.3	17.25	14.42	207.0	23.00	19.23	258.8	28.75	24.04
17-04	156.0	17.33	14.49	208.0	23.11	19.32	260.0	28.89	24.15
17-05	156.8	17.42	14.56	209.0	23.22	19.42	261.3	29.03	24.27
17-06	157.5	17.50	14.63	210.0	23.33	19.51	262.5	29.17	24.39
17-07	158.3	17.58	14.70	211.0	23.44	19.60	263.8	29.31	24.50
17-08	159.0	17.67	14.77	212.0	23.56	19.69	265.0	29.44	24.62
17-09	159.8	17.75	14.84	213.0	23.67	19.79	266.3	29.58	24.73
17-10	160.5	17.83	14.91	214.0	23.78	19.88	267.5	29.72	24.85
17-11	161.3	17.92	14.98	215.0	23.89	19.97	268.8	29.86	24.97

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
18-00	162.0	18.00	15.05	216.0	24.00	20.07	270.0	30.00	25.08
18-01	162.8	18.08	15.12	217.0	24.11	20.16	271.3	30.14	25.20
18-02	163.5	18.17	15.19	218.0	24.22	20.25	272.5	30.28	25.32
18-03	164.3	18.25	15.26	219.0	24.33	20.35	273.8	30.42	25.43
18-04	165.0	18.33	15.33	220.0	24.44	20.44	275.0	30.56	25.55
18-05	165.8	18.42	15.40	221.0	24.56	20.53	276.3	30.69	25.66
18-06	166.5	18.50	15.47	222.0	24.67	20.62	277.5	30.83	25.78
18-07	167.3	18.58	15.54	223.0	24.78	20.72	278.8	30.97	25.90
18-08	168.0	18.67	15.61	224.0	24.89	20.81	280.0	31.11	26.01
18-09	168.8	18.75	15.68	225.0	25.00	20.90	281.3	31.25	26.13
18-10	169.5	18.83	15.75	226.0	25.11	21.00	282.5	31.39	26.24
18-11	170.3	18.92	15.82	227.0	25.22	21.09	283.8	31.53	26.36
19-00	171.0	19.00	15.89	228.0	25.33	21.18	285.0	31.67	26.48
19-01	171.8	19.08	15.96	229.0	25.44	21.27	286.3	31.81	26.59
19-02	172.5	19.17	16.03	230.0	25.56	21.37	287.5	31.94	26.71
19-03	173.3	19.25	16.09	231.0	25.67	21.46	288.8	32.08	26.83
19-04	174.0	19.33	16.16	232.0	25.78	21.55	290.0	32.22	26.94
19-05	174.8	19.42	16.23	233.0	25.89	21.65	291.3	32.36	27.06
19-06	175.5	19.50	16.30	234.0	26.00	21.74	292.5	32.50	27.17
19-07	176.3	19.58	16.37	235.0	26.11	21.83	293.8	32.64	27.29
19-08	177.0	19.67	16.44	236.0	26.22	21.92	295.0	32.78	27.41
19-09	177.8	19.75	16.51	237.0	26.33	22.02	296.3	32.92	27.52
19-10	178.5	19.83	16.58	238.0	26.44	22.11	297.5	33.06	27.64
19-11	179.3	19.92	16.65	239.0	26.56	22.20	298.8	33.19	27.75
20-00	180.0	20.00	16.72	240.0	26.67	22.30	300.0	33.33	27.87
20-01	180.8	20.08	16.79	241.0	26.78	22.39	301.3	33.47	27.98
20-02	181.5	20.17	16.86	242.0	26.89	22.48	302.5	33.61	28.10
20-03	182.3	20.25	16.93	243.0	27.00	22.57	303.8	33.75	28.22
20-04	183.0	20.33	17.00	244.0	27.11	22.67	305.0	33.89	28.33
20-05	183.8	20.42	17.07	245.0	27.22	22.76	306.3	34.03	28.45
20-06	184.5	20.50	17.14	246.0	27.33	22.85	307.5	34.17	28.57
20-07	185.3	20.58	17.21	247.0	27.44	22.95	308.8	34.31	28.68
20-08	186.0	20.67	17.28	248.0	27.56	23.04	310.0	34.44	28.80
20-09	186.8	20.75	17.35	249.0	27.67	23.13	311.3	34.58	28.92
20-10	187.5	20.83	17.42	250.0	27.78	23.23	312.5	34.72	29.03
20-11	188.3	20.92	17.49	251.0	27.89	23.32	313.8	34.86	29.15
21-00	189.0	21.00	17.55	252.0	28.00	23.41	315.0	35.00	29.26
21-01	189.8	21.08	17.63	253.0	28.11	23.50	316.3	35.14	29.38
21-02	190.5	21.17	17.70	254.0	28.22	23.60	317.5	35.28	29.50
21-03	191.3	21.25	17.77	255.0	28.33	23.69	318.8	35.42	29.61
21-04	192.0	21.33	17.84	256.0	28.44	23.78	320.0	35.56	29.73
21-05	192.8	21.42	17.91	257.0	28.56	23.88	321.3	35.69	29.84
21-06	193.5	21.50	17.98	258.0	28.67	23.97	322.5	35.83	29.96
21-07	194.3	21.58	18.05	259.0	28.78	24.06	323.8	35.97	30.08
21-08	195.0	21.67	18.12	260.0	28.89	24.16	325.0	36.11	30.19
21-09	195.8	21.75	18.19	261.0	29.00	24.25	326.3	36.25	30.31
21-10	196.5	21.83	18.25	262.0	29.11	24.34	327.5	36.39	30.43
21-11	197.3	21.92	18.32	263.0	29.22	24.43	328.8	36.53	30.54

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
22-00	198.0	22.00	18.39	264.0	29.33	24.53	330.0	36.67	30.66
22-01	198.8	22.08	18.46	265.0	29.44	24.62	331.3	36.81	30.77
22-02	199.5	22.17	18.53	266.0	29.56	24.71	332.5	36.94	30.89
22-03	200.3	22.25	18.60	267.0	29.67	24.80	333.8	37.08	31.01
22-04	201.0	22.33	18.67	268.0	29.78	24.90	335.0	37.22	31.12
22-05	201.8	22.42	18.74	269.0	29.89	24.99	336.3	37.36	31.24
22-06	202.5	22.50	18.81	270.0	30.00	25.08	337.5	37.50	31.35
22-07	203.3	22.58	18.88	271.0	30.11	25.18	338.8	37.64	31.47
22-08	204.0	22.67	18.95	272.0	30.22	25.27	340.0	37.78	31.59
22-09	204.8	22.75	19.02	273.0	30.33	25.36	341.3	37.92	31.70
22-10	205.5	22.83	19.09	274.0	30.44	25.45	342.5	38.06	31.82
22-11	206.3	22.92	19.16	275.0	30.56	25.55	343.8	38.19	31.93
23-00	207.0	23.00	19.23	276.0	30.67	25.64	345.0	38.33	32.05
23-01	207.8	23.08	19.30	277.0	30.78	25.73	346.3	38.47	32.17
23-02	208.5	23.17	19.37	278.0	30.89	25.83	347.5	38.61	32.28
23-03	209.3	23.25	19.44	279.0	31.00	25.92	348.8	38.75	32.40
23-04	210.0	23.33	19.51	280.0	31.11	26.01	350.0	38.89	32.52
23-05	210.8	23.42	19.58	281.0	31.22	26.11	351.3	39.03	32.63
23-06	211.5	23.50	19.65	282.0	31.33	26.20	352.5	39.17	32.75
23-07	212.3	23.58	19.72	283.0	31.44	26.29	353.8	39.31	32.86
23-08	213.0	23.67	19.79	284.0	31.56	26.38	355.0	39.44	32.98
23-09	213.8	23.75	19.86	285.0	31.67	26.48	356.3	39.58	33.10
23-10	214.5	23.83	19.93	286.0	31.78	26.57	357.5	39.72	33.21
23-11	215.3	23.92	20.00	287.0	31.89	26.66	358.8	39.86	33.33
24-00	216.0	24.00	20.07	288.0	32.00	26.76	360.0	40.00	33.44
24-01	216.8	24.08	20.14	289.0	32.11	26.85	361.3	40.14	33.56
24-02	217.5	24.17	20.21	290.0	32.22	26.94	362.5	40.28	33.68
24-03	218.3	24.25	20.28	291.0	32.33	27.03	363.8	40.42	33.79
24-04	219.0	24.33	20.35	292.0	32.44	27.13	365.0	40.56	33.91
24-05	219.8	24.42	20.41	293.0	32.56	27.22	366.3	40.69	34.03
24-06	220.5	24.50	20.48	294.0	32.67	27.31	367.5	40.83	34.14
24-07	221.3	24.58	20.55	295.0	32.78	27.41	368.8	40.97	34.26
24-08	222.0	24.67	20.62	296.0	32.89	27.50	370.0	41.11	34.37
24-09	222.8	24.75	20.69	297.0	33.00	27.59	371.3	41.25	34.49
24-10	223.5	24.83	20.76	298.0	33.11	27.68	372.5	41.39	34.61
24-11	224.3	24.92	20.83	299.0	33.22	27.78	373.8	41.53	34.72
25-00	225.0	25.00	20.90	300.0	33.33	27.87	375.0	41.67	34.84
25-01	225.8	25.08	20.97	301.0	33.44	27.96	376.3	41.81	34.95
25-02	226.5	25.17	21.04	302.0	33.56	28.06	377.5	41.94	35.07
25-03	227.3	25.25	21.11	303.0	33.67	28.15	378.8	42.08	35.19
25-04	228.0	25.33	21.18	304.0	33.78	28.24	380.0	42.22	35.30
25-05	228.8	25.42	21.25	305.0	33.89	28.33	381.3	42.36	35.42
25-06	229.5	25.50	21.32	306.0	34.00	28.43	382.5	42.50	35.53
25-07	230.3	25.58	21.39	307.0	34.11	28.52	383.8	42.64	35.65
25-08	231.0	25.67	21.46	308.0	34.22	28.61	385.0	42.78	35.77
25-09	231.8	25.75	21.53	309.0	34.33	28.71	386.3	42.92	35.88
25-10	232.5	25.83	21.60	310.0	34.44	28.80	387.5	43.06	36.00
25-11	233.3	25.92	21.67	311.0	34.56	28.89	388.8	43.19	36.12

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
26-00	234.0	26.00	21.74	312.0	34.67	28.99	390.0	43.33	36.23
26-01	234.8	26.08	21.81	313.0	34.78	29.08	391.3	43.47	36.35
26-02	235.5	26.17	21.88	314.0	34.89	29.17	392.5	43.61	36.46
26-03	236.3	26.25	21.95	315.0	35.00	29.26	393.8	43.75	36.58
26-04	237.0	26.33	22.02	316.0	35.11	29.36	395.0	43.89	36.70
26-05	237.8	26.42	22.09	317.0	35.22	29.45	396.3	44.03	36.81
26-06	238.5	26.50	22.16	318.0	35.33	29.54	397.5	44.17	36.93
26-07	239.3	26.58	22.23	319.0	35.44	29.64	398.8	44.31	37.04
26-08	240.0	26.67	22.30	320.0	35.56	29.73	400.0	44.44	37.16
26-09	240.8	26.75	22.37	321.0	35.67	29.82	401.3	44.58	37.28
26-10	241.5	26.83	22.44	322.0	35.78	29.91	402.5	44.72	37.39
26-11	242.3	26.92	22.51	323.0	35.89	30.01	403.8	44.86	37.51
27-00	243.0	27.00	22.57	324.0	36.00	30.10	405.0	45.00	37.63
27-01	243.8	27.08	22.64	325.0	36.11	30.19	406.3	45.14	37.74
27-02	244.5	27.17	22.71	326.0	36.22	30.29	407.5	45.28	37.86
27-03	245.3	27.25	22.78	327.0	36.33	30.38	408.8	45.42	37.97
27-04	246.0	27.33	22.85	328.0	36.44	30.47	410.0	45.56	38.09
27-05	246.8	27.42	22.92	329.0	36.56	30.56	411.3	45.69	38.21
27-06	247.5	27.50	22.99	330.0	36.67	30.66	412.5	45.83	38.32
27-07	248.3	27.58	23.06	331.0	36.78	30.75	413.8	45.97	38.44
27-08	249.0	27.67	23.13	332.0	36.89	30.84	415.0	46.11	38.55
27-09	249.8	27.75	23.20	333.0	37.00	30.94	416.3	46.25	38.67
27-10	250.5	27.83	23.27	334.0	37.11	31.03	417.5	46.39	38.79
27-11	251.3	27.92	23.34	335.0	37.22	31.12	418.8	46.53	38.90
28-00	252.0	28.00	23.41	336.0	37.33	31.21	420.0	46.67	39.02
28-01	252.8	28.08	23.48	337.0	37.44	31.31	421.3	46.81	39.13
28-02	253.5	28.17	23.55	338.0	37.56	31.40	422.5	46.94	39.25
28-03	254.3	28.25	23.62	339.0	37.67	31.49	423.8	47.08	39.37
28-04	255.0	28.33	23.69	340.0	37.78	31.59	425.0	47.22	39.48
28-05	255.8	28.42	23.76	341.0	37.89	31.68	426.3	47.36	39.60
28-06	256.5	28.50	23.83	342.0	38.00	31.77	427.5	47.50	39.72
28-07	257.3	28.58	23.90	343.0	38.11	31.87	428.8	47.64	39.83
28-08	258.0	28.67	23.97	344.0	38.22	31.96	430.0	47.78	39.95
28-09	258.8	28.75	24.04	345.0	38.33	32.05	431.3	47.92	40.06
28-10	259.5	28.83	24.11	346.0	38.44	32.14	432.5	48.06	40.18
28-11	260.3	28.92	24.18	347.0	38.56	32.24	433.8	48.19	40.30
29-00	261.0	29.00	24.25	348.0	38.67	32.33	435.0	48.33	40.41
29-01	261.8	29.08	24.32	349.0	38.78	32.42	436.3	48.47	40.53
29-02	262.5	29.17	24.39	350.0	38.89	32.52	437.5	48.61	40.64
29-03	263.3	29.25	24.46	351.0	39.00	32.61	438.8	48.75	40.76
29-04	264.0	29.33	24.53	352.0	39.11	32.70	440.0	48.89	40.88
29-05	264.8	29.42	24.60	353.0	39.22	32.79	441.3	49.03	40.99
29-06	265.5	29.50	24.67	354.0	39.33	32.89	442.5	49.17	41.11
29-07	266.3	29.58	24.73	355.0	39.44	32.98	443.8	49.31	41.23
29-08	267.0	29.67	24.80	356.0	39.56	33.07	445.0	49.44	41.34
29-09	267.8	29.75	24.87	357.0	39.67	32.17	446.3	49.58	41.46
29-10	268.5	29.83	24.94	358.0	39.78	33.26	447.5	49.72	41.57
29-11	269.3	29.92	25.01	359.0	39.89	33.35	448.8	49.86	41.69

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
30-00	270.0	30.00	25.08	360.0	40.00	33.44	450.0	50.00	41.81
30-01	270.8	30.08	25.15	361.0	40.11	33.54	451.3	50.14	41.92
30-02	271.5	30.17	25.22	362.0	40.22	33.63	452.5	50.28	42.04
30-03	272.3	30.25	25.29	363.0	40.33	33.72	453.8	50.42	42.15
30-04	273.0	30.33	25.36	364.0	40.44	33.82	455.0	50.56	42.27
30-05	273.8	30.42	25.43	365.0	40.56	33.91	456.3	50.69	42.39
30-06	274.5	30.50	25.50	366.0	40.67	34.00	457.5	50.83	42.50
30-07	275.3	30.58	25.57	367.0	40.78	34.09	458.8	50.97	42.62
30-08	276.0	30.67	25.64	368.0	40.89	34.19	460.0	51.11	42.73
30-09	276.8	30.75	25.71	369.0	41.00	34.28	461.3	51.25	42.85
30-10	277.5	30.83	25.78	370.0	41.11	34.37	462.5	51.39	42.97
30-11	278.3	30.92	25.85	371.0	41.22	34.47	463.8	51.53	43.08
31-00	279.0	31.00	25.92	372.0	41.33	34.56	465.0	51.67	43.20
31-01	279.8	31.08	25.99	373.0	41.44	34.65	466.3	51.81	43.32
31-02	280.5	31.17	26.06	374.0	41.56	34.75	467.5	51.94	43.43
31-03	281.3	31.25	26.13	375.0	41.67	34.84	468.8	52.08	43.55
31-04	282.0	31.33	26.20	376.0	41.78	34.93	470.0	52.22	43.66
31-05	282.8	31.42	26.27	377.0	41.89	35.02	471.3	52.36	43.78
31-06	283.5	31.50	26.34	378.0	42.00	35.12	472.5	52.50	43.90
31-07	284.3	31.58	26.41	379.0	42.11	35.21	473.8	52.64	44.01
31-08	285.0	31.67	26.48	380.0	42.22	35.30	475.0	52.78	44.13
31-09	285.8	31.75	26.55	381.0	42.33	35.40	476.3	52.92	44.24
31-10	286.5	31.83	26.62	382.0	42.44	35.49	477.5	53.06	44.36
31-11	287.3	31.92	26.69	383.0	42.56	35.58	478.8	53.19	44.48
32-00	288.0	32.00	26.76	384.0	42.67	35.68	480.0	53.33	44.59
32-01	288.8	32.08	26.83	385.0	42.78	35.77	481.3	53.47	44.71
32-02	289.5	32.17	26.89	386.0	42.89	35.86	482.5	53.61	44.83
32-03	290.3	32.25	26.96	387.0	43.00	35.95	483.8	53.75	44.94
32-04	291.0	32.33	27.03	388.0	43.11	36.05	485.0	53.89	45.06
32-05	291.8	32.42	27.10	389.0	43.22	36.14	486.3	54.03	45.17
32-06	292.5	32.50	27.17	390.0	43.33	36.23	487.5	54.17	45.29
32-07	293.3	32.58	27.24	391.0	43.44	36.32	488.8	54.31	45.41
32-08	294.0	32.67	27.31	392.0	43.56	36.42	490.0	54.44	45.52
32-09	294.8	32.75	27.38	393.0	43.67	36.51	491.3	54.58	45.64
32-10	295.5	32.83	27.45	394.0	43.78	36.60	492.5	54.72	45.75
32-11	296.3	32.92	27.52	395.0	43.89	36.70	493.8	54.86	45.87
33-00	297.0	33.00	27.59	396.0	44.00	36.79	495.0	55.00	45.99
33-01	297.8	33.08	27.66	397.0	44.11	36.88	496.3	55.14	46.10
33-02	298.5	33.17	27.73	398.0	44.22	36.97	497.5	55.28	46.22
33-03	299.3	33.25	27.80	399.0	44.33	37.07	498.8	55.42	46.33
33-04	300.0	33.33	27.87	400.0	44.44	37.16	500.0	55.56	46.45
33-05	300.8	33.42	27.94	401.0	44.56	37.25	501.3	55.69	46.57
33-06	301.5	33.50	28.01	402.0	44.67	37.35	502.5	55.83	46.68
33-07	302.3	33.58	28.08	403.0	44.78	37.44	503.8	55.97	46.80
33-08	303.0	33.67	28.15	404.0	44.89	37.53	505.0	56.11	46.92
33-09	303.8	33.75	28.22	405.0	45.00	37.63	506.3	56.25	47.03
33-10	304.5	33.83	28.29	406.0	45.11	37.72	507.5	56.39	47.15
33-11	305.3	33.92	28.36	407.0	45.22	37.81	508.8	56.53	47.26

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
34-00	306.0	34.00	28.43	408.0	45.33	37.90	510.0	56.67	47.38
34-01	306.8	34.08	28.50	409.0	45.44	38.00	511.3	56.81	47.50
34-02	307.5	34.17	28.57	410.0	45.56	38.09	512.5	56.94	47.61
34-03	308.3	34.25	28.64	411.0	45.67	38.18	513.8	57.08	47.73
34-04	309.0	34.33	28.71	412.0	45.78	38.28	515.0	57.22	47.84
34-05	309.8	34.42	28.78	413.0	45.89	38.37	516.3	57.36	47.96
34-06	310.5	34.50	28.85	414.0	46.00	38.46	517.5	57.50	48.08
34-07	311.3	34.58	28.92	415.0	46.11	38.55	518.8	57.64	48.19
34-08	312.0	34.67	28.99	416.0	46.22	38.65	520.0	57.78	48.31
34-09	312.8	34.75	29.05	417.0	46.33	38.74	521.3	57.92	48.43
34-10	313.5	34.83	29.12	418.0	46.44	38.83	522.5	58.06	48.52
34-11	314.3	34.92	29.19	419.0	46.56	38.93	523.8	58.19	48.66
35-00	315.0	35.00	29.26	420.0	46.67	39.02	525.0	58.33	48.77
35-01	315.8	35.08	29.33	421.0	46.78	39.11	526.3	58.47	48.89
35-02	316.5	35.17	29.40	422.0	46.89	39.20	527.5	58.61	49.01
35-03	317.3	35.25	29.47	423.0	47.00	39.30	528.8	58.75	49.12
35-04	318.0	35.33	29.54	424.0	47.11	39.39	530.0	58.89	49.24
35-05	318.8	35.42	29.61	425.0	47.22	39.48	531.3	59.03	49.35
35-06	319.5	35.50	29.68	426.0	47.33	39.58	532.5	59.17	49.47
35-07	320.3	35.58	29.75	427.0	47.44	39.67	533.8	59.31	49.59
35-08	321.0	35.67	29.82	428.0	47.56	39.76	535.0	59.44	49.70
35-09	321.8	35.75	29.89	429.0	47.67	39.85	536.3	59.58	49.82
35-10	322.5	35.83	29.96	430.0	47.78	39.95	537.5	59.72	49.93
35-11	323.3	35.92	30.03	431.0	47.89	40.04	538.8	59.86	50.05
36-00	324.0	36.00	30.10	432.0	48.00	40.13	540.0	60.00	50.17
36-01	324.8	36.08	30.17	433.0	48.11	40.23	541.3	60.14	50.28
36-02	325.5	36.17	30.24	434.0	48.22	40.32	542.5	60.28	50.40
36-03	326.3	36.25	30.31	435.0	48.33	40.41	543.8	60.42	50.52
36-04	327.0	36.33	30.38	436.0	48.44	40.51	545.0	60.56	50.63
36-05	327.8	36.42	30.45	437.0	48.56	40.60	546.3	60.69	50.75
36-06	328.5	36.50	30.52	438.0	48.67	40.69	547.5	60.83	50.86
36-07	329.3	36.58	30.59	439.0	48.78	40.78	548.8	60.97	50.98
36-08	330.0	36.67	30.66	440.0	48.89	40.88	550.0	61.11	51.10
36-09	330.8	36.75	30.73	441.0	49.00	40.97	551.3	61.25	51.21
36-10	331.5	36.83	30.80	442.0	49.11	41.06	552.5	61.39	51.33
36-11	332.3	36.92	30.87	443.0	49.22	41.16	553.8	61.53	51.44
37-00	333.0	37.00	30.94	444.0	49.33	41.25	555.0	61.67	51.56
37-01	333.8	37.08	31.01	445.0	49.44	41.34	556.3	61.81	51.68
37-02	334.5	37.17	31.08	446.0	49.56	41.43	557.5	61.94	51.79
37-03	335.3	37.25	31.15	447.0	49.67	41.53	558.8	62.08	51.91
37-04	336.0	37.33	31.21	448.0	49.78	41.62	560.0	62.22	52.03
37-05	336.8	37.42	31.28	449.0	49.89	41.71	561.3	62.36	52.14
37-06	337.5	37.50	31.35	450.0	50.00	41.81	562.5	62.50	52.26
37-07	338.3	37.58	31.42	451.0	50.11	41.90	563.8	62.64	52.37
37-08	339.0	37.67	31.49	452.0	50.22	42.00	565.0	62.78	52.49
37-09	339.8	37.75	31.56	453.0	50.33	42.08	566.3	62.92	52.61
37-10	340.5	37.83	31.63	454.0	50.44	42.18	567.5	63.06	52.72
37-11	341.3	37.92	31.70	455.0	50.56	42.27	568.8	63.19	52.84

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
38-00	342.0	38.00	31.77	456.0	50.67	42.36	570.0	63.33	52.95
38-01	342.8	38.08	31.84	457.0	50.78	42.46	571.3	63.47	53.07
38-02	343.5	38.17	31.91	458.0	50.89	42.55	572.5	63.61	53.19
38-03	344.3	38.25	31.98	459.0	51.00	42.64	573.8	63.75	53.30
38-04	345.0	38.33	32.05	460.0	51.11	42.73	575.0	63.89	53.42
38-05	345.8	38.42	32.12	461.0	51.22	42.83	576.3	64.03	53.53
38-06	346.5	38.50	32.19	462.0	51.33	42.92	577.5	64.17	53.65
38-07	347.3	38.58	32.26	463.0	51.44	43.01	578.8	64.31	53.77
38-08	348.0	38.67	32.33	464.0	51.56	43.11	580.0	64.44	53.88
38-09	348.8	38.75	32.40	465.0	51.67	43.20	581.3	64.58	54.00
38-10	349.5	38.83	32.47	466.0	51.78	43.29	582.5	64.72	54.17
38-11	350.3	38.92	32.54	467.0	51.89	43.39	583.8	64.86	54.23
39-00	351.0	39.00	32.61	468.0	52.00	43.48	585.0	65.00	54.35
39-01	351.8	39.08	32.68	469.0	52.11	43.57	586.3	65.14	54.46
39-02	352.5	39.17	32.75	470.0	52.22	43.66	587.5	65.28	54.58
39-03	353.3	39.25	32.82	471.0	52.33	43.76	588.8	65.42	54.70
39-04	354.0	39.33	32.89	472.0	52.44	43.85	590.0	65.56	54.81
39-05	354.8	39.42	32.96	473.0	52.56	43.94	591.3	65.69	54.93
39-06	355.5	39.50	33.03	474.0	52.67	44.04	592.5	65.83	55.04
39-07	356.3	39.58	33.10	475.0	52.78	44.13	593.8	65.97	55.16
39-08	357.0	39.67	33.17	476.0	52.89	44.22	595.0	66.11	55.28
39-09	357.8	39.75	33.24	477.0	53.00	44.31	596.3	66.25	55.39
39-10	358.5	39.83	33.31	478.0	53.11	44.41	597.5	66.39	55.51
39-11	359.3	39.92	33.37	479.0	53.22	44.50	598.8	66.53	55.63
40-00	360.0	40.00	33.44	480.0	53.33	44.59	600.0	66.67	55.74
40-01	360.8	40.08	33.51	481.0	53.44	44.69	601.3	66.81	55.86
40-02	361.5	40.17	33.58	482.0	53.56	44.78	602.5	66.94	55.97
40-03	362.3	40.25	33.65	483.0	53.67	44.87	603.8	67.08	56.09
40-04	363.0	40.33	33.72	484.0	53.78	44.96	605.0	67.22	56.21
40-05	363.8	40.42	33.79	485.0	53.89	45.06	606.3	67.36	56.32
40-06	364.5	40.50	33.86	486.0	54.00	45.15	607.5	67.50	56.44
40-07	365.3	40.58	33.93	487.0	54.11	45.24	608.8	67.64	56.55
40-08	366.0	40.67	34.00	488.0	54.22	45.34	610.0	67.78	56.67
40-09	366.8	40.75	34.07	489.0	54.33	45.43	611.3	67.92	56.79
40-10	367.5	40.83	34.14	490.0	54.44	45.52	612.5	68.06	56.90
40-11	368.3	40.92	34.21	491.0	54.56	45.61	613.8	68.19	57.02
41-00	369.0	41.00	34.28	492.0	54.67	45.71	615.0	68.33	57.13
41-01	369.8	41.08	34.35	493.0	54.78	45.80	616.3	68.47	57.25
41-02	370.5	41.17	34.42	494.0	54.89	45.89	617.5	68.61	57.37
41-03	371.3	41.25	34.49	495.0	55.00	45.99	618.8	68.75	57.48
41-04	372.0	41.33	34.56	496.0	55.11	46.08	620.0	68.89	57.60
41-05	372.8	41.42	34.63	497.0	55.22	46.17	621.3	69.03	57.72
41-06	373.5	41.50	34.70	498.0	55.33	46.27	622.5	69.17	57.83
41-07	374.3	41.58	34.77	499.0	55.44	46.36	623.8	69.31	57.95
41-08	375.0	41.67	34.84	500.0	55.56	46.45	625.0	69.44	58.06
41-09	375.8	41.75	34.91	501.0	55.67	46.54	626.3	69.58	58.18
41-10	376.5	41.83	34.98	502.0	55.78	46.64	627.5	69.72	58.30
41-11	377.3	41.92	35.05	503.0	55.89	46.73	628.8	69.86	58.41

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
42-00	378.0	42.00	35.12	504.0	56.00	46.82	630.0	70.00	58.53
42-01	378.8	42.08	35.19	505.0	56.11	46.92	631.3	70.14	58.64
42-02	379.5	42.17	35.26	506.0	56.22	47.01	632.5	70.28	58.76
42-03	380.3	42.25	35.33	507.0	56.33	47.10	633.8	70.42	58.88
42-04	381.0	42.33	35.40	508.0	56.44	47.19	635.0	70.56	58.99
42-05	381.8	42.42	35.47	509.0	56.56	47.29	636.3	70.69	59.11
42-06	382.5	42.50	35.53	510.0	56.67	47.38	637.5	70.83	59.23
42-07	383.3	42.58	35.60	511.0	56.78	47.47	638.8	70.97	59.34
42-08	384.0	42.67	35.67	512.0	56.89	47.57	640.0	71.11	59.46
42-09	384.8	42.75	35.74	513.0	57.00	47.66	641.3	71.25	59.57
42-10	385.5	42.83	35.81	514.0	57.11	47.75	642.5	71.39	59.69
42-11	386.3	42.92	35.88	515.0	57.22	47.84	643.8	71.53	59.81
43-00	387.0	43.00	35.95	516.0	57.33	47.94	645.0	71.67	59.92
43-01	387.8	43.08	36.02	517.0	57.44	48.03	646.3	71.81	60.04
43-02	388.5	43.17	36.09	518.0	57.56	48.12	647.5	71.94	60.15
43-03	389.3	43.25	36.16	519.0	57.67	48.22	648.8	72.08	60.27
43-04	390.0	43.33	36.23	520.0	57.78	48.31	650.0	72.22	60.39
43-05	390.8	43.42	36.30	521.0	57.89	48.40	651.3	72.36	60.50
43-06	391.5	43.50	36.37	522.0	58.00	48.49	652.5	72.50	60.62
43-07	392.3	43.58	36.44	523.0	58.11	48.59	653.8	72.64	60.73
43-08	393.0	43.67	36.51	524.0	58.22	48.68	655.0	72.78	60.85
43-09	393.8	43.75	36.58	525.0	58.33	48.77	656.3	72.92	60.97
43-10	394.5	43.83	36.65	526.0	58.44	48.87	657.5	73.06	61.08
43-11	395.3	43.92	36.72	527.0	58.56	48.96	658.8	73.19	61.20
44-00	396.0	44.00	36.79	528.0	58.67	49.05	660.0	73.33	61.32
44-01	396.8	44.08	36.86	529.0	58.78	49.15	661.3	73.47	61.43
44-02	397.5	44.17	36.93	530.0	58.89	49.24	662.5	73.61	61.55
44-03	398.3	44.25	37.00	531.0	59.00	49.33	663.8	73.75	61.66
44-04	399.0	44.33	37.07	532.0	59.11	49.42	665.0	73.89	61.78
44-05	399.8	44.42	37.14	533.0	59.22	49.52	666.3	74.03	61.90
44-06	400.5	44.50	37.21	534.0	59.33	49.61	667.5	74.17	62.01
44-07	401.3	44.58	37.28	535.0	59.44	49.70	668.8	74.31	62.13
44-08	402.0	44.67	37.35	536.0	59.56	49.80	670.0	74.44	62.24
44-09	402.8	44.75	37.42	537.0	59.67	49.89	671.3	74.58	62.36
44-10	403.5	44.83	37.49	538.0	59.78	49.98	672.5	74.72	62.48
44-11	404.3	44.92	37.56	539.0	59.89	50.07	673.8	74.86	62.59
45-00	405.0	45.00	37.63	540.0	60.00	50.17	675.0	75.00	62.71
45-01	405.8	45.08	37.69	541.0	60.11	50.26	676.3	75.14	62.83
45-02	406.5	45.17	37.76	542.0	60.22	50.35	677.5	75.28	62.94
45-03	407.3	45.25	37.83	543.0	60.33	50.45	678.8	75.42	63.06
45-04	408.0	45.33	37.90	544.0	60.44	50.54	680.0	75.56	63.17
45-05	408.8	45.42	37.97	545.0	60.56	50.63	681.3	75.69	63.29
45-06	409.5	45.50	38.04	546.0	60.67	50.72	682.5	75.83	63.41
45-07	410.3	45.58	38.11	547.0	60.78	50.82	683.8	75.97	63.52
45-08	411.0	45.67	38.18	548.0	60.89	50.91	685.0	76.11	63.64
45-09	411.8	45.75	38.25	549.0	61.00	51.00	686.3	76.25	63.75
45-10	412.5	45.83	38.32	550.0	61.11	51.10	687.5	76.39	63.87
45-11	413.3	45.92	38.39	551.0	61.22	51.19	688.8	76.53	63.99

13.3.3 Computing Square Yards and Square Meters of Carpet—Continued

LENGTH	9 FEET			12 FEET			15 FEET		
FT. IN.	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M	SQ FT	SQ YDS	SQ M
46-00	414.0	46.00	38.46	552.0	61.33	51.28	690.0	76.67	64.10
46-01	414.8	46.08	38.53	553.0	61.44	51.37	691.3	76.81	64.22
46-02	415.5	46.17	38.60	554.0	61.56	51.47	692.5	76.94	64.33
46-03	416.3	46.25	38.67	555.0	61.67	51.56	693.8	77.08	64.45
46-04	417.0	46.33	38.74	556.0	61.78	51.65	695.0	77.22	64.57
46-05	417.8	46.42	38.81	557.0	61.89	51.75	696.3	77.36	64.68
46-06	418.5	46.50	38.88	558.0	62.00	51.84	697.5	77.50	64.80
46-07	419.3	46.58	38.95	559.0	62.11	51.93	698.8	77.64	64.92
46-08	420.0	46.67	39.02	560.0	62.22	52.03	700.0	77.78	65.03
46-09	420.8	46.75	39.09	561.0	62.33	52.12	701.3	77.92	65.15
46-10	421.5	46.83	39.16	562.0	62.44	52.21	702.5	78.06	65.26
46-11	422.3	46.92	39.23	563.0	62.56	52.30	703.8	78.19	65.38
47-00	423.0	47.00	39.30	564.0	62.67	52.40	705.0	78.33	65.50
47-01	423.8	47.08	39.37	565.0	62.78	52.49	706.3	78.47	65.61
47-02	424.5	47.17	39.44	566.0	62.89	52.58	707.5	78.61	65.73
47-03	425.3	47.25	39.51	567.0	63.00	52.68	708.8	78.75	65.84
47-04	426.0	47.33	39.58	568.0	63.11	52.77	710.0	78.89	65.92
47-05	426.8	47.42	39.65	569.0	63.22	52.86	711.3	79.03	66.08
47-06	427.5	47.50	39.72	570.0	63.33	52.95	712.5	79.17	66.19
47-07	428.3	47.58	39.79	571.0	63.44	53.05	713.8	79.31	66.30
47-08	429.0	47.67	39.85	572.0	63.56	53.14	715.0	79.44	66.43
47-09	429.8	47.75	39.92	573.0	63.67	53.23	716.3	79.58	66.54
47-10	430.5	47.83	39.99	574.0	63.78	53.33	717.5	79.72	66.66
47-11	431.3	47.92	40.06	575.0	63.89	53.42	718.8	79.86	66.77
48-00	432.0	48.00	40.13	576.0	64.00	53.51	720.0	80.00	66.89
48-01	432.8	48.08	40.20	577.0	64.11	53.60	721.3	80.14	67.01
48-02	433.5	48.17	40.27	578.0	64.22	53.70	722.5	80.28	67.12
48-03	434.3	48.25	40.34	579.0	64.33	53.79	723.8	80.42	67.24
48-04	435.0	48.33	40.41	580.0	64.44	53.88	725.0	80.56	67.35
48-05	435.8	48.42	40.48	581.0	64.56	53.98	726.3	80.69	67.47
48-06	436.5	48.50	40.55	582.0	64.67	54.07	727.5	80.83	67.59
48-07	437.3	48.58	40.62	583.0	64.78	54.16	728.8	80.97	67.70
48-08	438.0	48.67	40.69	584.0	64.89	54.25	730.0	81.11	67.82
48-09	438.8	48.75	40.76	585.0	65.00	54.35	731.3	81.25	67.93
48-10	439.5	48.83	40.83	586.0	65.11	54.44	732.5	81.39	68.05
48-11	440.3	48.92	40.90	587.0	65.22	54.53	733.8	81.53	68.17
49-00	441.0	49.00	40.97	588.0	65.33	54.63	735.0	81.67	68.28
49-01	441.8	49.08	41.04	589.0	65.44	54.72	736.3	81.81	68.40
49-02	442.5	49.17	41.11	590.0	65.56	54.81	737.5	81.94	68.52
49-03	443.3	49.25	41.18	591.0	65.67	54.91	738.8	82.08	68.63
49-04	444.0	49.33	41.25	592.0	65.78	55.00	740.0	82.22	68.75
49-05	444.8	49.42	41.32	593.0	65.89	55.09	741.3	82.36	68.86
49-06	445.5	49.50	41.39	594.0	66.00	55.18	742.5	82.50	68.98
49-07	446.3	49.58	41.46	595.0	66.11	55.28	743.8	82.64	69.10
49-08	447.0	49.67	41.53	596.0	66.22	55.37	745.0	82.78	69.21
49-09	447.8	49.75	41.60	597.0	66.33	55.46	746.3	82.92	69.33
49-10	448.5	49.83	41.67	598.0	66.44	55.56	747.5	83.06	69.44
49-11	449.3	49.92	41.74	599.0	66.56	55.65	748.8	83.19	69.56

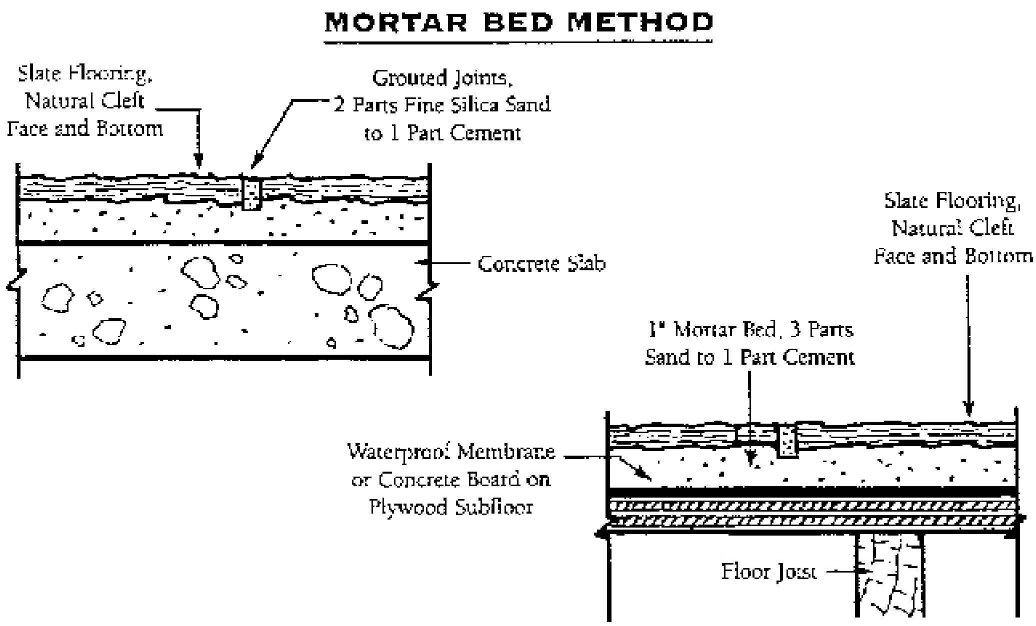
13.4.0 Seamless Flooring

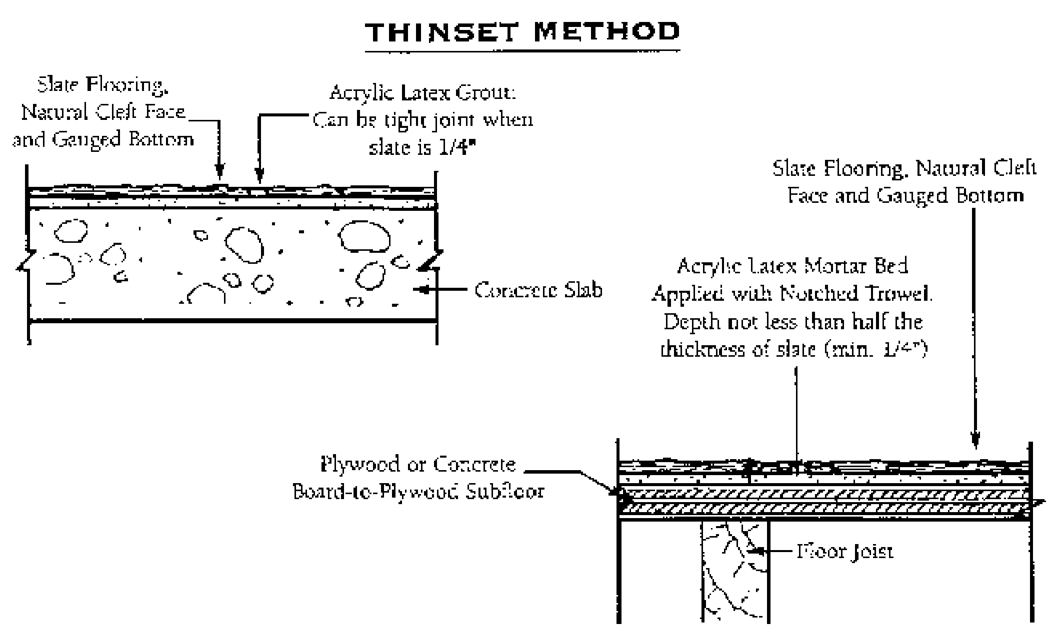
A monolithic surface containing a resin matrix, fillers, and a decorative topping. The thermosetting or thermoplastic matrix can be either an epoxy, one- or two-part polyester, one- or two-part polyurethane, or a one- or two-part neoprene (polychloroprene) material.

13.5.0 Stone Veneer Flooring

Various types of thin stone veneer flooring materials are available for installation over concrete or wood subfloors using a thin-set or mortar-bed installation process.

13.5.1 Thinset/Mortar-Bed Stone Veneer Installation Diagrammed





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13.6.0 Terrazzo Flooring

Derived from the Italian *terrace* or *terrazza*, this type of flooring is produced by embedding small pieces of marble in mortar. After curing, the surface is polished to a very smooth and shiny finish.

13.7.0 Terrazzo Floor Components

TERRAZZO: Derived from the Italian “Terrace” or “Terrazza” and by definition over the centuries: “A form of mosaic flooring made by embedding small pieces of marble in mortar and polishing.”

Today, the National Terrazzo and Mosaic Association (NTMA) defines this traditional material as follows; “Terrazzo consists of marble, granite, onyx or glass chips in portland cement, modified portland cement or resinous matrix. The terrazzo is poured, cured, ground, and polished. Typically used as a finish for floors, stairs or walls, Terrazzo can be poured in place or precast.”

“Rustic Terrazzo is a variation of where, in lieu of grinding and polishing, the surface is washed with water or otherwise treated to expose the chips. Quartz, quartzite, and river bed aggregates can also be used.”

“Mosaic is an artistic finish composed of small hand-cut pieces of smalti, glass, or marble called tessarae. The tessarae are mounted on paper by hand to form mosaic sheets. These sheets of mosaic are then set in mortar on the job site to create beautiful patterns, designs, and murals.”

MARBLE CHIPS: Marble has been defined as a metamorphic rock formed by the recrystallization of limestone. However, in recent decades, marble has been redefined to include all calcareous rocks capable of taking a polish (such as onyx, travertine, and attractive serpentine rocks). Marble is quarried, selected to avoid off color or contaminated material, crushed, and sized to yield marble chips for Terrazzo. Excellent domestic and imported marble chips are available for use in terrazzo in a wide range of colors and can be combined in infinite varieties to create color harmonies of every description.

MARBLE CHIP SIZES: Marble chips are graded by number according to size in accordance with standards adopted by producers as follows:

Number	Passes screen (in inches)	Retained on screen (in inches)
0	⅛	1⁄16
1	¼	⅛
2	⅜	¼
3	½	⅜
4	⅝	½
5	¾	⅝
6	⅞	¾
7	1	⅞
8	1⅛	1

CUSTOMARY SIZES FOR TOPPINGS:

1. Standard: No. 1 and 2.
2. Intermediate: No. 1, 2, 3, and 4.
3. Venetian: No. 1, 3, 4, 5, and 5; and/or 6, 7, and 8.
4. Resinous: (¼ inch thickness) No. 1 and 0.
5. Resinous: (⅜ inch thickness) No. 1, 2, and 0.

NOTE: Marble chip quarries normally produce 0, 1, and 2 as separate sizes. Larger sizes are frequently grouped; for example #3–4 mixed and #7–8 mixed, and #4–7 mixed. #00 chips (1⁄16 to 1⁄32 inch size) are available for use in industrial floors.

SELECTING MARBLE CHIPS: It is highly desirable that color combinations be designated by NTMA plate numbers (NTMA Color Plates). In the absence of NTMA color plates, it is important that the size and color combinations be shown due to price differentials.

MATRICES: The matrix is the ingredient in a terrazzo floor which acts as a binder to hold the chips in position. There are three basic type of matrices: cementitious, modified-cementitious and resinous.

CEMENTITIOUS MATRICES: Portland Cement provides a good background for marble chips. It can be tinted to produce various colors. White cement is color controlled during manufacture. Gray Portland Cement may not be color controlled. For use in terrazzo, portland cement should exceed the minimum standards of ASTM C-150.

MINERAL COLOR PIGMENTS: Interior: Shall not exceed two pound per bag of portland cement. Exterior: Pigment shall not exceed ½ pound per bag of Portland Cement.

MODIFIED CEMENTITIOUS MATRICES: Polyacrylate Modified Cement: A composition resinous material which has proven to be an excellent binder for use in thin-set terrazzo. Minimum physical properties are stipulated in Polyacrylate Terrazzo specification.

RESINOUS MATRICES—EPOXY OR POLYESTER: A two-component thermal setting resinous material which has proven to be an excellent binder for use in thin-set terrazzo. Minimum physical properties are stipulated in NTAM Terrazzo specifications.

DIVIDER STRIPS: White alloy of zinc, brass, or plastic are used for function and aesthetics. Brass and plastic may have a reaction with some resinous materials and should be used only if deemed safe by the supplier of the resin.

The following are the most common types of strips available (in some systems, the strips act as control joints).

> 1¼ inch Standard Divider Strip with anchoring device. Available in white alloy of zinc or brass and 14, 16, or 18 B & S gauge. Extensively used in Sand Cushion, Bonded to Concrete, Structural and other types of cementitious terrazzo systems. Also used in monolithic terrazzo where slab has been recessed or sawn to create a weakened vertical plane. Available in 1½ inch and greater depths for Venetian Terrazzo control joints and special conditions.
>
> 1¼ inch Heavy Top Divider Strips with anchoring device. Available in white alloy of zinc or galvanized steel bottom section. Top section available in white alloy of zinc, brass or colored plastic. Width of the top section is ⅛, ¼, ⅜, or ½ inch. Basic use is the same for the 1¼ inch Standard Divider Strip. (Some plastic strips are 3/16 inch and 5/16 inch instead of ⅛, ¼ and ½ inch).
>
> K or L Strips in standard gauges or with the heavy top feature for use in monolithic or resinous “thin-set” systems. Sizes vary according to the depth of the terrazzo topping. Can be attached to substrate with adhesive compatible with topping matrix.

CONTROL JOINTS: Double “L” strips (Angle strips) or straight strips positioned back to back are effective in allowing for anticipated shrinkage in the subfloor at construction joints. Double “L” (Angle strips) are used for Thin-set and Monolithic systems.

In Sand Cushion Terrazzo, the employment of the normal, single divider strips, regardless of the gauge inserted in the Sand Cushion underbed up to five feet or less on centers provides ample control of anticipated shrinkage that will take place when the terrazzo work is installed in accordance to these specifications as each divider picks up a minute amount of the contraction.

Construction joints in the structural slab have no bearing on the placement of divider strips in a Sand Cushion system due to the use of an isolation membrane.

NOTE: It is not this Association’s intent to make expansion joint recommendations. Architects should specify expansion joints and indicate locations and details on the project drawings.

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13.8.0 Resilient Flooring—Quality Control Checklist

Quality Control Checklist

Project no.

Section: **Resilient Flooring** No. **09651**

Date

1. Certificates, affidavits, etc., have been received.
2. Samples are on site, if required.
3. Type, pattern, and color of material is as approved.
4. Primer, adhesive, or cement is as required.
5. Base complies with approvals.
6. Containers labeled, sealed and unopened.
7. Boxes inspected for damage in transit.
8. Floor material is stored at proper temperature.
9. Preformed corners and end stops are proved.
10. Work is being installed in proper sequence with other trades.
11. All areas are cleaned before installation.
12. On slabs, surfaces are primed if required.
13. On slabs, moisture tests are performed if required.
14. Area temp maintained during and after installation.
15. Direction of tile is as specified.
16. Cement applied at proper rate and proper tackiness.
17. Joints and seams are tight and level.
18. Minimum length of pieces is observed.
19. Observe provisions are made for thresholds and joinings.
20. Observe level joining at electrical cover plates.
21. Excess adhesive removed after installation.
22. Scuffed, broken, or discolored tile is replaced.
23. Temporary protective cover is provided if required.
24. Subflooring has been prepared for receiving flooring.
25. Verify compatibility with floor hardener.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ______________________

13.9.0 Seamless Elastomeric Flooring—Quality Control Checklist

Quality
Control
Checklist

Project no.

Section
Seamless Elastomeric Flooring

No.
09701

Date

1. Approved submittals: shop drawings, samples, product data, certificates as required, are on site.
2. Statement of acceptance of contractor by manufacturer received.
3. Mock-up floor area approved.
4. Materials are properly stored on site and protected.
5. All materials furnished and approved types.
6. All accessory items furnished and approved types.
7. Observe coordination and scheduling with the work of related trades.
8. Environmental, climatic and temperature conditions are suitable.
9. Temporary protective wrappings provided at all materials adjacent to coatings operation.
10. Substrate conditions are as required.
11. Preparation of materials is as required.
12. Apply adhesion coat and reinforcing fabric as required.
13. Apply prime coats and sealer coats as required.
14. Install edging strips as required.
15. "Flood test" approved.
16. Conductive and nonsparking tests approved.
17. Repairs, replacement of seamless elastomeric flooring as required, performed.
18. Debris is removed periodically, not piled.
19. All coating—scattered surfaces cleaned.
20. Completed installation washed.
21. Flooring free from scratches.

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By ____________ ____________

Section

14

Painting

Contents

Although surface preparation is the key to the proper application of any paint, a wide range of commercially produced products are available for every functional and aesthetic purpose.

14.0.0 Generic Paint Formulations

Water-Based Coatings

The first water-based coating contained styrene or styrene butadiene and was known as *latex paint*. These paints were for interior use only, but over the years, acrylic or acrylic ester resins were developed for exterior use. Other water-based paints are alkyds, vinyl or polyvinyl acetates and cement-based coatings.

Acrylic coatings are available as either opaque (colored) or clear. Methyl methacrylate is often used as a clear coating for concrete to provide weathering protection.

Water-based coatings have higher permeability to water vapor, making them suitable for application over moist, porous surfaces, such as wood, concrete, and masonry.

Solvent-Based Coatings

These coatings can be purchased as either clear or opaque materials. Clear solvent-based coatings use drying oils mixed with a resin and are generally referred to as varnishes. Various clear coatings may contain:

- *Phenolics* Present good water and weathering characteristics. When mixed with tung oil, these varnishes are most durable for marine use. However, the relative dark color tends to darken with age and might preclude its use in some areas.
- *Shellacs* Shellac is a resin dissolved in spirit varnish, a volatile solvent. This coating is more often used as a sealer under a more-durable top coat.
- *Lacquers* Cellulose derivations in volatile spirits. They have some application in interior use, particularly for aesthetic considerations.
- *Silicon resins in a solvent solution of mineral spirits* This was once widely used as a masonry sealer. With a life span of 5 to 10 years, this coating has largely been replaced by acrylic coatings with a considerably longer life span.
- *Urethane* This is a one- or two-component, moisture-cured, solvent-based formulation with superior wear-resistance characteristics.

Opaque solvent-based coatings use alkyds as their principal binder and are available either water- or solvent-dispersed. When combined with an oil vehicle, these alkyd-oil coatings can be formulated to produce a flat, semigloss or gloss finish that is fast drying, flexible, durable, chalk resistant, and exhibits good color retention.

These coatings are not compatible with previous coatings that contain either lead or zinc. Alkyd-based paints could not be used to encapsulate lead-based paint because the new application will most likely cause blistering or peeling.

Chlorinated rubber coatings have good resistance to microorganisms, resistance to alkalis and acids, and low permeability to water and water vapor.

Chlorosulfonated polyethylene coatings are resistant to chlorine, bromine, oxygen, ozone, and ultraviolet radiation.

Expoxy-ester coatings are made of epoxy resins and drying oils. These coatings exhibit resistance to chemical fumes and the marine environment. The polyamide-cured type is very abrasion resistant and will tolerate repeated scrubbing and washings. Bitumen epoxy coatings (both coal tar and asphalt types) are generally used for heavy-duty immersion service, such as below-grade structural steel, and underground tank and pipe coatings.

14.1.0 Special-Purpose Coatings

- Fire retardant or intumescent coatings.
- Reflective coatings to absorb the ultraviolet band of solar radiation and reflect it as visible light.
- Bituminous coatings of either water-based emulsions or solvent cut-back coal tar pitch or asphalt materials.

14.2.0 Coating Specifications for Normal Exposures (Exterior)

This table will help the specification writer select the best detailed specifications for normal exposures such as schools, hotels, apartments, stores, etc., as well as light, moderate, and heavy duty industrial specifications. It has been designed from the specification writer's point of view; starting with the information the specifier has—the material and the surface. The specifier can choose the coating's generic type, the finish desired, the surface preparation necessary, the appropriate primer, and the number of topcoats necessary to achieve a satisfactory coating system. Surface preparations shown are minimums and should be upgraded if necessary because of the service or environmental conditions.

Note: standard alkyd and epoxy coatings will chalk on exterior exposure.

Substrate/Area	Topcoat: Vehicle	Topcoat: Finish	Surface Preparation	Specifications for Normal Exposures: Primers & Topcoats	Minimum dft: Mils	Minimum dft: Microns	Product: Series	Product: Page
Exterior Painting Recommendations—Normal Exposure								
drywall — exterior								
Drywall	acrylic latex	primer	S-W 8 or 12	1 ct: A-100 Exterior Latex Wood Primer	1.4	35	B42	27
		flat		2 cts: A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts: LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts: A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts: LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts: A-100 Exterior Latex Gloss	1.3	32	A8	26
masonry and cementitious surfaces								
Siding, Shingles	acrylic latex	primer	S-W 2, 4, 22, or 12	1 ct: A-100 Exterior Latex Wood Primer	1.4	35	B42	27
		flat		2 cts: A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts: LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts: A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts: LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts: A-100 Exterior Latex Gloss	1.3	32	A8	26
Concrete Masonry Units	latex	filler	S-W 3 or 12 or 12	1 ct: ProMar Interior/Exterior Latex Block Filler	8.0	200	B25	121
	acrylic latex	flat		2 cts: A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts: LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts: A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts: LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts: A-100 Exterior Latex Gloss	1.3	32	A8	26
Concrete, Stucco, Brick	acrylic latex	primer	S-W 5, 22, 4, or 12	1 ct: Loxon Exterior Acrylic Masonry Primer, or	3.1	77	A24	92
	alkyd	primer		1 ct: ProMar Masonry Conditioner	2.2	55	B46	122
	acrylic latex	flat		2 cts: Loxon Exterior Acrylic Masonry Coating, or	3.6	90	A24	92
		flat		2 cts: A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts: LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts: A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts: LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts: A-100 Exterior Latex Gloss	1.3	32	A8	26
	alkyd	primer	S-W 5, 22, 4, or 12	1 ct: ProMar Masonry Conditioner	2.2	55	B46	122
		gloss		2 cts: SWP Exterior Gloss Oil Base Paint	2.1	70	A2	30
Cementitious Hardboard	acrylic latex	primer	S-W 6 or 12	1 ct: Loxon Exterior Acrylic Masonry Primer	3.1	77	A24	92
		flat		2 cts: Loxon Exterior Acrylic Masonry Coating, or	3.6	90	A24	92
		flat		2 cts: A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts: LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts: A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts: LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts: A-100 Exterior Latex Gloss	1.3	32	A8	26
Concrete	acrylic stain or sealer	flat	S-W 5 or 12	1-2 cts: H&C Shield Plus Concrete Stain	none	none	-	74
Concrete	water repellent	none	S-W 5 or 12	1-2 cts: H&C HS-100 or HB-150 Water Repellent	none	none	-	73

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14.2.0 Coating Specifications for Normal Exposures (Exterior)—Continued

Substrate/Area	Topcoat Vehicle	Topcoat Finish	Surface Preparation	Primers & Topcoats		Minimum dft/ct Mils	Minimum dft/ct Microns	Product Series	Product Page
Exterior Painting Recommendations—Normal Exposure									
metal									
Aluminum Siding and trim	acrylic latex	flat	S-W 1 or 12	2 cts:	A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts:	LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts:	A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts:	LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts:	A-100 Exterior Latex Gloss	1.3	32	A8	26
Aluminum	acrylic	primer	SSPC-SP1	1 ct:	DTM Wash Primer	1.0	25	B66	59
	oleoresinous	aluminum		2 cts:	Silver-Brite Aluminum, B59S11	1.0	25	B59	130
Iron and Steel	alkyd	primer	SSPC-SP2	1 ct:	Kem Bond HS Universal Primer, or	5.0	125	B50	84
	acrylic latex			1 ct:	DTM Acrylic Primer/Finish	2.5	62	B66	57
		flat		2 cts:	A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts:	LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts:	A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts:	LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts:	A-100 Exterior Latex Gloss	1.3	32	A8	26
	alkyd	primer	SSPC-SP2	1 ct:	Kem Bond HS Universal Primer	5.0	125	B50	84
	oleoresinous	aluminum		2 cts:	Silver-Brite Aluminum, B59S11	1.0	25	B59	130
				2 cts:	Silver-Brite Rust Resistant Aluminum, B59S2	1.0	25	B59	131
Galvanized	acrylic latex	primer	SSPC-SP1	1 ct:	DTM Acrylic Primer/Finish (optional)	2.5	62	B66	57
		flat		2 cts:	A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts:	LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts:	A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts:	LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts:	A-100 Exterior Latex Gloss	1.3	32	A8	26
	acrylic	primer	SSPC-SP1	1 ct:	Galvite HS Primer	3.0	75	B50	72
	oleoresinous	aluminum		2 cts:	Silver-Brite Aluminum, B59S11	1.0	25	B59	130
wood									
Siding and Trim Paint	alkyd	primer	S-W 23 or 12	1 ct:	A-100 Exterior Oil Wood Primer	2.3	57	Y24	27
	acrylic latex			1 ct:	A-100 Exterior Latex Wood Primer	1.4	35	B42	27
		flat		2 cts:	A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts:	LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts:	A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts:	LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts:	A-100 Exterior Latex Gloss	1.3	32	A8	26
	alkyd	primer	S-W 23 or 12	1 ct:	A-100 Exterior Oil Wood Primer	2.3	57	Y24	27
		gloss		2 cts:	SWP Exterior Gloss Oil Base Paint	2.1	70	A2	139
Siding and Trim Stain	acrylic	stain—solid color	S-W 23 or 12	2 cts:	WoodScapes Solid Color Stain	2.0	50	A15	147
	polyurethane	stain—semi-transparent		2 cts:	WoodScapes Semi-Transparent	none	none	A15	146
Plywood Paint	acrylic latex	primer	S-W 23 or 12	1 ct:	A-100 Exterior Latex Wood Primer	1.4	35	B42	27
		flat		2 cts:	A-100 Exterior Latex Flat, or	1.3	32	A6	26
				2 cts:	LowTemp 35 Exterior Latex Flat, or	1.5	37	B15	91
		satin		2 cts:	A-100 Exterior Latex Satin, or	1.3	32	A82	26
				2 cts:	LowTemp 35 Exterior Latex Satin, or	1.3	32	B17	91
		semi-gloss		2 cts:	A-100 Exterior Latex Gloss	1.3	32	A8	26
Plywood Stain	acrylic	stain—solid color	S-W 23 or 12	2 cts:	WoodScapes Solid Color Stain	2.0	50	A15	147
	polyurethane	stain—semi-transparent		2 cts:	WoodScapes Semi-Transparent	none	none	A15	146

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14.2.0 Coating Specifications for Normal Exposures (Exterior)—Continued

Substrate/Area	Topcoat Vehicle	Topcoat Finish	Specifications for Normal Exposures: Surface Preparation	Specifications for Normal Exposures: Primers & Topcoats	Minimum dft/ct Mils	Minimum dft/ct Microns	Product Series	Product Page
Exterior Painting Recommendations—Normal Exposure								
wood								
	alkyd	varnish	S-W 23 or 12	2-3 cts: Exterior Varnish	1.8	45	A67	70
	alkyd	clear	S-W 23 or 12	1-2 cts: Cuprinol Clear Wood Preservative, or 1-2 cts: Cuprinol Clear Deck & Wood Seal	none none	none none	- -	52 50
	alkyd	clear	S-W 23 or 12	1-2 cts: Cuprinol Clear Deck & Siding Finish, or 1-2 cts: Cuprinol Clear Deck & Wood Seal	none none	none none	- -	51 50
	acrylic	flat	S-W 23 or 12	1-2 cts: Cuprinol Solid Color Deck Stain	2.0	50	-	53
vinyl siding								
Residential Siding	acrylic latex	flat satin semi-gloss	S-W 23 or 12	2 cts: A-100 Exterior Latex Flat, or 2 cts: LowTemp 35 Exterior Latex Flat, or 2 cts: A-100 Exterior Latex Satin, or 2 cts: LowTemp 35 Exterior Latex Satin, or 2 cts: A-100 Exterior Latex Gloss	1.3 1.5 1.3 1.3 1.3	32 37 32 32 32	A6 B15 A82 B17 A8	26 91 26 91 26
elastomeric coating systems — exterior								
Concrete, Stucco, Masonry	acrylic elastomeric	primer flat	S-W 5, 22	1 ct: Loxon Exterior Acrylic Masonry Primer 2 cts: Elastomeric Coating	3.1 4.8	77 120	A24 A5	92 60

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14.3.0 Coatings Specifications for Interior Surfaces

acoustical tiles									
Perforated Fiberboard	latex	primer	S-W 8 or 12	1 ct:	ProMar 200 or 400 Latex Wall Primer	1.1	27	B28	118
		flat		2 cts:	ProMar 200 or 400 Int. Latex Flat Wall Paint, or	1.4	35	B30	114
	alkyd	flat		2 cts:	ProMar 200 Int. Alkyd Flat Wall Paint	1.8	45	B32	109
Metal Pan Tiles	alkyd	primer	S-W 8 or 12	1 ct:	Wall & Wood Primer	1.6	40	B49	143
	latex	flat		2 cts:	ProMar 200 or 400 Int. Latex Flat Wall Paint, or	1.4	35	B30	114
	alkyd	flat		2 cts:	ProMar 200 Int. Alkyd Flat Wall Paint	1.8	45	B32	109
drywall— interior									
Gypsum Board, Plaster Board	latex	primer	S-W 8 or 12	1 ct:	ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct:	ProMar 200 or 400 Latex Wall Primer	1.1	27	B28	118
		flat		2 cts:	ProMar 200 or 400 Int. Latex Flat Wall Paint, or	1.4	35	B30	114
		eg-shel		2 cts:	ProMar 200 or 400 Int. Latex Eg-Shel, or	1.6	40	B20	115
		semi-gloss		2 cts:	ProClassic Waterborne Semi-Gloss Enamel, or	1.3	32	B31	108
				2 cts:	ProMar 200 or 400 Int. Latex Semi-Gloss, or	1.3	32	B31	116
		gloss		2 cts:	ProClassic Waterborne Gloss Enamel, or	1.3	32	B21	108
				2 cts:	ProMar 200 Int. Latex Gloss Enamel	1.5	37	B21	117
	latex texture	texture	S-W 8 or 12		Mixture of 1 gallon of ProMar Interior/Exterior Block	N/A	N/A	B25	121
					Filler and 1 gallon of ProMar 200 or 400 Latex Flat	N/A	N/A	B30	114
	latex	primer	S-W 8 or 12	1 ct:	ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct:	ProMar 200 or 400 Latex Wall Primer	1.1	27	B28	2118
	alkyd	flat		2 cts:	ProMar 200 Int. Alkyd Flat, or	1.8	45	B32	109
		eg-shel		2 cts:	ProMar 200 Int. Alkyd Eg-Shel, or	1.8	45	B33	110
		semi-gloss		2 cts:	ProClassic Interior Alkyd Semi-Gloss, or			B34	107
				2 cts:	ProClassic HS Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts:	ProMar 200 or 400 Int. Alkyd Semi-Gloss, or	1.7	42	B34	111
		gloss		2 cts:	ProMar 200 Int. Alkyd Gloss Enamel	1.6	40	B35	112

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14.3.0 Coatings Specifications for Interior Surfaces—Continued

Substrate/Area	Topcoat		Specifications for Normal Exposures		Minimum dft/ct		Product	
	Vehicle	Finish	Surface Preparation	Primers & Topcoats	Mils	Microns	Series	Page
Interior Painting Recommendations—Normal Exposure								
drywall—interior, continued								
Stain resistant topcoat	latex	primer	S-W 8 or 12	1 ct: ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct: ProMar 200 Interior Latex Wall Primer	1.1	27	B28	116
	acrylic	flat		2 cts: EverClean Interior Latex Flat, or	1.7	42	A96	69
		satin		2 cts: EverClean Interior Latex Satin, or	1.7	42	A97	69
		semi-gloss		2 cts: EverClean Interior Latex Semi-Gloss	1.3	32	A98	69
Low odor finishes	latex	primer	S-W 8 or 12	1 ct: HealthSpec Low Odor Int. Latex Primer	1.0	25	B11	76
	acrylic	flat		2 cts: HealthSpec Low Odor Int. Latex Flat, or	1.5	37	B5	75
		eg-shel		2 cts: HealthSpec Low Odor Int. Latex Eg-Shel, or	1.5	37	B9	75
		semi-gloss		2 cts: HealthSpec Low Odor Int. Latex Semi-Gloss	1.5	37	B10	75
Ceilings	latex	primer	S-W 8 or 12	1 ct: ProMar 200 Interior Latex Wall Primer	1.1	27	B28	116
	alkyd	flat		1 ct: Super Save Lite Hi-Tec Dryfall	2.0	50	B48	137
				1 ct: Dry Fall Flat White, or	4.0	100	B48	55
				1 ct: Super Save Lite Flat, or	3.0	75	B48	136
		semi-gloss		1 ct: Super Save Lite Semi-Gloss, or	3.0	75	B47	136
		gloss		1 ct: Super Save Lite Gloss	2.0	50	B47	136
masonry and cementitious surfaces								
Concrete, CMU Cement Board Block, Brick (unglazed)	latex	primer	S-W 5, 3, 4, or 12	1 ct: Loxon Interior Acrylic Masonry Primer, or	3.0	75	B28	93
		filler		1 ct: ProMar Interior/Exterior Block Filler	8.0	200	B25	121
		flat		2 cts: ProMar 200 or 400 Int. Latex Flat, or	1.4	35	B30	114
		eg-shel		2 cts: ProMar 200 or 400 Int. Latex Eg-Shel, or	1.6	40	B20	115
		semi-gloss		2 cts: ProClassic Waterborne Semi-Gloss Enamel, or	1.3	32	B31	106
				2 cts: ProMar 200 or 400 Int. Latex Semi-Gloss, or	1.3	32	B31	116
		gloss		2 cts: ProClassic Waterborne Gloss Enamel	1.3	32	B21	106
	latex	primer	S-W 5, 3, 4,	1 ct: ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct: ProMar 200 or 400 Latex Wall Primer, or	1.1	27	B28	116
		filler	or 12	1 ct: ProMar Interior/Exterior Block Filler	8.0	200	B25	121
	alkyd	flat		2 cts: ProMar 200 Int. Alkyd Flat, or	1.8	45	B32	109
		eg-shel		2 cts: ProMar 200 Int. Alkyd Eg-Shel, or	1.8	45	B33	110
		semi-gloss		2 cts: ProClassic Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts: ProClassic HS Interior Alkyd Semi-Gloss, or	2.3	57	B34	107
				2 cts: ProMar 200 or 400 Int. Alkyd Semi-Gloss, or	1.7	42	B34	111
		gloss		2 cts: ProMar 200 Int. Alkyd Gloss Enamel	1.6	40	B35	112
Low odor finishes	latex	primer	S-W 5, 3, 4,	1 ct: HealthSpec Low Odor Int. Latex Primer	1.0	25	B11	76
	acrylic	flat		2 cts: HealthSpec Low Odor Int. Latex Flat, or	1.5	37	B5	75
		eg-shel	or 12	2 cts: HealthSpec Low Odor Int. Latex Eg-Shel, or	1.5	37	B9	75
		semi-gloss		2 cts: HealthSpec Low Odor Int. Latex Semi-Gloss	1.5	37	B10	75
Concrete Floors	acrylic	gloss	S-W 5	1-2 cts: H&C Shield Plus Concrete Stain	none	none		74
metal								
Aluminum	acrylic	primer	S-W 1 or 12	1 ct: DTM Acrylic Primer/Finish	2.5	62	B66	57
	latex	flat		2 cts: ProMar 200 or 400 Int. Latex Flat, or	1.4	35	B30	114
		eg-shel		2 cts: ProMar 200 or 400 Int. Latex Eg-Shel, or	1.6	40	B20	114
		semi-gloss		2 cts: ProClassic Waterborne Semi-Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 or 400 Int. Latex Semi-Gloss, or	1.3	32	B31	116
		gloss		2 cts: ProClassic Waterborne Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 Int. Latex Gloss Enamel	1.5	37	B21	117
	acrylic	primer	S-W 1 or 12	1 ct: DTM Acrylic Primer/Finish	2.5	62	B66	57
	alkyd	flat		2 cts: ProMar 200 Int. Alkyd Flat, or	1.8	45	B32	109
		eg-shel		2 cts: ProMar 200 Int. Alkyd Eg-Shel, or	1.8	45	B33	110
		semi-gloss		2 cts: ProClassic HS Interior Alkyd Semi-Gloss, or	2.3	57	B34	107
				2 cts: ProClassic Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts: ProMar 200 or 400 Int. Alkyd Semi-Gloss, or	1.7	42	B34	111
		gloss		2 cts. ProMar 200 Int. Alkyd Gloss Enamel	1.6	40	B35	112

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14.3.0 Coatings Specifications for Interior Surfaces—Continued

Substrate/Area	Topcoat: Vehicle	Topcoat: Finish	Specifications for Normal Exposures: Surface Preparation	Specifications for Normal Exposures: Primers & Topcoats	Minimum/Ct: Mils	Minimum/Ct: Microns	Product: Series	Product: Page
Interior Painting Recommendations—Normal Exposure								
metal, continued								
Galvanized Steel	acrylic latex	primer	S-W 1 or 12	1 ct: DTM Acrylic Primer/Finish	2.5	62	B66	57
		flat		2 cts: ProMar 200 or 400 Int. Latex Flat, or	1.4	35	B30	114
		eg-shel		2 cts: ProMar 200 or 400 Int. Latex Eg-Shel, or	1.6	40	B20	115
		semi-gloss		2 cts: ProClassic Waterborne Semi-Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 or 400 Int. Latex Semi-Gloss, or	1.3	32	B31	116
		gloss		2 cts: ProClassic Waterborne Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 Int. Latex Gloss Enamel	1.5	37	B21	117
Galvanized Steel	acrylic alkyd	primer	S-W 1 or 12	1 ct: Galvite HS Primer	3.0	75	B50	72
		flat		2 cts: ProMar 200 Int. Alkyd Flat, or	1.8	45	B32	109
		eg-shel		2 cts: ProMar 200 Int. Alkyd Eg-Shel, or	1.8	45	B33	110
		semi-gloss		2 cts: ProClassic HS Interior Alkyd Semi-Gloss, or	2.3	57	B34	107
				2 cts: ProClassic Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts: ProMar 200 or 400 Int. Alkyd Semi-Gloss, or	1.7	42	B34	111
		gloss		2 cts: ProMar 200 Int. Alkyd Gloss Enamel	1.6	40	B35	112
Steel and Iron	acrylic alkyd latex	primer	S-W 14 or 12	1 ct: DTM Acrylic Primer/Finish, or	2.5	62	B66	57
		primer		1 ct: Kem Kromik Universal Metal Primer	3.0	75	B50	89
		flat		2 cts: ProMar 200 or 400 Int. Latex Flat, or	1.4	35	B30	114
		eg-shel		2 cts: ProMar 200 or 400 Int. Latex Eg-Shel, or	1.6	40	B20	115
		semi-gloss		2 cts: ProClassic Waterborne Semi-Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 or 400 Int. Latex Semi-Gloss, or	1.3	32.5	B31	116
		gloss		2 cts: ProClassic Waterborne Gloss Enamel, or	1.3	32	B31	108
				2 cts: ProMar 200 Int. Latex Gloss Enamel	1.5	37.5	B21	117
	alkyd	primer	S-W 14 or 12	1 ct: Kem Bond HS Universal Primer	5.0	125	B50	84
		flat		2 cts: ProMar 200 Int. Alkyd Flat, or	1.8	45.0	B32	109
		eg-shel		2 cts: ProMar 200 Int. Alkyd Eg-Shel, or	1.8	45.0	B33	110
		semi-gloss		2 cts: ProClassic HS Interior Alkyd Semi-Gloss, or	2.3	57	B34	107
				2 cts: ProClassic Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts: ProMar 200 Int. Alkyd Semi-Gloss, or	1.7	42.5	B34	111
				2 cts: ProMar 400 Int. Alkyd Semi-Gloss, or	1.6	40.0	B34	111
		gloss		2 cts: ProMar 200 Int. Alkyd Gloss Enamel	1.6	40.0	B35	112
	alkyd	primer	S-W 14 or 12	1 ct: Kem Bond HS Universal Metal Primer	2.0	50	B50	84
		aluminum		2 cts: Silver-Brite Aluminum, B59S11, or	1.0	25	B59	130
				2 cts: Silver-Brite Rust Resistant Aluminum, B59S2	1.0	25	B59	130
wood								
Walls, Trim, Doors Windows, Ceilings	alkyd	primer	S-W 24 or 12	1 ct: ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct: ProMar 200 Interior Enamel Undercoater, or	1.9	47	B49	113
				1 ct: Wall and Wood Primer	1.6	40	B49	143
		flat		2 cts: ProMar 200 Interior Alkyd Flat, or	1.8	45	B32	109
		eg-shel		2 cts: ProMar 200 Interior Alkyd Eg-Shel, or	1.8	45	B33	110
		semi-gloss		2 cts: ProClassic HS Interior Alkyd Semi-Gloss, or	2.3	57	B34	107
				2 cts: ProClassic Interior Alkyd Semi-Gloss, or	1.7	42	B34	107
				2 cts: ProMar 200 Interior Alkyd Semi-Gloss, or	1.7	42	B34	111
				2 cts: ProMar 400 Interior Alkyd Semi-Gloss, or	1.6	40	B34	111
		gloss		2 cts: ProMar 200 Interior Alkyd Gloss	1.6	40	B35	112
	alkyd	primer	S-W 24 or 12	1 ct: ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct: ProMar 200 Interior Enamel Undercoater, or	1.9	47	B49	113
				1 ct: Wall and Wood Primer	1.6	40	B49	143
	latex	flat		2 cts: ProMar 200 or 400 Interior Latex Flat, or	1.4	35	B30	114
		eg-shel		2 cts: ProMar 200 or 400 Interior Latex Eg-Shel, or	1.6	40	B20	115
		semi-gloss		2 cts: ProClassic Waterborne Latex Semi-Gloss, or	1.3	32	B31	108
				2 cts: ProMar 200 or 400 Interior Latex Semi-Gloss, or	1.3	32	B31	116
		gloss		2 cts: ProMar 200 Interior Latex Gloss Enamel	1.5	37	B21	117

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14.3.0 Coatings Specifications for Interior Surfaces—Continued

Substrate/Area	Topcoat Vehicle	Topcoat Finish	Specifications for Normal Exposures: Surface Preparation	Primers & Topcoats		Minimum dft: Mils	Minimum dft: Microns	Product Series	Product Page
Interior Painting Recommendations—Normal Exposure									
wood, continued									
Stain resistant topcoat	latex	primer	S-W 24 or 12	1 ct:	ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct:	ProMar 200 Interior Latex Wall Primer	1.1	27	B28	118
	acrylic	flat		2 cts:	EverClean Interior Latex Flat	1.7	42	A96	69
		satin		2 cts:	EverClean Interior Latex Satin	1.7	42	A97	69
		semi-gloss		2 cts:	EverClean Interior Latex Semi-Gloss	1.3	32	A98	69
Low odor finishes	latex	primer	S-W 24 or 12	1 ct:	HealthSpec Low Odor Int. Latex Primer	1.0	25	B11	76
	acrylic	flat		2 cts:	HealthSpec Low Odor Int. Latex Flat, or	1.5	37	B5	75
		eg-shel		2 cts:	HealthSpec Low Odor Int. Latex Eg-Shel, or	1.5	37	B9	75
		semi-gloss		2 cts:	HealthSpec Low Odor Int. Latex Semi-Gloss	1.5	37	B10	75
Ceilings	alkyd	primer	S-W 24 or 12	1 ct:	ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct:	ProMar 200 Interior Enamel Undercoater, or	1.9	47	B49	113
				1 ct:	Wall and Wood Primer	1.6	40	B49	143
		flat		1 ct:	Super Save Lite Hi-Tec Dryfall	2.0	50	B48	137
				1 ct:	Dry Fall Flat White, or	4.0	100	B48	55
				1 ct:	Super Save Lite Flat, or	3.0	75	B48	136
		semi-gloss		1 ct:	Super Save Lite Semi-Gloss, or	3.0	75	B47	136
		gloss		1 ct:	Super Save Lite Gloss	2.0	50	B47	136
	alkyd	primer	S-W 24 or 12	1 ct:	ProMar Classic Latex Primer, or	1.6	40	B28	119
				1 ct:	ProMar 200 Interior Enamel Undercoater, or	1.9	47	B49	113
				1 ct:	Wall and Wood Primer	1.6	40	B49	143
	acrylic	flat		1-2 cts:	Waterborne Acrylic Dryfall Flat	4.0	100	B42	145
		eg-shel		1-2 cts:	Waterborne Acrylic Dryfall Eg-Shel	4.0	100	B42	145
Clear Finishes Varnishes	alkyd	stain	S-W 24 or 12	1 ct:	Oil Stain (omit if clear finish is desired)	none	none	A48	101
		sealer		1 ct:	ProMar Varnish Sanding Sealer (optional)	1.0	25	B26	123
		satin		2 cts:	Oil Base Varnish, Satin, or	1.3	32	A66	100
		gloss		2 cts:	Oil Base Varnish, Gloss	1.3	32	A66	100
	alkyd	stain	S-W 24 or 12	1 ct:	Oil Stain (omit if clear finish is desired)	none	none	A48	101
	polyurethane	satin		2 cts:	Polyurethane Varnish, Satin, or	1.7	42	A67	105
		gloss		2 cts:	Polyurethane Varnish, Gloss	1.7	42	A67	105
Floors	alkyd	gloss	S-W 24 or 12	1 ct:	Oil Stain (omit if clear finish is desired)	none	none	A48	101
	alkyd			2 cts:	Oil Base Varnish, or	1.3	32	A66	100
	polyurethane			2 cts:	Polyurethane Varnish	1.7	42	A67	105

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14.4.0 Specifications for Industrial Exposure (Light/Moderate Duty)

Substrate/Area	Topcoat Vehicle	Topcoat Finish	Surface Preparation	Specifications for Normal Exposures: Primers & Topcoats		Minimum dft Mils	Minimum dft Microns	Product Series	Product Page
steel and iron									
walls, joists, trim, doors, ducts, vents, structural Items, miscellaneous	acrylic	primer	SSPC-SP2	1 ct:	DTM Acrylic Primer/Finish	5.0	125	B66	57
		flat		2 cts:	DTM Acrylic Primer/Finish	5.0	125	B66	57
	acrylic	primer	SSPC-SP2	1 ct:	DTM Acrylic Primer/Finish	5.0	125	B66	57
		semi-gloss		2 cts:	DTM Acrylic Semi-Gloss, or	4.0	100	B66	56
				2 cts:	Metalatex Semi-Gloss, or	4.0	100	B42	99
		gloss		2 cts:	DTM Acrylic Gloss	4.0	100	B66	56
	alkyd	semi-gloss	SSPC-SP2	2 cts:	Direct-to-Metal Alkyd Semi-Gloss	5.0	125	B55	54
	alkyd	primer	SSPC-SP2	1 ct:	Kem Kromik Universal Metal Primer, or	4.0	100	B50	89
				1 ct:	Kem Bond HS, or	2.0	125	B50	84
				1 ct:	High Solids Alkyd Metal Primer,or	5.0	125	B50	79
				1 ct:	Kromik Metal Primer	4.0	100	E41	90
		gloss		2 cts:	Industrial Enamel HS, or	4.0	100	B54Z	83
				2 cts:	Industrial Enamel VOC	3.0	75	B54Z	83
	alkyd	primer	SSPC-SP2	1 ct:	KemKromik Universal Metal Primer, or	4.0	100	B50	89
				1 ct:	Kem Bond HS Primer, or	2.0	125	B50	84
				1 ct:	High Solids Alkyd Metal Primer, or	5.0	125	B50	79
				1 ct:	Kromik Metal Primer	4.0	100	E41	90
	silicone alkyd	gloss		2 cts:	Silicone Alkyd Enamel Low VOC	4.0	100	B56	129
				2 cts:	Steel-Master 9500 Silicone Alkyd	3.0	75	B56	134
	polyamide epoxy	semi-gloss	SSPC-SP2	1-2 cts:	Surface Tolerant Epoxy Primer	8.0	200	B58	138
				1-2 cts:	Surface Tolerant Epoxy Coating	6.0	150	B58	138
	moisture cured urethane	primer	SSPC-SP2	1 ct:	Corothane I Zinc Primer	3.5	87	B65	48
				1 ct:	Corothane I Mastic	3.5	87	B65	47
		gloss		1 ct:	Corothane I Aromatic Finish, or	2.0	50	B65	45
				1 ct:	Corothane I Aliphatic Finish	2.0	50	B65	43
	moisture cured urethane	primer	SSPC-SP2	1 ct:	Corothane I Zinc Primer	3.5	87	B65	48
				1 ct:	Corothane I Aliphatic Finish, or	2.0	50	B65	43
		gloss		1 ct:	Corothane I Aluminum	3.0	75	B65	44
	water based epoxy	primer	SSPC-SP2	1 ct:	Water Based Catalyzed Epoxy Primer	5.0	125	B70	144
		gloss		2 cts:	Water Based Catalyzed Epoxy	3.0	75	B70	144
Ceilings	alkyd	primer	SSPC-SP2	1 ct:	High Solids Alkyd Metal Primer	3.0	75	B50	79
		flat		1-2 cts:	Super Save-Lite Hi-Tec Dryfall	1.5	37	B48	137
	alkyd	primer	SSPC-SP2	1 ct:	Kem Bond HS Universal Primer	5.0	125	B50	84
		flat		1 ct:	Dry Fall Flat White, or	4.0	100	B48	55
				1 ct:	Super Save Lite Flat, or	3.0	75	B48	136
		semi-gloss		1 ct:	Super Save Lite Semi-Gloss, or	3.0	75	B47	136
		gloss		1 ct:	Super Save Lite Gloss, or	2.0	50	B47	136
	acrylic	flat		2 cts:	DTM Acrylic Primer/Finish, or	5.0	125	B66	57
	epoxy ester	flat		1-2 cts:	Galvite Epoxy Ester Dry Fall	4.0	100	B48	71
	alkyd	flat	SSPC-SP2	1-2 cts:	Opti-Bond Multi-Surface Coating	3.5	87	B50	102
aluminum									
ducts, trim, miscellaneous	acrylic	semi-gloss	SSPC-SP1	2 cts:	DTM Acrylic Semi-Gloss, or	4.0	100	B66	56
				2 cts:	Metalatex Semi-Gloss, or	4.0	100	B42	99
		gloss		2 cts:	DTM Acrylic Gloss	4.0	100	B66	56
	acrylic	primer	SSPC-SP1	1 ct:	DTM Wash Primer	1.0	25	B71	59
	alkyd	gloss		2 cts:	Industrial Enamel HS, or	4.0	100	B54	83
				2 cts:	Industrial Enamel VOC	3.0	75	B54	83

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14.4.0 Specifications for Industrial Exposure (Light/Moderate Duty)—Continued

Substrate/Area	Topcoat		Specifications for Normal Exposures		Minimum dft		Product	
	Vehicle	Finish	Surface Preparation	Primers & Topcoats	Mils	Microns	Series	Page
Painting Recommendations—Industrial Exposure, Light/Moderate duty exposure								
masonry								
walls,	acrylic	filler	S-W 5	1 ct: Heavy Duty Block Filler (interior) 2 cts: Heavy Duty Block Filler (exterior)	10.0 10.0	250 250	B42 B42	77 77
	acrylic	filler flat semi-gloss gloss	S-W 5	1 ct: Heavy Duty Block Filler 2 cts: DTM Acrylic Primer/Finish, or 2 cts: DTM Acrylic Semi-Gloss Coating, or 2 cts: Metalatex Semi-Gloss, or 2 cts: DTM Acrylic Gloss Coating	10.0 5.0 4.0 4.0 4.0	250 125 100 100 100	B42 B66 B66 B42 B66	77 57 56 99 56
	acrylic alkyd	primer gloss	S-W 5	1 ct: ProMar Masonry Conditioner 2 cts: Industrial Enamel HS, or 2 cts: Industrial Enamel VOC	2.2 4.0 3.0	55 100 75	B46 B54Z B54Z	122 83 83
	acrylic silicone alkyd	filler gloss	S-W 5	1 ct: Heavy Duty Block Filler 2 cts: Steel-Master 9500 Silicone Alkyd	10.0 3.0	250 75	B42 B56	77 134
	epoxy ester	filler	S-W 5	1 ct: Epoxy Ester Masonry Filler/Sealer	10	250	B61	66
	acrylic	semi-gloss gloss	S-W 5	2 cts: DTM Acrylic Semi-Gloss Coating, or 2 cts: DTM Acrylic Gloss Coating	4.0 4.0	100 100	B66 B66	56 56
	epoxy ester water based epoxy	filler gloss	S-W 5	1 ct: Epoxy Ester Masonry Filler/Sealer 1-2 cts: Water Based Catalyzed Epoxy	10 3.0	250 75	B61 B70	66 144
	epoxy ester	filler	S-W 5	1-2 cts: Sher-Crete Epoxy Ester Masonry Coating	10	250	B61	127
Ceilings	alkyd	primer flat	S-W 5	1 ct: Epoxy Ester Masonry Filler Sealer 1-2 cts: Super Save-Lite Hi-Tec Dryfall	10 1.5	250 37	B61 B48	66 137
	epoxy ester alkyd	primer flat semi-gloss gloss	S-W 5	1 ct: Epoxy Ester Masonry Filler Sealer 1 ct: Dry Fall Flat White, or 1 ct: Super Save Lite Flat, or 1 ct: Super Save Lite Semi-Gloss, or 1 ct: Super Save Lite Gloss, or	10 4.0 3.0 3.0 2.0	250 100 75 75 50	B61 B48 B48 B47 B47	66 55 136 136 136
	acrylic epoxy ester	filler flat	S-W 5	1 ct: Heavy Duty Block Filler 1-2 cts: Galvite Epoxy Ester Dry Fall	10.0 4.0	250 100	B42 B45	77 71
	alkyd	flat	S-W 5	1-2 cts: Opti-Bond Multi-Surface Coating	3.5	87	B60	102
Concrete Floors	water based epoxy system	primer gloss	S-W 5	1 ct: ArmorSeal Water Based Epoxy Primer/Sealer 1 ct: ArmorSeal 700HS Water Based Epoxy	7.0 7.5	175 187	B70 B70	36 31
	waterbased epoxy system	primer gloss	S-W 5	1 ct: ArmorSeal Floor-Plex 7100 (reduced) 2 cts: ArmorSeal Floor-Plex 7100	2.0 2.0	50 50	B70 B70	34 34
	solvent based epoxy	gloss	S-W 5	1-2 cts: ArmorSeal 1000 HS Epoxy	4.5	112	B67	32

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14.5.0 Specifications for Industrial Exposure (Heavy Duty)

aluminum								
ducts, trim, miscellaneous	acrylic polyamide epoxy	primer gloss	SSPC-SP1	1 ct: DTM Wash Primer 2 cts: Tile-Clad High Solids Epoxy	1.0 4.0	25 100	B71 B62	59 141
	acrylic epoxy	primer	SSPC-SP1	2 cts: Water Based Catalyzed Epoxy	3.0	75	B70	144

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14.5.0 Specifications for Industrial Exposure (Heavy Duty)—Continued

Substrate/Area	Topcoat: Vehicle	Topcoat: Finish	Specifications for Normal Exposures: Surface Preparation	Specifications for Normal Exposures: Primers & Topcoats	Minimum dft: Mils	Minimum dft: Microns	Product: Series	Product: Page
Painting Recommendations—Industrial Exposure, Heavy duty exposure								
aluminum, continued								
	acrylic polyamide epoxy	primer gloss	SSPC-SP1	1 ct: DTM Wash Primer 2 cts: Sher-Tile High Solids Epoxy	1.0 8.0	25 200	B71 B67	59 128
	polyamide epoxy	low sheen	SSPC-SP1	2 cts: Heavy Duty Epoxy	7.0	175	B67	78
	epoxy mastic	semi-gloss	SSPC-SP1	2 cts: Macropoxy High Solids Epoxy	6.0	150	B58	97
galvanized steel								
ducts, trim, miscellaneous	acrylic epoxy	primer	SSPC-SP1	2 cts: Water Based Catalyzed Epoxy	3.0	75	B70	144
	epoxy	low gloss gloss	SSPC-SP1	2 cts: Heavy Duty Epoxy, or 2 cts: Tile-Clad High Solids Epoxy, or 2 cts: Sher-Tile High Solids Epoxy, or	7.0 4.0 8.0	175 100 200	B67 B52 B67	78 141 128
	epoxy mastic	semi-gloss	SSPC-SP1	2 cts: Macropoxy High Solids Epoxy	6.0	150	B58	97
	epoxy polyurethane	primer gloss	SSPC-SP1	1 ct: Recoatable Epoxy Primer 1-2 cts: Poly-Lon 1900 Polyester Polyurethane	6.0 2.0	150 50	B67 B65	124 104
steel and iron								
walls, joists, trim, doors, ducts, vents structural items, miscellaneous	acrylic epoxy	primer gloss	SSPC-SP3	1 ct: Water Based Catalyzed Epoxy Primer 1-2 cts: Water Based Catalyzed Epoxy	5.0 3.0	125 75	B70 B70	144 144
	polyamide epoxy	primer low sheen gloss	SSPC-SP5	1 ct: Recoatable Epoxy Primer 2 cts: Heavy Duty Epoxy, or 2 cts: Tile-Clad High Solids Epoxy, or 2 cts: Sher-Tile High Solids Epoxy	6.0 7.0 4.0 8.0	150 175 100 200	B67 B67 B52 B67	124 78 141 128
	polyamide epoxy	primer semi-gloss	SSPC-SP2	1 ct: Surface Tolerant Epoxy Primer 1-2 cts: Surface Tolerant Epoxy Coating	8.0 6.0	200 150	B58 B58	138 138
	epoxy mastic	aluminum semi-gloss	SSPC-SP2 SSPC-SP2	1-2 cts: Macropoxy Aluminum, or 1-2 cts: Macropoxy High Solids Epoxy, or 1-2 cts: Epoxy Mastic Coating	6.0 6.0 10	150 150 250	B58 B58 B58	97 97 68
	epoxy	pre-primer primer semi-gloss gloss	SSPC-SP2	1 ct: Macropoxy 920 Pre-Prime 1 ct: Macropoxy Primer 1-2 cts: Macropoxy 646 Fast Cure Epoxy, or 1-2 cts: Macropoxy High Solids Epoxy	2.0 6.0 10.0 6.0	50 150 250 150	B58 B58 B58 B58	96 97 94 97
	epoxy polyurethane	primer gloss	SSPC-SP6	1 ct: Epolon II Rust Inhibitive Epoxy Primer 1-2 cts: Poly-Lon 1900 Polyester Polyurethane	2.0 2.0	50 50	B62 B65	62 104
	epoxy mastic polyurethane	aluminum primer gloss	SSPC-SP2	1 ct: Epoxy Mastic Aluminum II, or 1 ct: Macropoxy High Solids Primer 1-2 cts: Corothane II Polyurethane, or 1-2 cts: Hi-Solids Polyurethane	6.0 6.0 4.0 4.0	150 150 100 100	B62 B58 B65 B65	67 97 49 82
	zinc rich epoxy epoxy mastic	zinc primer low gloss semi gloss gloss	SSPC-SP5	1 ct: Zinc Clad Primer 1-2 cts: Heavy Duty Epoxy, or 1-2 cts: Macropoxy High Solids Epoxy 1-2 cts: Sher-Tile Epoxy	5.0 7.0 6.0 8.0	125 175 150 200	B69 B67 B58 B67	148-151 78 97 128
	moisture cured urethane	primer matte gloss	SSPC-SP6	1 ct: Corothane I Zinc Primer 1 ct: Corothane I Mastic 1 ct: Corothane I Aliphatic Finish	3.5 2 2.0	87 50 50	B65 B65 B65	46 47 43

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14.5.0 Specifications for Industrial Exposure (Heavy Duty)—Continued

	Topcoat		Specifications for Normal Exposures		Minimum dft/ct		Product	
Substrate/Area	Vehicle	Finish	Surface Preparation	Primers & Topcoats	Mils	Microns	Series	Page
Painting Recommendations—Industrial Exposure, Heavy duty exposure								
steel and iron								
	zinc rich	zinc primer	SSPC-SP6	1 ct: Zinc Clad Primer	5.0	125	B69	148-151
	epoxy	semi-gloss		1-2 cts: Heavy Duty Epoxy	7.0	175	B67	78
	polyurethane	gloss		1 ct: Corothane II Polyurethane, or	4.0	100	B65	49
				1 ct: Hi-Solids Polyurethane	4.0	100	B65	82
	epoxy	primer	SSPC-SP6	1 ct: Recoatable Epoxy Primer	6.0	150	B67	124
	polyester epoxy	gloss		1-2 cts: Armor-Tile HS Polyester Epoxy	4.0	100	B67	37
	polyamide	primer	SSPC-SP6	1 ct: Epolon II Rust Inhibitive Epoxy Primer	4.0	100	B67	62
	epoxy	semi-gloss		1-2 cts: Epolon II Multi-Mil Epoxy	6	150	B62	61
masonry								
walls	epoxy	filler	brush blast	1 ct: Kem Cati-Coat Epoxy Filler/Sealer	30	750	B42	65
		semi-gloss		1-2 cts: Heavy Duty Epoxy, or	7.0	175	B67	78
		gloss		1-2 cts: Sher-Tile HS Epoxy	8.0	200	B67	128
	epoxy	filler	brush blast	1 ct: Kem Cati-Coat Epoxy Filler/Sealer	30	750	B42	65
	polyurethane	satin/gloss		1-2 cts: Corothane II Polyurethane, or	4.0	100	B65	49
		gloss		1-2 cts: Hi-Solids Polyurethane	4.0	100	B65	82
	moisture cured urethane	gloss	brush blast	1-2 cts: Corothane I Aliphatic Finish	2.0	50	B65	43
Concrete Floors	epoxy	primer	brush blast	1 ct: ArmorSeal 33 Epoxy Primer/Sealer	8.0	200	B58	28
		gloss		1 ct: ArmorSeal 300 Heavy Duty Non-Skid	42.0	1050	B67	29
	epoxy	primer	brush blast	1 ct: ArmorSeal 33 Epoxy Primer/Sealer	8.0	200	B58	28
		gloss		1 ct: ArmorSeal 550SL Self Leveling Epoxy	30	750	B58	30
	waterbased epoxy system	primer	S-W 5	1 ct: ArmorSeal Floor-Plex 7100 (reduced)	2.0	50	B70	34
		gloss		2 cts: ArmorSeal Floor-Plex 7100	2.0	50	B70	34

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14.6.0 Painting Recommendations (Immersion Exposure)

	Topcoat		Specifications for Normal Exposures		Minimum dft		Product	
Substrate/Area	Vehicle	Finish	Surface Preparation	Primers & Topcoats	Mils	Microns	Series	Page
Painting Recommendations—Immersion Exposure								
steel								
non-potable water	coal tar epoxy	semi-gloss	SSPC-SP10	1-2 cts: Coal Tar Epoxy C-200, or 1 ct: Hi-Mil Sher-Tar Epoxy, or 1-2 cts: Corothane I Coal Tar	16.0 24.0 7.0	400 600 175	B69 B69 B65	41 60 46
non-potable water	epoxy epoxy	primer semi-gloss	SSPC-SP10	1 ct: Epoxide 52 Epoxy Primer, or 1 ct: Copoxy Shop Primer 2 cts: Hi-Solids Catalyzed Epoxy, or 2 cts: Tank Clad HS Epoxy	3.0 5.0 6.0 8.0	75 125 150 200	B67 B62 B62 B62	64 42 81 140
potable water	epoxy	semi-gloss	SSPC-SP10	2-3 cts: Hi-Solids Catalyzed Epoxy, or 2 cts: Tank Clad HS Epoxy see AWWA or NSF specifications for additional details	6.0 8.0	150 200	B62 B62	81 140
	epoxy amine	low sheen	SSPC-SP10	2 cts: Epoxide 33/34 Potable Water Epoxy	5.0	125	B62	63
concrete								
non-potable water	coal tar epoxy	semi-gloss	Brush Blast	1-2 cts: Coal Tar Epoxy C-200, or 1 ct: Hi-Mil Sher-Tar Epoxy	16.0 24.0	400 600	B69 B69	41 60
	epoxy system	low sheen	SSPC-SP10	1 ct: Kem Cati-Coat Epoxy Filler/Sealer 1 ct: EpoSeal 3040 Fairing and Sealing Compound† 2 cts: Epoxide 33/34 Potable Water Epoxy contact a representative for information on this product	10.0 5.0	250 125	B42 B62	85 63
concrete, continued								
potable water	epoxy	semi-gloss	Brush Blast	2-3 cts: Hi-Solids Catalyzed Epoxy, or 2 cts: Tank Clad HS Epoxy see AWWA or NSF specifications for additional details	6.0 8.0	150 200	B62 B62	81 140

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14.7.0 Painting Recommendations (Low-Temperature Applications)

Down to 40°F: Steel	polyamide epoxy	semi-gloss	SSPC-SP2	2 cts: Macropoxy 846 Winter Grade Epoxy	8.0	200	B58	95
Aluminum	polyamide epoxy	semi-gloss	SSPC-SP1	2 cts: Macropoxy 846 Winter Grade Epoxy	8.0	200	B58	95
Galvanized	polyamide epoxy	semi-gloss	SSPC-SP1	2 cts: Macropoxy 846 Winter Grade Epoxy	8.0	200	B58	95
Down to 35°F: Steel	epoxy amine	low sheen	SSPC-SP2	1-2 cts: Polar Epoxy Low Temperature Cure Epoxy	7.0	175	B62	103

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14.8.0 Painting Recommendations (High-Temperature Exposure)

Steel									
up to 450°F	silicone acrylic	primer	SSPC-SP10	1 ct. 1 ct:	Kem Hi-Temp Heat Flex II 450 Zinc Dust Primer Kem Hi-Temp Heat-Flex II 450	1.5 1.5	37 37	B59 B59	87 87
	silicone acrylic	primer	SSPC-SP10	1 ct: 1 ct:	Kem Hi-Temp Heat-Flex II 450 Primer Kem Hi-Temp Heat-Flex II 450	1.5 1.5	37 37	B59 B59	87 87
up to 800°F	silicone	low luster	SSPC-SP10	2 cts:	Kem Hi-Temp Heat-Flex II 800	1.5	37	B59	88
up to 400°F interior/exterior	alkyd	aluminum	SSPC-SP6	2 cts:	Silver-Brite Aluminum, B59S11	1.5	37	B59	130
up to 700°F interior	alkyd	aluminum	SSPC-SP6	2 cts:	Silver-Brite Hi-Heat Resisting Aluminum, B59S3	0.5	12	B59	132
500°-1000°F interior/exterior	alkyd	aluminum	SSPC-SP6	2 cts:	Silver-Brite Hi-Heat Silicone Alkyd Aluminum B59S8	1.0	25	B59	133
Painting Recommendations—Traffic Marking Paints									
Concrete and Asphalt	latex	flat	SW	1 ct: 1 ct.	SetFast Acrylic Water Borne Traffic Paint Series TM226-White/TM225-Yellow, or SetFast Fast Dry Latex Traffic Marking Paint Series TM2136-White/TM2137-Yellow	7.0 8.5	175 212	TM TM	125 126

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14.9.0 Recommended Surface Preparation Procedures for Basic Construction Materials

Your responsibility, when writing a paint specification, is to understand the significant points in the task and include them in your specification. Details to be covered include: establish a central point from which the painting crew is to operate, provide parking space for painters' vehicles, proper identification, insurance, tools, etc. While these are important points that must be determined, they do not directly affect the paint job. Only those points pertaining to quality paint work will be covered here.

The scope of the paint job should be completely described, including everything that is to be cleaned and painted. DO NOT take anything for granted. Do not merely specify that "the surface should be sandblasted." Do specify the results you want to achieve and leave the choice of pressures, hose sizes, etc., up to the contractor. Allow the contractor to exercise initiative and ingenuity. You might get a better job at a lower price.

Write the specification in clear, precise, easy-to-understand language—so that all parties involved know what you mean. Be brief and to the point, do not confuse the reader. Remember, your primary objective is "a good paint job."

Surface Preparation

Coating performance is affected by proper product selection, surface preparation and application. Coating integrity and service life will be reduced because of improperly prepared surfaces. As high as 80% of all coatings failures can be directly attributed to inadequate surface preparation that affects coating adhesion. Selection and implementation of proper surface preparation ensures coating adhesion to the substrate and prolongs the service life of the coating system.

Selection of the proper method of surface preparation depends on the substrate, the environment, and the expected service life of the coating system. Economics, surface contamination, and the effect on the substrate will also influence the selection of surface preparation methods.

The surface must be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.

Remove mildew before painting by washing with a solution of 1 quart liquid household bleach and 3 quarts of warm water. Apply the solution and scrub the mildewed area. Allow the solution to remain on the surface for 10 minutes. Rinse thoroughly with clean water and allow the surface to dry 48 hours before painting. Wear protective glasses or goggles, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.

No exterior painting should be done immediately after a rain, during foggy weather, when rain is predicted, or when the temperature is below 50°F.

Aluminum S-W 1

Remove all oil, grease, dirt, oxide and other foreign material by cleaning per SSPC-SP1, Solvent Cleaning

Asbestos Siding S-W 2

Remove all dust and dirt. If siding has been weathered and is porous, treat with Masonry Conditioner.

Block (Cinder and Concrete) S-W 3

Remove all loose mortar and foreign material. Surface must be free of laitance, concrete dust, dirt, form release agents, moisture curing membranes, loose cement, and hardeners. Concrete and mortar must be cured at least 30 days at 75°F. The pH of the surface should be between 6 and 9. On tilt-up and poured-in-place concrete, commercial detergents and abrasive blasting may be necessary to prepare the surface. Fill bug holes, air pockets, and other voids with a cement patching compound.

Brick S-W 4

Must be free of dirt, loose and excess mortar, and foreign material. All brick should be allowed to weather for at least one year followed by wire brushing to remove efflorescence. Treat the bare brick with one coat of Masonry Conditioner.

Concrete S-W 5

The following guides will help assure maximum performance of the coating system and satisfactory coating adhesion:

1. Cure—Concrete must be cured prior to coating application. Cured is defined as concrete poured and aged at a material temperature of at least 75°F for at least 30 days. The pH of the surface should be between 6 and 9.
2. Moisture—(Reference ASTM D4263) Concrete must be free of moisture as much as possible (moisture seldom drops below 15% in concrete). Test for moisture or dampness by taping the 4 edges of an 18 inch by 18 inch plastic sheet (4 mils thick) on the bare surface (an asphalt tile or other moisture impervious material will also do), sealing all of the edges. After a minimum of 16 hours, inspect for moisture, discoloration, or condensation on the concrete or the underside of the plastic. If moisture is present, the source must be located and the cause corrected prior to painting.
3. Temperature—Air, surface and material temperature must be at least 50°F (10°C) during the application and until the coating is cured.
4. Contamination—Remove all grease, dirt, loose paint, oil, tar, glaze, laitance, efflorescence, loose mortar, and cement by the recommendations A, B, C, or D, listed below.
5. Surface Condition—Hollow areas, bug holes, honeycombs, voids, fins, form marks, protrusions, or rough edges are to be ground or stoned to provide a smooth, continuous surface of suitable texture for proper adhesion of the coating. Imperfections may require filling with a material compatible with the Sherwin-Williams' coatings.
6. Concrete Treatment—Hardeners, sealers, form release agents, curing compounds, and other concrete treatments must be compatible with the coatings, or be removed.

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14.9.0 Recommended Surface Preparation Procedures for Basic Construction Materials—Continued

Surface preparations for concrete
Method "A"—Blast Cleaning
(Reference ASTM D4259) Brush Blasting or Sweep Blasting—Includes dry blasting, water blasting, water blasting with abrasives, and vacuum blasting with abrasives.

1. Use 16 - 30 mesh sand and oil-free air.
2. Remove all surface contamination (ref. ASTM D4258). See Method "D" below.
3. Stand approximately 2 feet from the surface to be blasted.
4. Move nozzle at a uniform rate.
5. Laitance must be removed and bug holes opened.
6. Surface must be clean and dry (moisture check: ref. ASTM D4263) and exhibit a texture similar to that of medium grit sandpaper.
7. Vacuum or blow down and remove dust and loose particles from the surface (ref. ASTM D4258). See Method "D" below.

Method "B"—Acid Etching

1. Remove all surface contamination (ref. ASTM D4258)
2. Wet surface with clean water.
3. Apply a 10-15% Muriatic Acid or 50% Phosphoric Acid solution at the rate of one gallon per 75 square feet.
4. Scrub with a stiff brush.
5. Allow sufficient time for scrubbing until bubbling stops.
6. If no bubbling occurs, the surface is contaminated with grease, oil, or a concrete treatment which is interfering with proper etching. Remove the contamination with a suitable cleaner (ref. ASTM D4258, or Method "D" below) and then etch the surface.
7. Rinse the surface two or three times. Remove the acid/water mixture after each rinse.
8. Surface should have a texture similar to medium grit sandpaper.
9. It may be necessary to repeat this step several times if a suitable texture is not achieved with one etching. Bring the pH (ref. ASTM D4262) of the surface to neutral with a 3% solution of trisodium phosphate or similar alkali cleaner and flush with clean water to achieve a sound, clean surface.
10. Allow surface to dry and check for moisture (ref. ASTM D4263).

Method "C"—Power Tool Cleaning or Hand Tool Cleaning (ref. ASTM D4259)

1. Use needle guns or power grinders, equipped with a suitable grinding stone of appropriate size and hardness, which will remove concrete, loose mortar, fins, projections, and surface contaminants. Hand tools may also be used.
2. Vacuum or blow down and remove dust and loose particles from the surface (ref. ASTM D4258, or Method "D" below).
3. Test for moisture or dampness by taping the 4 edges of an 18 inch by 18 inch plastic sheet (4 mils thick) on the bare surface (an asphalt tile or other moisture impervious material will also do), sealing all of the edges. After a minimum of 16 hours, inspect for moisture, discoloration, or condensation on the concrete or the underside of the plastic. If moisture is present, the source must be located and the cause corrected prior to painting.

Method "D"—Surface Cleaning (ref. ASTM D4258)
The surface must be clean, free of contaminants, loose cement, mortar, oil, and grease. Broom cleaning, vacuum cleaning, air blast cleaning, water cleaning, and steam cleaning are suitable as outlined in ASTM D4258. Concrete curing compounds, form release agents, and concrete hardeners may not be compatible with recommended coatings. Check for compatibility by applying a test patch of the recommended coating system, covering at least 2 to 3 square feet. Allow to dry one week before testing adhesion per ASTM D3359. If the coating system is incompatible, surface preparation per methods outlined in ASTM D4259 are required.

Cement Composition Siding/Panels S-W 6

Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry. Existing peeled or checked paint should be scraped and sanded to a sound surface. Pressure clean, if needed, with a minimum of 2100 psi pressure to remove all dirt, dust, grease, oil, loose particles, laitance, foreign material, and peeling or defective coatings. Allow the surface to dry thoroughly. If the surface is new, test it for pH, many times the pH may be 10 or higher.

Copper S-W 7

Remove all oil, grease, dirt, oxide and other foreign material by cleaning per SSPC-SP 2, Hand Tool Cleaning.

Drywall—Interior and Exterior S-W 8

Must be clean and dry. All nail heads must be set and spackled. Joints must be taped and covered with a joint compound. Spackled nail heads and tape joints must be sanded smooth and all dust removed prior to painting. Exterior surfaces must be spackled with exterior grade compounds.

Exterior Composition Board (Hardboard) S-W 9

Some composition boards may exude a waxy material that must be removed with a solvent prior to coating. Whether factory primed or unprimed, exterior composition board siding (hardboard) must be cleaned thoroughly and primed with an alkyd primer.

Galvanized Metal S-W 10

Allow to weather a minimum of 6 months prior to coating. Clean per SSPC-SP1 using detergent and water or a degreasing cleaner, then prime as required. When weathering is not possible or the surface has been treated with chromates or silicates, first Solvent Clean per SSPC-SP1 and apply a test area, priming as required. Allow the coating to dry at least one week before testing. If adhesion is poor, Brush Blast per SSPC-SP7 is necessary to remove these treatments.

Plaster S-W 11

Must be allowed to dry thoroughly for at least 30 days before

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14.9.0 Recommended Surface Preparation Procedures for Basic Construction Materials—Continued

painting. Room must be ventilated while drying; in cold, damp weather, rooms must be heated. Damaged areas must be repaired with an appropriate patching material. Bare plaster must be cured and hard. Textured, soft, porous, or powdery plaster should be treated with a solution of 1 pint household vinegar to 1 gallon of water. Repeat until the surface is hard, rinse with clear water and allow to dry.

Previously Coated Surfaces

Maintenance painting will frequently not permit or require complete removal of all old coatings prior to repainting. However, all surface contamination such as oil, grease, loose paint, mill scale dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers must be removed to assure sound bonding to the tightly adhering old paint. Glossy surfaces of old paint films must be clean and dull before repainting. Thorough washing with an abrasive cleanser will clean and dull in one operation, or, wash thoroughly and dull by sanding. Spot prime any bare areas with an appropriate primer. Recognize that any surface preparation short of total removal of the old coating may compromise the service length of the system. Check for compatibility by applying a test patch of the recommended coating system, covering at least 2 to 3 square feet. Allow to dry one week before testing adhesion per ASTM D3359. If the coating system is incompatible, complete removal is required (per ASTM 4259, see Concrete, Method).

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14.10.0 Preservative Treatment for Exterior Woodwork

Modern technology has developed methods of treating certain species to extend their life when exposed to the elements. All lumber species used for exterior architectural woodwork, except species listed as "Resistant or very resistant" in the following tables (although it is desirable for those species) shall be treated with an industry tested and accepted formulation containing 3-iodo-2-propynyl butyl carbamate (IPBC) as its active ingredient according to manufacturer's directions.

Some domestic woods according to heartwood decay resistance:

Resistant or very resistant	Moderately resistant	Slightly or nonresistant
Cedars	Baldcypress (young growth) *	Ashes
Cherry, black	Douglas-fir	Basswood
Junipers	Pine, Eastern White *	Beech
White Oak	Pine, So. Longleaf *	Birches
Redwood, clear heart	Pine, Slash	Butternut
Walnut, black		Hemlocks
		Hickories
		Red Oak
		Pines (other than slash, longleaf, and E. white)
		Poplars
		Spruces
		True firs (western and eastern)

* - The southern and eastern pines and baldcypress are now largely second growth with a large proportion of sapwood. Substantial quantities of heartwood lumber of these species are not available.

Some imported woods according to heartwood decay resistance:

Resistant or very resistant	Moderately resistant	Slightly or nonresistant
Mahogany, American (Honduras)	Avodire	Obeche
Meranti **	European walnut	Mahogany, Philippine: Mayapis, White lauan
Teak	Mahogany, Philippine: Almon, Bagtikan, Red Lauan, Tangile	
	Sapele	

** - More than one species included, some of which may vary in resistance from that indicated.

DATA: U.S. Dept. of Agriculture, Forest Products Laboratory

14.11.0 Myth of Maintenance-Free Exterior Coatings

1. *What are the 20-year fluorocarbon paint coatings used on exterior aluminum members?*

   These coatings are high-molecular-weight polymers that have been formulated into a dispersion coating for application at the factory. Polyvinylidene fluoride (PVF2) is the base ingredient in these coatings. Other high-performance coatings are siliconized acrylics, siliconized polyesters, and other synthetic polymers.

2. *Are these coatings maintenance-free?*

   No. Unless proper maintenance procedures are followed, these coated surfaces will degrade, over time, in the presence of atmospheric weathering and airborne pollutants.

3. *What specifically causes problems leading to degradation?*

   The collection of airborne dirt and chemical pollutants, in the presence of moisture, increases the potential for erosion, corrosion, loss of surface gloss, stainings and discoloration.

4. *What is "chalking"?*

   Ultraviolet degradation of the resin vehicle and color in the coating results in loss of gloss and the formation of powder on the surface. This powder is referred to as *chalking*, a change in both the appearance and color of the coating. Regular maintenance can prevent chalking.

5. *When should the maintenance of exterior curtain walls begin?*

   As soon as possible after the installation and acceptance of the building by the owner so as to remove any dirt or pollutants caused during the construction process.

6. *What is AAMA 610.1?*

   The American Architectural Manufacturers Association (AAMA) developed AAMA 610.1, a procedure for the cleaning and maintenance of painted aluminum extrusions and curtain wall systems. These are general, not specific guidelines. AAMA suggests that owners hire experienced maintenance contractors for curtain wall cleaning, if they do not have such individuals on staff.

7. *What kind of cleaning cycles are considered adequate?*

   Exterior glazing is generally cleaned on a quarterly basis, depending upon the amount of atmospheric pollution in a specific geographic area. Curtain wall and exterior aluminum construction can be incorporated into the same schedule.

8. *Can the rundown from sealants contribute to the staining of aluminum with high performance coatings?*

   Yes. The oils and plasticizers in many caulking materials can bleed onto adjacent metal surfaces causing stains or discolorations.

9. *If a factory finish on a curtain wall is stained or discolored to the point where it needs to be recoated, can a field applied coating be used to repair a factory applied coating?*

   In many cases—Yes. Coating manufacturers have developed a number of field applied airdried primers and finish coats for in-place coating repairs. The coating manufacturer or an approved applicator should be consulted for specifics.

14.12.0 Steel-Structure Painting Procedures

The authority on surface preparation and the subsequent painting of steel structures, the Steel Structures Painting Council, has developed a series of procedures that have become industry standards. The Steel Structures Painting Council developed specific surface-preparation procedures for the proper application of various types of coatings. Each surface-preparation procedure has been given an "SP" number, prefaced by their organization letters (SSPC). A particular procedure is referred to as *SSPC-SP* (and the number).

14.12.1 SSPC Specifications

SSPC specification	Description (summarized)
SP 1 Solvent Cleaning	Removal of oil, grease, dirt, soil, salts, and contaminants by cleaning with solvents, vapor, alkali, emulsion, or steam.
SP 2 Hand Tool Cleaning	Removal of loose rust, loose mill scale, and loose paint, by hand chipping, scraping, sanding, and wire brushing.
SP 3 Hand Tool Cleaning	Removal of loose rust, loose mill scale, and loose paint, by power-tool chipping, descaling, sanding, wire brushing, and grinding.
SP 5 White Metal Blasting	Removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle, dry or wet, using sand, grit, or shot.
SP 6 Commercial Blast Cleaning	Blast cleaning until at least ⅔ of the surface area is free of all visible residues.
SP 7 Brush-off, Blast Cleaning	Blast cleaning of all, except tightly adhering residues of mill scale, rust, and coatings, exposing numerous evenly distributed flecks of underlying metal.
SP8 Pickling	Complete removal of rust and mill scale by acid pickling, duplex pickling, or electrolytic pickling.
SP 10 Near-White Blast Cleaning	Blast cleaning to nearly white-metal cleanliness, until at least 95% of the surface area is free of all visible residues.
SP 11-87T Power-Tool Cleaning to Bare Metal	Complete removal of all rust, scales, and paint by power tools with resultant surface profile.

Note: SSPC does not have an SP 9 category.

14.12.2 SSPC Grading of New and Previously Painted Steel

Four surface conditions of new steel, with respect to its oxidation and rust formation, established by SSPC are the following:

- *Rust Grade A* A steel surface covered completely by adherent mill scale with little or no visible rust.
- *Rust Grade B* A steel surface covered with both mill scale and rust.
- *Rust Grade C* A steel surface completely covered with rust; little or no pitting is visible.
- *Rust Grade D* A steel surface completely covered with rust; pitting is visible.

Four conditions of previously painted steel construction are designated by SSPC for maintenance painting and are based upon the rust-grade classifications established by the Council, which range from:

- *Grade E* Nondeteriorated steel with 0 to 0.1% rust
- *Grade F* Slightly to moderately deteriorated steel with 0.1% to 1% rust
- *Grade G* Deteriorated steel with 1 to 10% rust
- *Grade H* Severely deteriorated steel with more than 10% rust and up to 100% rust

14.12.3 Minimum Surface Preparation for Various Painting Systems

According to the SSPC, certain minimum surface-preparation requirements are necessary for the application of various painting systems.

Painting System	Minimum Surface Preparation
Oil base	Hand tool cleaning (SSPC-SP2)
Alykyd	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Phenolic	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Vinyl	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Rust-Preventative Compounds	Solvent cleaning (SSPC-SP1 or nominal cleaning)
Asphalt Mastic	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Coal-Tar Coatings	Commercial blast cleaning (SSPC-SP6)
Coal-Tar Epoxy	Commercial blast cleaning (SSPC-SP6)
Zinc Rich	Commercial blast cleaning (SSPC-SP6)
Epoxy Polyamide	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Chlorinated Rubber	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Silicone Alykyd	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Urethane	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)
Latex	Commercial blast cleaning (SSPC-SP6 or pickling, SSPC-SP8)

14.12.4 Steel Structures Painting Council (SSPC) Coating Systems

SSPC-PS 1.04	Three-coat oil-alkyd (lead and chromate free) painting system for galavanized or nongalvanized steel (with zinc-dust/zinc-oxide linseed-oil primer)
SSPC-PS 1.07	Three-coat oil-base red lead painting system
SSPC-PS 1.08	Four-coat oil-base red lead painting system
SSPC-PS 1.09	Three-coat oil-base zinc-oxide painting system (without lead or chromate pigment)
SSPC-PS 1.10	Four-coat oil-base zinc-oxide painting system (without lead or chromate pigment)
SSPC-PS 1.11	Three-coat oil-base red lead painting system
SSPC-PS 1.12	Three-coat oil-base zinc-chromate painting system
SSPC-PS 1.13	One-coat oil-base slow-drying maintenance painting system (without lead or chromate pigments)
SSPC-PS 2.03	Three-coat alkyd painting system with red lead-oxide primer (for weather exposure)
SSPC-PS 2.05	Three-coat alkyd painting system for unrusted galvanized steel (for weather protection)
SSPC-PS 4.01	Four-coat vinyl painting system with red lead primer (for salt-waste or chemical use)
SSPC-PS 4.02	Four-coat vinyl painting system (for fresh water, chemical, or corrosive atmospheres)
SSPC-PS 4.03	Three-coat vinyl painting system with wash primer (for salt-water and weather exposure)

SSPC-PS 4.04	Four-coat white or colored vinyl painting system (for fresh-water, chemical, or corrosive atmospheres)
SSPC-PS 4.05	Three-coat vinyl painting system with wash primer and vinyl alkyd finish coat (for atmospheric exposure)
SSPC-PS 8.01	One-coat rust-preventative painting system for thick-film compounds
SSPC-PS 9.01	Cold-applied asphalt mastic painting system with extra-thick film
SSPC-PS 10.01	Hot-applied coal-tar enamel painting system
SSPC-PS 10.02	Cold-applied coal-tar mastic painting system
SSPC-PS 11.02	Black (or dark red) coal-tar epoxy-polyamide painting system
SSPC-PS 12.01	One-coat zinc-rich painting system
SSPC-PS 13.10	Epoxy polyamide painting system
SSPC-PS 14.01	Steel-joist shop-painting system
SSPC-PS 15.01	Chlorinated-rubber painting system for salt-water immersion
SSPC-PS 15.02	Chlorinated-rubber painting system for fresh-water immersion
SSPC-PS 15.03	Chlorinated-rubber painting system for marine and industrial atmospheres
SSPC-PS 15.04	Chlorinated-rubber painting system for field application over a shop-applied solvent-base inorganic zinc-rich primer
SSPC-PS 16.01	Silicone alkyd-base painting system for new steel
SSPC-PS 18.01	Three-coat latex painting system

14.13.0 Generic High-Performance Coatings for Steel and Concrete

The following formulations are a sampling of the types and ranges of high-performance coating and their recommended service:

- *Polyurethane alkyd copolymer* Finish coat for pumps, motors, machinery, piping, and handrails, resulting in a high gloss that has excellent brush, roller, and spray characteristics. This finish exhibits excellent weathering capability and good abrasion resistance.
- *Epoxy polyamide* A 100% solid epoxy mastic that can be applied and cured underwater, providing protection against metal corrosion and erosion, and the deterioration of concrete and wood at (or below) the waterline. This type of coating is recommended for the repair of steel, concrete, or wood pilings; leaking tanks; boat hulls; and cracks in concrete; however, it is not recommended for immersion in (or exposure to) strong solvents or corrosive materials.
- *Aliphatic polyurethane* A two-part system that provides a satin finish coat on primed steel and exhibits very good resistance to splash and spillage of acids, alkalies, solvents, and salts. It has excellent abrasion-resistance qualities. This coating is used in chemical-processing, pulp and paper mills, and in the petrochemical industries.
- *Acrylic aliphatic polyurethane* Another two-part coating system that can be applied by brush, roller, or spray, and exhibits excellent weathering and abrasion-resistance chacteristics. This coating is recommended as a finish coat over pigmented polyurethanes for exterior exposure where chemical resistance, gloss retention, and as excellent weathering characteristics are required. This coating will be used to provide a graffiti-free surface.
- *Elastomeric polyurethane* A two-component coating system that is utilized as a build coat overall compatible primer to provide a waterproof topping over concrete floors, decks, and walkways. A nonskid aggregate is often added to this coating to provide a slip-resistant surface.
- *Zinc-rich chlorinated rubber coating* Considered a “cold galvanizing” coating. When this coating is applied to a structural-steel member, the zinc metal in the coating bonds in much the same manner as hot-dip galvanizing. This single-component coating is an excellent material for the field touch-up of hot galvanized surfaces.
- *Thixotropic coal-tar coatings* A coal tar-based material that can be applied in high-build layers by either brushing or rolling several coats to an 8-mil thickness. This coating is highly adaptable to application for underground or underwater usage.

14.14.0 Common Paint Problems—Alligatoring and Wrinkling

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Alligatoring & wrinkling

SELECT A PROBLEM

Cause

Alligatoring and cracking is caused by excessive buildup of paint. Eventually, multiple cracking of the paint film occurs as seasonal temperature variations inhibit expansion and contraction of the paint film with the substrate. Simultaneous to cracking, the inability of the thick paint film to expand and contract with the substrate results in adhesion loss. Paint applied to this surface will invariably accelerate flaking of the total film down to the substrate.

Wrinkling is caused by applying paint in excess of the recommended wet film thickness and by applying paint containing strong solvents to already dry paint films. These solvents cause the underlying paint film to dissolve and expand (wrinkle) under the newly applied paint. The result is a wrinkled finish.

Solution

Wrinkled surfaces can be power-sanded to a smooth surface.

Surfaces that show alligatoring or cracking must have the paint stripped to bare wood by power sanding, use of paint remover, or heating gun and scraper.

Bare wood that has been exposed to weathering must be sanded to fresh wood. Exposure of sanded fresh wood to sunlight for more than a one-week period will result in peeling of the newly applied paint.

Caution: Use a protective face mask to avoid inhalation of fumes and dust during paint removal.

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14.14.1 Common Paint Problems—Blistering and Peeling

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Blistering/peeling

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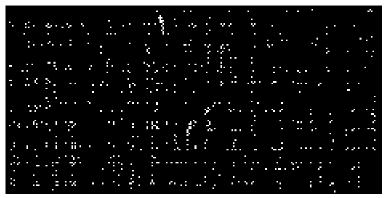

Click To Enlarge

Cause

- Moisture.
- Poor surface preparation by failing to remove chalk residue.
- Factory primer on new substrate is hard, glossy or contaminated.
- Application of latex paint below minimum application temperature.

Solution

- Remove loose paint with pressurized water.
- Scrape areas that are loose but resist removal by water blasting.
- Eliminate moisture by determining the need for:
  - caulking-cracks, holes and seams
  - wedge vents
  - attic louvers
  - exhaust fans
- Scrape off paint from problem area and then sand to fresh wood, feathering edges.

Note: Composition board or hardboard must be sanded carefully to avoid damaging the surface. Use extra precautions when removing paint film from these surfaces.

Recommended Sherwin-Williams Coating System

- Prime bare wood with Sherwin-Williams A-100 Latex or Alkyd Exterior Wood primer
- Apply two coats of Sherwin-Williams topcoat, preferably latex.

Note: When painting between 35° and 50°F or when the temperature is expected to drop to between 35° and 50°F within 48 hours of painting.

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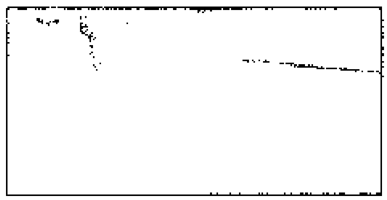
Peeling

SELECT A PROBLEM



Click To Enlarge

Cause

Peeling is caused by poor surface preparation, and refers to the removal of strips or sheets of paint due to loss of adhesion. The loss of adhesion could be the result of:

- painting over a coating containing wax;
- an excess buildup of moisture within the wood;
- painting over an old, smooth coating; or
- painting over heavy chalk surfaces.

Other surface conditions or contaminants known to affect the adhesion of newly applied topcoats are oil, grease, various forms of pollution such as dust, dirt and mildew, applying paint over hard glossy surfaces, and excessively thick film topcoats.

Peeling may also be the result of applying latex paint below its recommended application temperature.

Solution

Proper surface preparation will prevent peeling of the topcoat. If a peeling situation persists, the loose paint must be completely removed. Prepare surface by removing or abrading the problem surface. Sand all bare wood to fresh wood.

Remove surface contaminants with naphtha solvent, detergents and water. Glossy surfaces must be scuff sanded. All surfaces must be rinsed with clean water and allowed to dry thoroughly. Exposed wood areas must be sanded to fresh wood and primed with an alkyd or latex primer.

Caution: Wear a face mask to prevent inhalation of dust particles during the sanding procedure.

Continued

14.14.2 Common Paint Problems—Cracking Over Caulk

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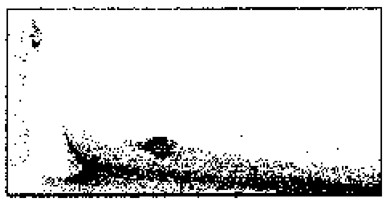
Cracking over caulk

SELECT A PROBLEM



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Cause

When paint is applied over a partially dried bead of caulk, the paint dries, first forming a film. As the caulk continues to dry, it separates from the underside of the paint film. Ultimately, the paint film cracks.

Conditions that affect the drying time for caulks are air, surface or caulk temperatures below 40°F; high humidity; and joints in excess of 1/2" in width or depth.

Solution

Surfaces to be sealed should be sound, dry, and free of oils, dust, mortar spatter, release agents, old caulk, bitumen, old paint or other contaminants. Remove flaky, loose and powdery material from the joint.

Apply caulk only when temperature of surrounding air, surfaces to be caulked and caulk are all above 40°F. Do not apply when rain or freezing temperatures are expected.

Joints should not be more than 1/2" in width or depth. Joints deeper than 1/2" should be filled within 1/2" of the surface with polyethylene rod or closed cell urethane foam. Fill the remaining joint with caulk, and tool within five minutes of application.

Recommended Sherwin-Williams Coating System

- One coat A-100 Latex or Alkyd Exterior Wood primer
- Two coats Exterior Latex House & Trim paint

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14.15.0 Painting—Quality Control Checklist

Quality Control Checklist

Project no.

Section: Painting

No.: 09901

Date

1. Color schedule is complete and understood.
2. Approved product data, shop drawings, and color samples are on job, and job site "paint-outs" are matched against samples.
3. Prior understanding is made on stopping points for change of color and finish.
4. All materials are new, and materials are products of same manufacturer if required. Containers are adequately identified. Disallow containers showing evidence of broken seal.
5. Surfaces to receive paint are dry. Moisture meter tests on plaster, concrete, or masonry surfaces are made if required. Damp, not wet surfaces are allowed for water-thinned paints.
6. Surfaces to receive paint are sanded; holes puttied or filled; pitch pocket, knot, and shakes are shellacked or treated and otherwide cleaned of deleterious substances. Metal surfaces are treated, primed, or otherwise cleaned as required.
7. Areas are suitably cleaned and free of conditions affecting drying and finish.
8. Dust control is maintained.
9. Temperature conditions for type of paint are provided, and heating is provided sufficiently in advance in order to have surfaces up to temperature and to avoid condensation.
10. Adequate lighting is provided for proper working conditions.
11. Protection of adjacent areas, surfaces, and items is provided. Hardware, trim, fixtures, and similar items are removed during painting operations or otherwise suitably protected. Clean drop cloths are provided over finished surfaces.
12. Observe occasionally the mixing and thinning of paints. Thinning should be controlled and the need demonstrated.
13. Required number of coats is provided. Tinting of undercoats is performed if required. Opacity is being achieved.
14. Required texture and method of application—spray, brush, roller, etc.—is understood.
15. Lumps or bumps do not appear on applied coats.
16. Workmanship and application are adequate. Do not allow runs, drops, laps, brush marks, "face curtains," variations in color, texture, finish, etc.
17. Doors receive first coats on both faces of wood at essentially the same time. Observe that tops and bottoms receive treatment.
18. Curing time required between coats is provided.
19. Sealers, fillers, and stains are applied and treated as required. Putty is not applied until after stain or priming and matches stained wood.
20. Hard-to-get-at places are painted—bottoms of shelves, back of trim in corners, etc.
21. Correction of all unsuitable work is made promptly. Clean-up of area and removal of splatters and smears are made as soon as possible on adjacent surfaces

USE REVERSE SIDE FOR ADDITIONAL REMARKS AND COMMENTS

Accepted By

Section

15

American Disabilities Act—Illustrated

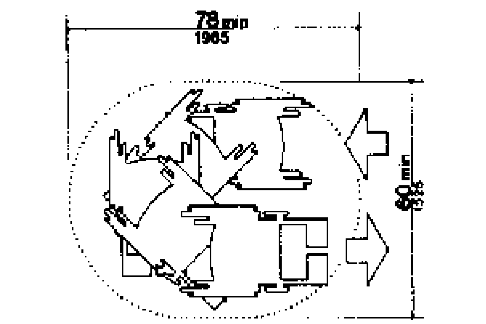
Contents

15.0.0 The American with Disabilities Act (ADA)

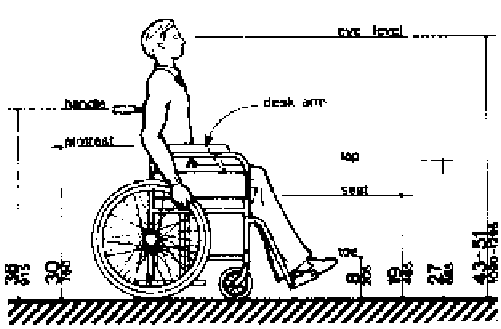
The federal government implemented Title III of the American with Disabilities Act of 1990, which prohibits discrimination on the basis of disability by public accommodations and requires places of public accommodation and commercial facilities to be designed, constructed and altered in compliance with the accessibility standards established by this act. The Department of Justice published a Code of Federal Regulations designated 28 CRF Part 36 which contains specific requirements to be followed to comply with those regulations

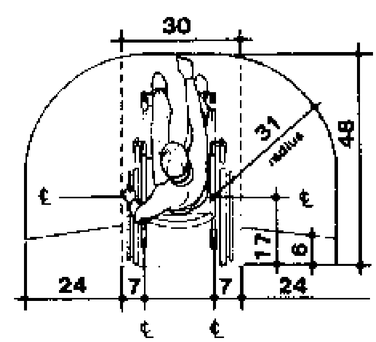
This section contains numerous diagrams and dimensional data to illustrate and explain many of the critical areas in building construction that must be made to comply with 28 CRF Part 36.

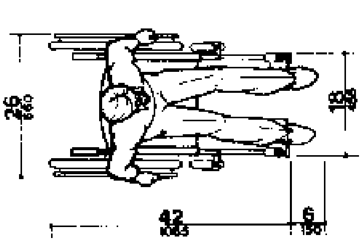
15.1.0 Dimensions of Adult-Size Wheelchairs



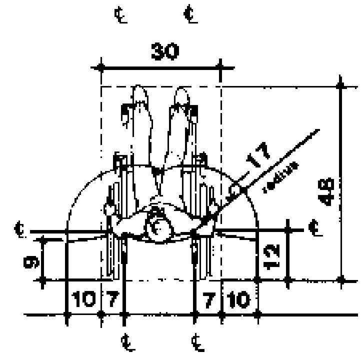
Space Needed for Smooth U-Turn in a Wheelchair



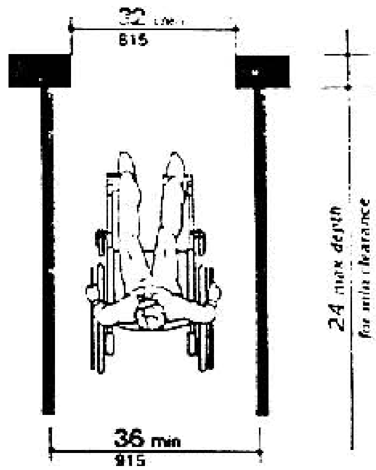




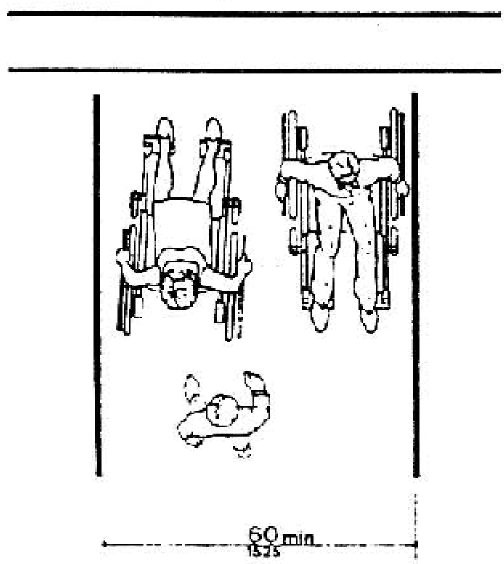
NOTE: Footrests may extend further for tall people



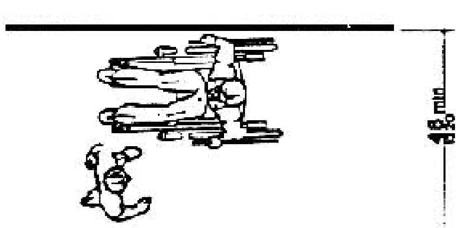
15.2.0 Minimum Clear Width for One/Two Wheelchairs



Minimum Clear Width
for Single Wheelchair

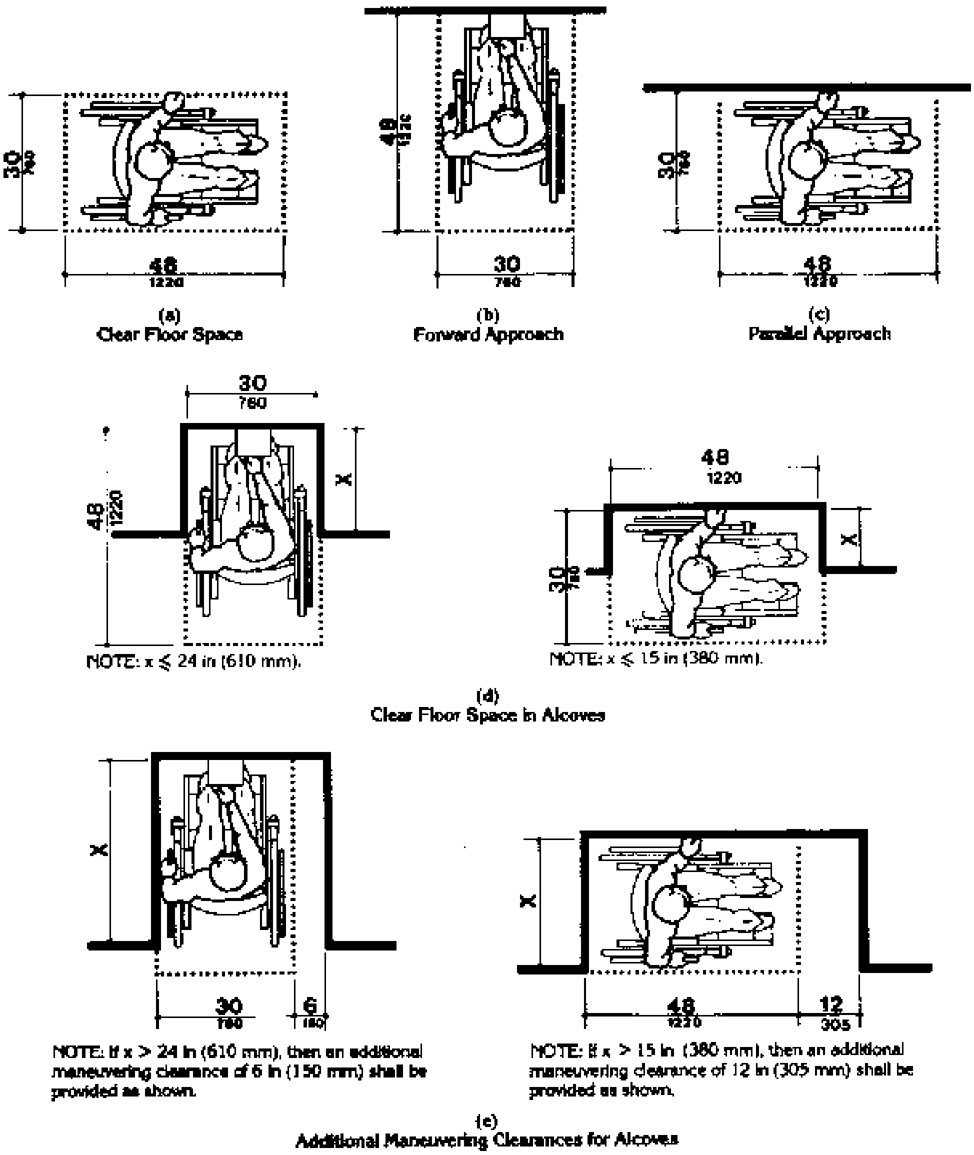


Minimum Clear Width
for Two Wheelchairs

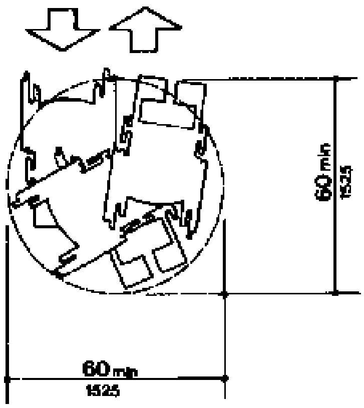


Minimum Passage Width for One Wheelchair
and One Ambulatory Person

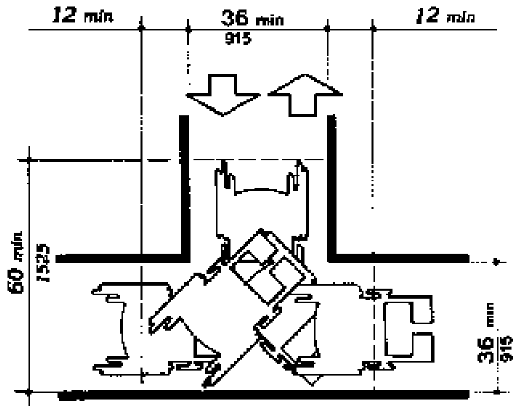
15.3.0 Minimum Clear Floor Space for Wheelchairs



15.4.0 Wheelchair Turning Space

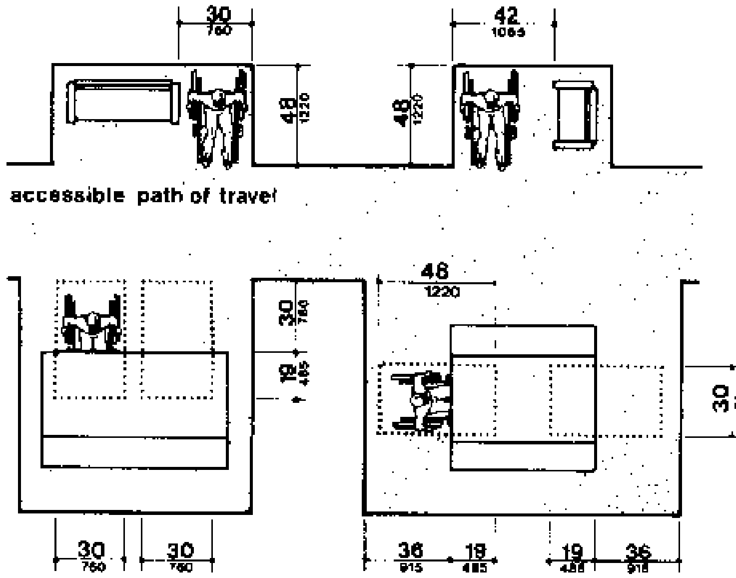


(a)
60-in (1525-mm)-Diameter Space

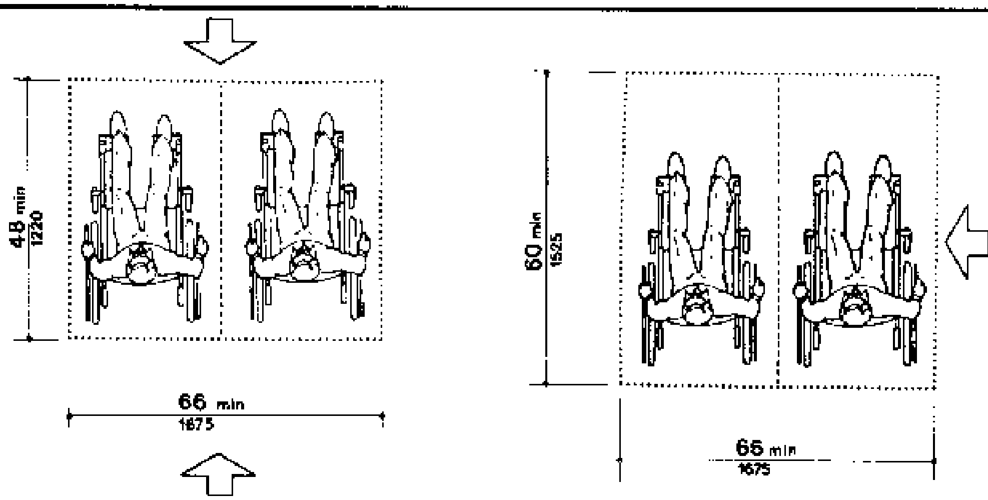


(b)
T-Shaped Space for 180° Turns

15.5.0 Minimum Clearance for Seating and Tables



Minimum Clearances for Seating and Tables

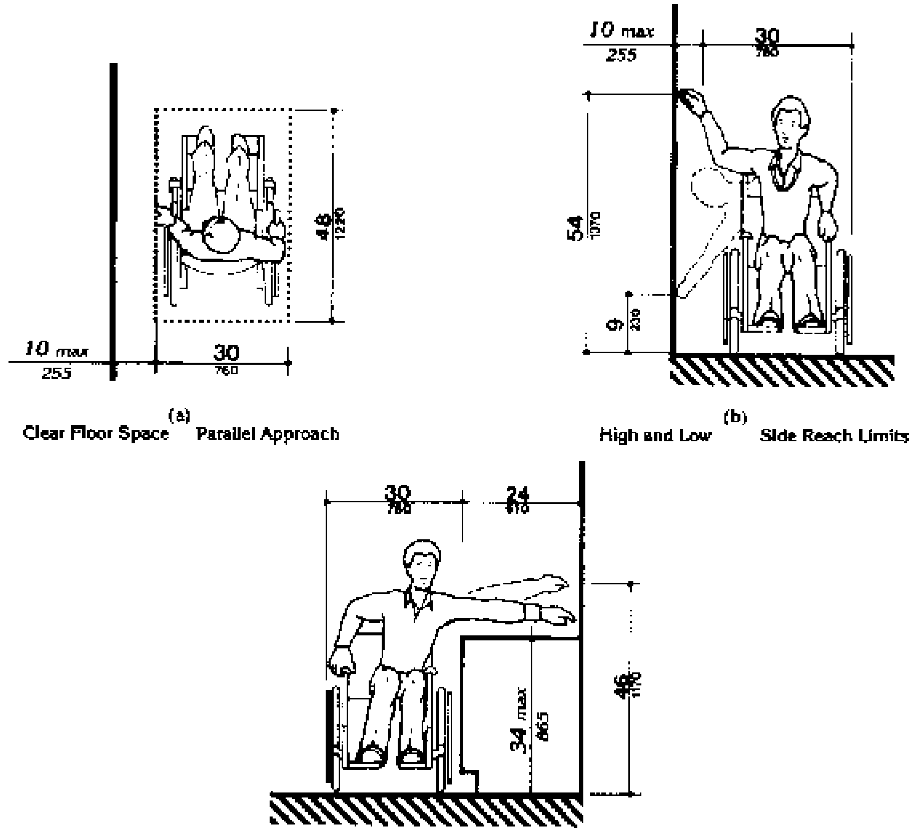


(a)
Forward or Rear Access

(b)
Side Access

Space Requirements for Wheelchair
Seating Spaces in Series

15.6.0 Side Reach From a Wheelchair



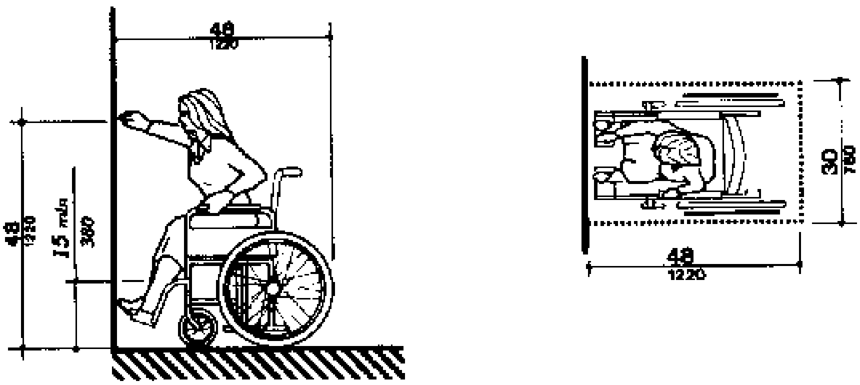
(a)
Clear Floor Space Parallel Approach

(b)
High and Low Side Reach Limits

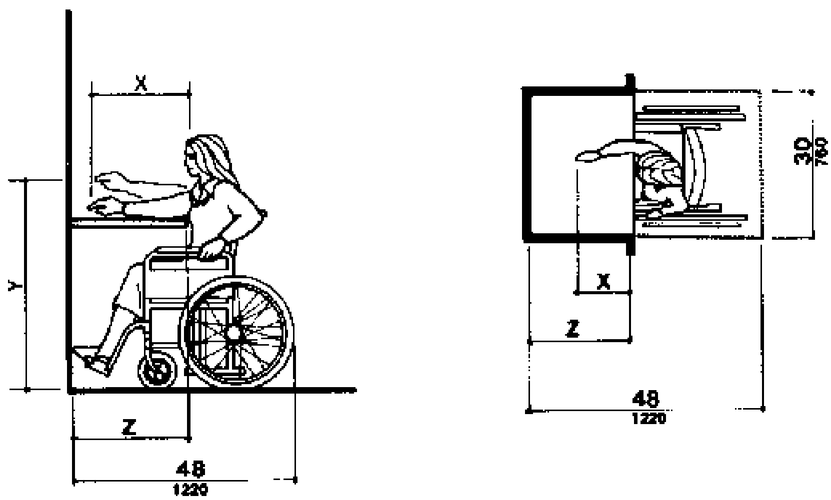
(c)
Maximum Side Reach over Obstruction

Side Reach

15.7.0 Forward Reach from a Wheelchair



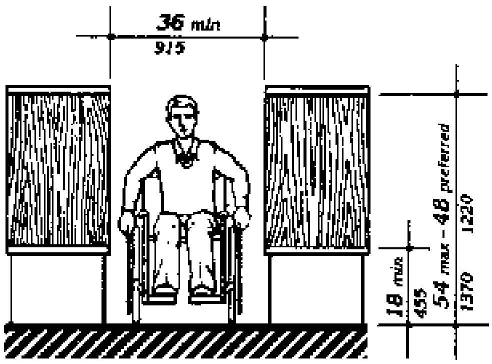
(a)
High Forward Reach Limit



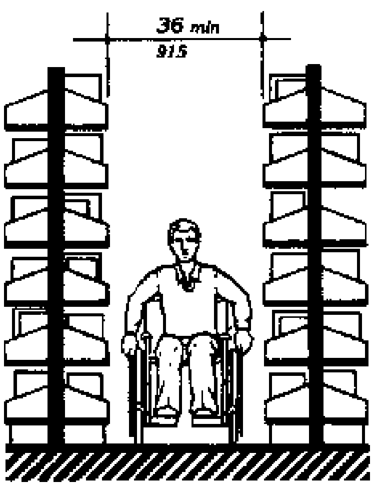
NOTE: x shall be ≤ 25 in (635 mm); z shall be ≥ x. When x < 20 in (510 mm), then y shall be 48 in (1220 mm) maximum. When x is 20 to 25 in (510 to 635 mm), then y shall be 44 in (1120 mm) maximum.

(b)
Maximum Forward Reach over an Obstruction

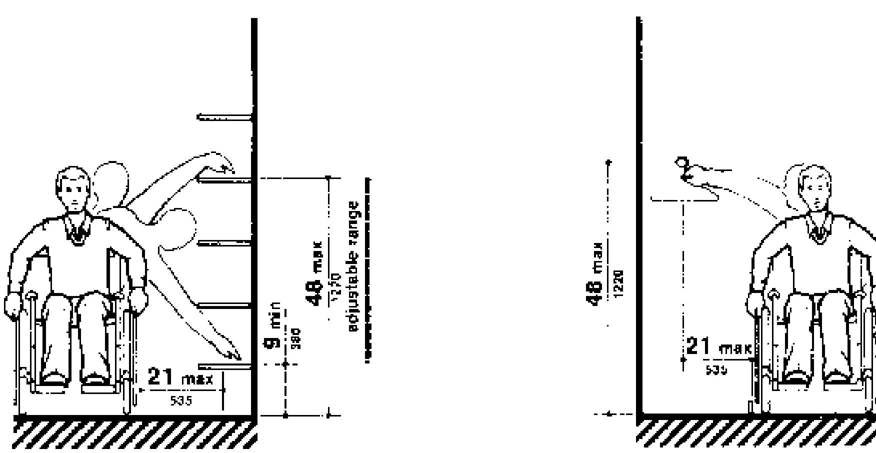
15.7.1 Reach for Card Catalogs



15.7.2 Reach for Stacks in a Library

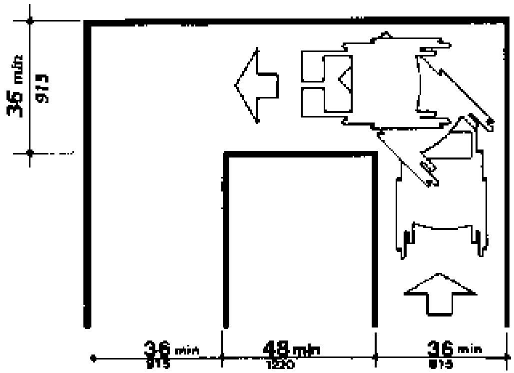


15.7.3 Reach for Shelves and Closets

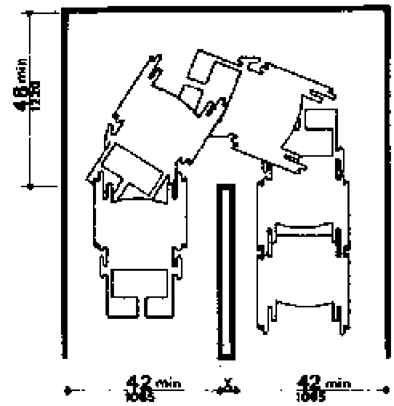


(a) Shelves (b) Closets

15.8.0 Accessible Routes

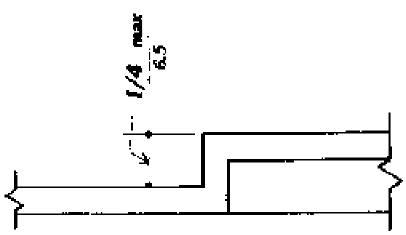


(a)
90° Turn

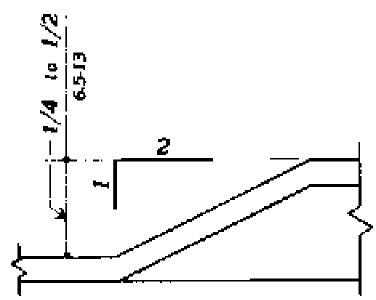


NOTE: Dimensions shown apply when x < 48 in (1220 mm).

(b)
Turns around an Obstruction

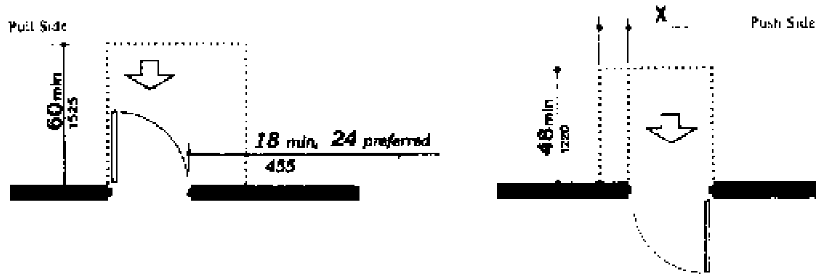


(c)
Changes in level



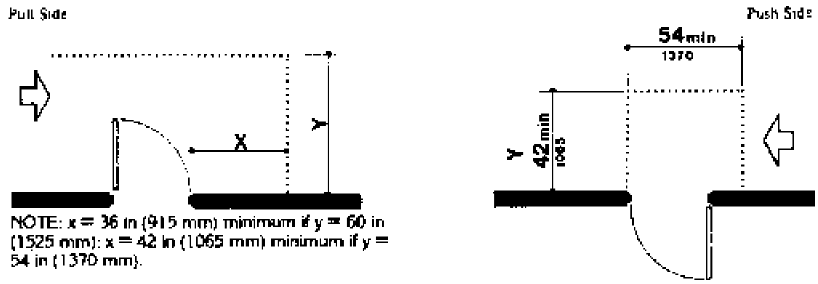
(d)
Changes in level

15.8.1 Maneuvering Clearance at Doors



NOTE: x = 12 in (305 mm) if door has both a closer and latch.

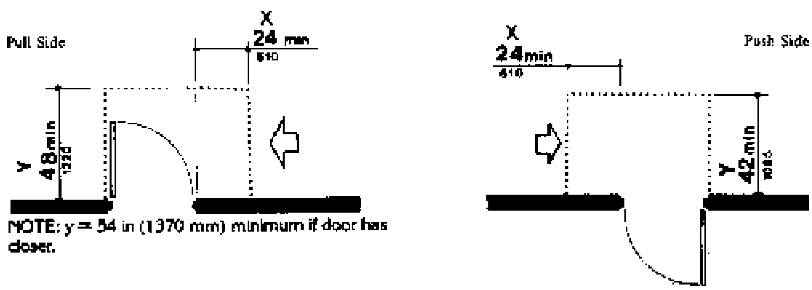
(a)
Front Approaches — Swinging Doors



NOTE: x = 36 in (915 mm) minimum if y = 60 in (1525 mm); x = 42 in (1065 mm) minimum if y = 54 in (1370 mm).

NOTE: y = 48 in (1220 mm) minimum if door has both a latch and closer.

(b)
Hinge Side Approaches — Swinging Doors

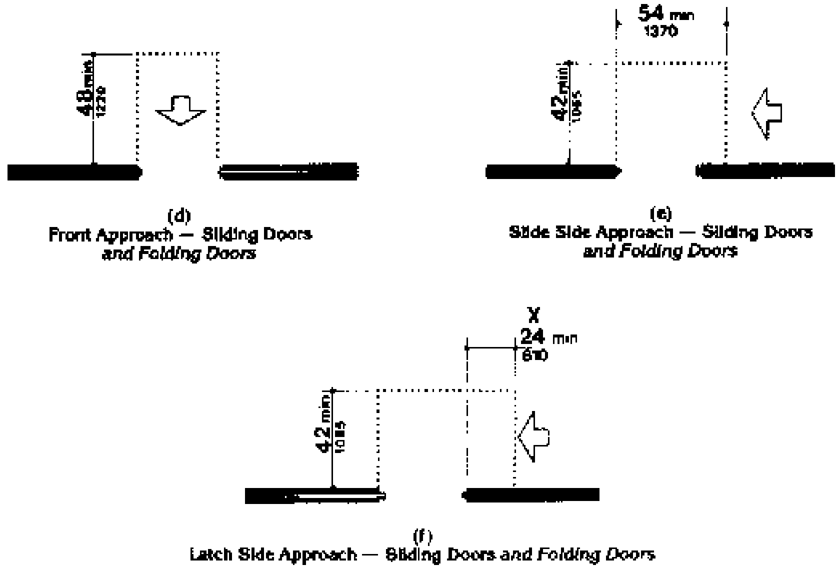


NOTE: y = 54 in (1370 mm) minimum if door has closer.

NOTE: y = 48 in (1220 mm) minimum if door has closer.

(c)
Latch Side Approaches — Swinging Doors

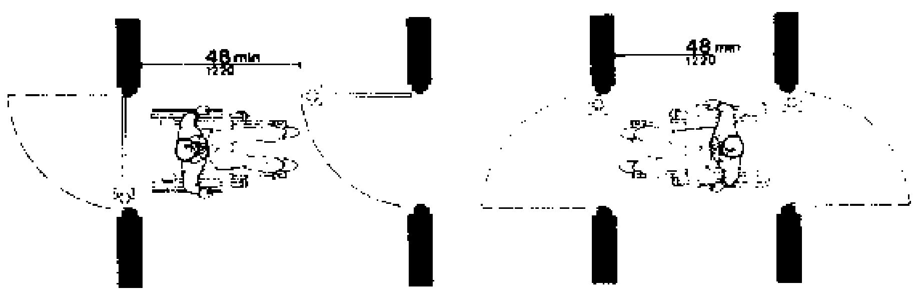
NOTE: All doors in alcoves shall comply with the clearances for front approaches.



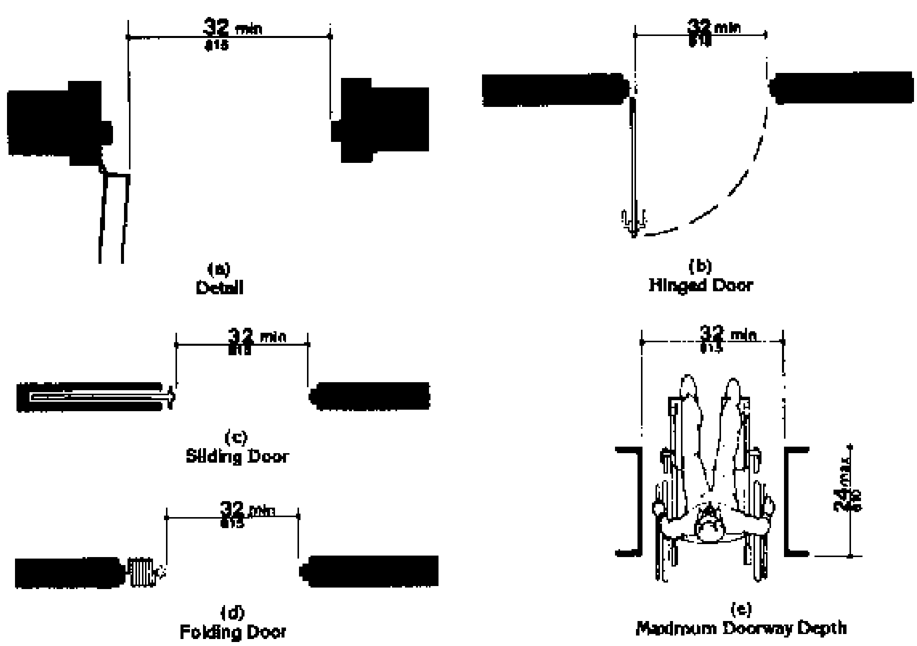
NOTE: All doors in alcoves shall comply with the clearances for front approaches.

Figure 15.8.1—*Continued*

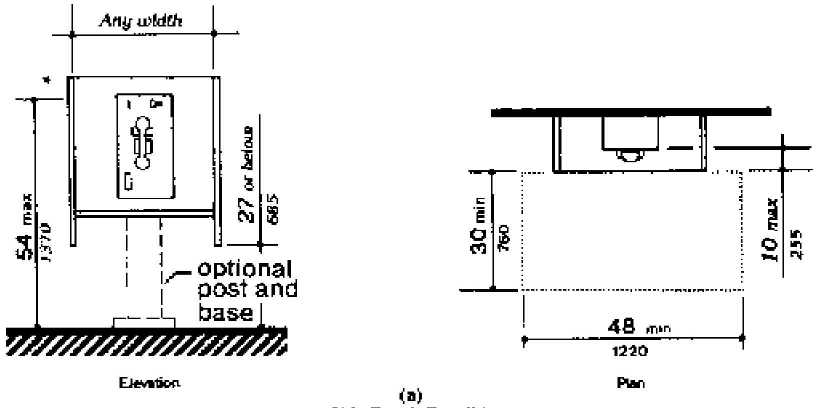
15.8.2 Two Hinged Doors in Series



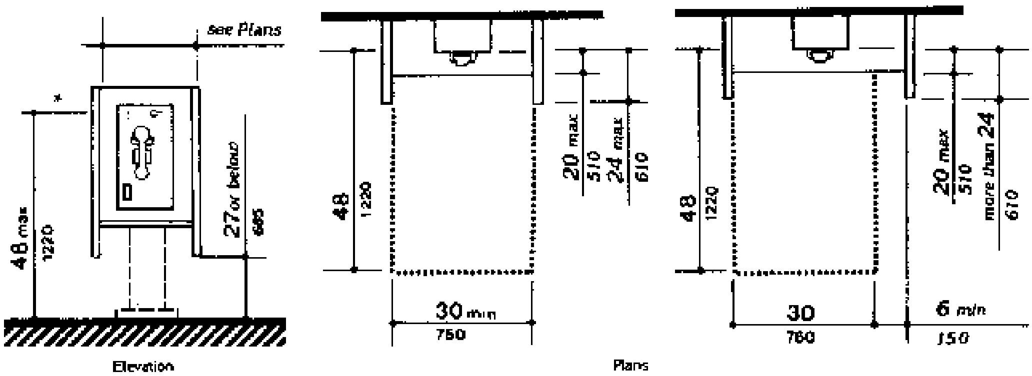
15.8.3 Clear Doorway Width and Depth



15.9.0 Mounting Heights for Telephones



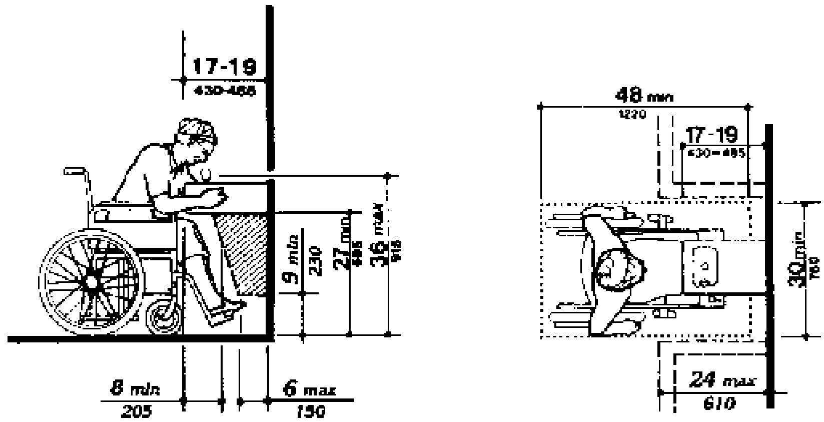
(a)
Side Reach Possible



*Height to highest operable parts which are essential to basic operation of telephone.

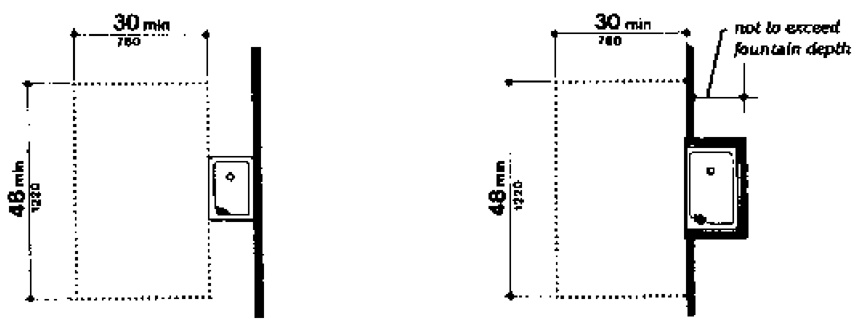
(b)
Forward Reach Required

15.10.0 Drinking Fountains and Water Coolers



(a)
Spout Height and
Knee Clearance

(b)
Clear Floor Space



(c)
Free-Standing
Fountain or Cooler

(d)
Built-In
Fountain or Cooler

15.11.0 Clear Space at Lavatories

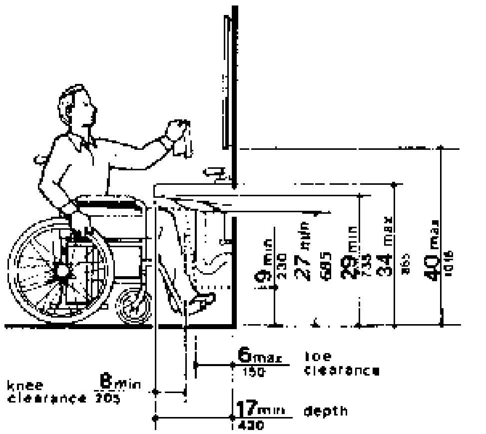
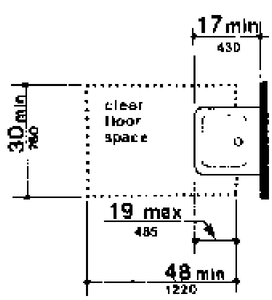
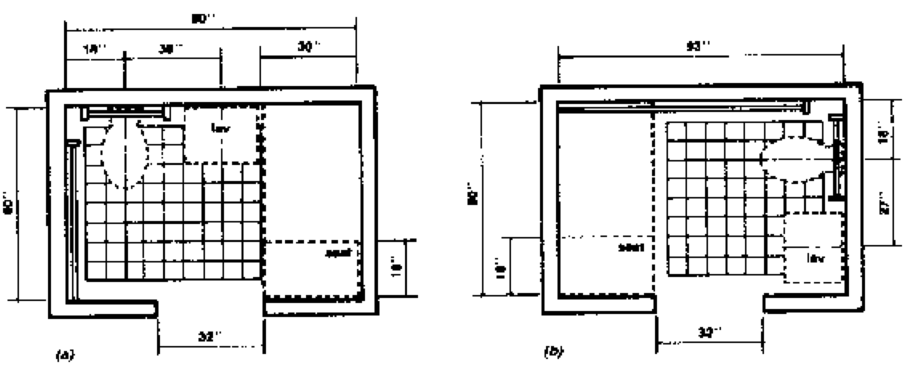


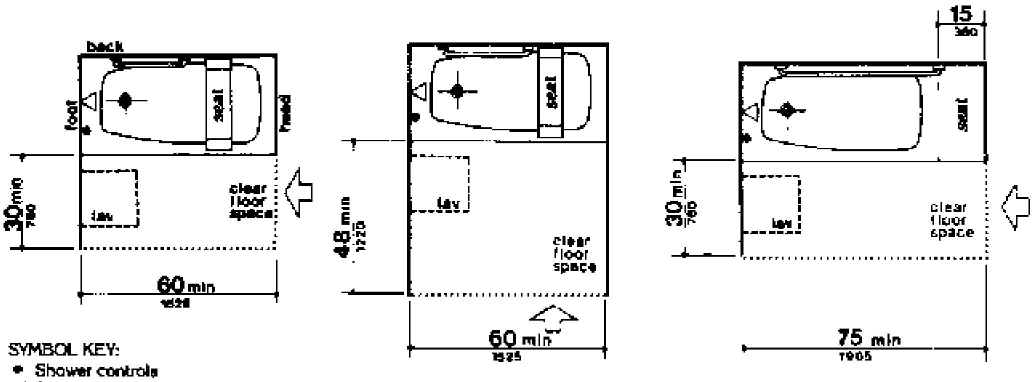
Fig. 31
Lavatory Clearances



15.12.0 Clear Space at Bathtubs

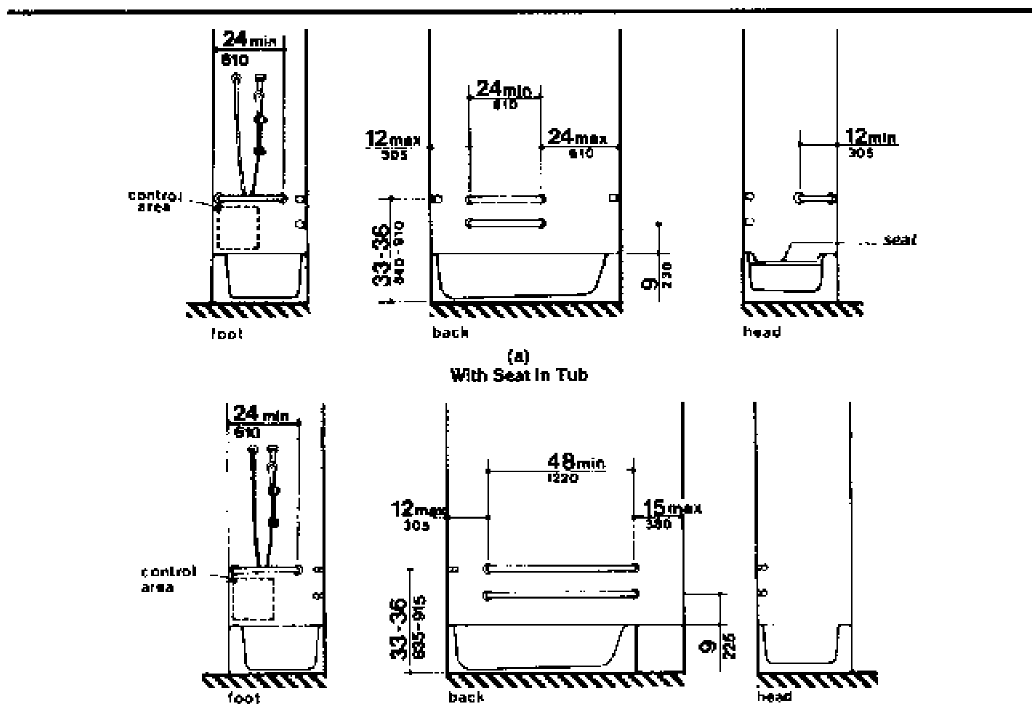


15.13.0 Grab Bars at Bathtubs



(a)
With Seat in Tub

(b)
With Seat at Head of Tub



(a)
With Seat In Tub

(b)
With Seat at Head of Tub

15.14.0 Grab Bars at Water Closets

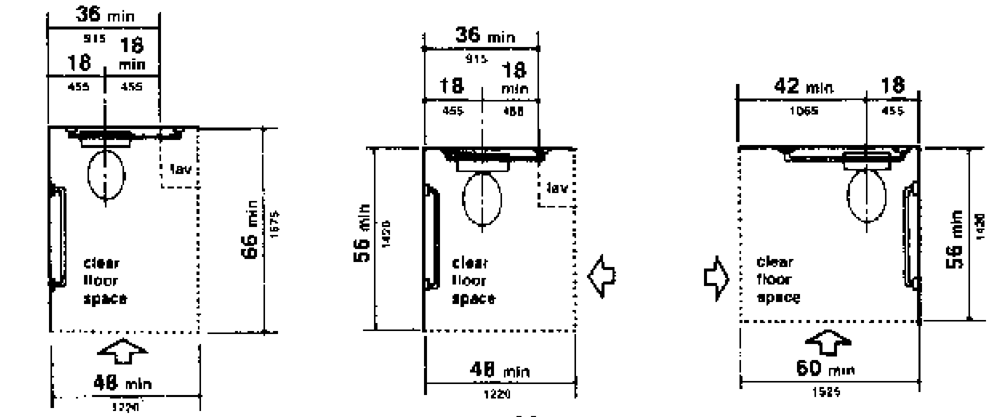
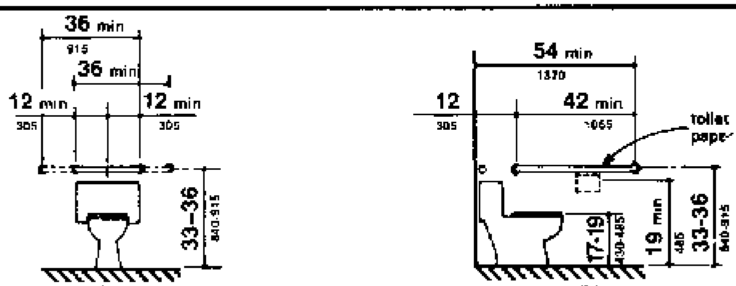


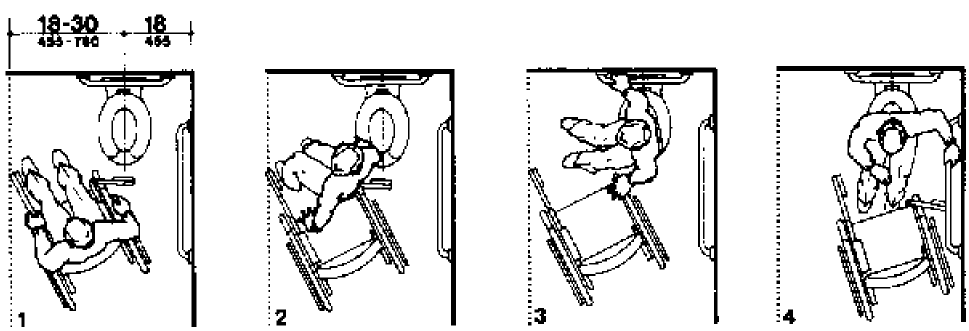
Fig. 28
Clear Floor Space at Water Closets



(a)
Back Wall

(b)
Side Wall

15.15.0 Wheelchair Transfers



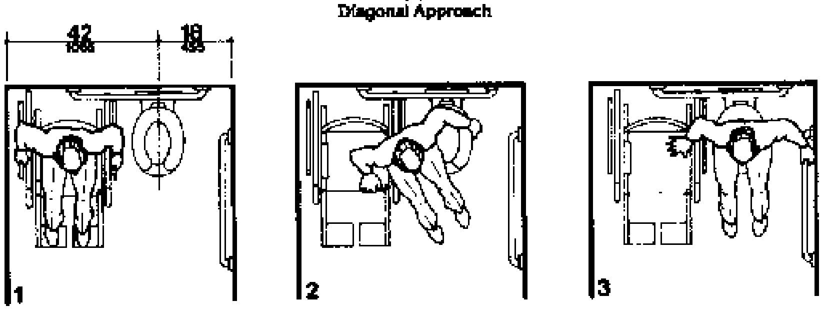
1 Takes transfer position, swings footrest out of the way, sets brakes.

2 Removes armrest, transfers.

3 Moves wheelchair out of the way, changes position (some people fold chair or pivot it 90° to the toilet).

4 Positions on toilet, releases brake.

(a)
Diagonal Approach



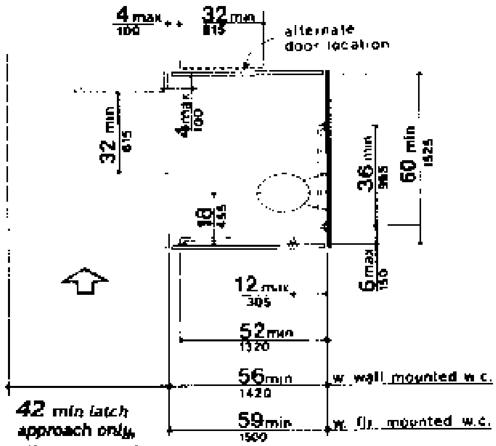
1 Takes transfer position, removes armrest, sets brakes.

2 Transfers.

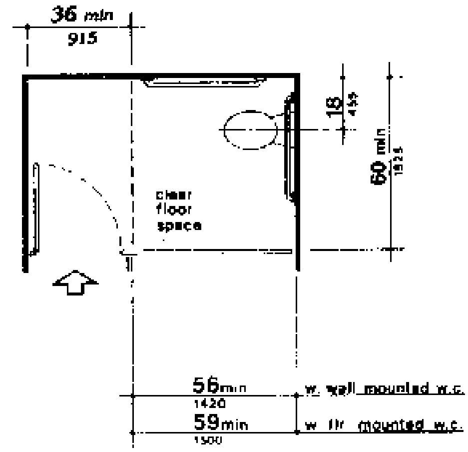
3 Positions on toilet.

(b)
Side Approach

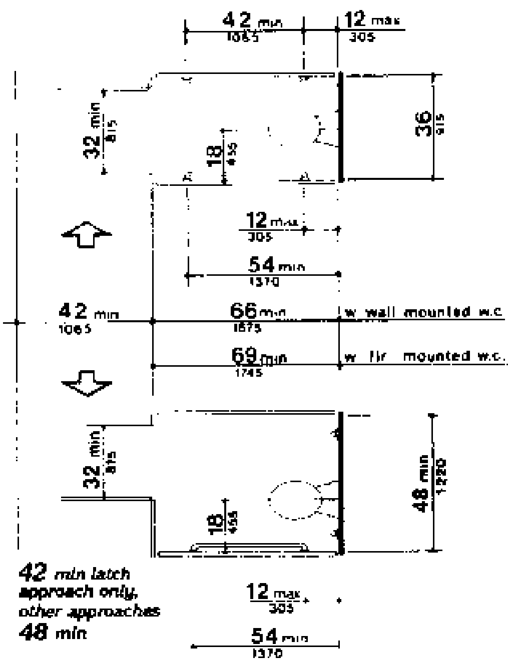
15.16.0 Toilet Stalls



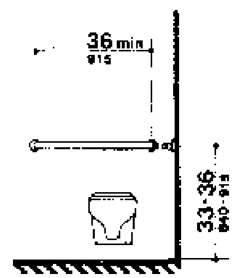
(a)
Standard Stall



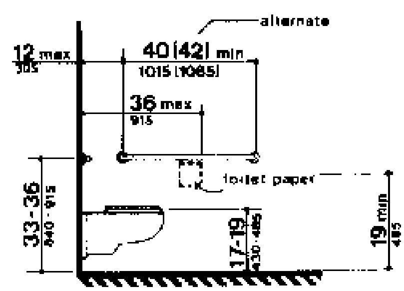
(a-1)
Standard Stall (end of row)



(b)
Alternate Stalls

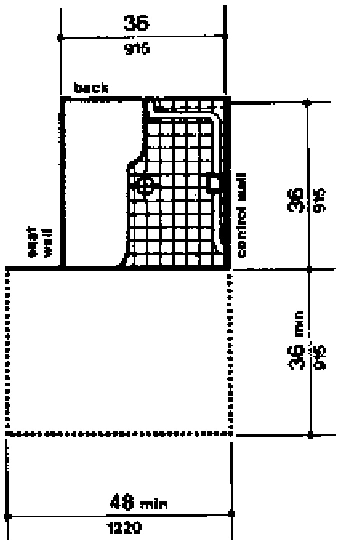


(c)
Rear Wall of Standard Stall

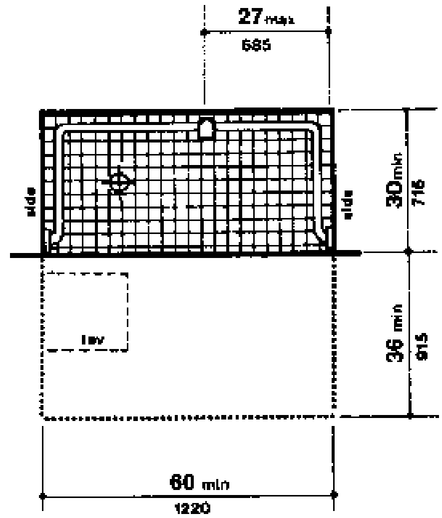


(d)
Side Walls

15.17.0 Shower Size and Clearances

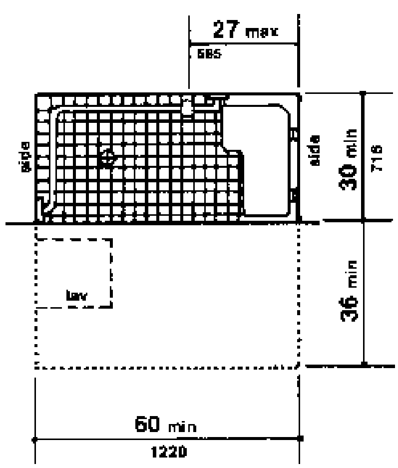


(a)
36-in by 36-in
(915-mm by 915-mm) Stall

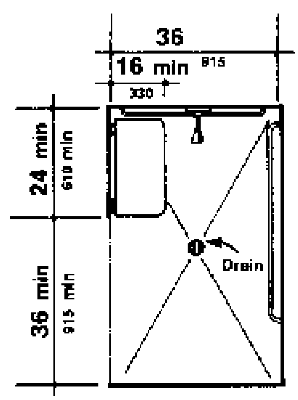


(b)
30-in by 60-in
(760-mm by 1525-mm) Stall

15.17.1 Roll-in Showers with Folding Seat

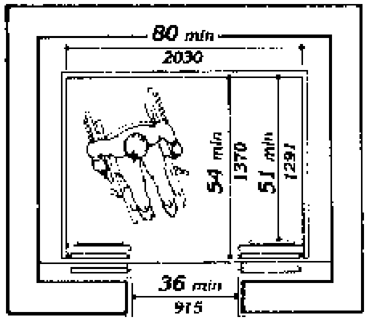


(a)

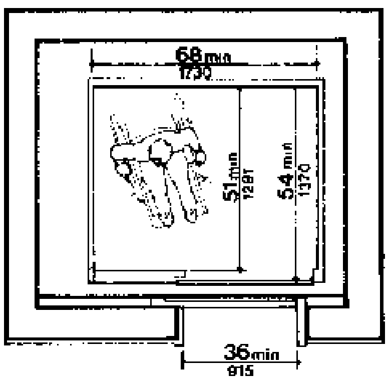


(b)

15.18.0 Elevator Cars—Minimum Dimensions

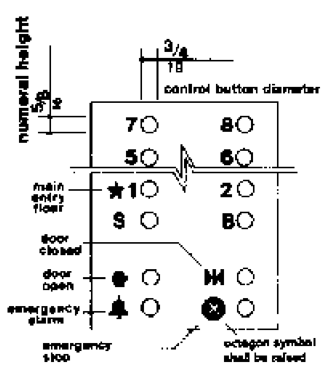


(a)

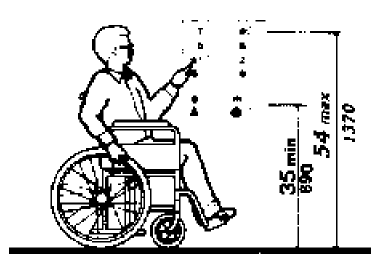


(b)

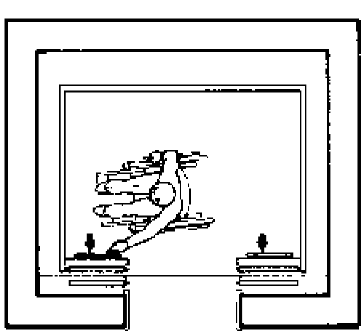
15.18.1 Elevator Car Controls



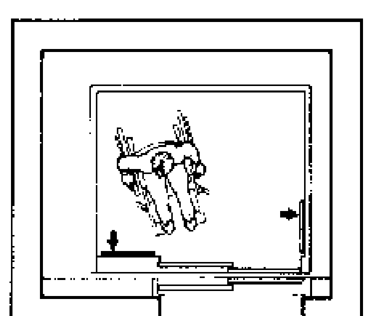
(a)
Panel Detail



(b)
Car Control Height

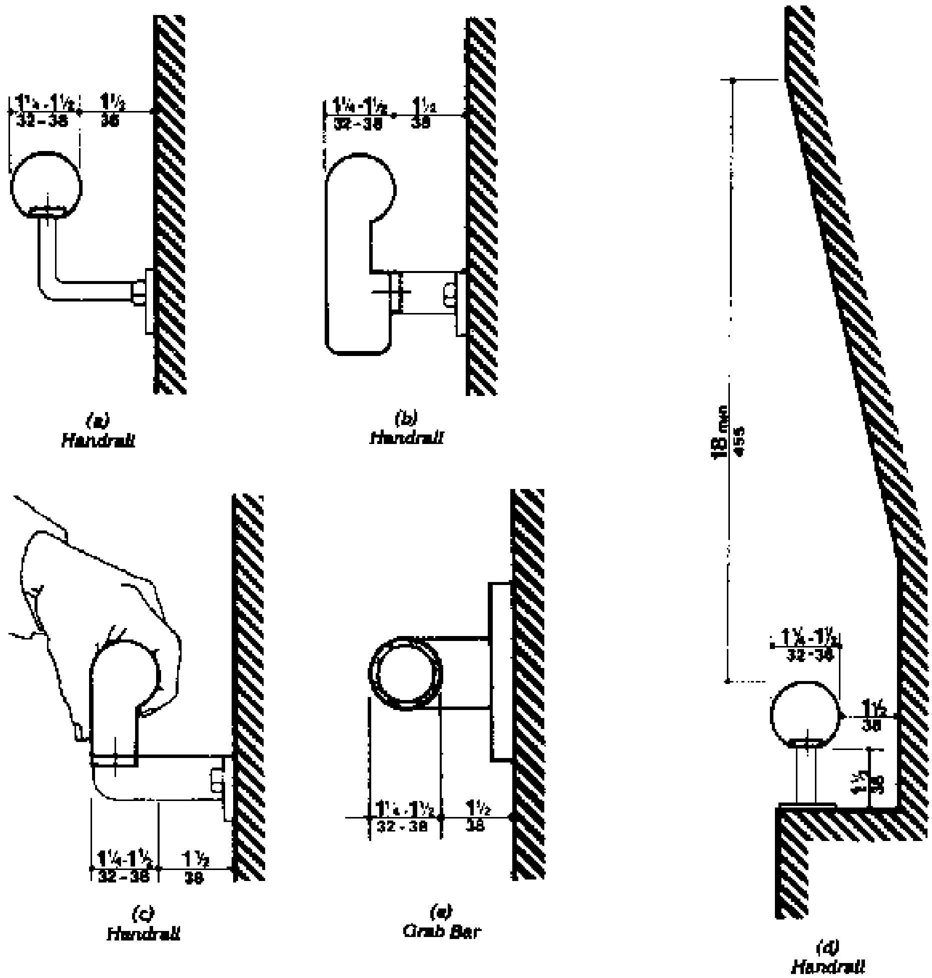


(c)
Alternate Locations of Panel with Center Opening Door

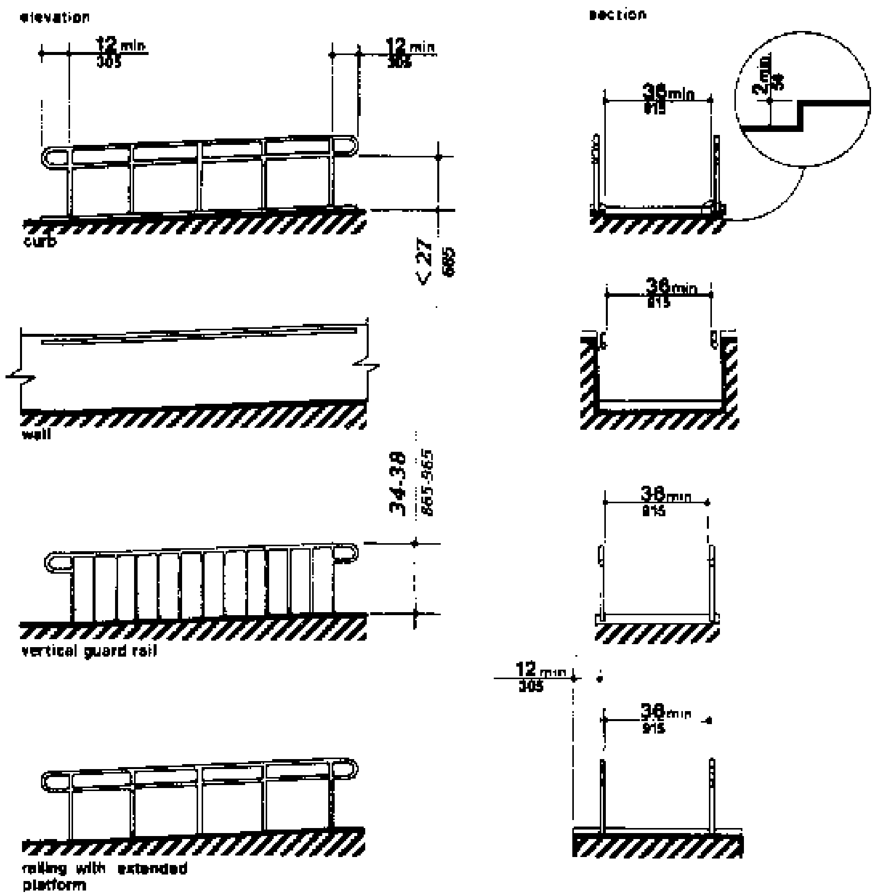


(d)
Alternate Locations of Panel with Side Opening Door

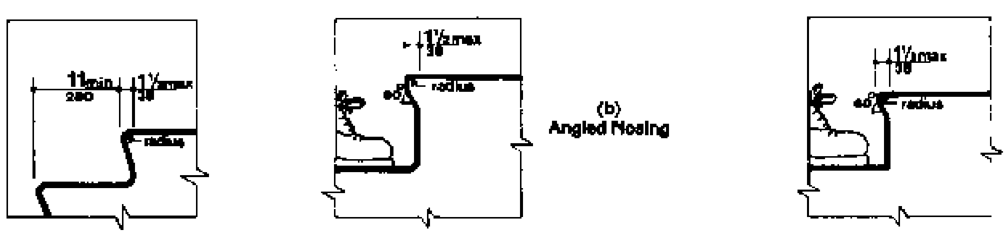
15.19.0 Size and Spacing of Handrails and Grab Bars



15.20.0 Handrail Extensions and Edge Protection



15.21.0 Usable Tread Width and Acceptable Nosings

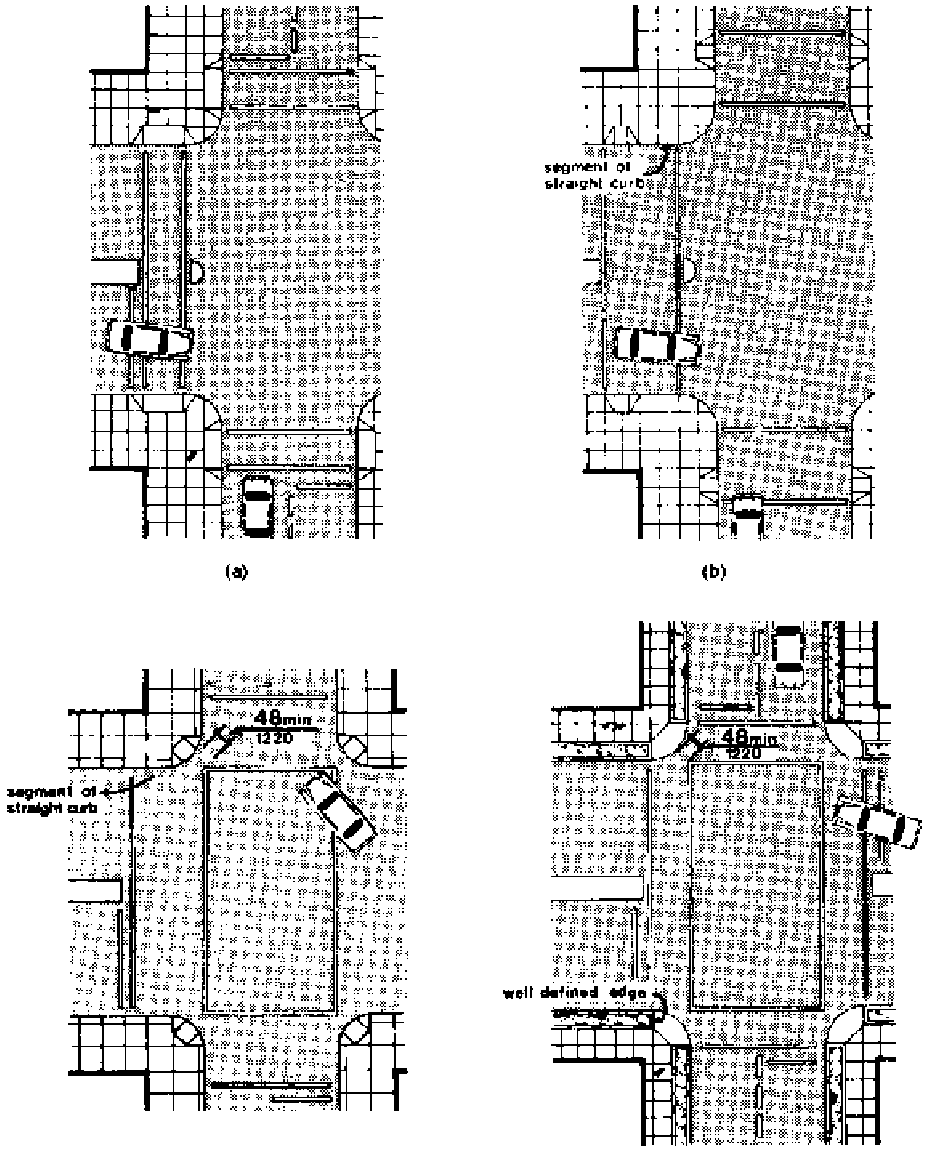


(a)
Flush Riser

(b)
Angled Nosing

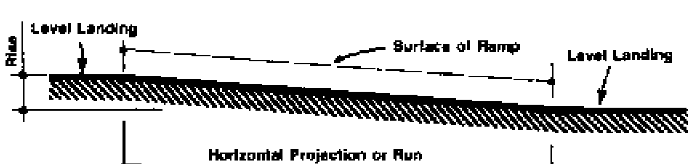
(c)
Rounded Nosing

15.22.0 Curb Ramps at Marked Crossings



(a) (b) (c) (d)

15.23.0 Components of Single Ramp Runs



	Maximum Rise		Maximum Horizontal Projection	
Slope	in	mm	ft	m
1:12 to < 1:16	30	760	30	9
1:16 to < 1:20	30	760	40	12

Section

16

Metrification

Contents

16.0.0 Introduction to the 1975 Metric Conversion Act

As the federal government moves to convert the inch-pound units to the metric system, in accordance with the 1975 Metric Conversion Act, various parts of the construction industry will begin the conversion to this more universal method of measurement.

Metric units are often referred to as *SI units*, an abbreviation taken from the French: le Système International d'Unités. Another abbreviation that will be seen with more frequency is ISO—the International Standards Organization charged with supervising the establishment of a universal standards system. For everyday transactions it may be sufficient to gain only the basics of the metric system.

Name of metric unit	Symbol	Approximate size (length/pound)
meter	m	39½ inches
kilometer	km	0.6 mile
centimeter	cm	width of a paper clip
millimeter	mm	thickness of a dime
hectare	ha	2½ acres
square meter	m^2	1.2 square yards
gram	g	weight of a paper clip
kilogram	kg	2.2 pounds
metric ton	t	long ton (2240 pounds)
liter	L	one quart and two ounces
milliliter	mL	⅕ teaspoon
kilopascal	kPa	atmospheric pressure is about 100 Pa

The Celsius temperature scale is used. Instead of referring to its measurement as *degree centigrade*, the term *degree Celsius* is the correct designation. Using this term, familiar points are

- Water freezes at 0 degrees
- Water boils at 100 degrees
- Normal body temperature is 37 degrees (98.6 F)
- Comfortable room temperature 20 to 35 (68 to 77 F)

16.1.0 What Will Change and What Will Stay the Same?

Metric Module and Grid

What will change:

- The basic building module, from 4 inches to 100 mm.
- The planning grid, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- A module and grid based on rounded, easy-to-use dimensions. The 100 mm module is the global standard.

Drawings

What will change:

- Units, from feet and inches to millimeters for all building dimensions and to meters for site plans and civil engineering drawings. Unit designations are unnecessary: if there is no decimal point, it is millimeters; if there is a decimal point carried to one, two, or three places, it is meters. In accordance with ASTM E621, centimeters are not used in construction because (1) they are not consistent with the preferred use of multiples of 1000, (2) the order of magnitude between a millimeter and centimeter is only 10 and the use of both units would lead to confusion and require the use of unit designations, and 93) the millimeter is small enough to almost entirely eliminate decimal fractions from construction documents.

- Drawing scales, from inch-fractions-to-feet to true rations. Preferred metric scales are:

  1:1 (full size)
  1:5 (close to 3" = 1'-0")
  1:10 (between 1" = 1'-0" and 1½" = 1'-0")
  1:20 (between ½" = 1'-0" and ¾" = 1'-0")
  1:50 (close to ¼" = 1'-0")
  1:100 (close to ⅛" = 1'-0")
  1:200 (close to 1⁄16" = 1'-0")
  1:500 (close to 1" = 40'-0")
  1:1000 (close to 1" = 80'-0")

As a means of comparison, inch-fraction scales may be converted to true ratios by multiplying a scale's divisor by 12; for example, for ¼" = 1'-0", multiply the 4 by 12 for a true ratio of 1:48.

- Drawing sizes, to ISO "A" series:

  A0 (1189 × 841 mm, 46.8 × 33.1 inches)
  A1 (841 × 594 mm, 33.1 × 23.4 inches)
  A2 (594 × 420 mm, 23.4 × 16.5 inches)
  A3 (420 × 297 mm, 16.5 × 11.7 inches)
  A4 (297 × 210 mm, 11.7 × 8.3 inches)

Of course, metric drawings can be made on any size paper.

What will stay the same:

- Drawing contents

Never use dual units (both inch-pound and metric) on drawings. It increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and only postpones the learning process. An exception is for construction documents meant to be viewed by the general public.

Specifications

What will change:

- Units of measure, from feet and inches to millimeters for linear dimensions, from square feet to square meters for area, from cubic yards to cubic meters for volume (except use liters for fluid volumes), and from other inch-pound measures to metric measures as appropriate.

What will stay the same:

- Everything else in the specifications

Do not use dual units in specifications except when the use of an inch-pound measure serves to clarify an otherwise unfamiliar metric measure; then place the inch-pound unit in parentheses after the metric. For example, "7.5 kW (10 horsepower) motor." All unit conversions should be checked by a professional to ensure that rounding does not exceed allowable tolerances.

For more information, see the July–August 1994 issue of *Metric in Construction.*

Floor Loads

What will change:

- Floor load designations, from "psf" to kilograms per square meter (kg/m^2) for everyday use and kilonewtons per square meter (kN/m^2) for structural calculations.

What will stay the same:

- Floor load requirements

Kilograms per square meter often are used to designate floor loads because many live and dead loads (furniture, filing cabinets, construction materials, etc.) are measured in kilograms. However, kilonewtons per square meter or their equivalent, kilopascals, are the proper measure and should be used in structural calculations.

Construction Products

What will change:

- Modular products: brick, block, drywall, plywood, suspended ceiling systems, and raised floor systems. They will undergo "hard" conversion; that is, their dimensions will change to fit the 100 mm module.
- Products that are custom-fabricated or formed for each job (for example, cabinets, stairs, handrails, ductwork, commercial doors and windows, structural steel systems, and concrete work). Such products usually can be made in any size, inch-pound or metric, with equal ease; therefore, for metric jobs, they simply will be fabricated or formed in metric.

What will stay the same:

- All other products, since they are cut-to-fit at the jobsite (for example, framing lumber, woodwork, siding, wiring, piping, and roofing) or are not dimensionally sensitive (for example, fasteners, hardware, electrical components, plumbing fixtures, and HVAC equipment). Such products will just be "soft" converted—that is, relabeled in metric units. A 2¾" × 4½" wall switch face plate will be relabeled 70 × 115 mm and a 30 gallon tank, 114 L. Manufacturers eventually may convert the physical dimensions of many of these products to new rational "hard" metric sizes but only when it becomes convenient for them to do so.

"2-By-4" Studs and Other "2-By" Framing (Both Wood and Metal)

What will change:

- Spacing, from 16" to 400 mm, and 24" to 600 mm.

What will stay the same:

- Everything else.

"2-bys" are produced in "soft" fractional inch dimensions so there is no need to convert them to new rounded "hard" metric dimensions. 2-by-4s may keep their traditional name or perhaps they will eventually be renamed 50 by 100 (mm), or, more exactly, 38 × 39.

Drywall, Plywood, and Other Sheet Goods

What will change:

- Widths, from 4'–0" to 1200 mm.
- Heights, from 8'-0" to 2400 mm, 10'-0" to 3000 mm.

What will stay the same:

- Thicknesses, so fire, acoustic, and thermal ratings will not have to be recalculated.

Metric drywall and plywood are readily available but may require longer lead times for ordering and may cost more in small amounts until their use becomes more common.

Batt Insulation

What will change:

- Nominal width labels, from 16" to 16"/400 mm and 24" to 24"/600 mm.

What will stay the same:

- Everything else.

Batts will not change in width, they will just have a tighter "friction fit" when installed between metric-spaced framing members.

Doors

What will change:

- Height, from 6'-8" to 2050 mm or 2100 mm and from 7'-0" to 2100 mm.
- Width, from 2'-6" to 750 mm, from 2'-8" to 800 mm, from 2'-10" to 850 mm, from 3"-0" to 900 mm or 950 mm, and from 3'-4" to 1000 mm.

What will stay the same:

- Door thicknesses.
- Door materials and hardware.

For commercial work, doors and door frames can be ordered in any size since they normally are custom-fabricated.

Ceiling Systems

What will change:

- Grids and lay-in ceiling tile, air diffusers and recessed lighting fixtures, from 2' × 2' to 600 × 600 mm and from 2' × 4' to 600 × 1200 mm.

What will stay the same:

- Grid profiles, tile thicknesses, air diffuser capacities, fluorescent tubes, and means of suspension.

On federal building projects, metric recessed lighting fixtures may be specified if their total installed costs are estimated to be more than for inch-pound fixtures.

Raised Floor Systems

What will change:

- Grids and lay-in floor tile, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Grid profiles, tile thicknesses, and means of support.

HVAC Controls

What will change:

- Temperature units, from Fahrenheit to Celsius.

What will stay the same:

- All other parts of the controls.

Controls are now digital so temperature conversions can be made with no difficulty.

Brick

What will change:

- Standard brick, to 90 × 57 × 190 mm.
- Mortar joints, from ⅜" and ½" to 10 mm.
- Brick module, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Brick and mortar composition.

Of the 100 or so brick sizes currently made, 5 to 10 are within a millimeter of a metric brick so the brick industry will have no trouble supplying metric brick.

For more information, see the March–April 1995 issue of *Metric in Construction.*

Concrete Block

What will change:

- Block sizes, to 190 × 190 × 390 mm.
- Mortar joints, from ½" to 10 mm.
- Block module, from 2' × 2' to 600 × 600 mm.

What will stay the same:

- Block and mortar composition.

On federal building projects, metric block may be specified if its total installed cost is estimated to be more than for inch-pound block. The Construction Metrication Council recommends that, wherever possible, block walls be designed and specified in a manner that permits the use of either inch-pound or metric block, allowing the final decision to be made by the contractor.

Sheet Metal

What will change:

- Designation, from "gage" to millimeters.

What will stay the same:

- Thickness, which will be soft-converted to tenths of a millimeter.

In specifications, use millimeters only or millimeters with the gage in parentheses.

Concrete

What will change:

- Strength designations, from “psi” to megapascals, rounded to the nearest 5 megapascals per ACI 318M as follows:

  2500 psi to 20 MPa
  3000 psi to 25 MPa
  3500 psi to 25 MPa
  4000 psi to 30 MPa
  4500 psi to 35 MPa
  5000 psi to 35 MPa

Depending on exact usage, however, the above metric conversions may be more exact than those indicated.

What will stay the same:

- Everything else.

For more information, see the November–December 1994 issue of *Metric in Construction.*

Rebar

What will change:

- Rebar will not change in size but will be renamed per ASTM A615M-96a and ASTM A706M-96a as follows:

No. 3 to No. 10	No. 9 to No. 29
No. 4 to No. 13	No. 10 to No. 32
No. 5 to No. 16	No. 11 to No. 36
No. 6 to No. 19	No. 14 to No. 43
No. 7 to No. 22	No. 18 to No. 57
No. 8 to No. 25	

What will stay the same:

- Everything else.

For more information, see the July–August 1996 issue of *Metric on Construction.*

Glass

What will change:

- Nominal pipe and fitting designations, from inches to millimeters.

What will stay the same:

- Pipe and fitting cross sections and threads.

Pipes and fittings are produced in “soft” decimal-inch dimensions but are identified in nominal-inch sizes as a matter of convenience. A 2-inch pipe has neither an inside nor an outside diameter of

2 inches, a 1-inch fitting has no exact 1-inch dimension, and a ½-inch sprinkler head contains no ½-inch dimension anywhere; consequently, there is no need to "hard" convert pipes and fittings to rounded metric dimensions. Instead, they will not change size but simply be relabeled in metric as follows:

⅛" = 6 mm	1½" = 40 mm
3⁄16" = 7 mm	2" = 50 mm
¼" = 8 mm	2½" = 65 mm
⅜" = 10 mm	3" = 75 mm
½" = 15 mm	3½" = 90 mm
⅝" = 18 mm	4" = 100 mm
¾" = 20 mm	4½" = 115 mm
1" = 25 mm	1" = 25 mm for all larger sizes
1¼" = 32 mm	

For more information, see the September–October 1993 issue of *Metric in Construction.*

Electrical Conduit

What will change:

- Nominal conduit designations, from inches to millimeters.

What will stay the same:

- Conduit cross sections.

Electrical conduit is similar to piping: it is produced in "soft" decimal-inch dimensions but is identified in nominal-inch sizes. Neither metallic nor nonmetallic conduit will change size; they will be relabeled in metric units as follows:

½" = 16 (mm)	2½" = 63 (mm)
¾" = 21 (mm)	3" = 78 (mm)
1" = 27 (mm)	3½" = 91 (mm)
1¼" = 35 (mm)	4" = 103 (mm)
1½" = 41 (mm)	5" = 129 (mm)
2" = 53 (mm)	6" = 155 (mm)

These new metric names were assigned by the National Electrical Manufacturers Association.

Electrical Wire

What will change:

- Nothing at this time.

What will stay the same:

- Existing American Wire Gage (AWG) sizes.

Structural Steel

What will change:

- Section designations, from inches to millimeters and from pounds per foot to kilograms per meter, in accordance with ASTM A6M.

- Bolts—to metric diameters and threads per ASTM A325M and A490M.

What will stay the same:

- Cross sections.

Like pipe and conduit, steel sections are produced in “soft” decimal-inch dimensions (with actual depths varying by weight) but are named in rounded-inch dimensions so there is no need to “hard” convert them to metric units. Rather, their names will be changed to metric designations, and rounded to the nearest 10 mm. Thus, a 10-inch section is relabeled as a 250-mm section and a 24-inch section is relabeled as a 610-mm section.

16.2.0 How Metric Units Will Apply in the Construction Industry

	Quantity	Unit	Symbol
Masonry	length	meter, millimeter	m, mm
	area	square meter	m^2
	mortar volume	cubic meter	m^3
Steel	length	meter, millimeter	m, mm
	mass	megagram (metric ton) kilogram	Mg (t) kg
	mass per unit length	kilogram per meter	kg/m
Carpentry	length	meter, millimeter	m, mm
Plastering	length	meter, millimeter	m, mm
	area	square meter	m^2
	water capacity	liter (cubic decimeter)	L (dm^3)
Glazing	length	meter, millimeter	m, mm
	area	square meter	m^2
Painting	length	meter, millimeter	m, mm
	area	square meter	m^2
	capacity	liter (cubic decimeter) milliliter (cubic centimeter)	L (dm^3) mL (cm^3)
Roofing	length	meter, millimeter	m, mm
	area	square meter	m^2
	slope	percent ratio of lengths	% mm/mm, m/m
Plumbing	length	meter, millimeter	m, mm
	mass	kilogram, gram	kg, g
	capacity	liter (cubic decimeter)	L (dm^3)
	pressure	kilopascal	kPa
Drainage	length	meter, millimeter	m, mm
	area	hectare (10 000 m2) square meter	ha m^2
	volume	cubic meter	m^3
	slope	percent ratio of lengths	% mm/mm, m/m
HVAC	length	meter, millimeter	m, mm
	volume (capacity)	cubic meter liter (cubic decimeter)	m^3 L (dm^3)
	air velocity	meter/second	m/s
	volume flow	cubic meter/second liter/second (cubic decimeter per second)	m^3/s L/s (dm^3/s)
	temperature	degree Celsius	°C
	force	newton, kilonewton	N, kN
	pressure	pascal, kilopascal	Pa, kPa
	energy	kilojoule, megajoule	kJ, MJ
	rate of heat flow	watt, kilowatt	W, kW
Electrical	length	millimeter, meter, kilometer	mm, m, km
	frequency	hertz	Hz
	power	watt, kilowatt	W, kW
	energy	megajoule kilowatt hour	MJ kWh
	electric current	ampere	A
	electric potential	volt, kilovolt	V, kV
	resistance	milliohm, ohm	mΩ, Ω

16.3.0 Metrification of Pipe Sizes

Pipe diameter sizes can be confusing because their designated size does not correspond to their actual size. For instance, a 2-inch steel pipe has an inside diameter of approximately 2⅛ inches and an outside diameter of about 2⅝ inches.

The *2 inch* designation is very similar to the 2" × 4" designation for wood studs, neither dimensions are "actual," but they are a convenient way to describe these items.

Pipe sizes are identified as *NPS* (*nominal pipe size*) and their conversion to metric would conform to ISO (International Standards Organization) criteria and are referred to as *DN* (*diameter nominal*). These designations would apply to all plumbing, mechanical, drainage, and miscellaneous pipe commonly used in civil works projects.

NPS size	*DN size*
⅛"	6 mm
3⁄16"	7 mm
¼"	8 mm
⅜"	10 mm
½"	15 mm
⅝"	18 mm
¾"	20 mm
1"	25 mm
1¼"	32 mm
1½"	40 mm
2"	50 mm
2½"	65 mm
3"	80 mm
3½"	90 mm
4"	100 mm
4½"	115 mm
5"	125 mm
6"	150 mm
8"	200 mm
10"	250 mm
12"	300 mm
14"	350 mm
16"	400 mm
18"	450 mm
20"	500 mm
24"	600 mm
28"	700 mm
30"	750 mm
32"	800 mm
36"	900 mm
40"	1000 mm
44"	1100 mm
48"	1200 mm

NPS size	*DN size*
52"	1300 mm
56"	1400 mm
60"	1500 mm

For all pipe over 60-inches nominal, use 1 inch equals 25 mm.

16.4.0 Metrification of Standard Lumber Sizes

Metric units: ASTM Standard E-380 was used as the authoritative standard in developing the metric dimensions in this standard. Metric dimensions are calculated at 25.4 millimeters (mm) times the actual dimension in inches. The nearest mm is significant for dimensions greater than 1/8 inch, and the nearest 0.1 mm is significant for dimensions equal to ore less than 1/8 inch.

The rounding rule for dimensions greater than 1/8 inch: If the digit in the tenth of mm position (the digit after the decimal point) is less than 5, drop all fractional mm digits; if it is greater than 5 or if it is 5 followed by at least one nonzero digit, round one mm higher; if 5 followed by only zeroes, retain the digit in the unit position (the digit before the decimal point) if it is even, or increase it one mm if it is odd.

The rounding rule for dimensions equal to or less than 1/8 inch: if the digit in the hundredths of mm position (the second digit after the decimal point) is less than 5, drop all digits to the right of the tenth position; if greater than or it is 5 followed by at least one nonzero digit, round one-tenth mm higher; if 5 followed by only zeros, retain the digit in the tenths position if it is even or increase it one-tenth mm if it is odd.

In case of a dispute on size measurements, the conventional (inch) method of measurement shall take precedence.

16.5.0 Metric Rebar Conversions

A615 M-96a & A706M-96a Metric Bar Sizes	Nominal Diameter	A615-96a & A706-96a Inch-Pound Bar Sizes
#10	9.5 mm/0.375"	#3
#13	12.7 mm/0.500"	#4
#16	15.9 mm/0.625"	#5
#19	19.1 mm/0.750"	#6
#22	22.2 mm/0.875"	#7
#25	25.4 mm/1.000"	#8
#29	28.7 mm/1.128"	#9
#32	32.3 mm/1.270"	#10
#36	35.8 mm/1.410"	#11
#43	43.0 mm/1.693"	#14
#57	57.3 mm/2.257"	#18

16.6.0 Metric Conversion of ASTM Diameter and Wall Thickness Designations

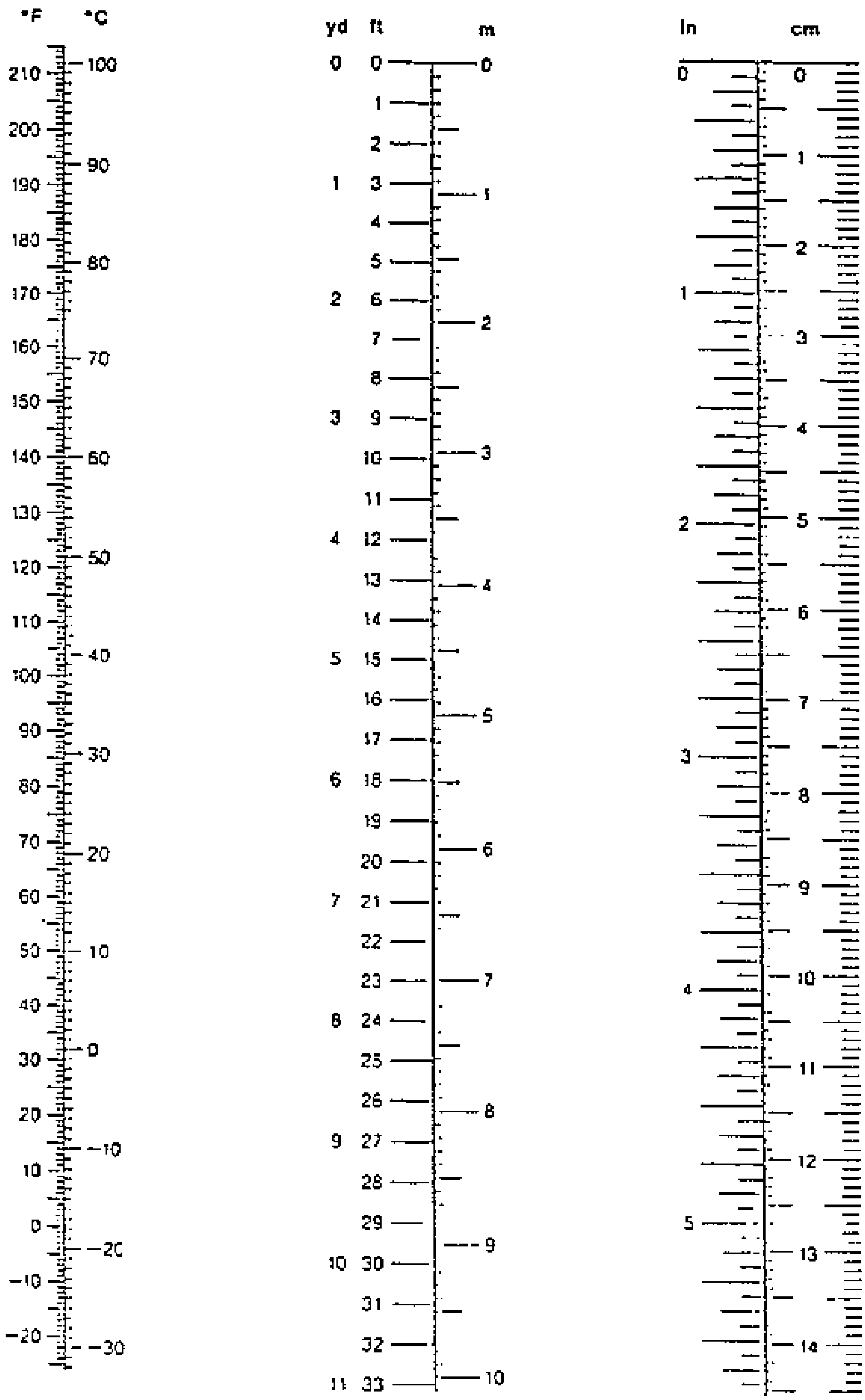
Metric conversion of ASTM diameter designations

in	mm	in	mm	in	mm	in	mm
6	150	30	750	57	1425	96	2400
8	200	33	825	60	1500	102	2550
10	250	36	900	63	1575	108	2700
12	300	39	975	66	1650	114	2850
15	375	42	1050	69	1725	120	3000
18	450	45	1125	72	1800	132	3300
21	525	48	1200	78	1950	144	3600
24	600	51	1275	84	2100	156	3900
27	675	54	1350	90	2250	168	4200

Metric conversion of ASTM wall thickness designations

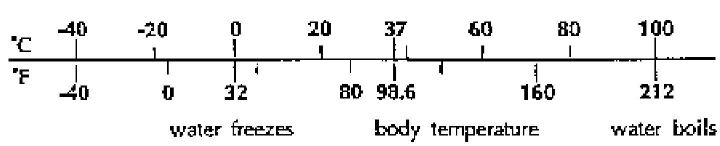
in	mm	in	mm	in	mm	in	mm
1	25	3-1/8	79	5	125	8	200
1-1/2	38	3-1/4	82	5-1/4	131	8-1/2	213
2	50	3-1/2	88	5-1/2	138	9	225
2-1/4	56	3-3/4	94	5-3/4	144	9-1/2	238
2-3/8	59	3-7/8	98	6	150	10	250
2-1/2	63	4	100	6-1/4	156	10-1/2	263
2-5/8	66	4-1/8	103	6-1/2	163	11	275
2-3/4	69	4-1/4	106	6-3/4	169	11-1/2	288
2-7/8	72	4-1/2	113	7	175	12	300
3	75	4-3/4	119	7-1/2	188	12-1/2	313

16.7.0 Metric Conversion Scales (Temperature and Measurements)



16.8.0 Approximate Metric Conversions

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1,000 kg)	1.1	short tons	
		VOLUME		
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	degrees Celsius	multiply by 9/5, add 32	degrees Fahrenheit	°F



(U.S. Department of Commerce Technology Administration, Office of Metric Programs, Washington, DC 20230.)

16.8.0 Approximate Metric Conversions—Continued

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	subtract 32, multiply by 5/9	degrees Celsius	°C

(United States Department of Commerce, Technology Administration, National Institute of Standards and Technology, Metric Program, Gaithersburg, Maryland 20899.)

16.9.0 Quick Imperial (Metric Equivalents)

Distance

Imperial	Metric
1 inch	= 2.540 centimetres
1 foot	= 0.3048 metre
1 yard	= 0.9144 metre
1 rod	= 5.029 metres
1 mile	= 1.609 kilometres

Metric	Imperial
1 centimetre	= 0.3937 inch
1 decimetre	= 0.3281 foot
1 metre	= 3.281 feet
	= 1.094 yard
1 decametre	= 10.94 yards
1 kilometre	= 0.6214 mile

Weight

1 ounce (troy)	= 31.103 grams
1 ounce (avoir)	= 28.350 grams
1 pound (troy)	= 373.242 grams
1 pound (avoir)	= 453.592 grams
1 ton (short)	= 0.907 tonne*

1 gram	= 0.032 ounce (troy)
1 gram	= 0.035 ounce (avoir)
1 kilogram	= 2.679 pounds (troy)
1 kilogram	= 2.205 pounds (avoir)
1 tonne	= 1.102 ton (short)

*1 tonne = 1000 kilograms

Capacity

Imperial	
1 pint	= 0.568 litre
1 gallon	= 4.546 litres
1 bushel	= 36.369 litres
1 litre	= 0.880 pint
1 litre	= 0.220 gallon
1 hectolitre	= 2.838 bushels

U.S.	
1 pint (U.S.)	= 0.473 litre
1 quart (U.S.)	= 0.946 litre
1 gallon (U.S.)	= 3.785 litres
1 barrel (U.S.)	= 158.98 litres

Area

1 square inch	= 6.452 square centimetres
1 square foot	= 0.093 square metre
1 square yard	= 0.836 square metre
1 acre	= 0.405 hectare*
1 square mile	= 259.0 hectares
1 square mile	= 2.590 square kilometres
1 square centimetre	= 0.155 square inch
1 square metre	= 10.76 square feet
1 square metre	= 1.196 square yard
1 hectare	= 2.471 acres
1 square kilometre	= 0.386 square mile

*1 hectare = 1 square hectometre

Volume

1 cubic inch	= 16.387 cubic centimetres
1 cubic foot	= 0.0283 cubic decimetres
1 cubic yard	= 0.765 cubic metre
1 cubic centimetre	= 0.061 cubic inch
1 cubic decimetre	= 35.314 cubic foot
1 cubic metre	= 1.308 cubic yard

16.10.0 Metric Conversion Factors

The following list provides the conversion relationship between U.S. customary units and SI (International System) units. The proper conversion procedure is to multiply the specified value on the left (primarily U.S. customary values) by the conversion factor exactly as given below and then round to the appropriate number of significant digits desired. For example, to convert 11.4 ft to meters: 11.4 × 0.3048 = 3.47472, which rounds to 3.47 meters. Do not round either value before performing the multiplication, as accuracy would be reduced. A complete guide to the SI system and its use can be found in ASTM E 380, Metric Practice.

To convert from	to	multiply by
Length		
inch (in.)	micron (μ)	25,400 E*
inch (in.)	centimeter (cm)	2.54 E
inch (in.)	meter (m)	0.0254 E
foot (ft)	meter (m)	0.3048 E
yard (yd)	meter (m)	0.9144
Area		
square foot (sq ft)	square meter (sq m)	0.09290304 E
square inch (sq in.)	square centimeter (sq cm)	6.452 E
square inch (sq in.)	square meter (sq m)	0.00064516 E
square yard (sq yd)	square meter (sq m)	0.8361274
Volume		
cubic inch (cu in.)	cubic centimeter (cu cm)	16.387064
cubic inch (cu in.)	cubic meter (cu m)	0.00001639
cubic foot (cu ft)	cubic meter (cu m)	0.02831685
cubic yard (cu yd)	cubic meter (cu m)	0.7645549
gallon (gal) Can. liquid	liter	4.546
gallon (gal) Can. liquid	cubic meter (cu m)	0.004546
gallon (gal) U.S. liquid**	liter	3.7854118
gallon (gal) U.S. liquid	cubic meter (cu m)	0.00378541
fluid ounce (fl oz)	milliliters (ml)	29.57353
fluid ounce (fl oz)	cubic meter (cu m)	0.00002957
Force		
kip (1000 lb)	kilogram (kg)	453.6
kip (1000 lb)	newton (N)	4,448.222
pound (lb) avoirdupois	kilogram (kg)	0.4535924
pound (lb)	newton (N)	4.448222
Pressure or stress		
kip per square inch (ksi)	megapascal (MPa)	6.894757
kip per square inch (ksi)	kilogram per square centimeter (kg/sq cm)	70.31
pound per square foot (psf)	kilogram per square meter (kg/sq m)	4.8824
pound per square foot (psf)	pascal (Pa)†	47.88
pound per square inch (psi)	kilogram per square centimeter (kg/sq cm)	0.07031
pound per square inch (psi)	pascal (Pa)†	6,894.757
pound per square inch (psi)	megapascal (MPa)	0.00689476
Mass (weight)		
pound (lb) avoirdupois	kilogram (kg)	0.4535924
ton, 2000 lb	kilogram (kg)	907.1848
grain	kilogram (kg)	0.0000648
Mass (weight) per length		
kip per linear foot (klf)	kilogram per meter (kg/m)	0.001488
pound per linear foot (plf)	kilogram per meter (kg/m)	1.488
Mass per volume (density)		
pound per cubic foot (pcf)	kilogram per cubic meter (kg/cu m)	16.01846
pound per cubic yard (lb/cu yd)	kilogram per cubic meter (kg/cu m)	0.5933
Temperature		
degree Fahrenheit (°F)	degree Celsius (°C)	$t_C = (t_F - 32)/1.8$
degree Fahrenheit (°F)	degree Kelvin (°K)	$t_K = (t_F + 459.7)/1.8$
degree Kelvin (°K)	degree Celsius (C°)	$t_C = t_K - 273.15$
Energy and heat		
British thermal unit (Btu)	joule (J)	1055.056
calorie (cal)	joule (J)	4.1868 E
Btu/°F · hr · ft²	W/m² · °K	5.678263
kilowatt-hour (kwh)	joule (J)	3,600,000. E
British thermal unit per pound (Btu/lb)	calories per gram (cal/g)	0.55556
British thermal unit per hour (Btu/hr)	watt (W)	0.2930711
Power		
horsepower (hp) (550 ft-lb/sec)	watt (W)	745.6999 E
Velocity		
mile per hour (mph)	kilometer per hour (km/hr)	1.60934
mile per hour (mph)	meter per second (m/s)	0.44704
Permeability		
darcy	centimeter per second (cm/sec)	0.000968
feet per day (ft/day)	centimeter per second (cm/sec)	0.000352

*E indicates that the factor given is exact.
**One U.S. gallon equals 0.8327 Canadian gallon.
†A pascal equals 1.000 newton per square meter.

Note.
One U.S. gallon of water weighs 8.34 pounds (U.S.) at 60°F.
One cubic foot of water weighs 62.4 pounds (U.S.).
One milliliter of water has a mass of 1 gram and has a volume of one cubic centimeter.
One U.S. bag of cement weighs 94 lb.

The prefixes and symbols listed below are commonly used to form names and symbols of the decimal multiples and submultiples of the SI units.

Multiplication Factor	Prefix	Symbol
$1{,}000{,}000{,}000 = 10^9$	giga	G
$1{,}000{,}000 = 10^6$	mega	M
$1{,}000 = 10^3$	kilo	k
$1 = 1$	—	—
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000001 = 10^{-6}$	micro	μ
$0.000000001 = 10^{-9}$	nano	n

Section

17

Useful Tables, Charts, and Formulas

Contents

17.0.0 Nails: Penny Designation ("d") and Lengths (U.S. and Metric)

Nail—penny size	Length in inches	Length in millimeters
2d	1	25.40
3d	1 1/4	31.75
4d	1 1/2	38.10
5d	1 3/4	44.45
6d	2	50.80
7d	2 1/4	57.15
8d	2 1/2	63.50
9d	2 3/4	69.85
10d	3	76.20
12d	3 1/4	82.55
16d	3 1/2	88.90
20d	3 3/4	95.25
30d	4 1/2	114.30
40d	5	127.00
50d	5 1/2	139.70
60d	6	152.40

17.1.0 Stainless Steel Sheets (Thicknesses and Weights)

	Thickness		Weight	
Gauge	inches	mm.	lb/ft^2	kg/m^2
8	0.17188	4.3658	7.2187	44.242
10	0.14063	3.5720	5.9062	28.834
11	0.1250	3.1750	5.1500	25.6312
12	0.10938	2.7783	4.5937	22.427
14	0.07813	1.9845	3.2812	16.019
16	0.06250	1.5875	2.6250	12.815
18	0.05000	1.2700	2.1000	10.252
20	0.03750	0.9525	1.5750	7.689
22	0.03125	0.7938	1.3125	6.409
24	0.02500	0.6350	1.0500	5.126
26	0.01875	0.4763	0.7875	3.845
28	0.01563	0.3970	0.6562	3.1816
Plates				
3/16″	0.1875	4.76	7.752	37.85
1/4″	0.25	6.35	10.336	50.46
5/16″	0.3125	7.94	12.920	63.08
3/8″	0.375	9.53	15.503	75.79
1/2″	0.50	12.70	20.671	100.92
5/8″	0.625	15.88	25.839	126.15
3/4″	0.75	19.05	31.007	151.38
1″	1.00	25.4	41.342	201.83

17.2.0 Comparable Thicknesses and Weights of Stainless Steel, Aluminum, and Copper

STAINLESS STEEL			ALUMINUM			COPPER		
Thickness (Inch)	Gauge (U.S. Standard)	Lb/sq ft	Thickness (Inch)	Gauge (B&S)	Lb/sq ft	Thickness (Inch)	Oz sq ft	Lb/sq ft
.010	32	.420	.010	30	.141	.0108	8	.500
.0125	30	.525	.0126	28	.177	.0121	9	.563
						.0135	10	.625
.0156	28	.556	.0156		.220	.0148	11	.688
			.0179	25	.253	.0175	13	.813
.0187	26	.788						
.0219	25	.919	.020	24	.282	.021	16	1.000
.025	24	1.050	.0253	22	.352			
						.027	20	1.250
.031	22	1.313	.0313	—	.441	.032	24	1.500
.0375	20	1.575	.032	20	.451	.0337	28	1.750
			.0403	18	.563	.0431	32	2.000
			.0453	17	.100			
.050	18	2.100	.0506	16	.126			

Note that U.S. Standard Gauge (stainless sheet) is not directly comparable with the B&S Gauge (aluminum). A 20-gauge stainless averages .0375" thick; while a 20-gauge aluminum averages .032" thick; and 20-ounce copper is .027" thick. The higher strength of stainless steel permits use of thinner gauges than required for aluminum or copper, which makes stainless more competitive with aluminum on a weight-to-coverage basis and provides stainless with a substantial weight saving compared to copper. For example, 100 sq ft of .032" aluminum will weigh about 45 pounds, .021" (16-ounce) copper will weigh about 100 pounds, and .015" stainless will weigh about 66 pounds.

17.3.0 Wire and Sheetmetal Gauges and Weights

Name of Gage	*United States Standard Gage		The United States Steel Wire Gage	American or Brown & Sharpe Wire Gage	New Birmingham Standard Sheet & Hoop Gage	British Imperial or English Legal Standard Wire Gage	Birmingham or Stubs Iron Wire Gage	Name of Gage
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Wire except Music Wire	Non-Ferrous Sheets and Wire	Iron and Steel Sheets and Hoops	Wire	Strips, Bands, Hoops and Wire	Principal Use
Gage No.	Weight Oz. per Sq. Ft.	Approx. Thickness Inches	Thickness, Inches					Gage No.
7/0's			.4900		.6666	.500		7/0's
6/0's			.4615	.5800	.625	.464		6/0's
5/0's			.4305	.5165	.5883	.432	.550	5/0's
4/0's			.3938	.4600	.5416	.400	.454	4/0's
3/0's			.3625	.3648	.500	.372	.425	3/0's
2/0's			.3310	.3249	.4452	.348	.380	2/0's
1/0			.3065	.2893	.3964	.324	.340	1/0
1			.2830	.2576	.3532	.300	.300	1
2			.2625	.2294	.3147	.276	.284	2
3	160	.2391	.2437	.2043	.2804	.252	.259	3
4	150	.2242	.2253	.1819	.250	.232	.238	4
5	140	.2092	.2070	.1620	.2225	.212	.220	5
6	130	.1943	.1920	.1443	.1981	.192	.203	6
7	120	.1793	.1770	.1285	.1764	.176	.180	7
8	110	.1644	.1620	.1144	.1570	.160	.165	8
9	100	.1495	.1483	.1019	.1398	.144	.148	9
10	90	.1345	.1350	.0907	.1250	.128	.134	10
11	80	.1196	.1205	.0808	.1113	.116	.120	11
12	70	.1046	.1055	.0720	.0991	.104	.109	12
13	60	.0897	.0915	.0641	.0882	.092	.095	13
14	50	.0747	.0800	.0571	.0785	.080	.083	14
15	45	.0673	.0720	.0508	.0699	.072	.072	15
16	40	.0598	.0625	.0453	.0625	.064	.065	16
17	36	.0538	.0540	.0403	.0556	.056	.058	17
18	32	.0478	.0475	.0359	.0495	.048	.049	18
19	28	.0418	.0410	.0320	.0440	.040	.042	19
20	24	.0359	.0348	.0285	.0392	.036	.035	20
21	22	.0329	.0317	.0253	.0349	.032	.032	21
22	20	.0299	.0286	.0226	.0313	.028	.028	22
23	18	.0259	.0258	.0201	.0278	.024	.025	23
24	16	.0239	.0230	.0179	.0248	.022	.022	24
25	14	.0209	.0204	.0159	.0220	.020	.020	25
26	12	.0179	.0181	.0142	.0196	.018	.018	26
27	11	.0164	.0173	.0126	.0175	.0164	.016	27
28	10	.0149	.0162	.0113	.0156	.0148	.014	28
29	9	.0135	.0150	.0100	.0139	.0136	.013	29
30	8	.0120	.0140	.0089	.0123	.0124	.012	30
31	7	.0105	.0132	.0080	.0110	.0116	.010	31
32	6.5	.0097	.0128	.0071	.0098	.0108	.009	32
33	6	.0090	.0118	.0063	.0087	.0100	.008	33
34	5.5	.0082	.0104	.0056	.0077	.0092	.007	34
35	5	.0075	.0095	.0050	.0069	.0084	.005	35
36	4.5	.0067	.0090	.0045	.0061	.0076	.004	36
37	4.25	.0064	.0085	.0040	.0054	.0068		37
38	4	.0060	.0080	.0035	.0048	.0060		38
39			.0075	.0031	.0043	.0052		39
40			.0070		.0039	.0048		40

* U.S. Standard Gage is officially a weight gage, in oz per sq ft as tabulated. The Approx. Thickness shown is the "Manufacturers' Standard" of the American Iron and Steel Institute, based on steel as weighing 501.81 lb per cu ft (489.6 true weight plus 2.5 percent for average over-run in area and thickness).

17.4.0 Weights and Specific Gravities of Common Materials

Substance	Weight Lb per Cu Ft	Specific Gravity
METALS, ALLOYS, ORES		
Aluminum, cast, hammered	165	2.55-2.75
Brass, cast, rolled	534	8.4-8.7
Bronze, 7.9 to 14% Sn	509	7.4-8.9
Bronze, aluminum	481	7.7
Copper, cast, rolled	556	8.8-9.0
Copper ore, pyrites	262	4.1-4.3
Gold, cast, hammered	1205	19.25-19.3
Iron, cast, pig	450	7.2
Iron, wrought	485	7.6-7.9
Iron, spiegel-eisen	468	7.5
Iron, ferro-silicon	437	6.7-7.3
Iron ore, hematite	325	5.2
Iron ore, hematite in bank	160-180	......
Iron ore, hematite loose	130-160	......
Iron ore, limonite	237	3.6-4.0
Iron ore, magnetite	315	4.9-5.2
Iron slag	172	2.5-3.0
Lead	710	11.37
Lead ore, galena	465	7.3-7.6
Magnesium, alloys	112	1.74-1.83
Manganese	475	7.2-8.0
Manganese ore, pyrolusite	259	3.7-4.6
Mercury	849	13.6
Monel Metal	556	8.8-9.0
Nickel	565	8.9-9.2
Platinum, cast, hammered	1330	21.1-21.5
Silver, cast, hammered	656	10.4-10.6
Steel, rolled	490	7.85
Tin, cast, hammered	459	7.2-7.5
Tin ore, cassiterite	418	6.4-7.0
Zinc, cast, rolled	440	6.9-7.2
Zinc ore, blende	253	3.9-4.2
VARIOUS SOLIDS		
Cereals, oats ... bulk	32	......
Cereals, barley ... bulk	39	......
Cereals, corn, rye ... bulk	48	......
Cereals, wheat ... bulk	48	......
Hay and Straw ... bales	20	......
Cotton, Flax, Hemp	93	1.47-1.50
Fats	58	0.90-0.97
Flour, loose	28	0.40-0.50
Flour, pressed	47	0.70-0.80
Glass, common	156	2.40-2.60
Glass, plate or crown	161	2.45-2.72
Glass, crystal	184	2.90-3.00
Leather	59	0.86-1.02
Paper	58	0.70-1.15
Potatoes, piled	42	......
Rubber, caoutchouc	59	0.92-0.96
Rubber goods	94	1.0-2.0
Salt, granulated, piled	48	......
Saltpeter	67	......
Starch	96	1.53
Sulphur	125	1.93-2.07
Wool	82	1.32
TIMBER, U. S. SEASONED		
Moisture Content by Weight:		
Seasoned timber 15 to 20%		
Green timber up to 50%		
Ash, white, red	40	0.62-0.65
Cedar, white, red	22	0.32-0.38
Chestnut	41	0.66
Cypress	30	0.48
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Elm, white	45	0.72
Hemlock	29	0.42-0.52
Hickory	49	0.74-0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, long-leaf	44	0.70
Pine, yellow, short-leaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0.42
Spruce, white, black	27	0.40-0.46
Walnut, black	38	0.61
Walnut, white	26	0.41
VARIOUS LIQUIDS		
Alcohol, 100%	49	0.79
Acids, muriatic 40%	75	1.20
Acids, nitric 91%	94	1.50
Acids, sulphuric 87%	112	1.80
Lye, soda 66%	106	1.70
Oils, vegetable	58	0.91-0.94
Oils, mineral, lubricants	57	0.90-0.93
Water, 4°C. max. density	62.428	1.0
Water, 100°C.	59.830	0.9584
Water, ice	56	0.88-0.92
Water, snow, fresh fallen	8	.125
Water, sea water	64	1.02-1.03
GASES		
Air, 0°C. 760 mm.	.08071	1.0
Ammonia	.0478	0.5920
Carbon dioxide	.1234	1.5291
Carbon monoxide	.0781	0.9673
Gas, illuminating	.028-.036	0.35-0.45
Gas, natural	.038-.039	0.47-0.48
Hydrogen	.00559	0.0693
Nitrogen	.0784	0.9714
Oxygen	.0892	1.1056

The specific gravities of solids and liquids refer to water at 4°C, those of gases to air at 0°C and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

17.4.0 Weights and Specific Gravities of Common Materials—Continued

Substance	Weight Lb per Cu Ft	Specific Gravity
METALS, ALLOYS, ORES		
Aluminum, cast, hammered	165	2.55-2.75
Brass, cast, rolled	534	8.4-8.7
Bronze, 7.9 to 14% Sn	509	7.4-8.9
Bronze, aluminum	481	7.7
Copper, cast, rolled	556	8.8-9.0
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Iron, ferro-silicon	437	6.7-7.3
Iron ore, hematite	325	5.2
Iron ore, hematite in bank	160-180	....
Iron ore, hematite loose	130-160	....
Iron ore, limonite	237	3.6-4.0
Iron ore, magnetite	315	4.9-5.2
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Lead	710	11.37
Lead ore, galena	465	7.3-7.6
Magnesium, alloys	112	1.74-1.83
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Mercury	849	13.6
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Zinc ore, blende	253	3.9-4.2
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Cereals, oats ......bulk	32	......
Cereals, barley ......bulk	39	......
Cereals, corn, rye ......bulk	48	......
Cereals, wheat ......bulk	48	......
Hay and Straw ......bales	20	......
Cotton, Flax, Hemp	93	1.47-1.50
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Glass, common	156	2.40-2.60
Glass, plate or crown	161	2.45-2.72
Glass, crystal	184	2.90-3.00
Leather	59	0.86-1.02
Paper	58	0.70-1.15
Potatoes, piled	42	......
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Rubber goods	94	1.0-2.0
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Sulphur	125	1.93-2.07
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Chestnut	41	0.66
Cypress	30	0.48
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Elm, white	45	0.72
Hemlock	29	0.42-0.52
Hickory	49	0.74-0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, long-leaf	44	0.70
Pine, yellow, short-leaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0.42
Spruce, white, black	27	0.40-0.46
Walnut, black	38	0.61
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VARIOUS LIQUIDS		
Alcohol, 100%	49	0.79
Acids, muriatic 40%	75	1.20
Acids, nitric 91%	94	1.50
Acids, sulphuric 87%	112	1.80
Lye, soda 66%	106	1.70
Oils, vegetable	58	0.91-0.94
Oils, mineral, lubricants	57	0.90-0.93
Water, 4°C. max. density	62.428	1.0
Water, 100°C.	59.830	0.9584
Water, ice	56	0.88-0.92
Water, snow, fresh fallen	8	.125
Water, sea water	64	1.02-1.03
GASES		
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Ammonia	.0478	0.5920
Carbon dioxide	.1234	1.5291
Carbon monoxide	.0781	0.9673
Gas, illuminating	.028-.036	0.35-0.45
Gas, natural	.038-.039	0.47-0.48
Hydrogen	.00559	0.0693
Nitrogen	.0784	0.9714
Oxygen	.0892	1.1056

The specific gravities of solids and liquids refer to water at 4°C, those of gases to air at 0°C and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

17.5.0 Useful Formulas

Circumference of a circle = π × *diameter* or 3.1416 × *diameter*

Diameter of a circle = *circumference* × 0.31831

Area of a square = *length* × *width*

Area of a rectangle = *length* × *width*

Area of a parallelogram = *base* × *perpendicular height*

Area of a triangle = ½ *base* × *perpendicular height*

Area of a circle = π *radius squared or diameter squared* × 0.7854

Area of an ellipse = *length* × *width* × 0.7854

Volume of a cube or rectangular prism = *length* × *width* × *height*

Volume of a triangular prism = *area of triangle* × *length*

Volume of a sphere = *diameter cubed* × 0.5236 (*diameter* × *diameter* × *diameter* × 0.5236)

Volume of a cone = π × *radius squared* × ⅓ *height*

Volume of a cylinder = π × *radius squared* × *height*

Length of one side of a square × 1.128 = *diameter of an equal circle*

Doubling the diameter of a pipe or cylinder increases its capacity 4 times

Pressure (in lb/sq in.) *of a column of water* = *height of the column* (in feet) × 0.434

Capacity of a pipe or tank (in U.S. gallons) = *diameter squared* (in inches) × *length* (in inches) × 0.0034

1 gal water = 8⅓ lb = 231 cu in.

1 cu ft water = 62½ lb = 7½ gal.

17.6.0 Decimal Equivalents of Inches in Feet and Yards

Inches	Feet	Yards
1	.0833	.0278
2	.1667	.0556
3	.2500	.0833
4	.333	.1111
5	.4166	.1389
6	.5000	.1667
7	.5833	.1944
8	.6667	.2222
9	.7500	.2500
10	.8333	.2778
11	.9166	.3056
12	1.000	.3333

17.7.0 Conversion of Fractions to Decimals

Fractions	Decimal	Fractions	Decimal
1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.1719	43/64	.67187
3/16	.1875	11/16	.6875
13/64	.2031	45/64	.70312
7/32	.2188	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/10	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.398625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	60/64	.921875
7/16	.4375	15/16	.9375
20/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.50	1"	1.000000

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17.7.1 Decimals of a Foot for Each 1/32"

Inch	0	1	2	3	4	5
0	0	.0833	.1667	.2500	.3333	.4167
1/32	.0026	.0859	.1693	.2526	.3359	.4193
1/16	.0052	.0885	.1719	.2552	.3385	.4219
3/32	.0078	.0911	.1745	.2578	.3411	.4245
1/8	.0104	.0938	.1771	.2604	.3438	.4271
5/32	.0130	.0964	.1797	.2630	.3464	.4297
3/16	.0156	.0990	.1823	.2656	.3490	.4323
7/32	.0182	.1016	.1849	.2682	.3516	.4349
1/4	.0208	.1042	.1875	.2708	.3542	.4375
9/32	.0234	.1068	.1901	.2734	.3568	.4401
5/16	.0260	.1094	.1927	.2760	.3594	.4427
11/32	.0286	.1120	.1953	.2786	.3620	.4453
3/8	.0313	.1146	.1979	.2812	.3646	.4479
13/32	.0339	.1172	.2005	.2839	.3672	.4505
7/16	.0365	.1198	.2031	.2865	.3698	.4531
15/32	.0391	.1224	.2057	.2891	.3724	.4557
1/2	.0417	.1250	.2083	.2917	.3750	.4583
17/32	.0443	.1276	.2109	.2943	.3776	.4609
9/16	.0469	.1302	.2135	.2969	.3802	.4635
19/32	.0495	.1328	.2161	.2995	.3828	.4661
5/8	.0521	.1354	.2188	.3021	.3854	.4688
21/32	.0547	.1380	.2214	.3047	.3880	.4714
11/16	.0573	.1406	.2240	.3073	.3906	.4740
23/32	.0599	.1432	.2266	.3099	.3932	.4766
3/4	.0625	.1458	.2292	.3125	.3958	.4792
25/32	.0651	.1484	.2318	.3151	.3984	.4818
13/16	.0677	.1510	.2344	.3177	.4010	.4844
27/32	.0703	.1536	.2370	.3203	.4036	.4870
7/8	.0729	.1563	.2396	.3229	.4063	.4896
29/32	.0755	.1589	.2422	.3255	.4089	.4922
15/16	.0781	.1615	.2448	.3281	.4115	.4948
31/32	.0807	.1641	.2474	.3307	.4141	.4974

17.7.2 Decimals of in inch for Each 1/64", with Millimeter Equivalents

Fraction	1/64ths	Decimal	Millimeters (Approx.)	Fraction	1/64ths	Decimal	Millimeters (Approx.)
...	1	.015625	0.397	...	33	.515625	13.097
1/32	2	.03125	0.794	17/32	34	.53125	13.494
...	3	.046875	1.191	...	35	.546875	13.891
1/16	4	.0625	1.588	9/16	36	.5625	14.288
...	5	.078125	1.984	...	37	.578125	14.684
3/32	6	.09375	2.381	19/32	38	.59375	15.081
...	7	.109375	2.778	...	39	.609375	15.478
1/8	8	.125	3.175	5/8	40	.625	15.875
...	9	.140625	3.572	...	41	.640625	16.272
5/32	10	.15625	3.969	21/32	42	.65625	16.669
...	11	.171875	4.366	...	43	.671875	17.066
3/16	12	.1875	4.763	11/16	44	.6875	17.463
...	13	.203125	5.159	...	45	.703125	17.859
7/32	14	.21875	5.556	23/32	46	.71875	18.256
...	15	.234375	5.953	...	47	.734375	18.653
1/4	16	.250	6.350	3/4	48	.750	19.050
...	17	.265625	6.747	...	49	.765625	19.447
9/32	18	.28125	7.144	25/32	50	.78125	19.844
...	19	.296875	7.541	...	51	.796875	20.241
5/16	20	.3125	7.938	13/16	52	.8125	20.638
...	21	.328125	8.334	...	53	.828125	21.034
11/32	22	.34375	8.731	27/32	54	.84375	21.431
...	23	.359375	9.128	...	55	.859375	21.828
3/8	24	.375	9.525	7/8	56	.875	22.225
...	25	.390625	9.922	...	57	.890625	22.622
13/32	26	.40625	10.319	29/32	58	.90625	23.019
...	27	.421875	10.716	...	59	.921875	23.416
7/16	28	.4375	11.113	15/16	60	.9375	23.813
...	29	.453125	11.509	...	61	.953125	24.209
15/32	30	.46875	11.906	31/32	62	.96875	24.606
...	31	.484375	12.303	...	63	.984375	25.003
1/2	32	.500	12.700	1	64	1.000	25.400

17.8.0 Solutions of the Right Triangle

To find side	When you know side	Multiply side	For 45 Ells-By	For 22 1/2 Ells-By	For 67 1/2 Ells-By	For 72 Ells-By	For 60 Ells-By	For 80 Ells-By
L	S	S	1.4142	2.6131	1.08	1.05	1.1547	2.00
S	L	L	.707	.3826	.92	.95	.866	.50
R	S	S	1.000	2.4142	.414	.324	.5773	.1732
S	R	R	1.000	.4142	2.41	3.07	1.732	.5773
L	R	R	1.4142	1.0824	2.61	3.24	2.00	1.1547
R	L	L	.7071	.9239	.38	.31	.50	.866

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17.9.0 Area and Other Formulas

Parallelogram	*Area* = *base* × *distance between the two parallel sides*
Pyramid	*Area* = ½ *perimeter of base* × *slant height* + *area of base* *Volume* = *area of base* × ⅓ *of the altitude*
Rectangle	*Area* = *length* × *width*
Rectangular prisms	*Volume* = *width* × *height* × *length*
Sphere	*Area of surface* = *diameter* × *diameter* × 3.1416 *Side of inscribed cube* = *radius* × 1.547 *Volume* = *diameter* × *diameter* × *diameter* × 0.5236
Square	*Area* = *length* × *width*
Triangle	*Area* = *one half of height times base*
Trapezoid	*Area* = *one half of the sum of the parallel sides* × *height*
Cone	*Area of surface* = *one half of circumference of base* × *slant height* + *area of base* *Volume* = *diameter* × *diameter* × 0.7854 × *one third of the altitude*
Cube	*Volume* = *width* × *height* × *length*
Ellipse	*Area* = *short diameter* × *long diameter* × 0.7854
Cylinder	*Area of surface* = *diameter* × 3.1416 × *length* + *area of the two bases* *Area of base* = *diameter* × *diameter* × 0.7854 *Area of base* = *volume* + *length* *Length* = *volume* + *area of base* *Volume* = *length* × *area of base* *Capacity in gallons* = *volume in inches* + 231 *Capacity of gallons* = *diameter* × *diameter* × *length* × 0.0034 *Capacity in gallons* = *volume in feet* × 7.48
Circle	*Circumference* = *diameter* × 3.1416 *Circumference* = *radius* × 6.2832 *Diameter* = *radius* × 2 *Diameter* = *square root of* = (*area* + 0.7854) *Diameter* = *square root of area* × 1.1283

17.10.0 Volume of Vertical Cylindrical Tanks (in Gallons per Foot of Depth)

Diameter in Feet	Diameter in Inches	U. S. Gallons	Diameter in Feet	Diameter in Inches	U. S. Gallons	Diameter in Feet	Diameter in Inches	U. S. Gallons
1	0	5.875	3	6	71.97	6	0	211.5
1	1	6.895	3	7	75.44	6	3	220.5
1	2	7.997	3	8	78.99	6	6	248.2
1	3	9.180	3	9	82.62	6	9	267.7
1	4	10.44	3	10	86.33	7	0	287.9
1	5	11.79	3	11	90.13	7	3	308.8
1	6	13.22	4	0	94.00	7	6	330.5
1	7	14.73	4	1	97.96	7	9	352.9
1	8	16.32	4	2	102.0	8	0	376.0
1	9	17.99	4	3	106.1	8	3	399.9
1	10	19.75	4	4	110.3	8	6	424.5
1	11	21.58	4	5	114.6	8	9	449.8
2	0	23.50	4	6	119.0	9	0	475.9
2	1	25.50	4	7	123.4	9	3	502.7
2	2	27.58	4	8	127.9	9	6	530.2
2	3	29.74	4	9	132.6	9	9	558.5
2	4	31.99	4	10	137.3	10	0	587.5
2	5	34.31	4	11	142.0	10	3	617.3
2	6	36.72	5	0	146.9	10	6	647.7
2	7	39.21	5	1	151.8	10	9	679.0
2	8	41.78	5	2	156.8	11	0	710.9
2	9	44.43	5	3	161.9	11	3	743.6
2	10	47.16	5	4	167.1	11	6	777.0
2	11	49.98	5	5	172.4	11	9	811.1
3	0	52.88	5	6	177.7	12	0	846.0
3	1	55.86	5	7	183.2	12	3	881.6
3	2	58.92	5	8	188.7	12	6	918.0
3	3	62.06	5	9	194.2	12	9	955.1
3	4	65.28	5	10	199.9			
3	5	68.58	5	11	205.7			

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17.11.0 Volume of Rectangular Tank Capacities (in U.S. Gallons per Foot of Depth)

Width Feet	LENGTH OF TANK — IN FEET						
	2	2 1/2	3	3 1/2	4	4 1/2	5
2	29.92	37.40	44.88	52.36	59.84	67.32	74.81
2 1/2	—	46.75	56.10	65.45	74.81	84.16	93.51
3	—	—	67.32	78.55	89.77	101.0	112.2
3 1/2	—	—	—	91.64	104.7	117.8	130.9
4	—	—	—	—	119.7	134.6	149.6
4 1/2	—	—	—	—	—	151.5	168.3
5	—	—	—	—	—	—	187.0

Width Feet	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2
2	82.29	89.77	97.25	104.7	112.2	119.7	127.2
2 1/2	102.9	112.2	121.6	130.9	140.3	149.6	159.0
3	123.4	134.6	145.9	157.1	168.3	179.5	190.8
3 1/2	144.0	157.1	170.2	183.3	196.4	209.5	222.5
4	164.6	179.5	194.5	209.5	224.4	239.4	254.3
4 1/2	185.1	202.0	218.8	235.6	252.5	269.3	286.1
5	205.7	224.4	243.1	261.8	280.5	299.2	317.9
5 1/2	226.3	246.9	267.4	288.0	308.6	329.1	349.7
6	—	269.3	291.7	314.2	336.5	359.1	381.5
6 1/2	—	—	316.1	340.4	364.7	389.0	413.3
7	—	—	—	366.5	392.7	418.9	445.1
7 1/2	—	—	—	—	420.8	448.8	476.9
8	—	—	—	—	—	478.8	508.7
8 1/2	—	—	—	—	—	—	540.5

Width Feet	9	9 1/2	10	10 1/2	11	11 1/2	12
2	134.6	142.1	149.6	157.1	164.6	172.1	179.5
2 1/2	168.3	177.7	187.0	196.4	205.7	215.1	224.4
3	202.0	213.2	224.4	235.6	246.9	258.1	269.3
3 1/2	235.6	248.7	261.8	274.9	288.0	301.1	314.2
4	269.3	284.3	299.2	314.2	329.1	344.1	359.1
4 1/2	303.0	319.8	336.6	353.5	370.3	387.1	403.9
5	335.6	355.3	374.0	392.7	411.4	430.1	448.8
5 1/2	370.3	390.9	411.4	432.0	452.6	473.1	493.7
6	403.9	426.4	448.8	471.3	493.7	516.2	538.6
6 1/2	437.6	461.9	486.2	510.5	534.9	559.2	583.5
7	471.3	497.5	523.6	549.8	576.0	602.2	628.4
7 1/2	504.9	533.0	561.0	589.1	617.1	645.2	673.2
8	538.6	568.5	598.4	628.4	658.3	688.2	718.1
8 1/2	572.3	604.1	635.8	667.6	699.4	731.2	763.0
9	605.9	639.6	673.2	706.9	740.6	774.2	807.9
9 1/2	—	675.1	710.6	746.2	781.7	817.2	852.8
10	—	—	748.1	785.5	822.9	860.3	897.7
10 1/2	—	—	—	824.7	864.0	903.3	942.5
11	—	—	—	—	905.1	946.3	987.4
11 1/2	—	—	—	—	—	989.3	1032.0
12	—	—	—	—	—	—	1077.0

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17.12.0 Capacity of Horizontal Cylindrical Tanks

% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity
1	.20	26	20.73	51	51.27	76	81.50
2	.50	27	21.86	52	52.55	77	82.60
3	.90	28	23.00	53	53.81	78	83.68
4	1.34	29	24.07	54	55.08	79	84.74
5	1.87	30	25.31	55	56.34	80	85.77
6	2.45	31	26.48	56	57.60	81	86.77
7	3.07	32	27.66	57	58.86	82	87.76
8	3.74	33	28.84	58	60.11	83	88.73
9	4.45	34	30.03	59	61.36	84	89.68
10	5.20	35	31.19	60	62.61	85	90.60
11	5.98	36	32.44	61	63.86	86	91.50
12	6.80	37	33.66	62	65.10	87	92.36
13	7.64	38	34.90	63	66.34	88	93.20
14	8.50	39	36.14	64	67.56	89	94.02
15	9.40	40	37.36	65	68.81	90	94.80
16	10.32	41	38.64	66	69.97	91	95.50
17	11.27	42	39.89	67	71.16	92	96.26
18	12.24	43	41.14	68	72.34	93	96.93
19	13.23	44	42.40	69	73.52	94	97.55
20	14.23	45	43.66	70	74.69	95	98.13
21	15.26	46	44.92	71	75.93	96	98.66
22	16.32	47	46.19	72	77.00	97	99.10
23	17.40	48	47.45	73	78.14	98	99.50
24	18.50	49	48.73	74	79.27	99	99.80
25	19.61	50	50.00	75	80.39	100	100.00

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17.13.0 Round-Tapered Tank Capacities

$$Volume = \frac{h^3}{3}\,\frac{[(Area_{\text{Top}} + Area_{\text{Base}}) + \sqrt{(Area_{\text{Top}} + Area_{\text{Base}}}]}{231}$$

If inches are used.

$$Volume = \frac{h}{3}\,[(Area_{\text{Base}} + Area_{\text{Top}}) + \sqrt{(Area_{\text{Base}} + Area_{\text{Top}}}] \times 7.48$$

If feet are used.

Sample Problem

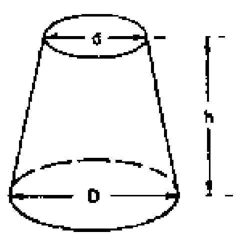
Let d be 12" (2 ft)
D be 36" (3 ft)
h be 48" (4 ft)
Find volume in gallons.

$$Volume = \frac{48}{3}\,\frac{[(\pi \times 12^2) + (\pi + 18^2) + \sqrt{\pi\ 12^2 \times 18^2}]}{231}$$

Where dimensions are in inches

$$Volume = \frac{4}{3}\,[(\pi \times 12^2) + (\pi + 1½^2) + \sqrt{(\pi \times 1^2) \times ½^2)}] \times 7.48$$

Where dimensions are in feet



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17.14.0 Circumferences and Areas of Circles

Of One Inch				Of Inches or Feet					
Fract.	Decimal	Circ.	Area	Dia.	Circ.	Area	Dia.	Circ.	Area
1/64	.015625	.04909	.00019	1	3.1416	.7854	64	201.06	3216.99
1/32	.03125	.09818	.00077	2	6.2832	3.1416	65	204.20	3318.31
3/64	.046875	.14726	.00173	3	9.4248	7.0686	66	207.34	3421.19
1/16	.0625	.19635	.00307	4	12.5664	12.5664	67	210.49	3525.65
5/64	.078125	.24545	.00479	5	15.7080	19.635	68	213.63	3631.68
3/32	.09375	.29452	.00690	6	18.850	28.274	69	216.77	3739.28
7/64	.109375	.34363	.00939	7	21.991	38.485	70	219.91	3848.45
1/8	.125	.39270	.01227	8	25.133	50.266	71	223.05	3959.19
9/64	.140625	.44181	.01553	9	28.274	63.617	72	226.19	4071.50
5/32	.15625	.49087	.01917	10	31.416	78.540	73	229.34	4185.50
11/64	.171875	.53999	.02320	11	34.558	95.033	74	232.48	4300.84
3/16	.1875	.58.905	.02761	12	37.699	113.1	75	235.62	4417.86
13/64	.203125	.63817	.03241	13	40.841	132.73	76	238.76	4536.46
7/32	.21875	.68722	.03757	4	43.982	153.94	77	241.90	4656.63
15/64	.234375	.73635	.04314	15	47.124	176.71	78	245.04	4778.36
1/4	.25	.78540	.04909	16	50.265	201.06	79	248.19	4901.67
17/64	.265625	.83453	.05542	17	53.407	226.98	80	251.33	5026.55
9/32	.28125	.88357	.06213	18	56.549	254.47	81	254.47	5153.0
10/64	.296875	.93271	.06922	19	59.690	283.53	82	257.61	5281.02
5/16	.3125	.98175	.07670	20	63.832	314.16	83	260.75	5410.61
21/64	.328125	1.0309	.08456	21	65.973	346.36	84	263.89	5541.77
11/32	.34375	1.0799	.09281	22	69.115	380.13	85	267.04	5674.50
23/64	.35975	1.1291	.10144	23	72.257	415.48	86	270.18	5808.80
3/8	.375	1.1781	.11045	24	75.398	452.39	87	273.32	5944.68
25/64	.390625	1.2273	.11984	25	78.540	490.87	88	276.46	6082.12
13/32	.40625	1.2763	.12962	26	81.681	530.93	89	279.60	6221.14
27/64	.421875	1.3254	.13979	27	84.823	572.56	90	282.74	6361.71
7/16	.4375	1.3744	.15033	28	87.965	615.75	91	258.88	6503.88
29/64	.453125	1.4236	.16126	29	91.106	660.52	92	289.03	6647.61
15/32	.46875	1.4726	.17257	30	94.248	706.86	93	292.17	6792.91
31/64	.484375	1.5218	.18427	31	97.389	754.77	94	295.31	6939.78
1/2	.5	1.5708	.19635	32	100.53	804.25	95	298.45	7088.22

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17.14.0 Circumferences and Areas of Circles—Continued

Of One Inch					Of Inches or Feet				
Fract.	Decimal	Circ.	Area	Dia.	Circ.	Area	Dia.	Circ.	Area
33/64	.515625	1.6199	.20880	33	103.67	855.30	96	301.59	7238.23
17/32	.53125	1.6690	.22166	34	106.81	907.92	97	304.73	7339.81
35/64	.546875	1.7181	.23489	35	109.96	962.11	98	307.88	7542.96
9/16	.5625	1.7671	.24850	36	113.10	1017.88	99	311.02	7697.69
37/64	.578125	1.8163	.26248	37	116.24	1075.21	100	314.16	7853.98
19/32	.59375	1.8653	.27688	38	119.38	1134.11	101	317.30	8011.85
30/64	.609375	1.9145	.29164	39	122.52	1194.59	102	320.44	8171.28
5/8	.625	1.9635	.30680	40	125.66	1256.64	103	323.58	8332.29
41/64	.640625	2.0127	.32232	41	128.81	1320.25	104	326.73	8494.87
21/32	.65625	2.0617	33824	42	131.95	1385.44	105	327.87	8659.01
43/64	.671875	2.1108	.35453	43	135.09	1452.20	106	333.01	8824.73
11/16	.6875	2.1598	.37122	44	138.23	1520.53	107	336.15	1992.02
45/64	.703125	2.2090	.38828	45	141.37	1590.43	108	339.29	9160.88
23/32	.71875	2.2580	.40574	46	144.51	1661.90	109	342.43	9331.32
47/64	.734375	2.3072	.42356	47	147.65	1734.94	110	345.58	9503.32
3/4	.75	2.3562	.44179	48	150.80	1809.56	111	348.72	9676.89
49/64	.765625	2.4050	.45253	49	153.94	1885.74	112	351.86	9853.03
23/32	.78125	2.4544	.47937	50	157.08	1963.50	113	355.0	10028.75
51/64	.796875	2.5036	.49872	51	160.22	2042.82	114	358.14	10207.03
13/16	.8125	2.5525	.51849	52	163.36	2123.72	115	361.28	10386.89
53/64	.828125	2.6017	.53862	53	166.50	2206.18	116	364.42	10568.32
27/32	.84375	2.6507	.55914	54	169.65	2290.22	117	367.57	10751.32
55/64	.859375	2.6999	.58003	55	172.79	2375.83	118	370.71	10935.88
7/8	.875	2.7489	.60123	56	175.93	2463.01	119	373.85	11122.02
57/64	.890625	2.7981	.62298	57	179.07	2551.76	120	376.99	11309 ´3
29/32	.90625	2.8471	.64504	58	182.21	2642.08	121	380.13	11499 01
59/64	.921875	2.8963	.66746	59	185.35	2733.97	122	383.27	11689.07
15/16	.9375	2.9452	.69029	60	188.50	2827.43	123	386.42	11882.29
61/64	.953125	2.9945	.71349	61	191.64	2922.47	124	389.56	12076.28
31/32	.96875	3.0434	.73708	62	194.78	3019.07	125	392.70	12271.85
63/64	.984375	3.0928	.76097	63	197.92	3117.25	126	395.84	12468.98

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17.15.0 Tap Drill Sizes for Fractional Size Threads

Approximately 65% Depth Thread / AMERICAN NATIONAL THREAD FORM

Tap Size	Threads per Inch	Hole Diameter	Drill
1/16	72	.049	3/64
1/16	64	.047	3/64
1/16	60	.046	56
5/64	72	.065	52
5/64	64	.063	1/16
5/64	60	.062	1/16
5/64	56	.061	53
3/32	60	.077	5/64
3/32	56	.076	48
3/32	50	.074	49
3/32	48	.073	49
7/64	56	.092	42
7/64	50	.090	43
7/64	48	.089	43
1/8	48	.105	36
1/8	40	.101	38
1/8	36	.098	40
1/8	32	.095	3/32
9/64	40	.116	32
9/64	36	.114	33
9/64	32	.110	35
5/32	40	.132	30
5/32	36	.129	30
5/32	32	.126	1/8
11/64	36	.145	27
11/64	32	.141	9/64
3/16	36	.161	20
3/16	32	.157	22
3/16	30	.155	23
3/16	24	.147	26
13/64	32	.173	17
13/64	30	.171	11/64
13/64	24	163	20
7/32	32	.188	12
7/32	28	.184	13
7/32	24	.178	16
15/64	32	.204	6
15/64	28	.200	8
15/64	24	.194	10
1/4	32	.220	7/32
1/4	28	.215	3
1/4	27	.214	3
1/4	24	.209	4
1/4	20	.201	7
5/16	32	.282	9/32
5/16	27	.276	J
5/16	24	.272	I
5/16	20	.264	17/64
5/16	18	.258	F
3/8	27	.339	R
3/8	24	.334	Q
3/8	20	.326	21/64
3/8	16	.314	5/16
7/16	27	.401	Y
7/16	24	.397	X
7/16	20	.389	25/64
7/16	14	.368	U
1/2	27	.464	15/32
1/2	24	.460	29/64

Tap Size	Threads per Inch	Hole Diameter	Drill
1/2	20	.451	29/64
1/2	13	.425	27/64
1/2	12	.419	27/64
9/16	27	.526	17/32
9/16	18	.508	33/64
9/16	12	.481	31/64
5/8	27	.589	19/32
5/8	18	.571	37/64
5/8	12	.544	35/64
5/8	11	.536	17/32
11/16	16	.627	5/8
11/16	11	.599	19/32
3/4	27	.714	23/32
3/4	16	.689	11/16
3/4	12	.669	43/64
3/4	10	.653	21/32
13/16	12	.731	47/64
13/16	10	.715	23/32
7/8	27	.839	27/32
7/8	18	.821	53/64
7/8	14	.805	13/16
7/8	12	.794	51/64
7/8	9	.767	49/64
15/16	12	.856	55/64
15/16	9	.829	53/64
1	27	.964	31/32
1	14	.930	15/16
1	12	.919	59/64
1	8	.878	7/8
1 1/16	8	.941	15/16
1 1/8	12	1.044	1 3/64
1 1/8	7	.986	63/64
1 3/16	7	1.048	1 3/64
1 1/4	12	1.169	1 11/64
1 1/4	7	1.111	1 7/64
1 5/16	7	1.173	1 11/64
1 3/8	12	1.294	1 19/64
1 3/8	6	1.213	1 7/32
1 1/2	12	1.419	1 27/64
1 1/2	6	1.338	1 11/32
1 5/8	5 1/2	1.448	1 29/64
1 3/4	5	1.555	1 9/16
1 7/8	5	1.680	1 11/16
2	4 1/2	1.783	1 25/32
2 1/8	4 1/2	1.909	1 29/32
2 1/4	4 1/2	2.034	2 1/32
2 3/8	4	2.131	2 1/8
2 1/2	4	2.256	2 1/4
2 5/8	4	2.381	2 3/8
2 3/4	4	2.506	2 1/2
2 7/8	3 1/2	2.597	2 19/32
3	3 1/2	2.722	2 23/32
3 1/8	3 1/2	2.847	2 27/32
3 1/4	3 1/2	2.972	2 31/32
3 3/8	3 1/4	3.075	3 1/16
3 1/2	3 1/4	3.200	3 3/16
3 5/8	3 1/4	3.325	3 5/16
3 3/4	3	3.425	3 7/16
4	3	3.675	3 11/16

17.16.0 Common Material R-Values

R-value is a unit of measure for the rate of heat flow through a given thickness material(s) by conduction. It can include a cavity that incorporates air space reflective insulation. It is measured by the temperature difference between outside surfaces required to cause one **BTU** to flow through one square hour. A **BTU,** (British Thermal Unit), is the amount of heat required to raise temperature of one pound of water 1°F.

MATERIAL	R-value	MATERIAL	R-value	MATERIAL	R-value
1" mineral wool	3.70	3½" fiberglass	13.48	3" honeycomb	2.59
1/2" gypsum	0.45	½" mineral tile	1.19	3" isocyanurate	22.5
1/2" plywood	0.02	1" isocyanurate	7.50	3" polystyrene	12.0
1/8" floor tile	0.05	1" polystyrene	4.00	3" polyurethane	17.6
1/8" hardboard	0.09	1" wood core door	1.96	8" con. block	1.11
3/16" hardboard	0.14	6" fiberglass	19.00	insulated glass	1.65
5/8" gypsum	0.56	1" polyurethane	5.88	single glass pane	0.94

17.17.0 Conversion Factors—Power, Pressure, Energy

Power

Multiply	By	To Get
Boiler hp	33,472	Btu/hr
Boiler hp	34.5	lbs H_2O evap. at 212°F
Horsepower	2,540	Btu/hr
Horsepower	550	ft-lb/sec
Horsepower	33,000	ft-lb/min
Horsepower	42.42	Btu/min
Horsepower	0.7457	Kilowatts
Kilowatts	3,415	Btu/hr
Kilowatts	56.92	Btu/min
Watts	44.26	ft-lb/min
Watts	0.7378	ft-lb/sec
Watts	0.05692	Btu/min
Tons refrig	12,000	Btu/hr
Tons refrig	200	Btu/min
Btu/hr	0.00002986	Boiler hp
lb H_2O evap. at 212°F	0.0290	Boiler hp
Btu/hr	0.000393	Horsepower
ft-lb/sec	0.00182	Horsepower
ft-lb/min	0.0000303	Horsepower
Btu/min	0.0236	Horsepower
Kilowatts	1.341	Horsepower
Btu/hr	0.000293	Kilowatts
Btu/min	0.01757	Kilowatts
ft-lb/min	0.02259	Watts
ft-lb/sec	1.355	Watts
Btu/min	17.57	Watts
Btu/hr	0.0000833	Tons refrig.
Btu/min	0.005	Tons refrig

Energy

Multiply	By	To Get
Btu	778	ft-lb
Btu	0.000393	hp-hr
Btu	0.000293	kw-hr
Btu	0.0010307	(lbs H_2O evap. at 212°F)
Btu	0.293	Watt-hr
ft-lb	0.3765	Watt-hr
(Latent heat of ice)	143.33	Btu/lb H_2O
(lb H_2O evap.) at 212°F	0.284	kw-hr
(lb H_2O evap.) at 212°F	0.381	hp-hr
ft-lb	0.001287	Btu
hp-hr	2,540	Btu
kw-hr	3,415	Btu
(lb H_2O evap.) at 212°F	970.4	Btu
Watt-hr	3.415	Btu
Watt-hr	2,656	ft-lb
Btu/lb H_2O	0.006977	(Latent heat of ice)
kw-hr	3.52	(lb H_2O evap. at 212°F)
hp-hr	2.63	(lb H_2O evap. at 212°F)

Pressure

Multiply	By	To Get
atmospheres	29.92	(in Mercury (at 62°F))
atmospheres	406.8	(in H_2O (at 62°F))
atmospheres	33.90	(ft. H_2O (at 62°F))
atmospheres	14.70	lb/in²
atmospheres	1.058	ton/ft²
(in. H_2O (at 62°F))	0.0737	(in. Mercury (at 62°F))
(ft H_2O (at 62°F))	0.881	(in. Mercury (at 62°F))
(ft H_2O (at 62°F))	0.4335	lb/in²
(ft H_2O (at 62°F))	62.37	lb/ft²
(in. Mercury (at 62°F))	70.73	lb/ft²
(in. Mercury (at 62°F))	0.4912	lb/in²
(in. Mercury (at 62°F))	0.03342	atmospheres
(in. H_2O (at 62°F))	0.002458	atmospheres
(ft. H_2O (at 62°F))	0.0295	atmospheres
lb/in²	0.0680	atmospheres
ton/ft²	0.945	atmospheres
(in. Mercury (at 62°F))	13.57	(in. H_2O (at 62°F))
(in. Mercury (at 62°F))	1.131	(ft. H_2O (at 62°F))
lb/in²	2.309	(ft H_2O (at 62°F))
lb/ft²	0.01603	(ft H_2O (at 62°F))
lb/ft²	0.014138	(in. Mercury (at 62°F))
lb/in²	2.042	(in. Mercury (at 62°F))
lb/in²	0.0689	Bar
lb/in²	0.0703	kg/cm²

Velocity of Flow

Multiply	By	To Get
ft/min	0.01139	miles/hr
ft/min	0.01667	ft/sec
cu ft/min	0.1247	gal/sec
cu ft/sec	448.8	gal/min
miles/hr	88	ft/min
ft/sec	60	ft/min
gal/sec	8.02	cu ft/min
gal/min	0.002228	cu ft/sec

Heat Transmission

Multiply	By	To Get
(Btu/in) /sq ft /hr/°F	0.0833	(Btu/ft) /sq ft /hr/°F
(Btu/ft) /sq ft /hr/°F	12	(Btu/in) /sq ft /hr/°F

Weight

Multiply	By	To Get
lb	7,000	grains
lb H_2O (60°F)	0.01602	cu ft H_2O
lb H_2O (60°F)	0.1198	gal H_2O
tons (long)	2,240	lb
tons (short)	2,000	lb
grains	0.000143	lb
cu ft H_2O	62.37	lb H_2O (60°F)
gal H_2O	8.3453	lb H_2O (60°F)
lb	0.000446	tons (long)
lb	0.000500	tons (short)

Circular Measure

Multiply	By	To Get
Degrees	0.01745	Radians
Minutes	0.00029	Radians
Diameter	3.142	Circumference
Radians	57.3	Degrees
Radians	3,438	Minutes
Circumference	0.3183	Diameter

Volume

Multiply	By	To Get
Barrels (oil)	42	gal (oil)
cu ft	1,728	cu in
cu ft	7.48	gal
cu in	0.00433	gal
gal (oil)	0.0238	barrels (oil)
cu in	0.000579	cu ft
gal	0.1337	cu ft
gal	231	cu in

Temperature

F = (°C x 1.8) + 32
C = (°F - 32) ÷ 1.8

Fractions and Decimals

Multiply	By	To Get
Sixty-fourths	0.015625	Decimal
Thirty-seconds	0.03125	Decimal
Sixteenths	0.0625	Decimal
Eighths	0.125	Decimal
Fourths	0.250	Decimal
Halves	0.500	Decimal
Decimal	64	Sixty-fourths
Decimal	32	Thirty-seconds
Decimal	16	Sixteenths
Decimal	8	Eighths
Decimal	4	Fourths
Decimal	2	Halves

Gallons shown are U.S. standard.

17.18.0 Useful Engineering Tables—Schedule 40 Pipe Dimensions, Diameter of Circles, and Drill Sizes

Schedule 40 Pipe, Standard Dimensions

Size (in)	Diameters: External (in)	Diameters: Approximate Internal (in)	Nominal Thickness (in)	Circumference: External (in)	Circumference: Internal (in)	Transverse Areas: External (sq in)	Transverse Areas: Internal (sq in)	Transverse Areas: Metal (sq in)	Length of Pipe per sq ft: External Surface (Feet)	Length of Pipe per sq ft: Internal Surface (Feet)	Length of Pipe Containing One Cubic Foot (Feet)	Nominal Weight per foot: Plain Ends	Nominal Weight per foot: Threaded and Coupled	Number Threads per inch of Screw
1/4	0.540	0.364	0.088	1.696	1.114	0.229	0.104	0.125	7.073	10.493	1383.789	0.424	0.425	18
1/4	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.167	5.658	7.747	754.360	0.567	0.568	18
1/2	0.640	0.622	0.109	2.639	1.954	0.554	0.304	0.250	4.547	6.141	473.906	0.850	0.852	14
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.333	3.637	4.635	270.034	1.130	1.134	14
1	1.315	1.049	0.133	4.131	3.296	1.358	0.864	0.494	2.904	3.641	166.618	1.678	1.684	11 1/2
1 1/4	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.669	2.301	2.767	96.275	2.272	2.281	11 1/2
1 1/2	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.799	2.010	2.372	70.733	2.717	2.731	11 1/2
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	42.913	3.652	3.678	11 1/2
2 1/2	2.675	2.469	0.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.616	8
3 1/2	4.000	3.548	0.226	12.566	11.146	12.566	9.886	2.680	0.954	1.076	14.565	9.109	9.202	8
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	3.174	0.848	0.948	11.312	10.790	10.899	8
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	4.300	0.686	0.756	7.198	14.617	14.810	8
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	5.581	0.576	0.629	4.984	18.974	19.185	8
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	8.399	0.442	0.478	2.878	28.554	28.809	8
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	11.908	0.355	0.381	1.826	40.483	41.132	8
12	12.750	11.938	0.406	40.055	37.699	127.640	111.900	15.740	0.299	0.318	1.288	53.600	—	—
14	14.000	13.125	0.437	43.982	41.217	153.940	135.300	18.640	0.272	0.280	1.069	63.000	—	—
16	16.000	15.000	0.500	50.265	47.123	201.050	176.700	24.350	0.238	0.254	0.817	78.000	—	—
18	18.000	16.874	0.563	56.548	52.998	254.850	224.000	30.850	0.212	0.226	0.643	105.000	—	—
20	20.000	18.814	0.593	62.831	59.093	314.150	278.000	36.150	0.191	0.203	0.519	123.000	—	—
24	24.000	22.626	0.687	75.398	71.063	452.400	402.100	50.300	0.159	0.169	0.358	171.000	—	—

Equivalent Length of Pipe to be Added for Fittings—Schedule 40 Pipe

Pipe Size (in)	Length in Feet to be Added Run: Standard Elbow	Side Outlet Tee	Gate Valve*	Globe Valve*	Angle Valve*
1/2	1.3	3	0.3	14	7
3/4	1.8	4	0.4	18	10
1	2.2	5	0.5	23	12
1 1/4	3.0	6	0.6	29	15
1 1/2	3.5	7	0.8	34	16
2	4.3	8	1.0	46	22
2 1/2	5.0	11	1.1	54	27
3	6.5	13	1.4	66	34
3 1/2	8.0	15	1.6	80	40
4	9.0	18	1.9	92	45
5	11.0	22	2.2	112	56
6	13.0	27	2.8	136	67
8	17.0	35	3.7	180	92
10	21.0	45	4.6	230	112
12	27.0	53	5.5	270	132

*Valve in full open position

Thermal Expansion of Pipe

*From Piping Handbook, by Walker and Crocker, by special permission.

This table gives the expansion from −20°F to temperature in question. To obtain the amount of expansion between any two temperatures take the difference between the figures in the table for those temperatures. For example, if cast iron pipe is installed at a temperature of 80°F and is operated at 240°F, the expansion would be 1.780 − 0.649 = 1.131 in.

Temp (°F)	Elongation in Inches per 100 Ft from −20°F Up: Cast Iron Pipe	Steel Pipe	Wrought Iron Iron Pipe	Copper Pipe
−20	0.000	0.000	0.000	0.000
0	0.127	0.145	0.152	0.204
20	0.255	0.293	0.306	0.442
40	0.390	0.430	0.465	0.655
60	0.518	0.593	0.620	0.888
80	0.649	0.725	0.780	1.100
100	0.787	0.898	0.939	1.338
120	0.926	1.055	1.110	1.570
140	1.051	1.209	1.265	1.794
160	1.200	1.368	1.427	2.008
180	1.345	1.526	1.597	2.255
200	1.495	1.691	1.778	2.500
240	1.780	2.020	2.110	2.960
280	2.085	2.350	2.465	3.422
320	2.395	2.690	2.800	3.900
360	2.700	3.029	3.175	4.380
400	3.008	3.375	3.521	4.870
500	3.847	4.296	4.477	6.110
600	4.725	5.247	5.455	7.388

Diameters and Areas of Circles and Drill Sizes

Drill Size	Dia.	Area	Drill Size	Dia.	Area	Drill Size	Dia.	Area	Drill Size	Dia.	Area
3/64	.0469	.00173	27	.1440	.01629	C	.2420	.04600	27/64	.4219	.13920
55	.0520	.00212	26	.1470	.01697	D	.2460	.04753	7/16	.4375	.15033
54	.0550	.00238	25	.1495	.01705	1/4	.2500	.04909	29/64	.4531	.16117
53	.0595	.00278	24	.1520	.01815	E	.2500	.04909	15/32	.4688	.17257
1/16	.0625	.00307	23	.1540	.01863	F	.2570	.05187	31/64	.4844	.18398
52	.0635	.00317	5/32	.1562	.01917	G	.2610	.05350	1/2	.500	.19635
51	.0670	.00353	22	.1570	.01936	17/64	.2656	.05515	33/64	.5156	.20831
50	.0700	.00385	21	.1590	.01986	H	.2660	.05557	17/32	.5313	.22166
49	.0730	.00419	20	.1610	.02036	I	.2720	.05811	9/16	.5625	.24850
48	.0760	.00454	19	.1660	.02164	J	.2770	.06026	19/32	.5937	.27688
5/64	.0781	.00479	18	.1695	.02256	K	.2810	.06202	5/8	.6250	.30680
47	.0785	.00484	11/64	.1719	.02320	9/32	.2812	.06213	21/32	.6562	.33824
46	.0810	.00515	17	.1730	.02351	L	.2900	.06605	11/16	.6875	.37122
45	.0820	.00528	16	.1770	.02461	M	.2950	.06835	23/32	.7187	.40574
44	.0860	.00581	15	.1800	.02545	19/64	.2969	.06881	3/4	.7500	.44179
43	.0890	.00622	14	.1820	.02602	N	.3020	.07163	25/32	.7812	.47937
42	.0935	.00687	13	.1850	.02688	5/16	.3125	.07670	13/16	.8125	.51849
3/32	.0938	.00690	3/16	.1875	.02761	O	.3160	.07843	27/32	.8437	.55914
41	.0960	.00724	12	.1890	.02806	P	.3230	.08194	7/8	.8750	.60132
40	.0980	.00754	11	.1910	.02865	21/64	.3281	.08449	29/32	.9062	.64504
39	.0995	.00778	10	.1935	.02941	Q	.3320	.08657	15/16	.9375	.69029
38	.1015	.00809	9	.1960	.03017	R	.3390	.09026	31/32	.9687	.73708
37	.1040	.00850	8	.1990	.03110	11/32	.3438	.09281	1	1.0000	.78540
36	.1065	.00891	7	.2010	.03173	S	.3480	.09511	1-1/16	1.0625	.88664
7/64	.1094	.00940	13/64	.2031	.03241	T	.3580	.10066	1-1/8	1.1250	.99402
35	.1100	.00950	6	.2040	.03268	23/64	.3594	.10122	1-3/16	1.1875	1.1075
34	.1110	.00968	5	.2055	.03317	U	.3680	.10636	1-1/4	1.2500	1.2272
33	.1130	.01003	4	.2090	.03431	3/8	.3750	.11045	1-5/16	1.3125	1.3530
32	.1160	.01039	3	.2130	.03563	V	.3770	.11163	1-3/8	1.3750	1.4859
31	.1200	.01131	7/32	.2188	.03758	W	.3860	.11702	1-7/16	1.4375	1.6230
1/8	.1250	.01227	2	.2210	.03836	25/64	.3906	.11946	1-1/2	1.5000	1.7671
30	.1285	.01242	1	.2280	.04083	X	.3970	.12379	1-5/8	1.6250	2.0739
29	.1360	.01453	A	.2340	.04301	Y	.4040	.12819	1-3/4	1.7500	2.4053
28	.1405	.01550	15/64	.2344	.04314	13/32	.4062	.12962	1-7/8	1.8750	2.7612
9/64	.1406	.01553	8	.2380	.0449	Z	.4130	.13396	2	2.0000	3.1416

17.19.0 Thermal Expansion of Various Materials

Material	Inches per inch 10^{-n} X per °F	Inches per 100′ of pipe per 100°F.	Ratio-assuming cast iron equals 1.00
Cast iron	6.2	0.745	1.00
Concrete	5.5	0.66	.89
Steel (mild)	6.5	0.780	1.05
Steel (stainless)	7.8	0.940	1.26
Copper	9.2	1.11	1.49
PVC (high impact)	55.6	6.68	8.95
ABS (type 1A)	56.2	6.75	9.05
Polyethylene (type 1)	94.5	11.4	15.30
Polyethylene (type 2)	83.3	10.0	13.40

Here is the *actual* increase in length for 50 feet of pipe and 70° temperature rise.

Cast Iron		.261
Concrete	Building Materials	.231
Mild Steel	Building Materials	2.73
Copper	Other Materials	.388
PVC (high Impact)	Plastics	2.338
ABS (type 1A)	Plastics	2.362
Polyethylene (type 1)	Plastics	3.990
Polyethylene (type 2)	Plastics	3.500

17.20.0 Miscellaneous Tables of Weights, Measures, and Other Information

Square Measure

144 inches	1 square foot
9 square feet	1 square yard
30¼ sq. yds. 272¼ sq. ft.	1 square rod
160 square rods	1 acre
640 acres	1 square mile

Cubic Measure

1728 cubic inches	1 cubic foot
1 cubic foot	7.4805 gallons
27 cubic feet	1 cubic yard
128 cubic feet	1 cord

Dry Measure

2 pints	1 quart
8 quarts	1 peck
4 pecks	1 bushel
1 bushel	1.24 cu. feet
1 bushel	2150.42 cu inches

Liquid Measure

4 gills	1 pint
2 pints	1 quart
4 quarts	1 gallon
31½ gallons	1 barrel
2 barrels	1 hogshead

Linear Measure

12 inches	1 foot
3 feet	1 yard
16½ feet	1 rod or pole
5½ yards	1 rod or pole
40 rods or poles	1 furlong
8 furlongs	1 statute mile
320 rods	1 mile
5280 feet	1 mile
4 inches	1 hand
7.92 inches	1 link
18 inches	1 cubit
1.15156 miles	1 knot or 1 nautical mile

Weight – Avoirdupois or Commercial

437.5 grains	1 ounce
16 ounces	1 pound
112 pounds	1 hundredweight
2000 pounds	1 net ton or 1 short ton
20 hundredweight	1 gross or long ton
20 hundredweight	2240 pounds
2204.6 pounds	1 metric ton

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