MATERIALS

CONTENTS

SECTION 2

DUNNAGE

USE THE CURRENT ASTM STANDARD D996

Basic Function of Dunnage

- Abrasion Protection
- Void Filling
- Package Protection (such as crushing, denting, or internal damage)
- Load Separation

Commonly used material for each function are:

ABRASION PROTECTION

- Wood/Nails used in the construction decking or risers to protect drum rolling hoops and heads from abrasion
- Plywood
- Kraft paper
- Wood overlay with Kraft paper

Criteria for Wood and Nails

Condition

Select all blocking and bracing material from sound lumber free from cross grain or dry rot. Do not use lumber with knots, knotholes and check for splits which affect its strength or interfere with proper nailing.

International shipments require compliance with ISPM 15.

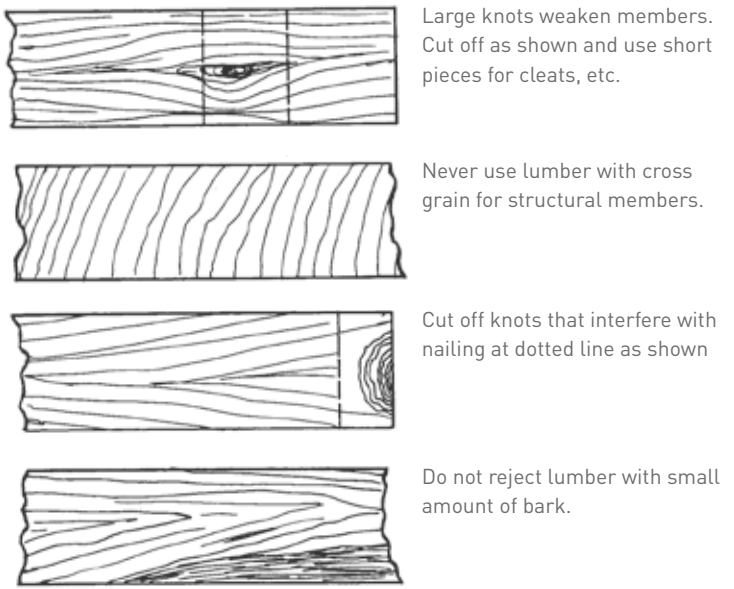


FIGURE 2.1 Criteria for Wood

Use properly seasoned lumber, free of pests, for all blocking and bracing. Do not use green lumber as it does not have the strength or stiffness qualities of dry lumber. Under certain conditions green lumber will give off quantities of moisture which can have harmful effects on some commodities.

TABLE 2.A
Species of Wood Most Commonly Used for Blocking and Bracing

Group I Soft Woods	Specific Gravity	Group 2 and 3 Medium Woods	Specific Gravity	Group 4 Hard Woods	Specific Gravity
Cottonwood	0.37	Douglas-Fir	0.51	Ash	0.64
Fir (Balsam)	0.41	Hemlock	0.44	Beech	0.67
Fir (White)	0.42	Maple (Hard Black)	0.62	Elm	0.66
Pine (Lodgepole)	0.43	Larch	0.59	Hickory	0.80
Pine (Ponderosa)	0.42	Pine (So. Yellow)	0.59	Maple (Hard Sugar)	0.68
Pine (White East)	0.37	Pine (Norway)	0.47	Oak (White)	0.71
Pine (White West)	0.42	Cedar (Port Oxford)	0.44	Oak (Red)	0.66
Spruce (White)	0.45	Sweet Gum	0.53		
Poplar (Yellow)	0.43				

TABLE 2.B
Standard Thickness for Yard Lumber

Nominal Thickness Rough Lumber	Actual Thickness S4S*
2" x 4"	1 ½" x 3 ½"
2" x 6"	1 ½"x 5 ½"
2" x 8"	1 ½" x 7 ½"
4" x 4"	3 ½" x 3 ½"
4" x 6"	3 ½" x 5 ½"
4" x 8"	3 ½" x 7 ¼"

*Surfaced four sides

When selecting the size of lumber, give consideration to the weight, size and nature of the commodity to be secured.

TABLE 2.C
Wood Groups

Group II and III Woods Medium	Group I Woods Soft
Size 2" x 3"	Size 2" x 4"
Size 2" x 4"	Size 2" x 6"
Size 2" x 6"	Size 2" x 8"
Size 3" x 4"	Size 3" x 6"
Size 4" x 4"	Size 4" x 6"
Size 4" x 6"	Size 4" x 8"
Size 6" x 6"	Size 6" x 8"
Size 6" x 8"	Size 6" x 10"

Storage

Lumber should be properly stored to protect it from the elements. This will prevent decay from affecting its strength.

Criteria for Nails

Type

Table D shows the sizes of common nails, power driven nails, staples, and spikes which may be used in the construction of blocking and bracing.

TABLE 2.D
Common Nails, Power Driven Nails, Power Driven Staples and Spikes

	Common Nails		Power Driven Nails		Power Driven Staples		Spikes	
Size Penny Weight	**Length** in Inches	**Wire** Diameter Inches	**Length** in Inches	**Wire** Diameter Inches	**Length** in Inches	**Wire** Diameter Inches	**Length** in Inches	**Wire** Diameter Inches
6d	2	.113	--	--	--	--	--	--
8d	2 ½	.131	2 3/8	.113	2½, 2	.080	--	--
10d	3	.148	3	.120	¾	.080	3	.192
12d	3 ¼	.148	3 ¼	.131	3, 3 ¼	--	3 ¼	.192
16d	3 ½	.162	3 ½	.131	--	.080	3 ½	.207
20d	4	.192	4	.145	3 ½	.080	4	.225
30d	4 ½	.207	4 ¾	.165	3 ½	--	4 ½	.244
40d	5	.225	5 1/8	.165	--	--	5	.263
50d	5 ½	.244	--	--	--	--	5 ½	.283
60d	6	.263	--	--	--	--	6	.283
5/16	--	--	--	--	--	--	7	.312
3/8	--	--		--	--	--	8	.375

Size

Consult Tables 2.E & 2.F to determine proper size for nails. It is important to use proper size nails to achieve sufficient holding power. Nails one size smaller than those used for medium or soft wood may be used for extremely hardwood (Group 4 of table 2.A).

Table 2.E
Sizes of Nails and Spikes for Various Thicknesses of Material

Thickness of Material (Rough Lumber) Holding Head of Nail or Spike	Thickness of Material (Rough Lumber) Holding Point of Nail						
1"	1 ¼"	2"	3"	4"	5"	6"	
1"	6d *8d	6d *8d	10d *12d	16d --	16d --	16d --	16d --
2"	10d *12d	10d 12d	16d --	20d 30d	40d 50d	40d 60d	40d 60d
3"	16d 20d	20d *30d	30d 40d	40d 60d	60d 7" spike	7" spike --	8" spike --
4"	40d *50d	40d 50d	50d 60d	60d 7" spike	7" spike 8" spike	8" spike 9" spike	9" spike --
5"	50d 60d	60d --	60d 7" spike	7" spike 8" spike	8" spike 9" spike	9" spike --	10" spike --
6"	7" spike --	7" spike --	7" spike 8" spike	8" spike 9" spike	9" spike 10" spike	10" spike --	10" spike --

d – Penny *Nails Clinched

Table II.F
Withdrawal Power of Common & Threaded Nails
Allowable Loads In Pounds Per Inch of Penetration

	Size of Nails			
Specific Gravity	8d	12d	16d	20d
0.75	87	---	---	127
0.68	69	78	85	101
0.67	66	75	82	97
0.66	64	72	79	94
0.62	55	62	68	80
0.51	34	38	42	49
0.47	27	31	34	40
0.45	25	28	30	36
0.44	23	26	29	34
0.43	22	25	27	32
0.42	21	23	25	30
0.41	21	22	24	29
0.37	15	17	19	22

Number

The number of nails will vary with the size and weight of the load. Use a sufficient number of nails as the strength of the blocking and bracing increases directly with the number and size of nails.

Position

Drive nails into side grain of lumber. In this position they have 50 percent more holding power. It is preferable to drive nails in position where they will see lateral resistance as shown in Fig. 2.2 and Fig. 2.3.

Figure 2.2

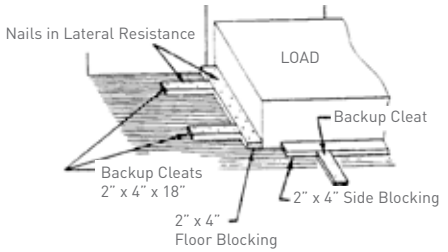


Figure 2.3

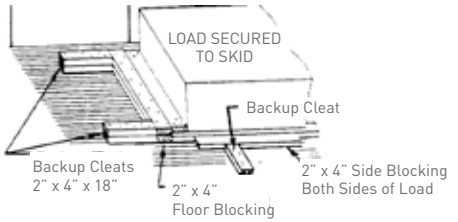


FIGURE 2.2 & 2.3

Pre-drill

Lumber may be pre-drilled with holes slightly smaller than the diameter of the shank of the nail. This will facilitate driving, prevent splitting and increase the holding power of the nail.

TABLE 2.G
Lateral resistance of Nails (in pounds)
When Nailed Through 2" Thick Floor Blocking and Into Trailer Floor

1 ¼" Trailer Floor – Hardwoods (Group IV)				
Size of Common Nail (d)				
8	10	12	16	20
344	733	916	956	1043

Load applied is at a 90° angle to the shank or direction of driving of nail point in the securing wood.

Note: For types of lumber see Table 2.A.

Automatic Type Nails

It is permissible to use smaller nails than those specified in Table 2.E when using an Automatic Type nail. However, the number of nails used must be increased by one-third (1/3) and only the following size substitution may be made:

Common Nails		Power Driven Nails
10d	or	8d or 10d
20d	or	16d or 20d

Separator

When stacking commodities in multiple layers, use a separator to provide an even base for the upper layers. The separator material selected should provide adequate support for the weight of the lading. Generally ½" plywood sheets or other suitable material may be used as a separator. In cases where units consist of bags or bales, place fiberboard to protect between separator material and tops of lower units.

Slip Sheets

Heavy-duty rough finish Kraft paper or other suitable material is useful as transportation equipment liner and to protect printed surfaces.

Corner Protection

Corner posts are used to square up the load and as corner protectors on unitized loads. Corner posts also provide space to protect packages from abrasion. Corner posts may be constructed from plywood, hardboard, multi-wall-corrugated fiberboard or other suitable material.

VOID FILLING

These structures are used to fill crosswise or lengthwise space in a trailer/container, not occupied by the lading. Void fillers are used to minimize the movement of lading during transportation. Void fillers should be of sufficient height to protect the tallest stack of cargo.

Dunnage Bags

Dunnage bags are usually made of paper, plastic or rubber that are inflated to secure cargo. Filled dunnage bags must not touch floor, as chafing can lead to rupture. Dunnage bags are used to fill voids in a crosswise or lengthwise direction to restrain loads.

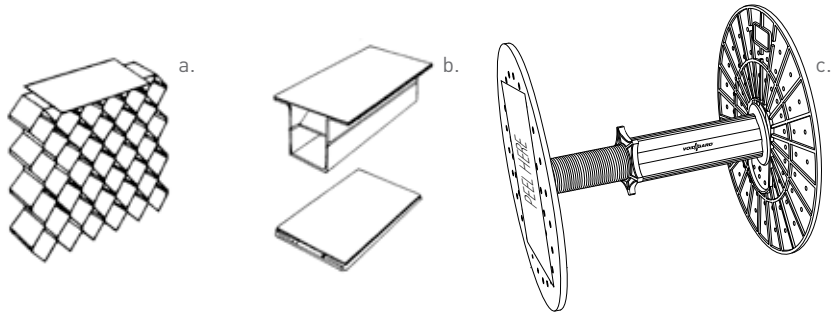
Bulkheads

Bulkheads are custom built wood structures used generally to fill voids in a drum load. They are also useful to separate a section of drums in a mixed load. Bulkheads can be faced with plywood to provide a smooth face separator for sections of other type packages.

Fiberboard Fillers

Corrugated or solid fillers come in various shapes and sizes. These types are usually used to prevent side to side motion of the lading. See examples of void fillers below.

FIGURE 2.4 Dunnage Bags
Dunnage Bags are NOT B.O.E. or
AAR approved for Dangerous Goods Applications



a. Honeycomb style
b. Collapsible
c. Void Gard

FIGURE 2.5

RESTRAINT SYSTEM COMPONENTS

Restraint systems usually consist of three components:

- the restraint itself (belt, strap, or bulkhead);
- a means of anchoring the restraint to the transport unit; and
- a means of tightening (for belts or straps)

STRAPPING AND WEBBING

Heavy-duty steel strapping has long been the primary choice of unitizing cargos; however, plastic strapping or webbing has seen an increase in use. Strap protectors, such as corner guards or metal plates, should be used to provide a suitable radius to protect straps at all points on lading having sharp edges and/or sharp corners. Be sure tensioning and sealing equipment is used properly. Check the tools periodically to ensure proper operating conditions.

Steel Strapping

Many sizes and strengths of steel strapping are available. In determining which strap is to be used, the shipper must be aware of the weight of each section of the load to be strapped. As a general rule, more straps of lower strength should be used to restrain a load, as opposed to fewer straps of higher strength.

The combined joint strength of the number of straps for rigid braced loads in each longitudinal impact direction must equal the weight of the lading being secured, except as provided in approved loading methods.

Use the proper combination of steel straps, seals, sealing tools, notches or crimps to provide the minimum joint strength for sizes listed in Table 2.H. Figure 2.6 provides examples of notches or crimps.

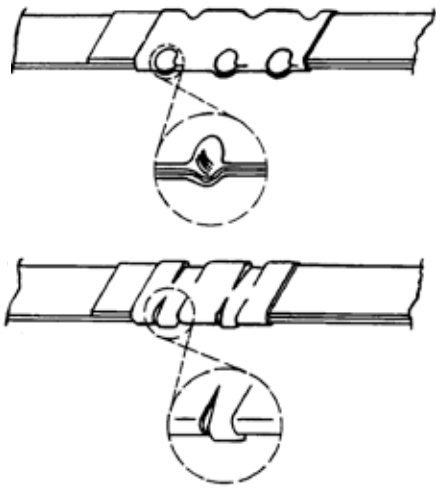


FIGURE 2.6 Examples of Notches

TABLE 2.H

Width & Thickness (in.)	Width & Thickness (mm)	Minimum Breaking Strength (lbs.)	Minimum Joint Strength (lbs.)	Minimum No. of Pairs of Notches on Joint	Minimum No. of Pairs of Crimps on Joint					
					Surface Finish					
Securement Bands		--	--	Surface Finish All Types	Uncoated-Dry		Coated-Not Waxed		Waxed	
1 ¼ x .031	32 x .75	4750	3565	2	3					
1 ¼ x .035	--	4750	3565	2	3					
1 ¼ x .044	--	6750	5065	4	4					
1 ¼ x .050	--	6750	5065	4	4					
--	--	--	--	--	Std.	Grit	Std.	Grit	Std.	Grit
2 x .044	--	10600	7950	4	4	4	4	4	6	4
2 x .050	--	10600	7950	4	4	4	4	4	6	4
2 x .065	--	13800	10350		4	4	4	4	6	4

Plastic Strapping

The unique feature of plastic strapping is its ability to stretch under load, then return to its previous tension. Plastic strapping is usually non-woven, taking the form of flat extrusions or adhering strands. The most common width is ½" and it is widely available in nylon, polyester, rayon and polypropylene. This makes it superior to steel strapping for compressible packages. In these loads, plastic strapping can retain tension, whereas steel straps may go slack (Note: there may be a loss of tension due to stretching as shown in Figure 2.7). These properties are illustrated in Figure 2.8 and Table 2.J.

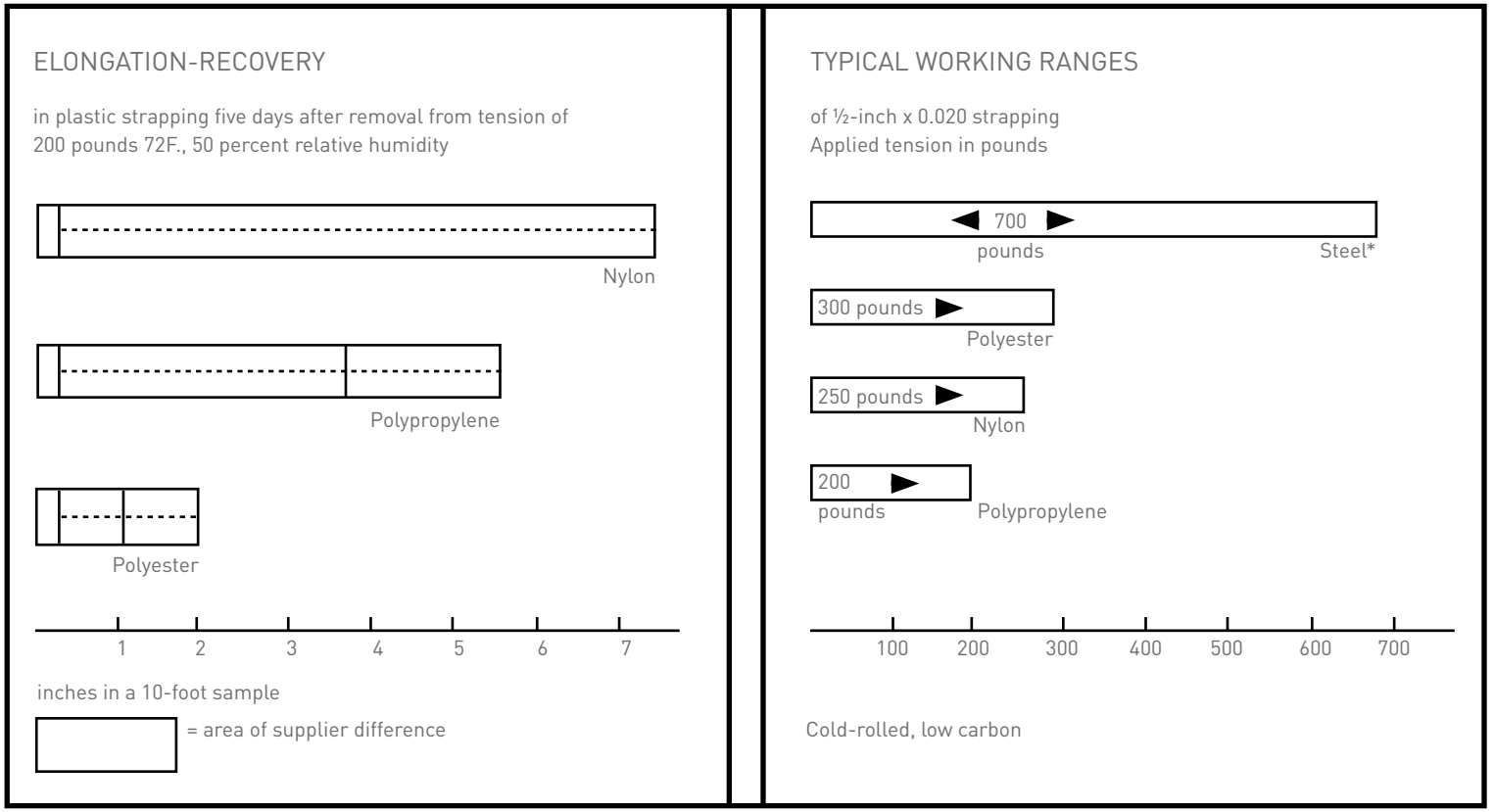


FIGURE 2.7 & 2.8 Plastic Strapping Properties

TABLE 2.J
STRAPPING PROPERTIES

Strapping	Break Strength* (Pounds)	Working Range (per cent)	Elongation Recovery inches	Retained Tension**
Steel***	1,170	0.1	0.1	700/665
Polyester	600	2.5	2	300/224
Nylon	630	7.0	9	250/175
Polypropylene	500	5.0	5.4	200/50

*For 1.2 x 0.020-inch samples
***Initially tension at maximum of working range after 24 hours
***Low carbon cord-rolled steel

Webbing

Webbing is woven to meet various high strength needs; it is available in various materials and weaves. Some typical polyester specifications may be found in Table 2.K. Nylon webbing has similar values but with 3-4 times higher elongation. Polypropylene in those sizes has about 2/3 the strength of polyester with even higher elongation. For this reason polyester is generally recommended for restraint systems. Joint strength of properly made attachment is normally at least 95% of tensile.

Remember that webbing stretches and may loosen. Webbing must be supported at the gate to prevent falling away from load face.

As this is generally a customized or patented application, it works well. However, in general usage as a system to serve all cargoes, a shipper should beware. Persons using web securing should be trained. All webbing used for this purpose must be rated and carry certification. Most belting systems are color coded for safe working limit. Extreme caution must be taken in regards to chaffing or its use on sharp or uneven surfaces or the webbing will rapidly wear or tear. Also some synthetic fibers will degrade in strong ultraviolet sunlight.

The webbing and fasteners must be carefully checked prior to use to assure they are in good order. And finally, should the system be exposed to extreme heat it will fail far more quickly than steel wire.

TABLE 2.K
SOME TYPICAL SPECIFICATIONS IN POLYESTER

WIDTH		BREAKING STRENGTH	
in.	mm.	lbs.	kgs.
1	25	3500	1550
1	25	5000	2250
1 ½	37	7500	3400
1 ¾	45	6500	3000
1 ¾	45	13600	6150
1 ¾	45	15000	6800

This method of bracing is used only in trailers equipped with belt rails attached to the side walls, logistics posts, or in systems using temporary anchoring devices applied to floors that are capable of securing the weight desired. The number, size and strength required under these methods is dependent upon the weight and dimensions of the commodity loaded. The anchored load provides rigid bracing of the lading by the use of steel straps secured to the trailer side walls with load anchors or floor with approved anchor plates.

Apply load anchors per manufacturers' instructions using correct anchors with appropriate belt rails or logistics posts (see Figure 2.9). Install load anchors a minimum of 18" behind face of load and stagger so no more than two are secured in vertical alignment (see Figure 2.9). Use gates constructed as illustrated in Figures 2.10 and 2.11 with these load anchors. The restraining capacity of two 1 ¼" x .031" steel straps, which are correctly sealed and anchored on each side wall and correctly tensioned and sealed across the face of the lading, is 7,100 lbs.

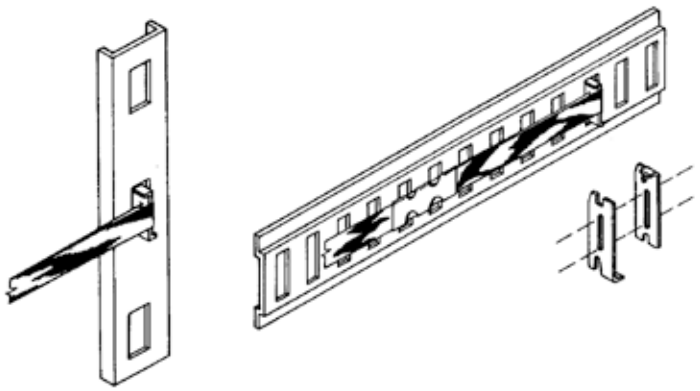


FIGURE 2.9 Load-Restraining Systems
Load Anchors

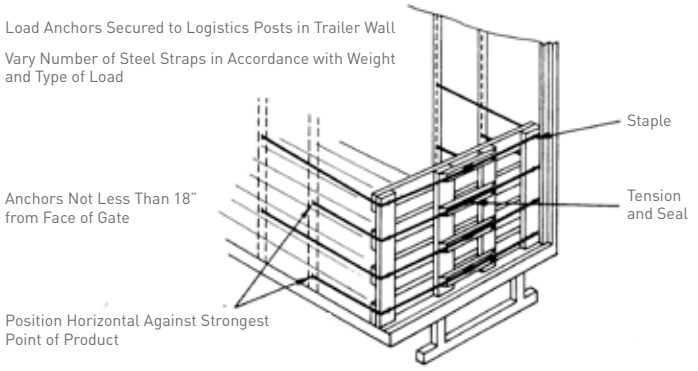
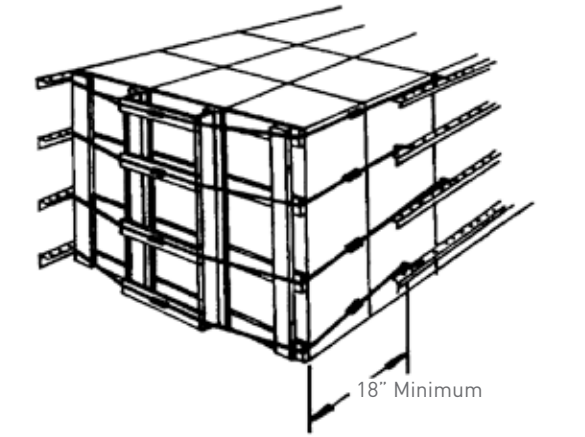
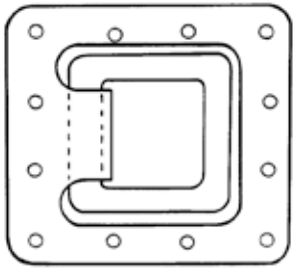


FIGURE 2.10 Construction of Gates

When two or more steel straps are used, tension the straps simultaneously to bring the load back uniformly in position and seal the straps (see Figure 2.11). 'D' Ring strengths are specified in ISO 1496 Annex F. Bottom rail D rings have 500 Kg maximum capacity and upper D rings have a 1000 Kg maximum capacity. It is very important not to exceed this weight bearing capacity when using D rings as anchor points for your securing systems. One must also take into account G forces when calculating ultimate load.



Container 'D' Ring



Retrofit 'D' Ring

FIGURE 2.11 (above) **& 2.12** Seal the Straps & 'D' Rings

“T” Gates and Beams

“T” Gates - rigid bulkhead designed to fit doorpost slots or vertical brace slots of transport equipment. Not suitable where doorposts are flush with walls.

“T” Gate Beams may be inserted into slotted doorposts at rear of container to restrain packages. Use minimum 2” x 4” lumber, free of knots or other strength impairing defects, of suitable length to fit snugly between doorposts. Use a sufficient number of bulkheads to prevent lading from contacting rear doors. When necessary, use a wooden bulkhead and spacers to fill voids to “T” Gate.

Interior Load Bars

Load Bars are usually made of steel or aluminum. Standard duty bars are designed for economy and ease of use. Heavy-duty bars are designed for maximum restraint. Bars are available in various sizes and some may be equipped with rubber shoes to prevent the bar from slipping.

Rubber Mats

Rubber restraint mats provide a quick and easy method of restraining paper rolls and dense products. Mats eliminate nail damage to floors and have the added benefit of reducing loading and unloading time. Mats are generally reusable, improve safety in loading and are available in pads or perforated rolls.

Ty-Gard

Bonded Fabric load securement is constructed of spun-bonded polyester and polyester yarn with a tensile strength of 600 pounds per inch of width. A 16” wide strip has a load retention value of 9000 pounds. A pressure sensitive adhesive system is used to adhere the laminated webbing to virtually any type side wall.

Other Securement systems

Title 49 Code of Federal Regulations Part 393 describe regulations regarding the use of tie down assembly for U.S. highway transportation. Although the rules apply to cargo securement in motor vehicles, there are intermodal implications when containerized freight is being transported. Specific rules for tie downs are found in 49CFR section 393.102 of the Federal Motor Carrier Safety regulations.