CHAPTER 6

CRATES

6-1. Introduction to Crates

a. Nomenclature and Related Terms. Crates are rigid containers constructed of structural members fastened together to protect the contents. Crate design involves numerous names and terms which must be defined if the construction of crates is to be explained without confusion. When the names of the separate components are known, although they differ in various specifications and drawings, their functions and relationship to each other are more easily understood. In order that both general and detail design requirements may be clearly understood, reference to items described in (1) and (2) below is recommended.

(1) *Nomenclature.*

Baffle. A piece of plywood, wood, or metal placed over ventilation holes to deflect air or water entering the crate.

Bottom Sheathing. Boards nailed to the bottom surface of the frame members of a sill base. Also known as *flooring.*

Bridging. Members of the same depth as joists or sills placed at right angles to the intermediate longitudinal or crosswise sills or headers to prevent lateral turning or buckling of the joists or sills.

Cleats. Auxiliary reinforcements for plywood panels placed between vertical struts to strengthen the panel.

Covered Crate. A crate with open-type frame with an outside covering of plywood or paper-overlaid veneer.

Crate Base. The bottom load bearing unit of a crate.

Crate Covering. A lightweight material fastened to the frame of an open crate to give more positive weatherproofing than is offered by an open crate and shroud.

Diagonals. Frame members positioned between parallel frame members and placed at angles of nearly 45° to the latter.

Diagonal Floorboards. Usually 1-inch boards, cut at 45° angle to the skids and placed between the forklift areas.

End Frame Members. Members of the top panel of an open crate, placed crosswise at each end of the top.

End Sills. Members forming the ends of a sill frame.

Filler Strips. Boards placed across the ends of thin, nonload bearing floorboards which fill the space below the lower frame member of the sides.

Floor Members. Boards and timbers nailed or bolted to the top of the skids forming a platform for the contents and a bottom closure for the crates.

Forklift Area. Area extending 42 inches in from each end of the crate, usually floored with 2-inch boards.

Frame Members. Those wood members which form the fundamental structure of the crate.

Gusset Plate. A square piece, usually plywood, placed at the junction of the diagonals for reinforcement.

Hanger, Metal. Metal strapping formed in a manner to support intermediate sills on a sill-type crate or joists of the top.

Headers or End Cross Members (Open Crate). Cross members attached at the end of the skids which hold the skids together. Also longitudinal members at each end of top joists.

Horizontal Braces. Members positioned between struts and parallel to upper and lower frame members of the sides or ends.

Horizontal Top Bracing Joist Support. Horizontal member attached to the frame members in which the top joists rest.

Intermediate Crosswise Sills. Full length members located between the end sills and parallel to them.

Intermediate Frame Members. Members of the top panel of an open crate located between and parallel to the side frames of the top.

Intermediate Longitudinal Sills. Full length members located between the side sills and parallel to them.

Intermediate Skids. Full length beams located between and parallel to the skids.

Joists. Members extending across the crate that support the top and prevent crushing when grab hooks are used.

Joists Supports. Members, usually 2 × 4, nailed to the frame under each joist and extending to the floor.

Kick Blocks. Short members attached at the junction of the corner post and upper or lower edge member. They are used on end panels having no braces or those with a single diagonal brace.

Lag Bolt Reinforcing Strap. Galvanized strapping drilled to take lag bolts and nailed to the inner face of the sheathing at the center line of the skid and header.

Load Bearing Floor Members. Heavier or reinforced floorboards used to hold the concentrated weight of the crate load.

Lower Frame Member. Horizontal frame member at the lower edge of the side and end panels. Formerly called *lower edge member.*

Open Crate. A crate formed of frame members only, without exterior sheathing attached.

Reinforcing Straps. Metal strapping applied at the corners or base corners to reinforce and fasten the panels together.

Rubbing Strips. Boards nailed to the underside of skids or bottom sheathing.

Sheathed Crate. A crate in which the frame members are completely covered with sheathing.

Sheathing. Material such as plywood, lumber, or fiberboard nailed to the frame of a crate across all openings to add strength to the crate, or to prevent loss of contents, pilferage, or entry of dirt, water, etc., into the crate.

Side Frame Members. Members of the top panel of an open crate, placed lengthwise of each side of the top.

Side Sills. The members forming the sides of a sill base crate.

Sills. The continuous frame members of a sill base.

Sill Base. A crate which has its frame members (sills) built on the inside of the crate to which the bottom sheathing is attached.

Sill Bridging. Members of the same depth as the sills placed at right angles to the intermediate lengthwise or crosswise sills of a sill base to prevent twisting or buckling.

Skids. The outside longer beams of a skid base which support the weight of the crate and contents.

Skid Base. A crate base which has its longer beams on the outside.

Sleeper. Reinforcing members secured to the underside of the floorboards, at right angles to the floorboards to provide secure anchorage for the item.

Spacers. Members which position the ends of joist or sills.

Spreaders. Members placed at right angles to the floorboards, between the item and the floorboards, to distribute the load over a wider area.

Sling Notches. Open spaces between the ends of the rubbing strips and the ends of the crate, or cutaway sections at the ends of the skids.

Struts. Vertical frame members between the upper and lower frame members.

Top Joist Spacers. Short members nailed between the top joists, to the inside face of the upper frame members, which act as end bridging.

Top Sheathing. Board or plywood forming the closure of the top.

Upper Frame Member or Upper Edge Member. Horizontal frame member at the upper edge of the side and end panels.

(2) *Terms.*

Actual Size Lumber. The true dimension of a piece of lumber as measured with a scale.

Center of Balance. The point along the length of a crate at which it would balance on a fulcrum, placed at right angles to the skids or sills.

End Grain Nailing. Nails driven parallel to the grain of the wood.

Gross Weight. Total weight of the crate and its contents when ready for shipment.

Holddowns. Devices constructed of wood or metal, used to secure the item to the base of the crate.
Liner. Waterproof barrier material placed between the frame and the sheathing.
Net Weight. The weight of the item alone, excluding dunnage, wrappings, or containers.
Nominal Size Lumber. Dimension of lumber before it is dressed.
Overdriving. Driving nails into wood so that the heads sink below the surface of the wood.
Side Grain Nailing. Nails driven at right angles to the grain of the wood.
Tare Weight. The weight of the crate, including dunnage, holddowns, and packing materials.
Underdriving. Driving nails into wood so that the heads protrude above the surface of the wood.

b. Classification of Crates. Crates are grouped into several categories. They may be open or sheathed (fig 6–1). Crates may be nondemountable, single trip crates of nailed construction, or bolted, reusable, demountable crates. Crates may be designed for domestic use only, or for both domestic and oversea shipments. Some crates are designed for general use and others are constructed in accordance with a specification for a particular item. Of course, the classification of a crate may include a combination of several of the above factors.

(1) *Open crates.* An open crate is a container formed of frame members only, without exterior sheathing attached. When plywood or paper-overlaid veneer is used to provide additional weather protection, they may be called covered crates as opposed to sheathed crates. The open crates discussed in this section are the most widely used (fig 6–2, 6–3, and 6–4).

(*a*) Small open crates. Small open crates may be subdivided into the following categories:

1. Flat Crates. These crates are normally not more than 12 feet in length, 4 feet in width, and 2 feet in height, as illustrated in figure 6–2, Type II. The net weight of contents should not exceed 1,000 pounds. However, there are exceptions to these requirements which are explained in the footnote of table 6–3.

2. Lightweight crates. These crates are designed for net weight of contents not exceeding 250 pounds. The size is limited to 4 feet in length, 3 feet in width, and 3 feet in height (fig 6–2 and 6–3, Type I).

3. Medium weight crates. Crates in this classification are normally designed for a net weight of contents not exceeding 1,000 pounds. The size is limited to 6 feet in length, 4 feet in height, and 4 feet in width (fig 6–2, Type IV).

4. Heavy weight crates. These crates are normally designed for a net weight of contents not exceeding 4,000 pounds. The size is limited to 32 feet in length, 6 feet in width, and 10 feet in height (fig 6–2 and 6–3, Type V).

(*b*) *Large open crates.* For military use, two kinds have been selected.

1. Nailed crates. These crates are designed for a net weight of contents ranging up to 12,000 pounds. The maximum size limit is not to exceed 16 feet in length, 8 feet in width, and 8 feet in height (fig 6–4).

2. Bolted crates. These crates are designed for reuse with a net weight of contents ranging up to 16,000 pounds. These crates are designed with a size limit not to exceed 40 feet in length, 8 feet in width, and 16 feet in height (fig 6–5).

(2) *Sheathed crates.* A sheathed crate is similar to an open crate except that the frame members are completely covered with sheathing material, such as lumber or plywood, fastened to the frame. This adds strength to the crate, prevents loss of contents, reduces pilferage, and prevents the entry of dirt, water, etc. The main difference between a nailed wood box and a sheathed crate is that the top, bottom, and side faceboards of a nailed wood box provides the main structural strength, whereas in a crate, the frame members sustain the load and provide the strength. Many sheathed crate designs exist in our military system; however, the designs selected for this section are considered to be the most widely and generally used (fig 6–6).

(*a*) *Sheathed nailed crates.* These crates are not designed for reuse and are constructed in the same manner as bolted crates with minor exceptions. The crates should not exceed 30 feet in length, 9 feet in width, and 10 feet in height. The net weight of contents may range up to 30,000 pounds. These limitations may be exceeded, however, when the size and weight of the item require a larger crate.

(*b*) *Sheathed bolted crates.* All bolted crates are designed for reuse. The size and weight limitations are the same as for the nailed crates.

(3) *Special use crates.* Crates in this classification are of special design for specific items. These crates may be fabricated of metal or wood, either open, sheathed, nailed, or bolted. Crate dimensions and weight will vary depending upon the

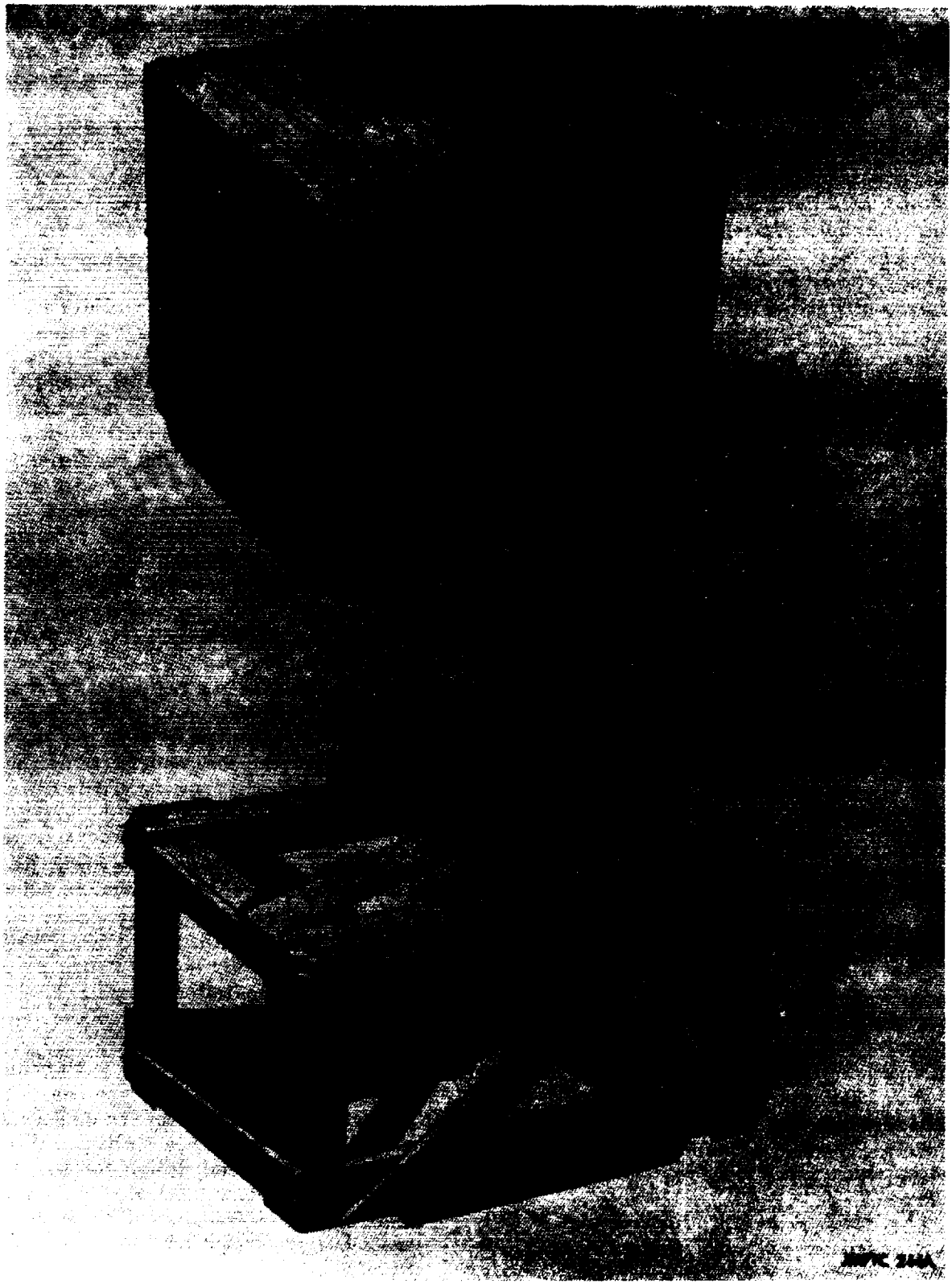


Figure 6–1. Open and sheathed crates.

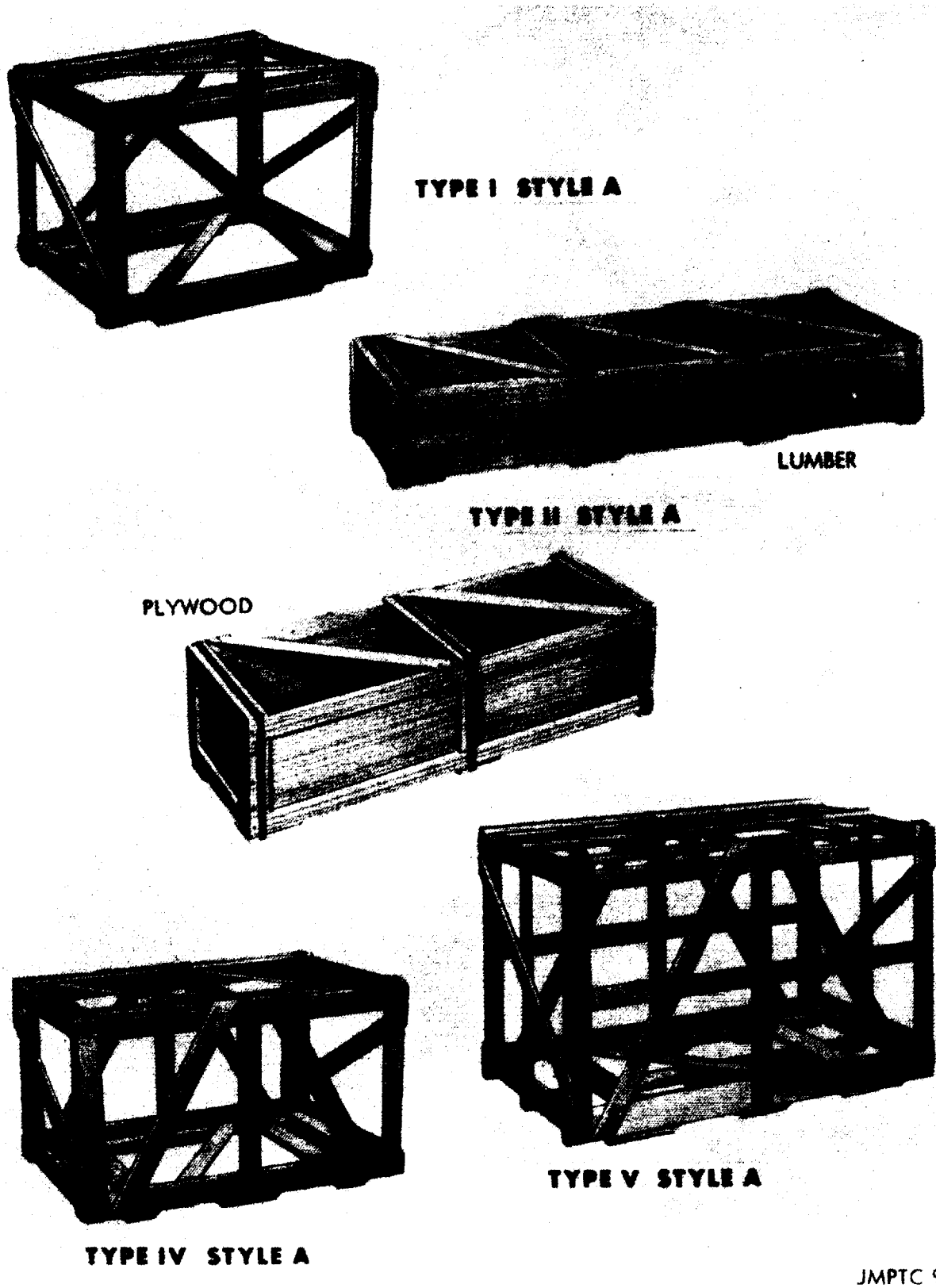


Figure 6-2. Styles of open crates (MIL-C-52950).

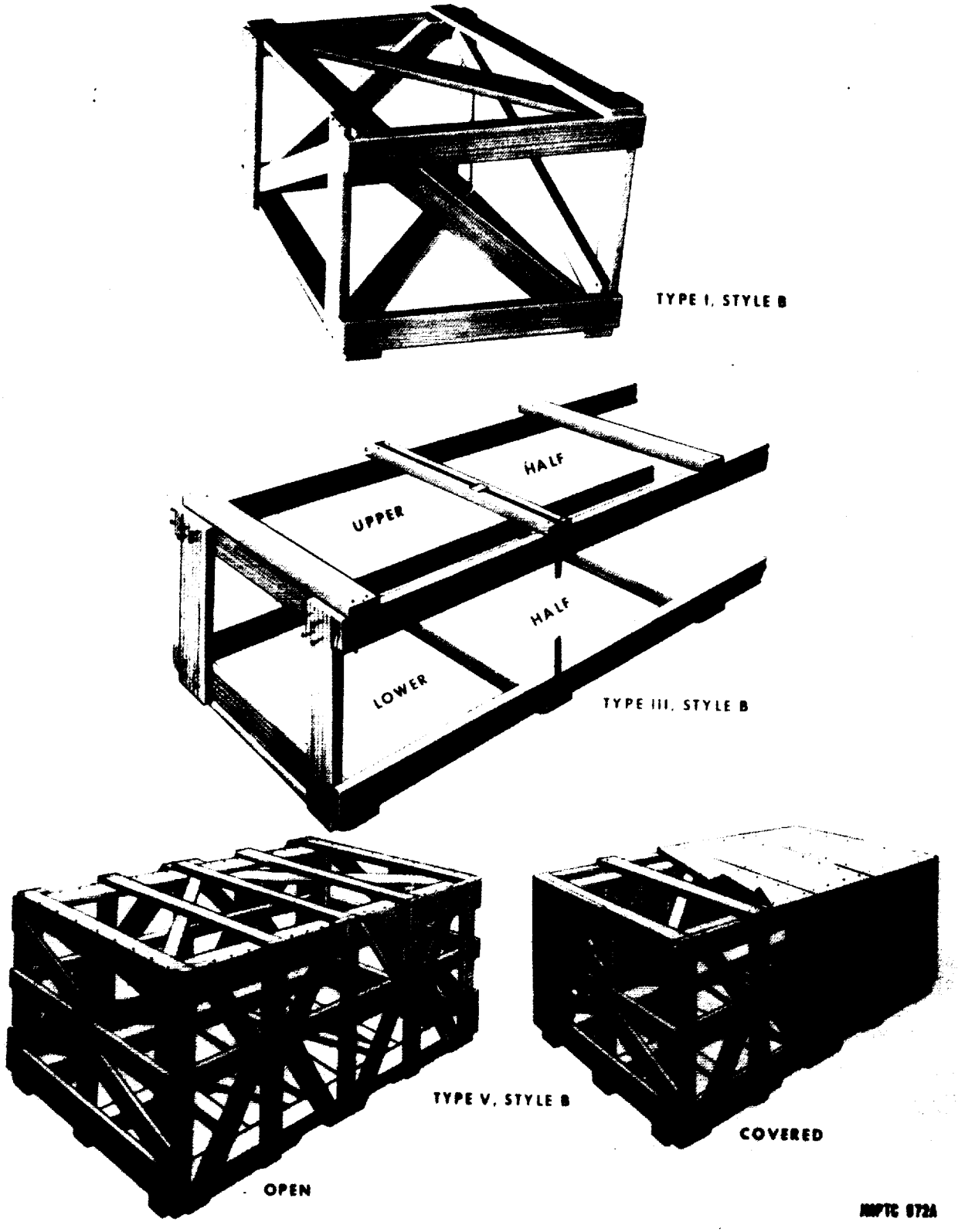


Figure 6-3. Styles of open crates (MIL-C-52590).

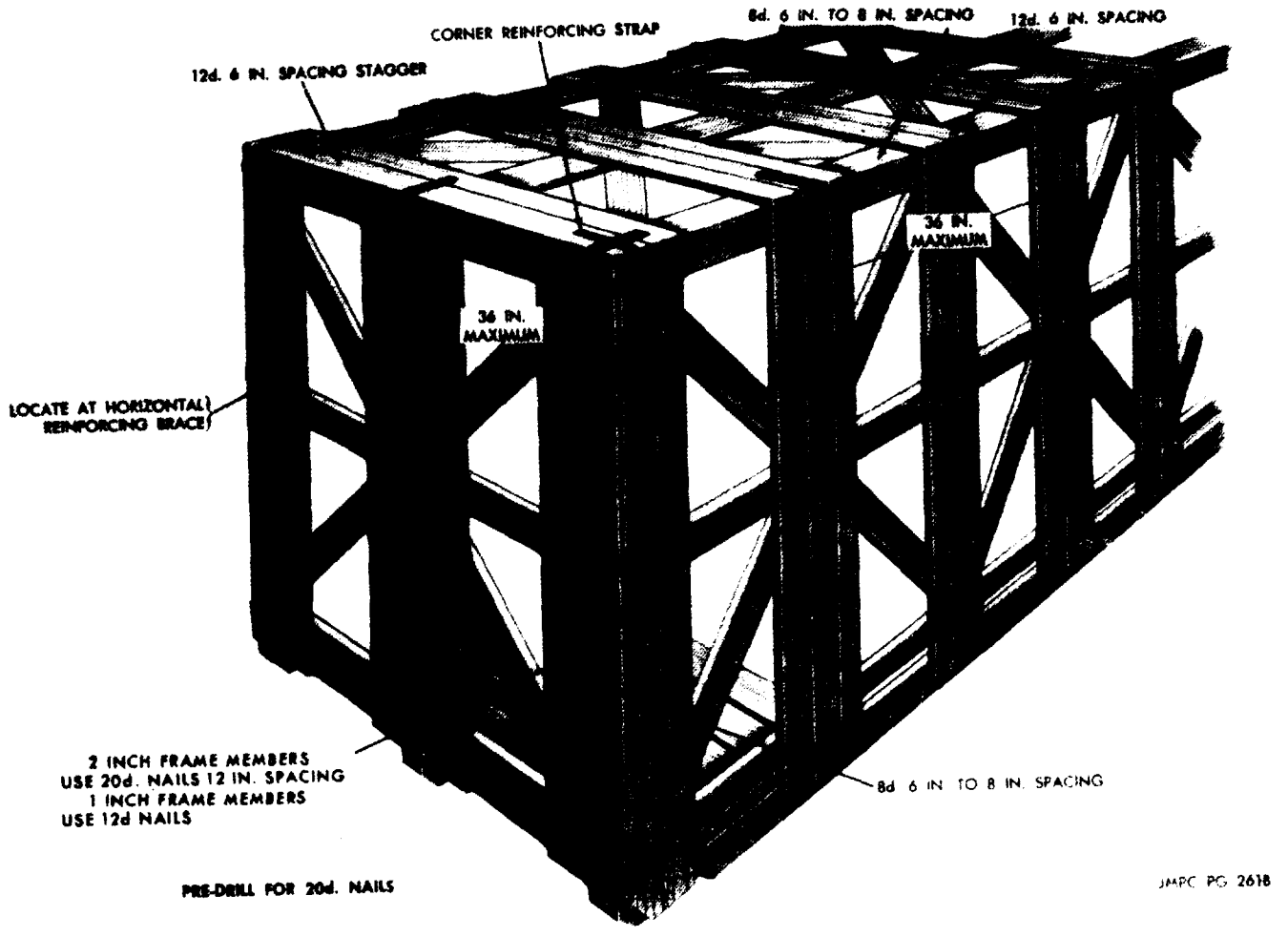


Figure 6-4. Assembly of open nailed crate (MIL-C-3774).

size, weight, and characteristics of the contents. Examples of special crates are illustrated in figure 6-7. The slotted angle crate (MIL-C-9897) is an example of a special metal crate which may be either open (Type I) or sheathed (Type II) with either plywood, paper overlaid veneer, or fiberboard (fig 6-8). It may be fabricated without skids (Style A), or with skid blocks or skids with rubbing strips (Style B). Both the open and sheathed Style A slotted angle crates are restricted to items not to exceed 200 pounds, with dimensions not to exceed 80 inches in length, 30 inches in width, and 48 inches in height, except when a specific design has been approved by the contracting activity. Both the open and the sheathed Style B carry up to 3,000 pounds and are limited to not over 30 feet in length, 4 feet in width, and 7 feet in height (fig 6-8).

c. Criteria for Crate Design. Crates are selected instead of boxes for several reasons. The item may be too large to be shipped in a box. The weight of the item may exceed the weight limitations of a box specification. The item may not require complete enclosure for protection, yet it may require crating to facilitate storage and handling. Crates provide better facilities for clearances, blocking, bracing, and anchoring of the item. To select the proper crate for the item or items to be packed, it is necessary to consider certain basic factors that may influence the selection.

(1) *Size and weight.* Basically, it is desirable to design a crate not to exceed 30 feet in length, 9 feet in width, and 10 feet in height, with a weight limitation not to exceed 11,200 pounds. This maximum size and weight is indicated because the length of 30 feet will permit lowering the crate through the average ship's hatch without excessive tilting. The 9-foot width and 10-foot height is designed for the average width and clearance limits for transporting by rail on a standard flat car. Taking the weight factor into consideration will permit ease of handling by the average ship's hoisting facilities.

(2) *Degree of protection.* To determine the

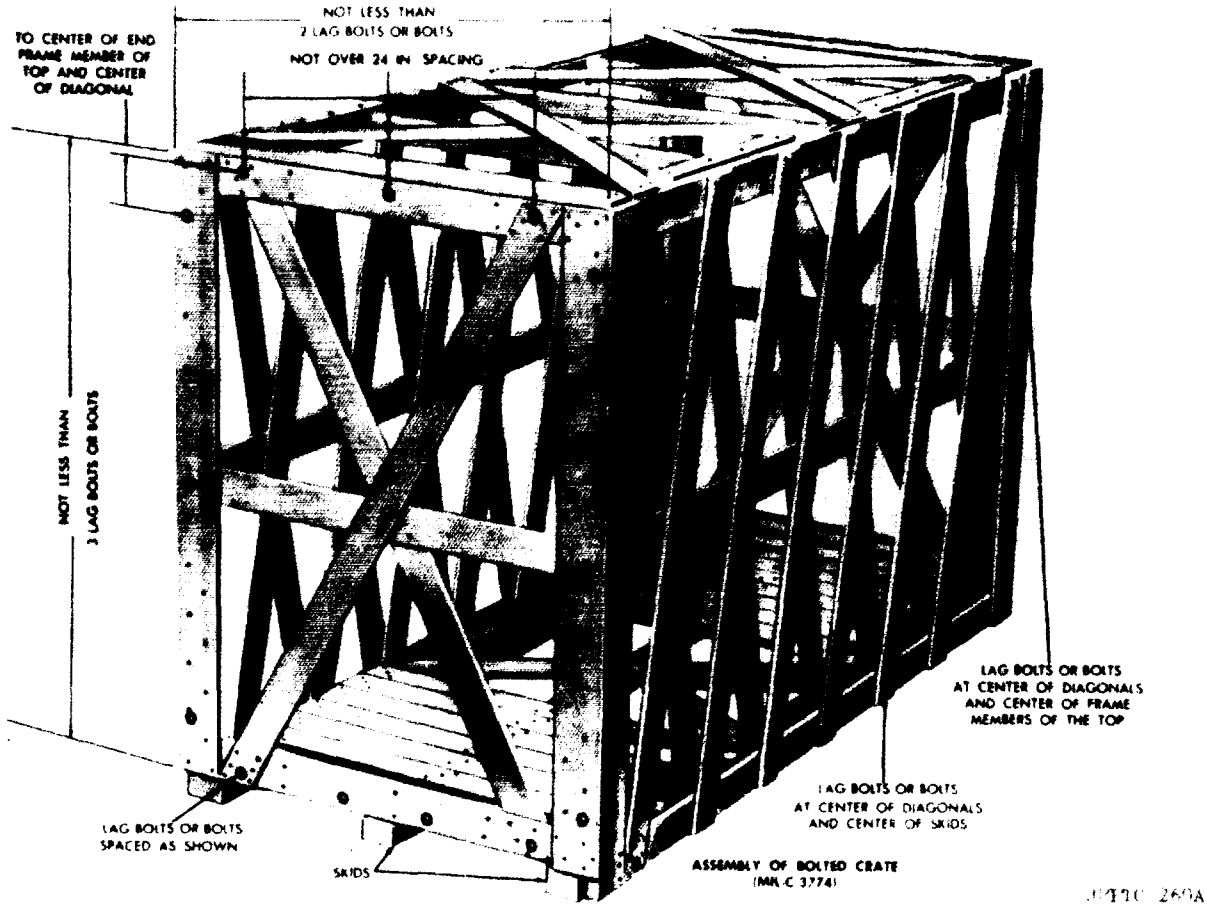


Figure 6-5. Assembly of Open Bolted Crate (MIL-C-3774).

degree of protection required for the contents, it is necessary to know the nature of the item and, if possible, the storage, handling, and shipping hazards to be encountered. If the item requires little protection from the elements, use an open crate. When the nature of the contents requires some protection from the elements, select an open crate and place an interior shroud over the contents or provide a type V, style B, covered, crate (fig 6-3). When the contents requires the maximum amount of protection, use a fully sheathed crate.

(3) *Degree of disassembly.* When determining the size, weight, shape, and strength, consideration should be given to partial disassembly of the item or its components to reduce the overall size of the crate. However, do not disassemble the item to the point where special tools or personnel are needed to reassemble it.

(4) *Weight distribution.* In designing crates over 5 feet in length, weight distribution becomes an important factor. Whenever possible, the center of gravity of the contents should coincide with the geometrical center (center of balance) of the loaded crate.

(5) *Anchoring of the contents.* A thorough study of the contents should be made in order to insure that provisions are made for anchoring the contents within the crate to prevent damage during handling and shipment. When necessary, use cushioning and padding at points on the item where blocking, bracing, or strapping is used to prevent movement. Bolts, steel strapping, iron bands, rods and lumber holddowns are acceptable methods for anchoring and supporting the contents (fig 6-9). Some items are designed with packing and shipping in mind and are provided with holddown features. If the item does not have these characteristics, utilize the stronger areas of the item for anchoring.

(6) *Clearance.* Normally, a minimum of one-inch clearance is required between the contents and the nearest framing member of the sides, ends, and top. This clearance allows for the distortion and vibration to which the crate may be

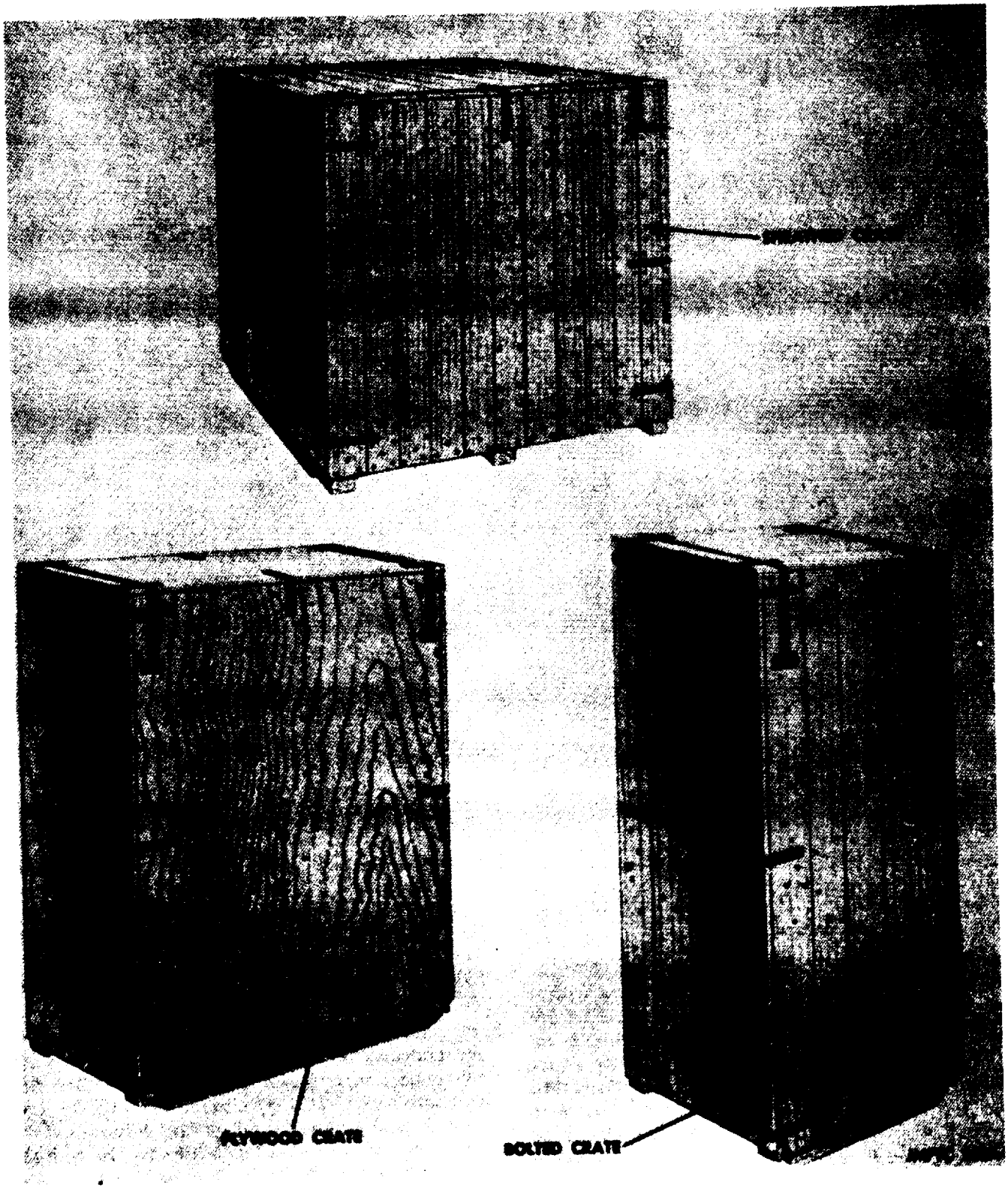


Figure 6-6. Sheathed crates.

Figure 6-7. Special use crates.

subjected during rough handling and transit. Items that are fragile in nature, or items within floating bag barriers (submethods IIa and IA-16) require from 2 to 4 inches of clearance (chap 3, vol I). Additional clearance may be required for shock mounted items. Through careful design, it is often possible to allow protruding points of the item to extend between the joists, or the joists may be spaced, within specified limits, to accommodate these protrusions.

(7) *Types of bases.* The selection of a skid or a sill base will depend on the physical characteristics of the item to be crated.

(*a*) *Sill bases.* Sill bases (fig 6-10) are designed for items that can be supported above their lowest point. Examples are transmission housing, engines and vehicles with brake drums projecting below the frame or axles.

(*b*) *Skid bases.* Skid bases are designed to accommodate loads that can be supported on their lowest portion, or items that are made to rest flat on their bases. Skid-type bases are preferred in most cases; however, when the item must be supported above its lowest point, the use of a sill base will reduce the overall height of the crate. Savings in height should be more than 6 inches before substituting a sill base for a skid base (fig 6-11).

d. Engineering Factors in Crate Design. A crate is an engineered container. The use of sound engineering principles and actual tests of crates

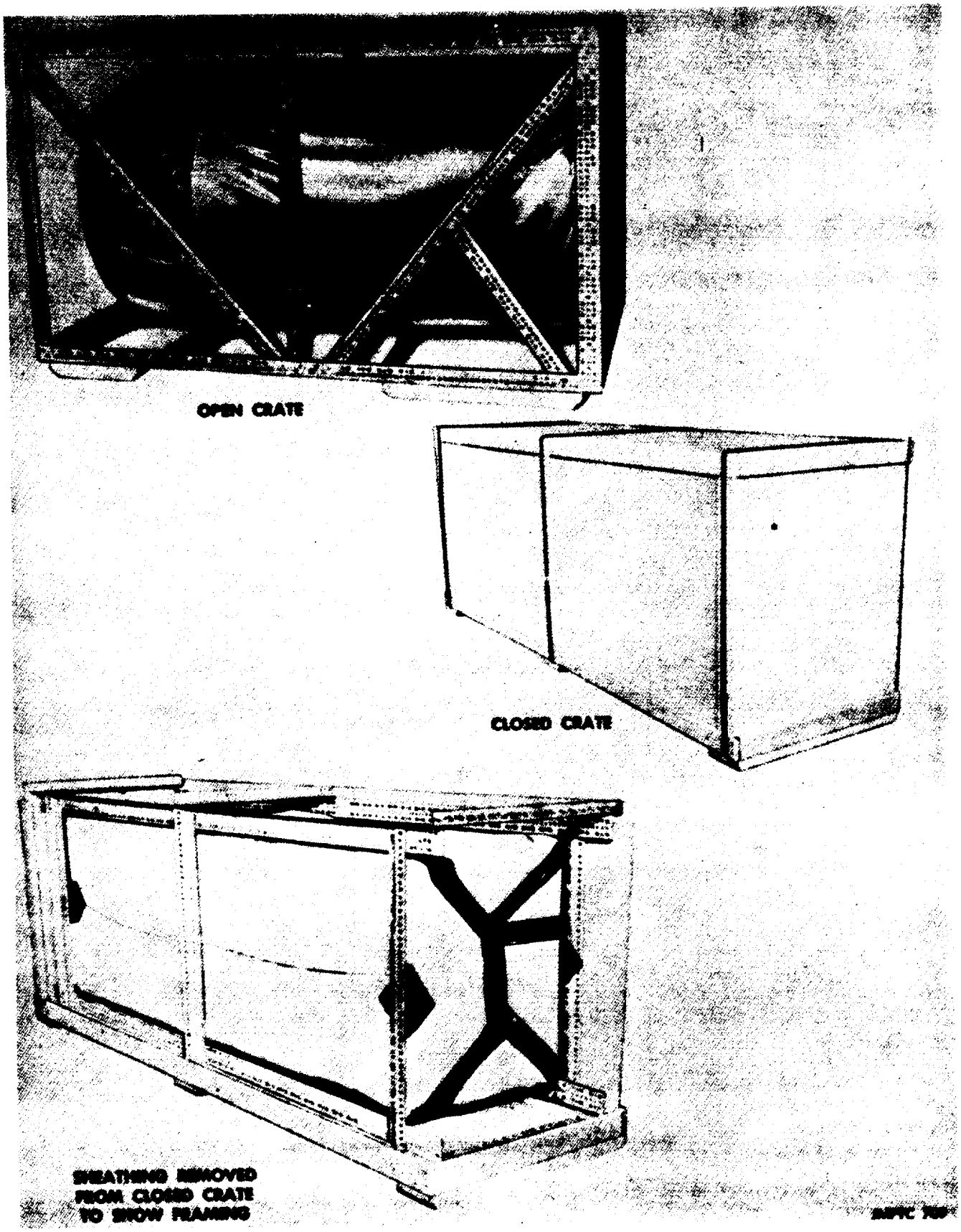


Figure 6-8. Slotted angle crates.

Figure 6-9. Methods of anchoring contents in crates.

with contents has resulted in the following design requirements:

(1) *Tops.* The top of a sheathed crate is designed to carry a uniform, well-distributed, superimposed load of 50 pounds per square foot. Top loading plus the span or width of the crate will determine the kind of top and the size of joist required to transfer the load to the sides. Top load-

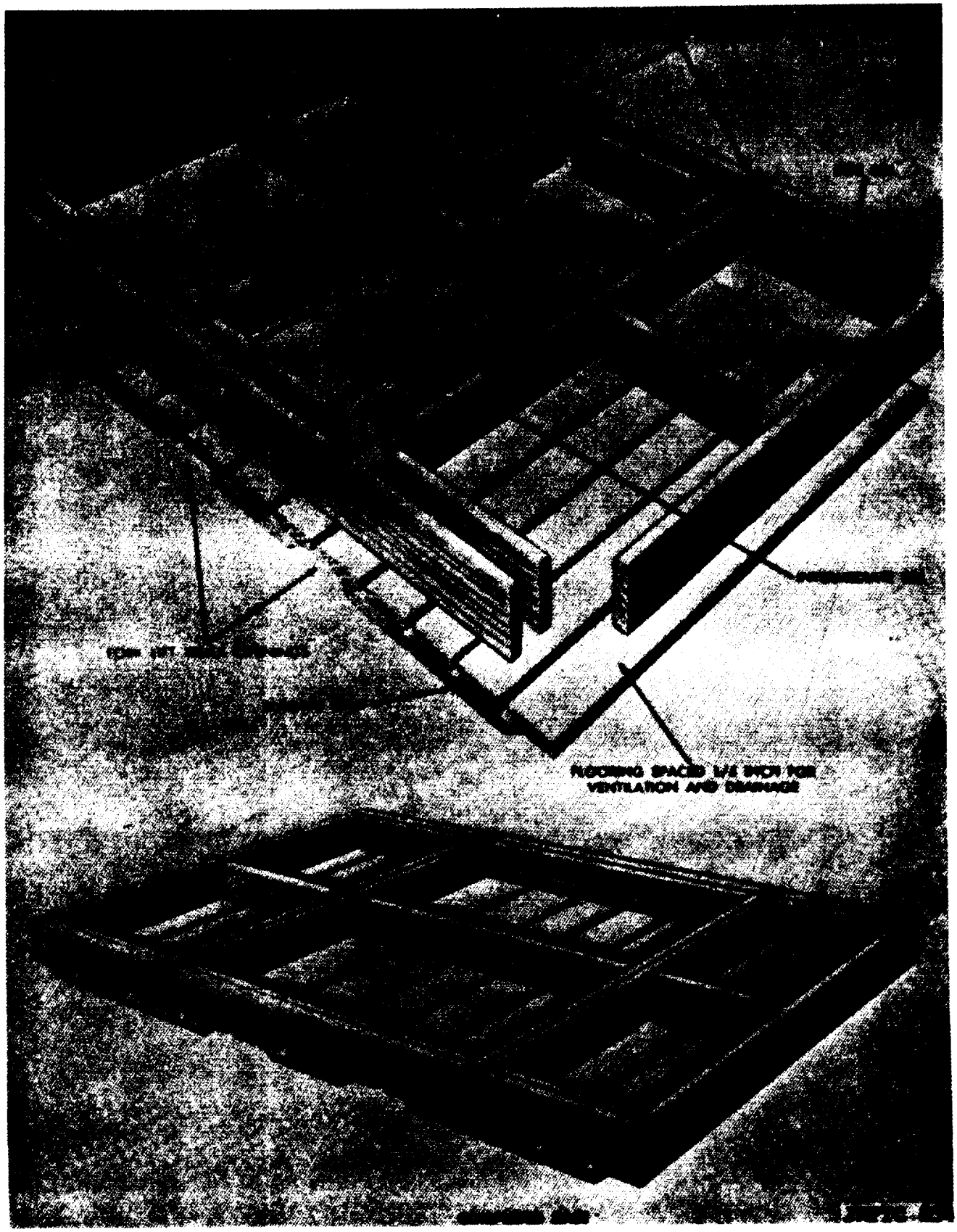


Figure 6-10. Sill base.

Figure 6-11. Skid base.

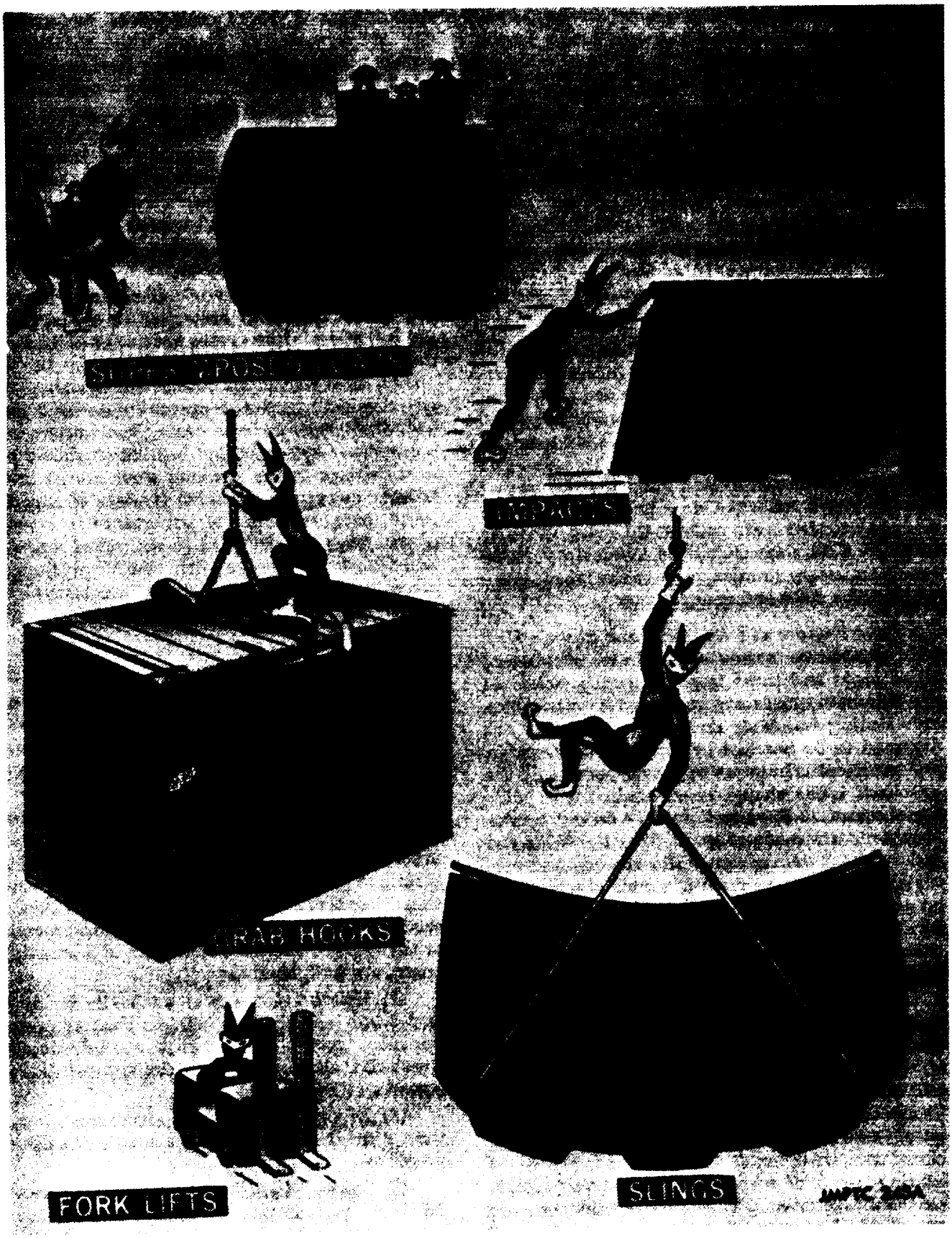


Figure 6-12. Resistance to forces.

ing is calculated without dunnage. In open crate design, dunnage is used and the load is supported by the side and end panels.

(2) *Sides and ends.* For crate design, the side and end panels of sheathed crates are considered as trusses. The selection and size of members for the sides and ends are calculated on the basis of the span, height, and the amount of stress each member can withstand. These crate design factors are for sides having top loads, with dunnage, in the amount of 200 pounds per square foot, for net loads to 10,000 pounds. In addition, they may be designed for 400 pounds per square foot, for net loads over 10,000 pounds.

(3) *Bases.* The base is treated as a unit and is designed to support the contents. In the engineering analysis, the skids of the base are considered as part of the lower frame members of the sides. The lower frame members and skids act together when the crate is lifted as a unit. This analysis allows the reduction of skid sizes, thereby saving materials and cube, but does not allow the handling of a loaded crate without the sides and ends in place. Skid sizes should be increased if it becomes necessary to raise or move the loaded crate without the sides and ends in place.

e. Load Factors and Handling and Storage Hazards. In addition to the external forces of superimposed loads and those imposed by the weight of the contents, crates are subjected to other hazards during handling and shipping. Crates are designed to be handled by forklift trucks, slings, and grabhooks. In order to prevent crushing, the grabhook areas should be reinforced with additional material. For handling with forklift trucks, provisions are made to enter from the sides and ends without damaging the floorboards and contents. Forklift entry from the ends places stress on the headers, load bearing floorboards, and forklift members. Therefore, these members should be well secured with nails or bolts (fig 6-12).

(1) *Modes of transportation.* Crates may be shipped by rail, truck, plane, or ship. Some of the hazards involved in shipment are shock stresses and impact stresses resulting from sudden stops and starts. Vibration is also a shipping hazard. Crates shipped on open cars shall always be fastened securely to prevent any movement. In closed cars, there are several preferred methods of loading, some of which allow movement under controlled conditions. The preferred methods are the snubbed load, the floating load, and the rigid braced load. The method selected depends upon the fragility, size and shape of the item, and the center of gravity of the loaded crate. The snubbed load utilizes antiskid plates, while the floating load depends entirely upon the friction between the crate and the car floor. These loads are designed for items with a low center of gravity. The rigid braced loads utilize lumber and metal straps. This material should be applied in such a manner as to eliminate all movement. Shiploading involves stacking load stresses. Dunnage should be placed on top of crates to transfer superimposed loads to the sides of the crates, which have been designed to carry such loads.

(2) *Exposure and storage.* Sheathed crates will provide for long-term protection in exposed storage conditions. Open crates are designed for items that require very little protection from the elements. Sites slected for outside storage should be well drained in order to prevent water and moisture from entering the crate. Well constructed tops, proper drainage, and ventilation should prevent damage to the contents when stored under adverse conditions. Stacking stresses of superimposed loads are of major importance in storage. Open crates are designed to withstand superimposed loads in storage with additional dunnage placed on the top, transferring the load to the sides.

6-2. Crate Materials

a. Lumber. Lumber used in crate construction must meet the same rigid requirements as for other wooden containers. Lumber used in crate construction shall be free of defects that would materially weaken the container.

(1) Knots and divergence of grain (cross-grain) are probably the most common defects in lumber used for framing members, and will affect the strength of these members more than the sheathing boards. Knots or knot clusters that exceed one-fourth the width of a structural member or that exceed one-third the width of a sheathing board, are prohibited.

(2) Moisture content of lumber is an important factor and shall be not less than 12 percent nor more than 19 percent of its oven dry weight. Otherwise, shrinkage may occur and nail holding power may be reduced.

(3) Divergence of grain (cross-grain) more than 1 inch in 10 inches in the length of a piece is prohibited.

(4) The width and thickness of lumber used in fabricating crates are always minimum from a design standpoint. When nominal sizes are given in a crate specification, the actual minimum sizes will be as indicated in table 6-1.

Note. All lumber dimensions referenced in this section are nominal. Actual dimensions are so indicated when actual sizes are required.

Table 6-1. Minimum Thickness and Width of Lumber

Thickness in inches (smaller dimension)		Width in inches (larger domension)	
Nominal size	Minimum (actual)	Nominal size	Minimum (actual)
1	3/4	2	1-1/2
		3	2-1/2
2	1-1/2	4	3-1/2
3	2-1/2	5	4-1/2
4	3-1/2	6	5-1/2
5	4-1/2	8	7-1/4
6	5-1/2	10	9-1/4
7	6-1/2	12	11-1/4

b. Plywood (NN-P-530). Plywood is used in crate construction for sheathing, for nonload bearing flooring, for tops, and gusset plates. While plywood is usually more expensive than lumber, it requires no diagonals or crate liner material when used as sheathing, and a lighter, more economical crate may result from its use. Tests have shown that plywood is actually stronger than lumber, the dimensions being the same. When using plywood, select the standard size sheet stock that conforms closest to the crate dimensions, otherwise waste of material will result. The type of plywood selected will be on the basis of its intended use. Where prolonged exposure to the elements or attack by micro-organisms (mold, fungi, etc.) is expected, materials must be selected that will withstand the extreme conditions.

c. Nails (FF-N-105). Nails are used in the fabrication of the components for both nailed and bolted crates. They are also used in the assembly of nailed crates. The preferred types of nails used for crate assembly are the sinker, corker, or common. If these nails are not available, coolers or standard box nails may be used. Nails used for fastening plywood should be 14-gage with heads no less than $^{7}/_{32}$-inch diameter (fig 3-4).

d. Staples (FF-N-105). Staples are sometimes used to fasten plywood sheathing to the framing members. When used for this purpose, staples should be made of 16-gage wire with a crown not less than one-half inch.

e. Bolts, Nuts, and Washers. Many types of bolts are used in crate construction. The most common types used are standard steel carriage, step, and machine bolts (fig 6-13). Bolt holes should be drilled the same size as the shank of the bolt. Plain washers should be used under the heads of the machine bolts and under all nuts. Special holding plates have been designed for use under the heads of square shank bolts to prevent turning. The use of plates is not mandatory. Counter-sinking of bolt heads is prohibited. The bolt threads projecting beyond the nut after tightening should be painted with P-1 or P-19 (hard drying preservative), unthinned lead paint or other similar material to prevent loosening.

f. Lag Bolts (FF-B-561). Lag bolts are sometimes referred to as "lag screws." There are three types of lag bolts—Type I, Gimlet Point, Square Head; Type II, Cone Point, Square Head; and Type III, Cone Point, Square Head, Fetter Drive (fig 6-13). Types I and II have a standard V-type thread and Type III has a buttress type of thread. Lag bolts are used to assemble the sides, ends, and tops of demountable crates. These bolts are prohibited for use as holddowns or to tie the headers and the floorboards to the skids. When using lag bolts for assembly, drill the lead hole to the same diameter as the shank, although the threaded portion may be larger than the shank. The size of the lead hole for the threaded portion will depend upon the group of wood used. When using lag bolts in soft woods, make smaller lead holes. Use plain washers under the heads and tighten firmly against the washer (table 6-2).

Note. Lag bolts should never be driven with a hammer. When power wrench is used, care must be taken that the bolts are not overdriven.

Table 6-2. Application of Lag Bolts

Diameter of threaded portion of lag bolts	Diameter of lead hole	
	Groups, I, II and III wood	Group IV wood
Inch	*Inch*	*Inch*
1/4	3/16	3/16
5/16	1/4	1/4
3/8	1/4	5/16
1/2	3/8	7/16
5/8	3/8	1/2
3/4	1/2	5/8

g. Nut Sleeve Assembly. A nut sleeve assembly, as illustrated in figure 6-14, may be used as an alternate for lag bolts in demountable crates. These bolts must be the same size as the fasteners they replace and are spaced the same distance apart.

h. Metal Strapping (QQ-S-781). Metal strapping is used for reinforcing crate corners, sill bases, securing tops, as lag bolts reinforcing straps for demountable crates, and for strengthening sill and load bearing headers for sill-type bases. It is also used to reinforce crate corners and the tops of open crates. Metal straps used for this purpose

shall be Class 1 Type I or II, and not less than ¾ x 0.028-inch (fig 6-15).

(1) *Corner straps.* Metal strapping used for reinforcing tops, corners, and sill-type bases is usually annealed and predrilled for ease of application. This type of strapping is used on all nailed crates and on bolted crates with net loads over 3,000 pounds. The legs of the corner straps are usually 8 inches in length. They are nailed to the frame members with a minimum of three galvanized roofing nails, 1¼ to 1½ inches long. The straps are spaced no more than 36 inches apart.

(2) *Tension straps.* Tension straps are used to secure the top to the sides of the crate. They are secured to the sides of the crate by anchor plates, which are nailed to the frame members. The straps are drawn tight with a tensioning device and held in tension with two seals. Tension straps are spaced no more than 6 feet apart.

(3) *Lag bolt reinforcing straps.* This strap is fabricated from galvanized steel and is used on the side and end panels of many demountable crates to prevent the lag screws from tearing through the sheathing as the crate is lifted. The strapping material is prepunched or predrilled. Lag bolts three-eighths inch in length require 1¼ x 0.035-inch straps. For ½-inch and ⅝-inch lag screws, 2 x 0.050-inch straps are needed. Nail these straps to the lower inner face of the sheathing between the lower edge of the bottom frame member and the bottom frame member and the bottom frame member and the bottom of the sheathing. Locate them to coincide with the center of the skids and headers. Use clout or similar nails to secure the strapping. Space the nails a maximum of 2 inches on center and clinch at least three-fourths of an inch (fig 6-16).

(4) *Metal hanger.* Metal hangers are used for reinforcing joists of tops, load bearing headers, and intermediate sills on sill-type bases. Hangers are fabricated from steel straps 1¼ x 0.035-inch. The strapping material is prepunched or predrilled. When used to reinforce load bearing headers or intermediate sills, eightpenny nails are used to secure straps in place, followed by driving from two to four twentypenny nails into the end-grain of the holding member (fig 6-17).

(5) *Sill base straps.* In addition to the straps applied to other areas of the crate, sill bases must be reinforced with ¾ x 0.028-inch metal straps (fig 6-18). Use a minimum of three galvanized roofing nails 1¼ to 1½-inch long in each leg of the strap. Locate all nails to penetrate a framing member.

i. Waterproof Liners and Shrouds (PPP-B-1055). Waterproof barrier material is made by laminating layers of kraft paper with asphalt. Seven different classes of material may be used for crate liners. The most common classes used are E-1, E-2, and C-2. This material, when used as a liner, is placed horizontally between the sheathing and the frame members of the sides and ends. If more than one width of material is required, use a minimum of 4-inch shingle lap for proper drainage. The barrier should cover the entire framed area. When vertical joints are required, the 4-inch lap will be located at a vertical member. Liners are not required for plywood sheathed crates. Interior shrouds, large bags, or envelopes fabricated from waterproof barrier material are used in open crates to cover items which require additional protection. All sharp projections of the item should be cushioned or padded to prevent puncturing the material. The class of material to use is optional, although the most common class is E-2. All joints in the material are made by using MMM-A-260 adhesive. Shrouds should hang free of the item to provide proper ventilation and should extend to within 6 inches of the bottom of crate. Material conforming to Specification L-P-378 may also be used for interior shrouds. This material is constructed of polyethylene and does not contain asphalt (fig 6-19 and 6-20).

j. Roofing Felt (SS-R-501). Roofing felt is used in the construction of tops for sheathed crates. This material should have a smooth uncoated surface with a minimum weight of 45 pounds per square (a square is an area of 10 feet by 10 feet, or 100 square feet). The material is placed between the outer lumber sheathing and inner plywood sheathing of the top as illustrated in figure 6-59. When a joint is required, overlap the felt 4 inches and seal with a non-hardening caulk or mastic compound. As an alternative, polyethylene film, not less than 4 mils thick, may be used in place of roofing felt.

k. Screens and Ventilators. Screens are fabricated from heavy rust-resisting wire of ¼ or ⅜-inch mesh and used over ventilating and drainage holes to prevent entry of birds, insects, rodents, or other animals. Ventilators fabricated from metal are sometimes used over ventilating holes. Some of the most common methods are illustrated in figure 6-49.

l. Inspection Doors. When inspection doors are required, they are made without cutting into the framing members. Doors are fabricated from the same material as the sheathing. Hinge at the top and fasten with lag bolts or wood screws at the sides and bottom (fig 6-21). Make cleats and stops from 1-inch material. Drill holes through the door

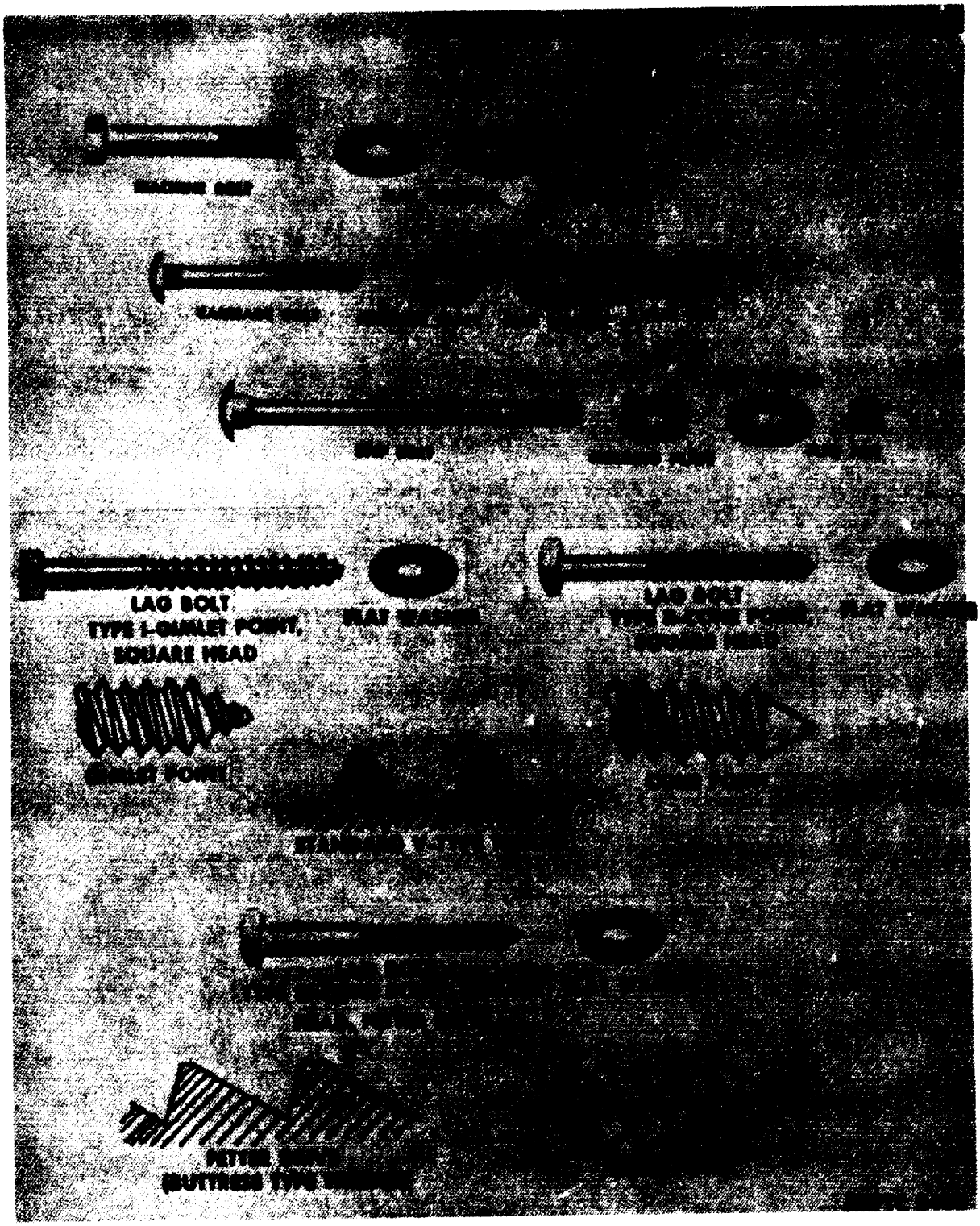


Figure 6–13. Bolts, screws, and accessories.

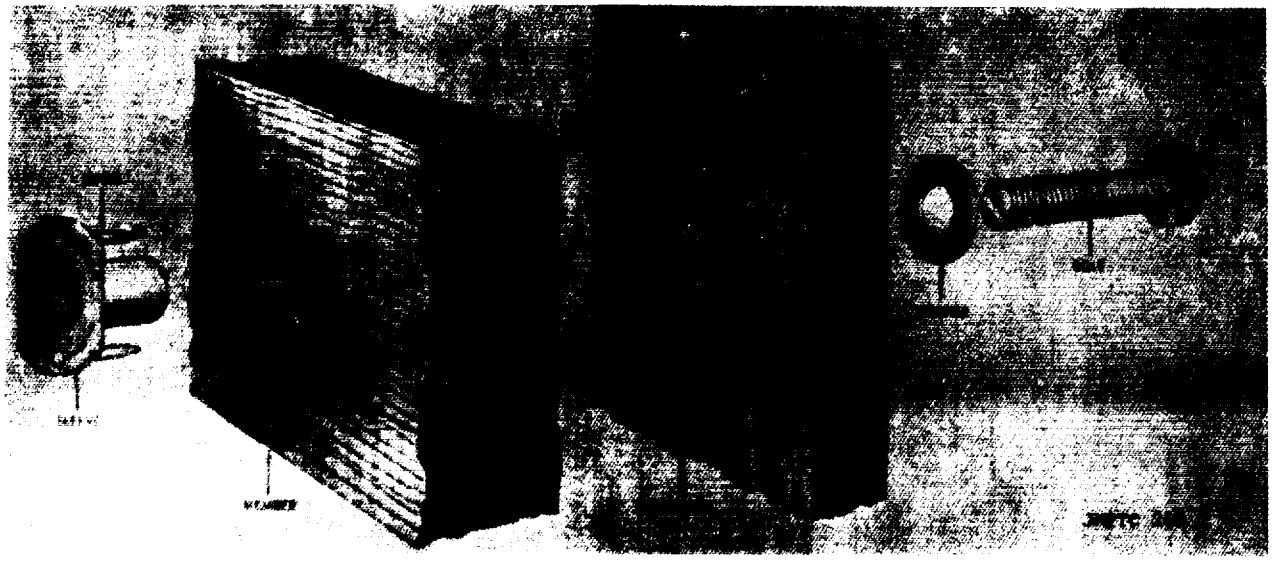


Figure 6–14. Nut sleeve assembly.

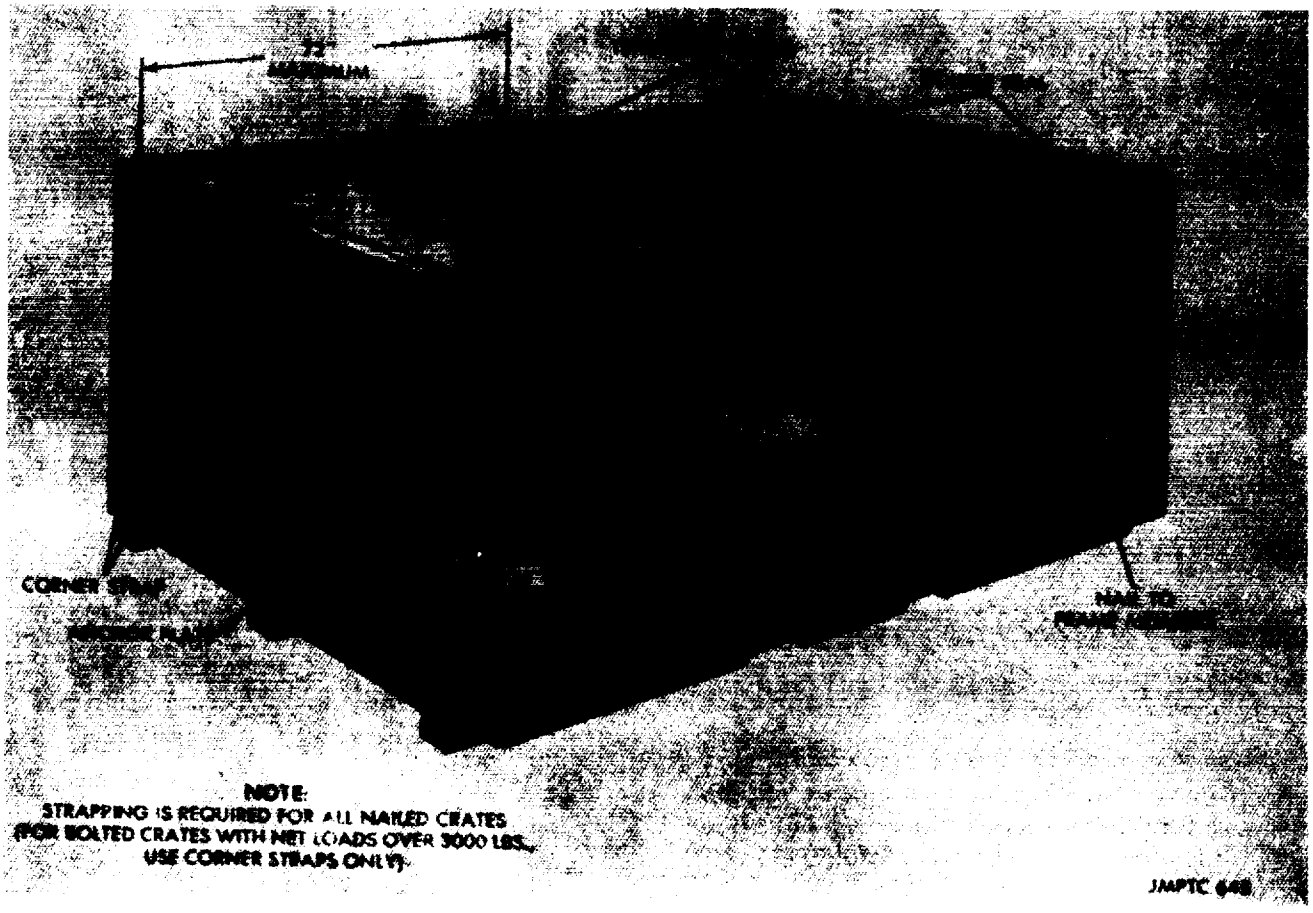


Figure 6–15. Tension and corner strapping.

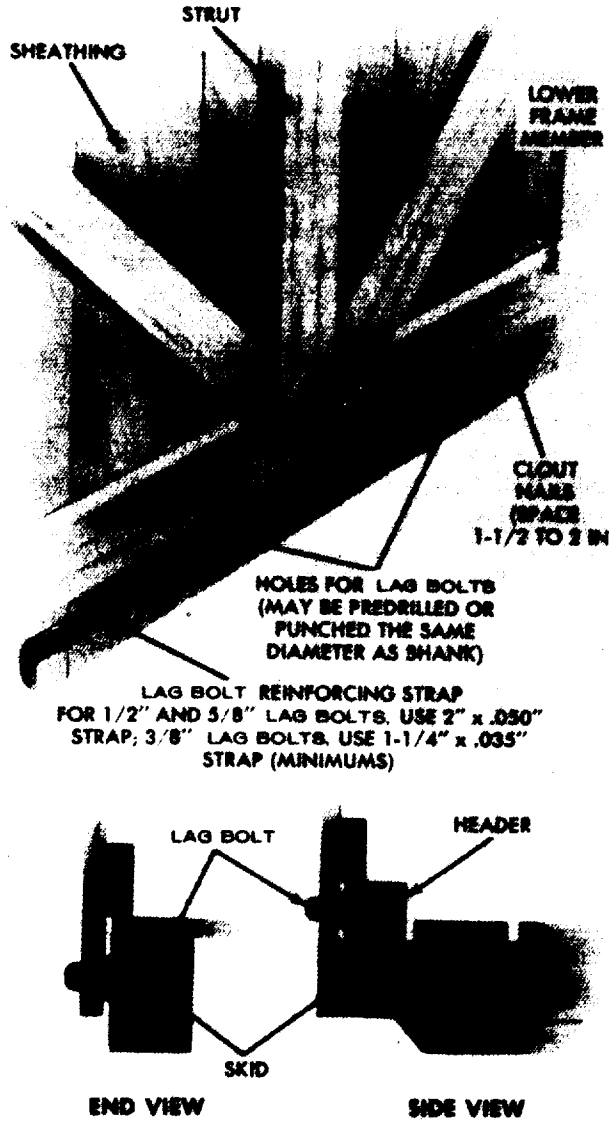


Figure 6-16. Lag bolt reinforcing strap.

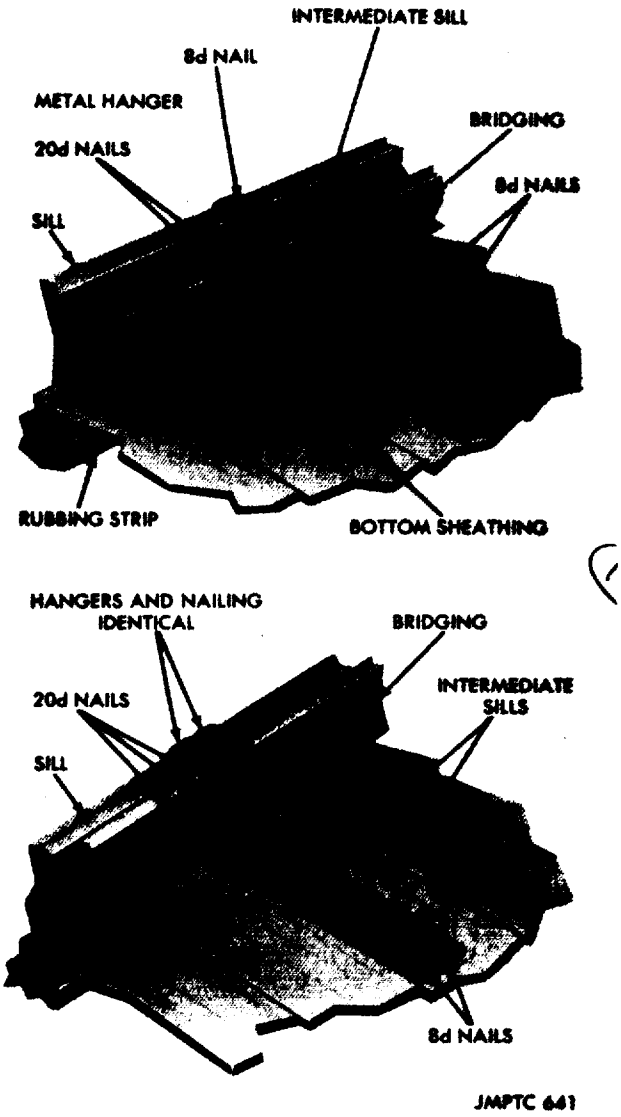


Figure 6-17. Use of metal hangers.

and adjacent frame member to provide for a seal wire and lead seal bearing the inspector's stamp. The size and location of the doors will vary with the nature of the item.

6-3. Wood Crates, Open and Covered, MIL-C-52950 (General)

a. Crate design. Open wood crates described in this section are designed for general use and are employed for both domestic and oversea shipments. Only items which are not readily damaged from outside forces and which require limited protection should be shipped in open crates. Usually, items which are designed for outdoor use or of rugged construction are shipped in open crates. When there are a variety of items to be shipped, each crate will be designed for each item with the necessary clearance for blocking, bracing, and cushioning.

b. Classification. Crates fabricated or procured under Specification MIL-C-52950 on the basis of weight, size, and construction features, as indicated in table 6-3.

c. Wood requirements.

(1) The requirements for lumber will be in accordance with MIL-STD-731 with this exception. Divergence of grain (cross-grain) should not exceed one inch in ten inches of length. Plywood, when used, will conform to NN-P-530.

(2) *Nails and nailing.*

(a) Nails used shall be sinkers, coolers, corkers, or common. For fastening covering materials

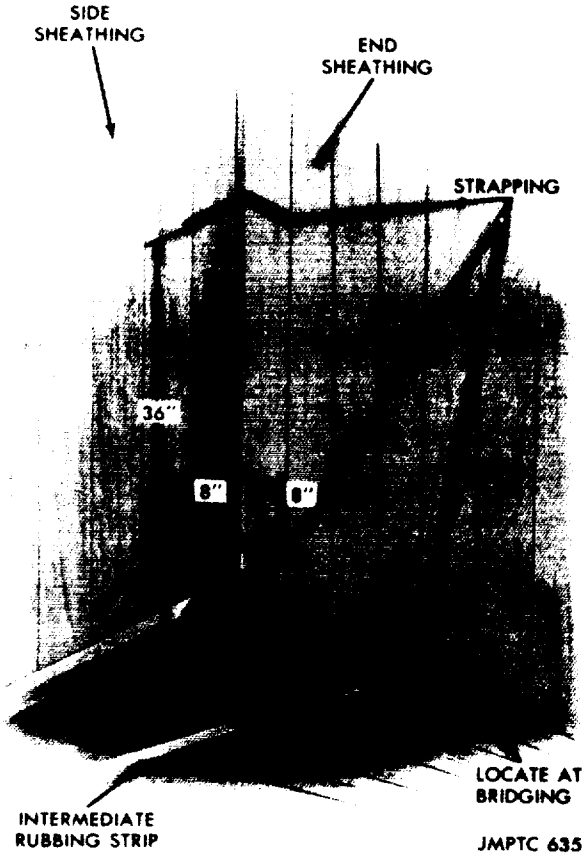


Figure 6-18. Application of strapping (sill base).

to members, nails shall be not less than 1 inch long but shall not exceed the sum of the thickness of the covering material and member. Nail sizes specified for the fabrication of the various crates are based on Groups I and II woods.

(b) When group III or IV woods are used, nail sizes may be onepenny size smaller than those specified. The patterns to be used for the nailing of two flat pieces of lumber shall conform to the details shown in Figure 6-23. Unless otherwise specified herein, the following requirements shall determine size, placement, and quantity of nails:

1. All adjacent crate members shall be securely fastened to each other, either directly or by means of the covering.

2. All nails that are not to be clinched shall be cement coated or mechanically deformed (helically or annularly threaded).

3. Nails shall be driven through the thinner member into the thicker member wherever possible.

4. When the flat faces of pieces of lumber are nailed together and the combined thickness is 3 inches or less (except for top joints and covering material), nails shall be long enough to pass through both thicknesses and shall be clinched not less than ¼ inch nor more than ⅜ inch.

5. When the flat faces of lumber are nailed together and the combined thickness is more than 3 inches or when the flat face of one or more pieces is nailed to the edge or end face of another, nails shall not be clinched. The portion of the nail in the thicker piece shall not be less than 2 times the length of the nail in the thinner pieces for tenpenny nails and smaller, and not less than 1½ inches for twelvepenny nails and larger.

6. When splitting occurs with the use of diamondpoint nails, the nails shall be slightly blunted. When blunting does not prevent the splitting, holes slightly smaller than the diameter of the nail shall be drilled for each nail.

Table 6-3. Classification of MIL-C-52950 Crates

Type	Style A—Heavy Duty				Style B—Light Duty			
	Maximum net load	Max. Inside Dimensions			Maximum net load	Max. Inside Dimensions		
		Length	Width	Height		Length	Width	Height
	(pounds)	*(feet)*	*(feet)*	*(feet)*	*(pounds)*	*(feet)*	*(feet)*	*(feet)*
I	250	4	3	3	200	4	3	3
II[1]	1000	12	4	2	NO STYLE B			
III	NO STYLE A				No load or size restriction except as limited by handling methods. Crates are designed for long, self-supporting items such as structural sections.			
IV	1000	6	4	4	NO STYLE B			
V[2]	2500	12	6	6	4000	32	6	10

[1] Items such as ladders, tubing, and extrusions weighing less than 200 pounds and not exceeding 20 feet long, 3 feet wide, and 2 feet high may be packed in Type II crates.
[2] Type V, Styles A and B crates shall be further classified as being nondemountable or demountable. Type V, Style B crates may be open or covered.

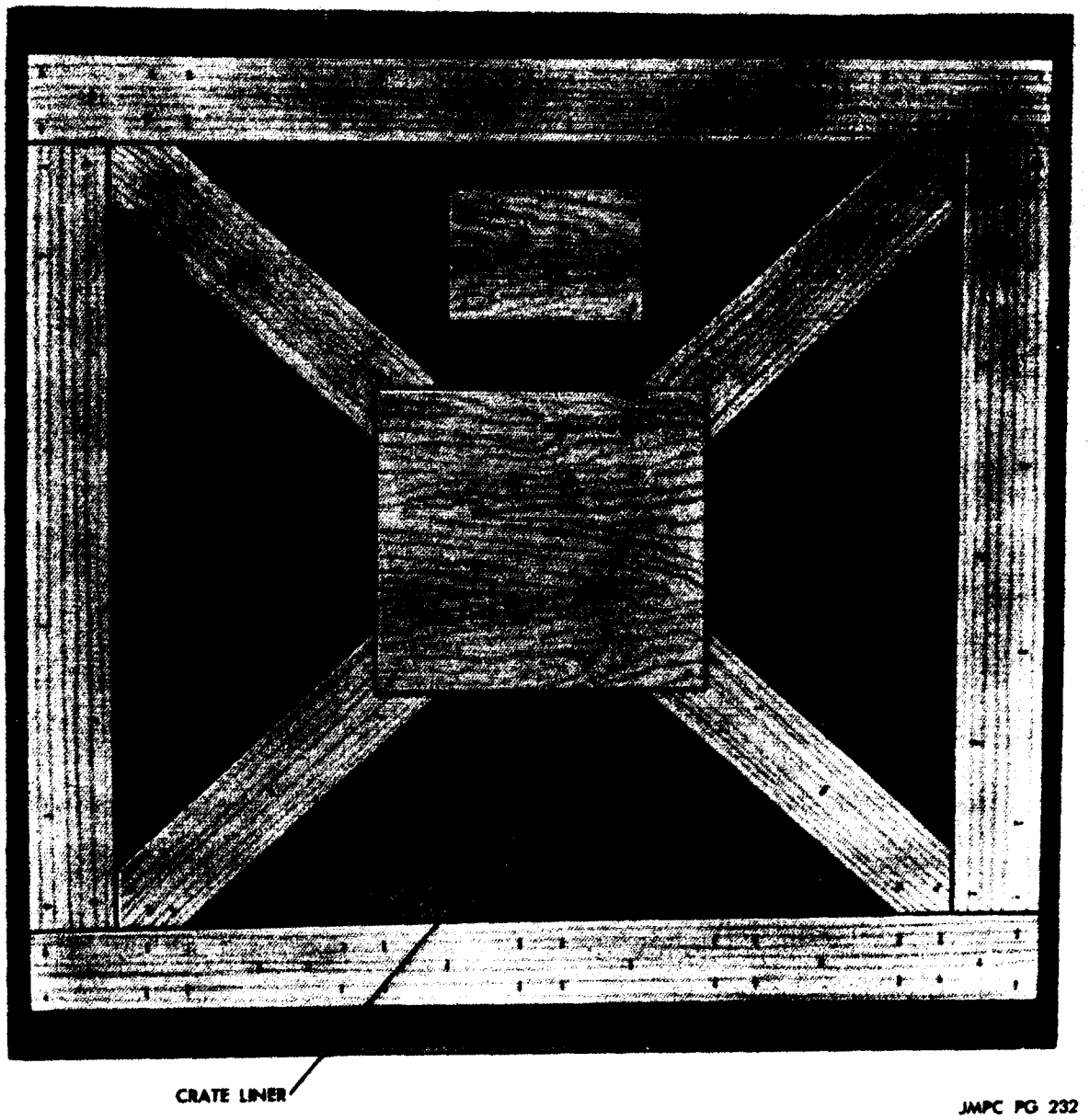


Figure 6-19. Crate liner.

7. Nails shall be driven so that neither the head nor the point projects above thesurface of the wood. Occasional overdriving will be permitted, but nails shall not be over-driven more than one-ighth the thicknes of the piece hlding the head.

8. Nails shall be positioned not less than the thickness of the piece from the end nor less than one-half the thickness of the piece from the side edge of the lumber whenever possible. Nails driven into the side edge of the lumber shall be centered on the side edge.

9. When two members having parallel grain are attached, the number of rows of nails shall be determined by the nominal width of the surfaces in contact, one row for widths up to and including 2 inches, two rows for widths greater than 2 inches but not greater than 6 inches, and three rows for widths over 6 inches.

10. When plywood is nailed to cleats, nails shall be spaced not more than 4 inches apart on centers placed in staggered rows which are less than 1¾ inches apart or less than ¾ inches from the edge of the cleat.

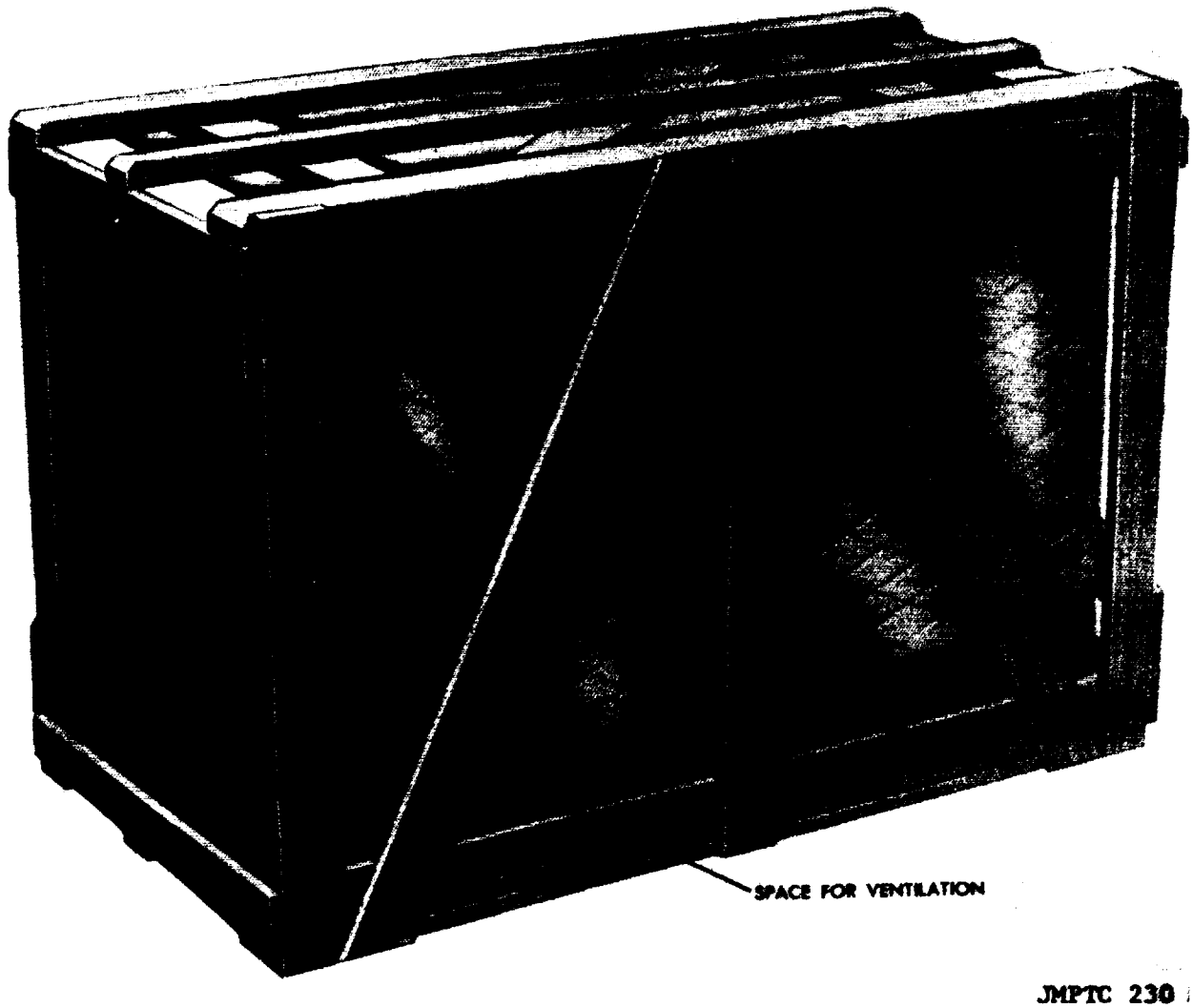


Figure 6-20. Interior shroud.

(3) *Staples.* The crown of the staples used for fastening covering materials for frame members shall be not less than ⅜ inch. The length of the staples shall not exceed the sum of the thicknesses of the covering materials and the frame member; however, staples shall be not less than 1 inch in length.

(4) *Bolt application.* Holes shall be prebored to receive carriage bolts and shall be the exact diameter of the bolt. The lead holes for lag bolts shall be the same diameter as the shank, even though the threaded portion may have a greater diameter than the shank, and shall be as shown in Table 6-2.

(5) *Splices.* Splices and butt joints made in frame members and skids of long crates shall be as shown in Figure 6-24.

(6) *Waterproofing materials.* (See 6-2, i.)

6-4. Type 1, Style A—Heavy Duty Crate (MIL-C-52950)

a. Design Requirements (figure 6-25).

(1) *Load and size limitations.*

(a) Limitations shall be as specified in Table 6-3.

(b) Style A crates shall be used only for items forming a Type I load and weighing not more than 250 pounds.

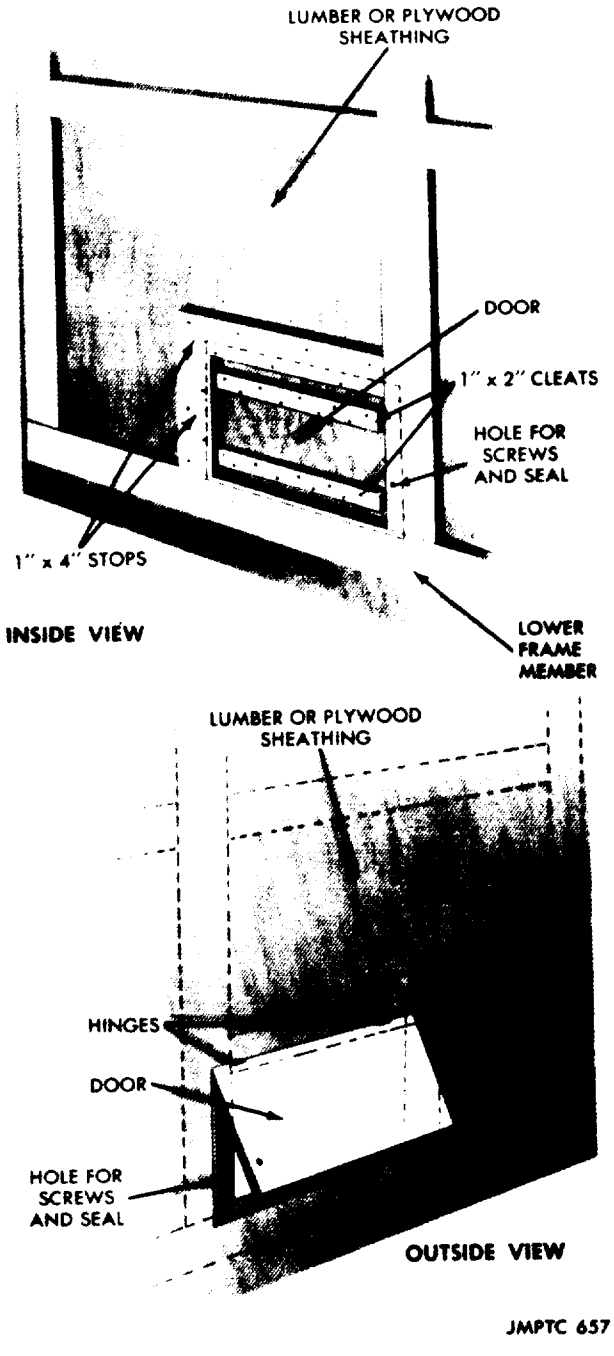


Figure 6-21. Crate inspection door.

(2) *Base.*

(a) Skids. The skids shall be 2 by 4 inch lumber.

(b) Diagonals. Diagonals shall be 1 by 4 inches in size.

(c) End floor members.

1. End floor members shall be the same thickness and width as the skids except when used as loadbearing members; their size shall be as specified in Table 6-4.

Table 6-4. Allowable Load Per Inch of Load-bearing Floorboard Width of Groups I and II Woods

Distance between skids	Nominal Thickness of Floorboard (inches)					
	1	2	3	4	6	8
12	50	200	557	1090	2690	4680
18	34	134	370	740	1790	3140
24	25	100	280	545	1350	2330
30	20	80	222	450	1150	1870
36	17	66	185	361	895	1560
42	15	57	158	311	767	1335
48	12	50	139	272	671	1170
54	11	45	124	242	596	1039
60	10	40	111	218	537	936
66	9	37	104	198	488	850

Note. When Group IV woods are used, the above allowable loads may be increased by 20 percent.

2. End floor members shall be bolted to each skid with ⅜-inch diameter carriage bolts.

(3) *Rubbing strips.*

(a) Single piece rubbing strips used on each skid shall be a minimum 3 by 4 inches in size and beveled at each end at an angle of 45 degrees for at least one-half their thickness.

(b) The length shall be less than the skid length to allow open space at each end for sling and fork truck handling.

(c) The open space shall be not less than 4 inches and not more than 10 inches long. On crates over 36 inches long, the rubbing strip length shall be adjusted to provide a distance of not more than 28 inches between end openings.

(4) *Slide, end and top panels.* All members of the side, end and top panels shall be 1 by 4 inch lumber. Nailing and nailing patterns shall be as specified in 6-3, *c.*(2) and as shown in figure 6-23.

b. Assembly. Assembly of the crates shall be as shown in Figure 6-25 and as specified herein. Nailing shall be specified herein as in 6-3, *c.*(2).

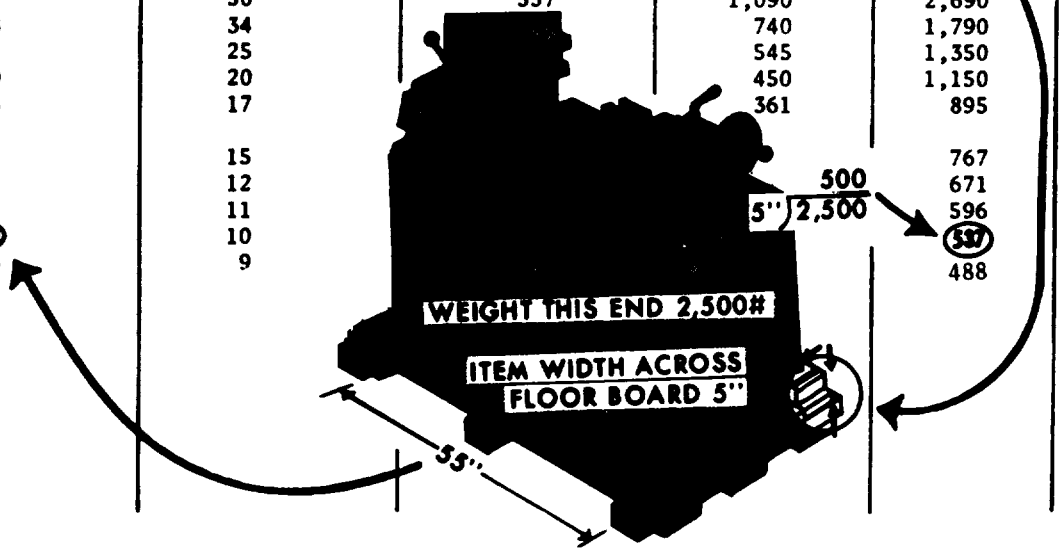
(1) The sides shall be fastened to the base by nailing the extensions of the vertical struts and diagonals to the skids with eightpenny nails.

(2) The ends shall be fastened to the base by nailing the lower edge member of the panels to the end floor member with eightpenny nails spaced 6 to 8 inches apart.

(3) The sides shall be fastened to the ends by nailing the end vertical struts of the sides to the vertical struts of the ends with eightpenny nails spaced 8 to 10 inches apart. The sides shall be fastened to the top nailing the extensions of the diagonals and vertical struts of the sides to the longitudinal members of the top with eightpenny nails.

ALLOWABLE LOAD PER INCH OF FLOORBOARD WIDTH OF GROUPS I AND II WOODS (MIL-C-52590)

LENGTH BETWEEN SKIDS (IN.)	THICKNESS OF LOAD BEARING FLOORBOARDS (IN.)				
	1"	3"	4"	6"	8"
	pound	pounds	pounds	pounds	pounds
12	50	557	1,090	2,690	4,680
18	34		740	1,790	3,140
24	25		545	1,350	2,330
30	20		450	1,150	1,870
36	17		361	895	1,560
42	15			767	1,335
48	12			671	1,170
54	11			596	1,039
60	10			537	936
66	9			488	850



[1]If group IV woods are used, the above allowable loads may be increased by 20 percent.
[2]Wood thicknesses shown are actual nominal thicknesses.

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Figure 6-22. Use of table to determine thickness of load bearing floorboards.

(4) the top shall be fastened to the ends by nailing the extensions of the longitudinal and diagonal members of the top to the upper edge member of the ends with eightpenny sinker nails.

(5) The upper edge members of the ends shall be nailed to the edge lateral members of the top with eightpenny sinker nails spaced 8 to 10 inches apart.

6-5. Type I, Style B—Light Duty Crate (MIL-C-52950)

a. Design Requirements (Figure 6-26).

(1) *Load and size limitations.*

(a) Limitations shall be as specified in Table 6-3.

(b) Style B crates shall be used only for items forming a type I load and weighing not more than 200 pounds.

(2) *Frame member size.* All frame members shall be 1 by 3 inches in size for net loads up to 100 pounds by 1 by 4 inches in size for loads between 100 to 200 pounds.

b. Assembly. Assembly of the crates shall be as shown in Figure 6-26. Diagonals, struts, cross members, and longitudinal members shall be nailed together in pattens as shown in Figure 6-23 with sixpenny nails.

6-6. Type II, Style A—Heavy Duty Crate (MIL-C-52950)

a. Design Requirements (Figure 6-27).

(1) *Load and size limitations.* Limitations shall be as specified in Table 6-3.

(2) *Ends.* The ends shall be of lumber or cleated-plywood as shown in Figure 6-27. The cleats shall be fastened to the end boards or to the

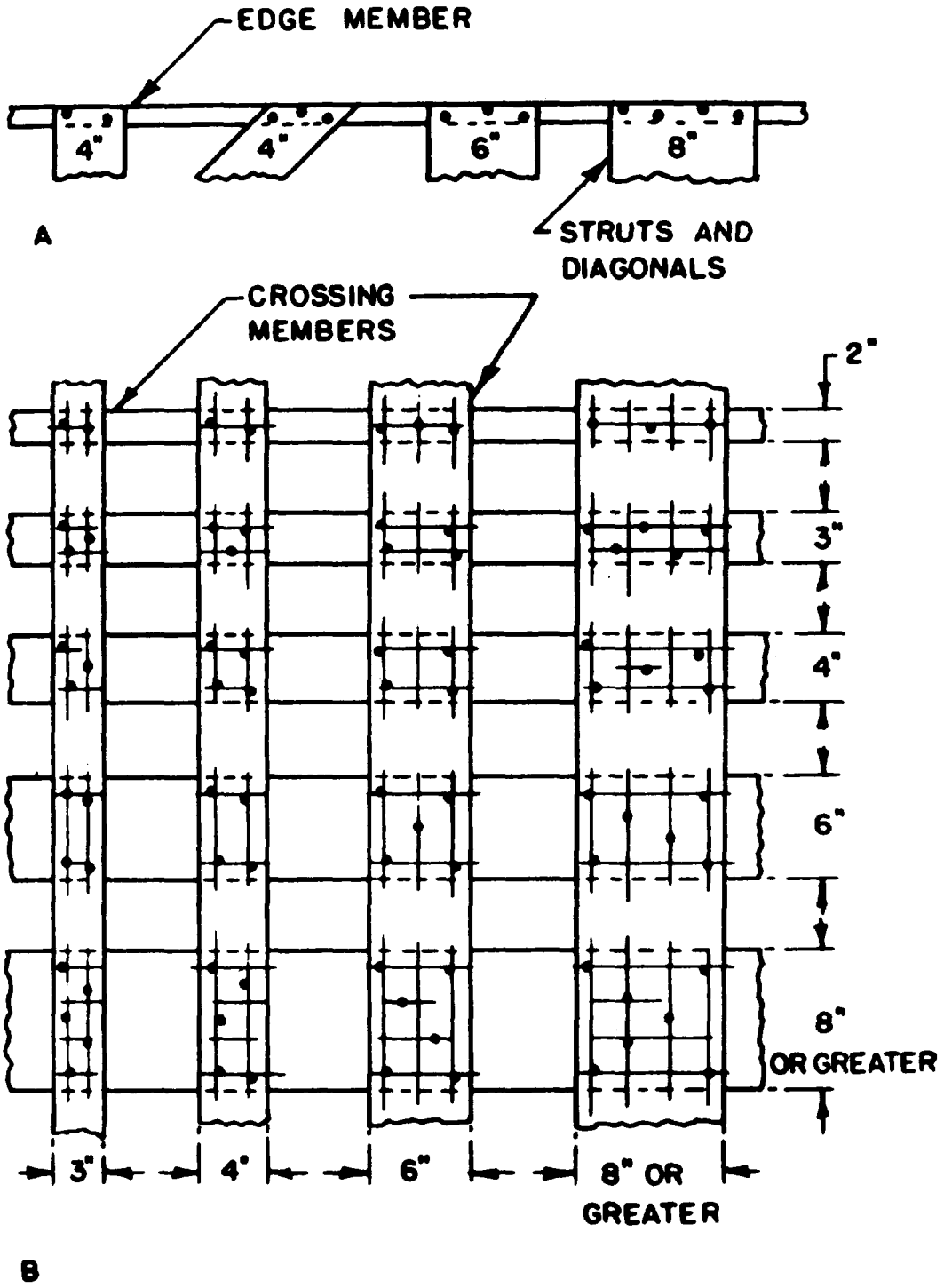

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Figure 6-23. Nailing patterns. (All widths are nominal. Similar patterns shall be used when boards cross at angles other than 90°.)

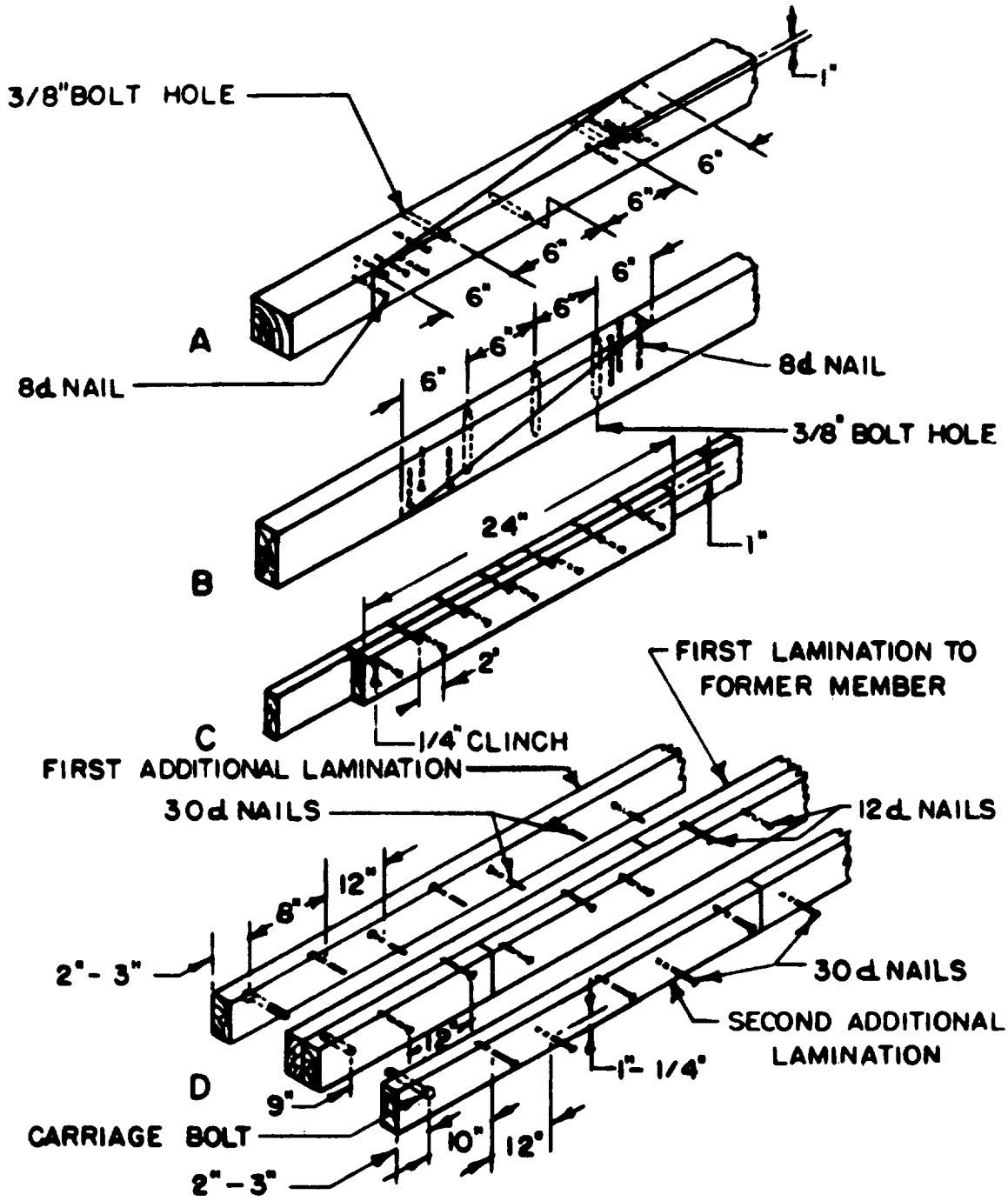

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Figure 6–24. Splicing of members; A, Splice of 4–by–4 inch or 4–by–6 inch skids; B, splice of 2–inch member; C, splice of 1–inch member; D, lamination of skid.

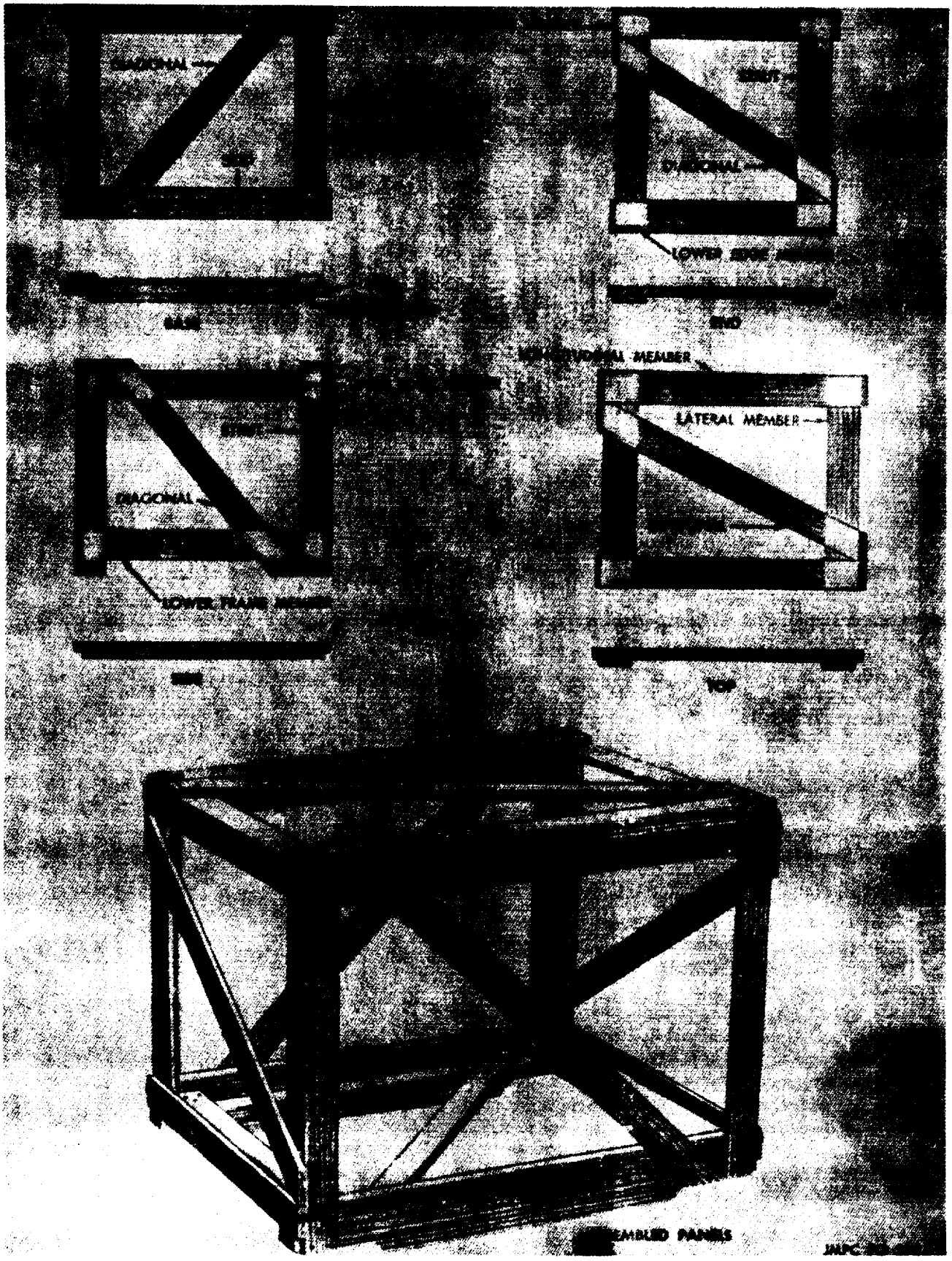

Figure 6–25. Type I, style A crate assembly (MIL-C–52950)

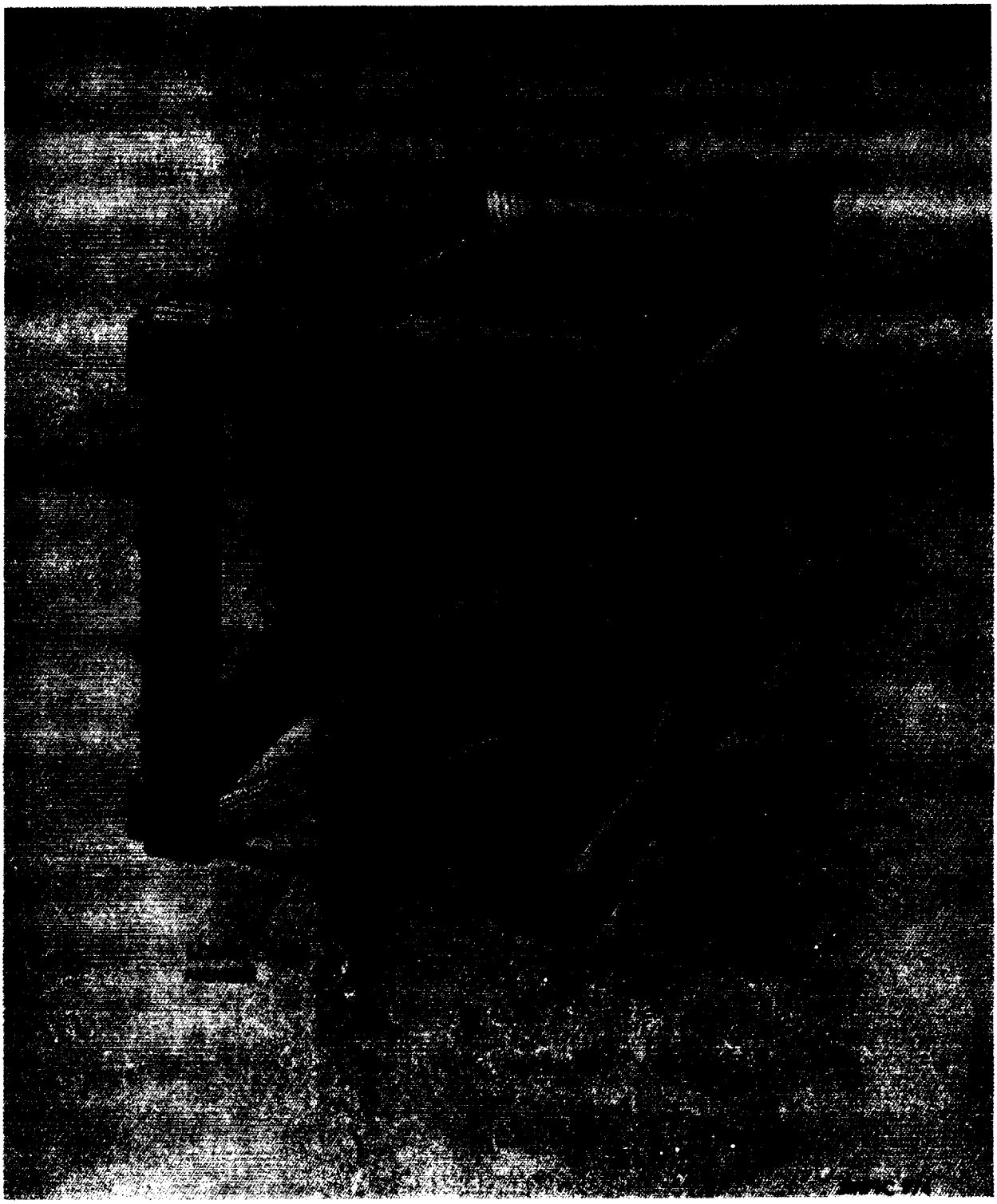

Figure 6–26. Type I, style B crate assembly (MIL-C–52950).

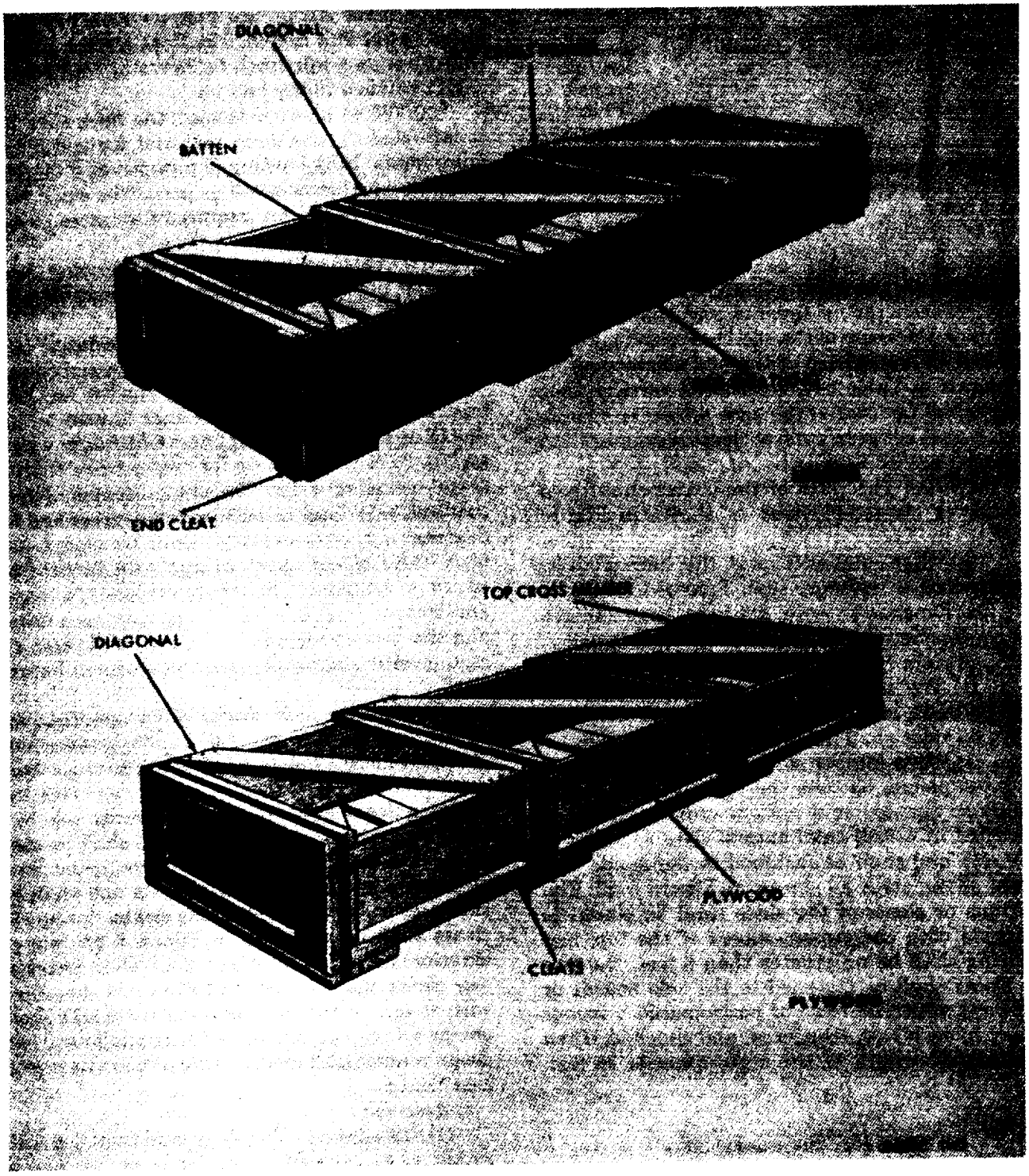

Figure 6–27. Type II, style A crate assembly (MIL-C–52950).

Table 6-5. Thickness of Ends

Maximum Net Load	Plywood	Lumber	Size of end Cleats
(pounds)	*(inch)*	*(inches)*	*(inches)*
100	1/4	3/4	3/4 by 2 3/4
250	3/8	3/4	3/4 by 3 1/2
500	1/2	1 1/16	1 1/16 by 3 1/2
1000	1/2	1 5/16	1 1/2 by 3 1/2

Additional vertical filler cleats shall be used in the ends when the unsupported span between outside cleats is greater than 3 feet.

plywood with two rows of nails spaced 4 inches apart in each row, staggered and clinched. The minimum thickness of the end boards and plywood and the minimum size of the end cleats shall be as shown in Table 6-5. Additional vertical filler cleats shall be used in the ends when the unsupported span between outside cleats is greater than 3 feet.

(3) *Sides.* The sides of the crates shall be of lumber or cleated-plywood as shown in Figure 6-27.

(*a*) When lumber is used, the sides shall be constructed or not more than 3 pieces for heights of 1 foot 3 inches or more, not more than 2 pieces for heights between 7 1/2 inches and 1 foot 3 inches, and one piece for heights 7 1/2 inches or less.

(*b*) The minimum thickness of the lumber and plywood, and the minimum size of cleats for plywood sides shall be as shown in Table 6-6.

(*c*) When lumber sides are composed of two or more pieces, battens the same thickness and width as the top and bottom crossmembers as specified in 6-6,(4) shall extend the full depth of the side and shall be fastened to the inside surfaces of the sides as shown in Figure 6-27. The battens or cleats of the sides shall be placed to coincide with the crossmembers of the top, and spacing shall be no greater than 3 feet. Battens or cleats shall be fastened to the side boards or plywood with two rows of nails spaced 4 inches apart in each row, staggered, and clinched. When the overall length of the crate exceeds 14 feet,

Table 6-6. Thickness of Sides

Maximum Net Load	Plywood	Lumber	Size of Cleats for Plywood Sides
(pounds)	*(inch)*	*(inches)*	*(inches)*
100	1/4	3/4	3/4 by 2 3/4
250	3/8	3/4	3/4 by 2 3/4
500	1/2	1 1/16	7/8 by 3 1/2
1000	1/2	1 5/16	7/8 by 3 1/2

pieces of lumber used in the construction of the sides shall be either the required full length or shall be made up of two pieces which together make up the full length. The joint of such pieces shall abut on a full depth batten, and both pieces shall be nailed to the bottom.

(*d*) When plywood is used, the sides shall be constructed on one-piece material for width requirements. Butt jointing of plywood at an intermediate cleat location will be permitted when two lengths of plywood are required for crates in excess of 8 feet in length.

(*e*) Crates may be one of the following combinations of sides and end panels, as specified:

1. Lumber ends and sides.

2. Cleated-plywood ends and sides.

3. Lumber ends and cleat-plywood sides.

(4) *Top and bottom members.* The top and bottom members shall be 1- by 4-inch lumber for all crates up to and including 2 feet 6 inches in width and 1- by 6-inch lumber for crates more than 2 feet 6 inches in width. The angle between diagonals and side shall be between 30 degrees and 60 degrees, but crossmembers shall be placed not more than 3 feet apart in line with battens or cleats of the sides. The crossmembers of the top and bottom shall be directly opposite each other and the bottom diagonals shall be in reverse direction with the top diagonals as shown in Figure 6-27.

(5) *Exterior side cleats.* When specified, for gross weights exceeding 200 pounds, exterior side cleats shall be used to facilitate fork truck handling of crates on their sides. On lumber sides, the exterior cleats shall replace the interior side battens. On plywood sides, filler pieces shall be used under the exterior side cleats; filler pieces shall pass between the horizontal cleats and shall be the same width as exterior side cleats. Spacing of cleats shall be as shown in Figure 6-28. Size of exterior side cleats shall be 3 × 4 inches. Exterior side cleats shall be secured to the side sheathing with nails as specified for battens in 6-6,a(3). Short one-panel crates with lumber ends shall have end cleats a nominal 3 inches thick in lieu of exterior side cleats.

b. Assembly.

(1) *Sides to ends.* The sides shall be nailed with sinker or corker nails to the ends as specified in Table 6-7. Nailings shall be as specified in 6-3c(2).

(2) *Top and bottom members to sides.* The top and bottom crossmembers and diagonals shall be nailed to the cleats of the sides or to the lumber sides with eightpenny sinker nails when the side cleats or sides are less than 1 inch in thickness and ninepenny sinker nails when side members

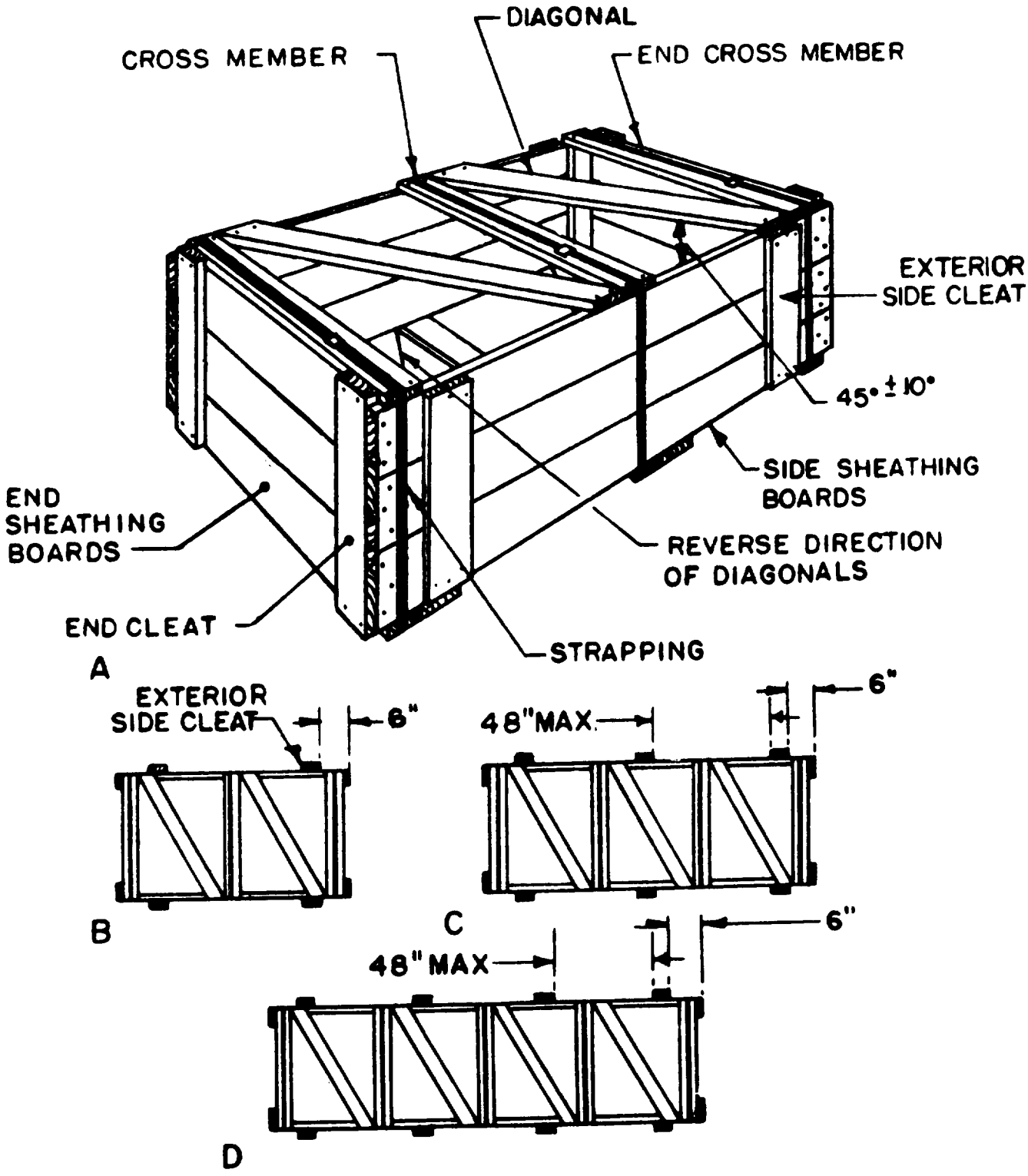

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Figure 6-28. Type II, crate with exterior side cleats: A, complete crate; B, two panel; C, three panel; and D, four panel.

Table 6-7. Nailing Schedule for Assembly of Type II, Style A Crates

Cleated-Plywood Sides to Plywood or Lumber Ends[1]			Lumber Sides to Lumber Ends[1]		
Plywood thickness	Nail size	Nail spacing	Thickness of sides	Nail size	Nail spacing
¼	8	3	¾	8	2½
⅜	10	3¼	1 1/16	10	2¾
½	12	3½	1 5/16	12	3

[1] Nails shall be staggered when ends are lumber.

are 1 inch or more in thickness. The end top and bottom crossmembers shall also be nailed to the end sheathing or cleats if the ends are lumber or plywood, respectively. The nailing patterns, location of nails, and nailing procedures shall be as shown in Figures 6-23 and Figure 6-27, and as specified in 6-3,c,(2).

6-7. Type III, Style B—Light Duty Crate (MIL-C-52590)

a. Design Requirements (Figure 6-29).

(1) *Style B.* Style B crates shall be as shown in Figure 6-29. There shall be no size or load restrictions for this crate except as limited by handling methods. The size and spacing of members shall be as specified in Table 6-8. Vertical end cleats shall be long enough to permit full nailing to the upper horizontal end cleats when the crate is assembled.

(2) *Nailing.* The upper and lower halves of the crate shall be fabricated with sixpenny nails; the

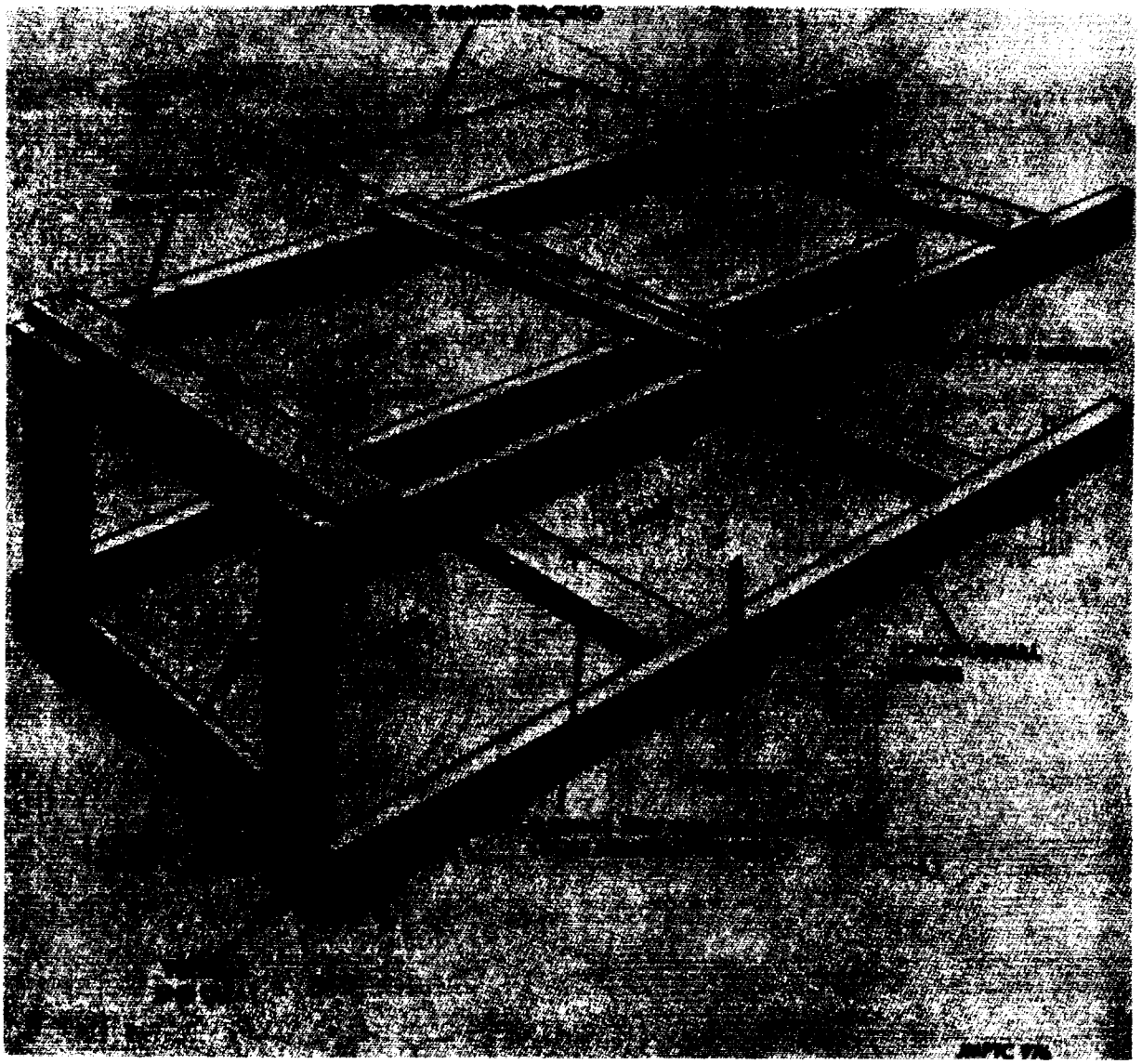


Figure 6-29. Type III, style B crate assembly (MIL-C-52950).

Table 6-8. Member Sizes and Spacing for Type III, Style B Crates

Member	Member Size					Member spacing		
	Depth of Crate			Width of Crate		Length of Crate		
	0 to 8 Inches	Over 8 to 12 Inches	Over 12 Inches	0 to 24 Inches	Over 24 Inches	0 to 10 Feet	Over 10 to 20 Feet	Over 20 Feet
	(inches)	*(inches)*	*(inches)*	*(inches)*	*(inches)*	*(feet)*	*(feet-inches)*	*(feet)*
Longitudinal members	1 × 3	1 × 4	1 × 6					
Vertical end cleats	1 × 3	1 × 4	1 × 6					
Horizontal end cleats	1 × 3	1 × 4	1 × 6					
Top and bottom crossmembers				1 × 4	1 × 6	2	2-6	3
Rubbing strips				3 × 4	3 × 6			

vertical end cleats shall be fastened to the lower half with clinched nails to the lower horizontal end cleats. Two nails shall be used in each end of 3- and 4-inch-wide longitudinal members and three nails shall be used in 6-inch-wide longitudinal members.

(3) *Rubbing strips.* Beveled rubbing strips, of sizes shown in Table 6-8, shall be attached to the undersurface of each lower crossmember to facilitate fork truck handling. Rubbing strips shall be fastened to the crossmembers with sixteenpenny nails placed in two rows and spaced 5 inches apart in each row and clinched. Rubbing strips shall be applied at time of crate packing after strapping has been secured to crossmembers.

b. Assembly. Assembly of the crates shall be as shown in Figure 6-29. After items have been nested in the lower half of the crate, the upper half shall be positioned and strapping shall be applied. The upper ends of the vertical end cleats shall be nailed to the upper horizontal end cleats with fourpenny nails. The upper longitudinal members of the sides shall be nailed to the vertical end cleats with eightpenny nails.

6-8. Type IV, Style A—Heavy Duty Crate (MIL-C-52950)

a. Design Requirements (Figure 6-30).

(1) *Load and size requirements.* The limitations shall be as specified in Table 6-3.

(2) *Base.* Skids shall be 2- by 4-inch lumber for loads through 500 pounds and 2- by 6-inch lumber for over 500 pounds.

(*a*) The size of the load-bearing floor member shall be as specified in Table 6-4. Floorboards over 2 inches in nominal thickness shall be bolted to the skids with ⅜-inch diameter carriage bolts as specified in 6-3,c,(4). Diagonals shall be 1 by 6 inches.

(*b*) The size and placement of end floor members and rubbing strips shall be as specified in 6-4,a,(2). On crates over 5 feet long, the rubbing strips shall be in three pieces, with the center piece 16 inches long, the fork openings 12 inches long, and the end pieces of a length which will allow end sling openings of 4 inches.

(3) *Side, end, and top panels.* All the members of the side, end, and top panels shall be 1- by 6-inch lumber. Three vertical struts shall be used in the side panels when the length of the crate is greater than 4 feet or greater than 1½ times the height. The lateral members of the top panel shall coincide with the vertical struts of the side panels and shall be equal in number. Nailing and nailing patterns shall be as specified in 6-3,c,(2) and as shown in Figure 6-23.

b. Assembly. Assembly of the crates shall be as specified in 6-4*b* and as shown in Figure 6-30. The longitudinal members of the top shall bear on the upper frame members of the sides and the end lateral members of the top shall be adjacent to the upper member of the ends.

6-9. Type V, Style A—Heavy Duty (MIL-C-52950)

a. Design Requirements. (Figure 6-31)

(1) *Load and size limitations.*

(*a*) The limitations shall be as specified in Table 6-3.

(*b*) Nailing shall be as specified in 6-3,c,(2) as shown in Figure 6-23.

(2) *Base.*

(*a*) *Skids.* The skids shall consist of 4- by 4-inch lumber. An intermediate 4- by 4-inch skid shall be used when the distance between the outer skids is greater than 36 inches.

(*b*) *Load-bearing floor members.* The size of the load-bearing floor members shall be as specified in Table 6-4. Floorboards over 2 inches in nominal thickness shall be bolted to each outside skid with ⅜-inch carriage bolts as specified in 6-3,c,(4).

(*c*) *Diagonals.* The diagonals shall be 1- by 6-inch lumber and the angle between the skid and

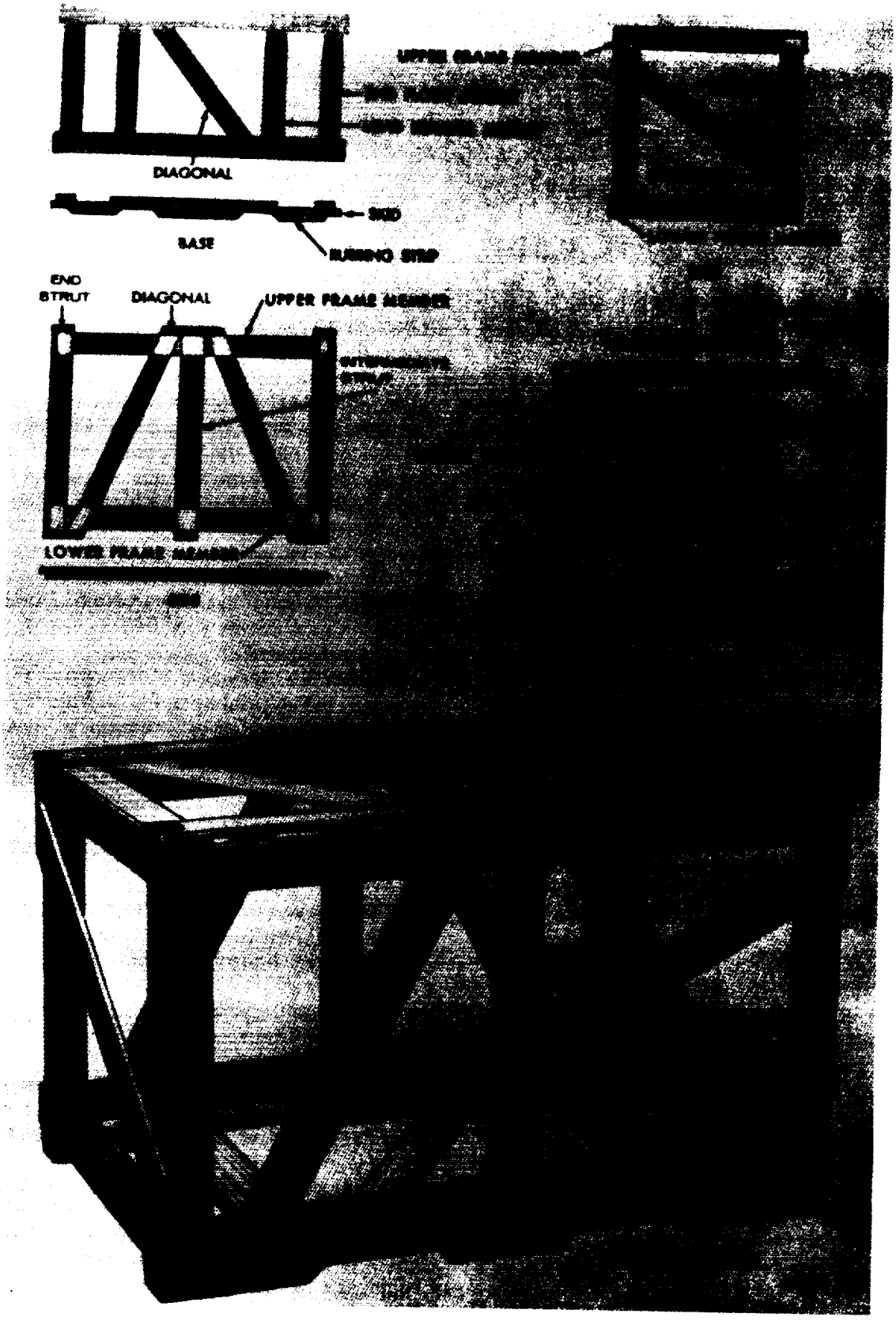


Figure 6–30. Type IV, style A crate assembly (MIL-C–52950).

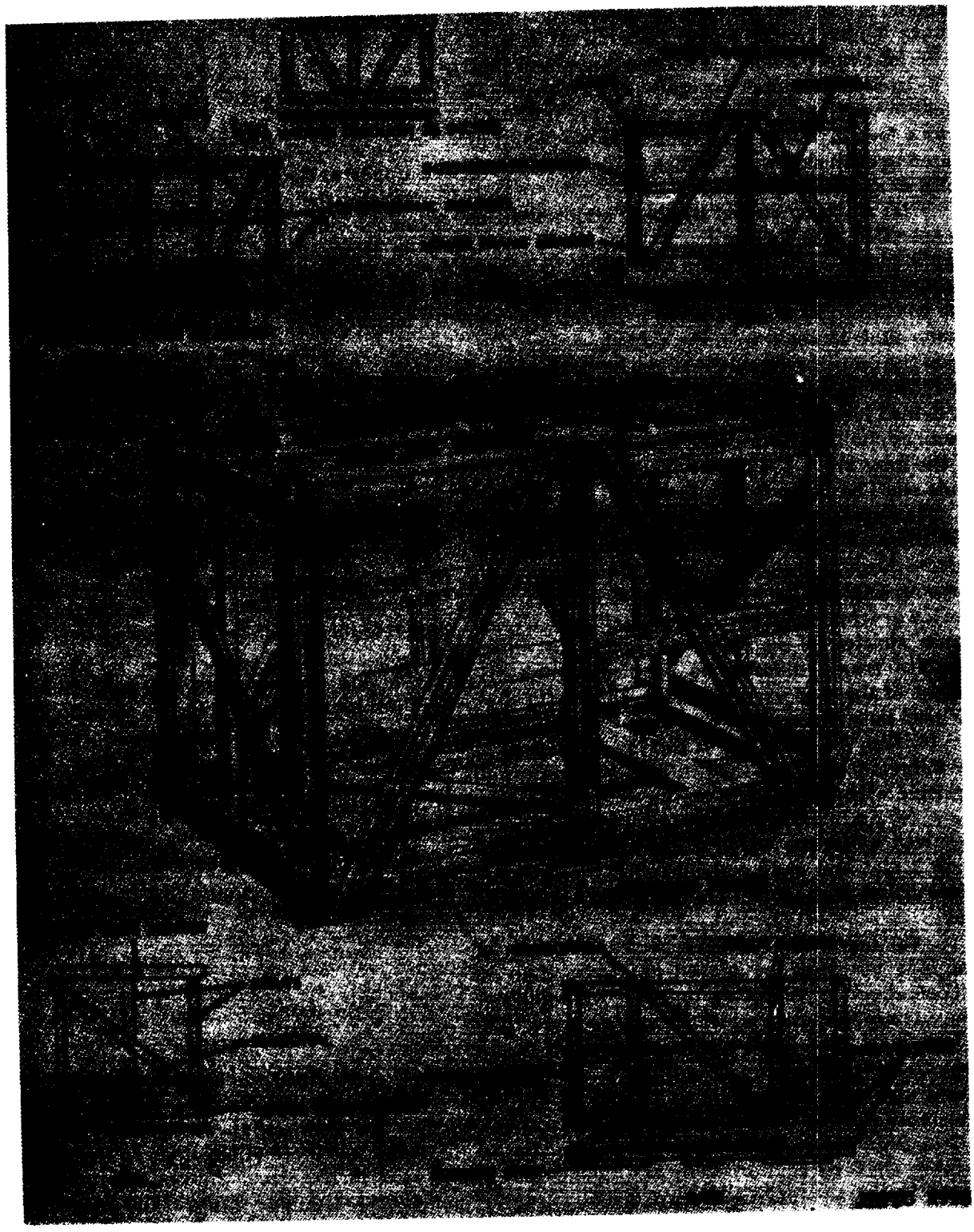


Figure 6–31. Type V, style A crate assembly (MIL-C–52950).

the diagonal shall be between 30 degrees and 60 degrees, except that when the angle of a single diagonal is less than 30 degrees, two diagonals and a 1– by 6–inch center crossmember shall be used.

(*d*) *Crossmembers.* End crossmembers shall be 2– by 6–inch lumber for crates not greater than 4 feet in width and 4– by 4–inch lumber for crates over 4 feet in width. End crossmembers shall be bolted to each skid with ⅜–inch diameter carriage bolts as specified in 6–3,c,(4).

(*e*) *Rubbing strips.* Rubbing strips shall be as specified in 6–8,a,(2).

(3) *Ends.* Vertical struts shall be 2– by 4–inch lumber. An intermediate strut shall be used when the width of the crate is greater than 3 feet. All struts shall coincide with the skids and shall bear upon the end crossmembers of the base. The upper and lower frame members of the ends shall be 1– by 6–inch lumber except that a 1– by 8–inch lower member shall be used when the end crossmembers of the base are 4 × 4 inches. The diagonals of the ends shall be 1– by 6–inch lumber.

(4) *Sides.* All side framing members, struts, and diagonals shall be 1– by 6–inch lumber. Intermediate struts shall be placed so that diagonals form an angle of between 30 and 60 degrees with the lower frame member. Struts shall have a maximum spacing of 42 inches. A horizontal intermediate frame member is required when the height of the side exceeds 4 feet. Diagonals shall be used between each two adjacent struts.

(5) *Top.* All members of the top shall be of 2– by 4–inch lumber. The longitudinal members shall coincide with the vertical struts of the ends.

(*a*) An intermediate longitudinal member is required when the width of the crate is greater than 3 feet and shall coincide with the intermediate struts of the ends. The joists shall be placed flat.

(*b*) Joists shall coincide with each strut of the side but shall be spaced not more than 40 inches apart for crates up to 3 feet wide and not more than 30 inches apart for crates more than 3 feet wide. The diagonals shall be nailed to the longitudinal members. When more than three joists are used, only each end panel of the top assembly shall be braced as shown in Figure 6–31.

(6) *Non-demountable crate assembly.* The assembly shall be reinforced by the application of metal straps as shown in Figure 6–31.

(*a*) *Sides to base.* The sides shall be fastened to the base by nailing the overlap of the vertical struts and diagonals to the skids with twelvepenny nails. The nailing patterns shall follow those shown in Figure 6–23.

(*b*) *Ends to base.* The ends shall be fastened to the base by nailing the lower frame member of the end panels to the end crossmembers of the base with twelvepenny sinker nails spaced 6 to 8 inches apart.

(*c*) *Sides to ends and ends to sides.* The edge struts of the sides shall be fastened to the edge struts of the ends with eightpenny sinker nails spaced 8 to 10 inches apart. The extensions of the upper and lower frame members and the diagonals of the end shall be nailed to the edge struts of the side with eightpenny sinker nails as shown in Figure 6–23.

(*d*) *Top to sides and ends.* The top shall be fastened to the sides and ends by nailing the upper frame members of the ends and the extensions of the vertical struts and diagonals of the sides to the adjacent edge members of the top with eightpenny sinker nails as shown in Figure 6–23.

(7) *Demountable crate assembly.* All demountable crates shall be assembled with lag bolts. Lead holes shall be used for all lag bolts as specified in 6–3,c,(4). When specified as an alternate, the top, side, and end panels may be nailed to each other as specified in 6–9,a,(6),(c), and 6–9,a,(6),(d), and the unit may be fastened to the skids and end crossmembers of the base by means of lag bolts for demountable crates as specified in 6–9,a,(7),(a) and 6–9,a,(7),(b).

(*a*) *Sides to base.* Lag bolts, ¾ by 3½ inches, shall be used to fasten the sides to the skids. Diagonals shall be arranged to provide the maximum number of fastening points to the base near the center of the skids. The minimum number of lag bolts shall correspond to the following tabulation. Not less than one lag bolt shall be placed in each strut and diagonal.

Gross Load (crate and contents) (pounds)	*Minimum Number of ⅜–inch Lag bolts for each side of Crate*
1000	4
2000	5
3000	8

(*b*) *Ends to base, sides to ends, and ends to top.* Lag bolts, 5/16 by 3 inches, spaced 12 to 14 inches apart, shall be used to fasten: the lower edge members of the ends to the end crossmembers of the base; the end vertical struts of the sides to the edge struts of the ends; and the upper edge members of the end to the edge joists of the top.

(*c*) *Sides to top.* One 5/16 by 3–inch lag bolt shall be used to fasten each strut and diagonal of the sides to the edge longitudinal member of the top.

6–10. Type V, Style B—Light Duty Crate (MIL-C–52950)

a. Design Requirements (Figure 6–32).

(1) *Load and size limitations.*

(*a*) The limitations shall be as specified in Table 6–3.

(*b*) They shall be open, or covered, and demountable or non-demountable as specified.

(*c*) Nailing shall be as specified in 6–3,c,(2), as shown in Figure 6–23, and as specified herein.

(2) *Base.*

(*a*) *Skids.*

1. Skid sizes shall conform to the following tabulation:

Net load (pounds)	Skid Size (Nominal) 2 Skids (inches)	3 Skids (inches)
Up to 500	2 × 4 (flat)	2 × 4 (flat)
501 to 2000	3 × 4 (flat)	3 × 4 (flat)
2001 to 3000	4 × 4	3 × 4 (flat)
3001 to 4000	4 × 4	4 × 4

2. Crates over 42 inches wide shall have three skids. Splices shall be located no further from the ends than one-third of the length of the skids, and splice locations shall be alternated in adjacent skids. All 4 × 4 members may also consist of two 2 × 4's placed on edge and laminated in accordance with Figure 6–24.

(*b*) *Rubbing strips.* Rubbing strips shall be a minimum of 3 by 4 inches in size. The strips shall be as specified in 6–4,a,(2) and positioned as shown in Figure 6–32. They shall be nailed to the skids with two rows of nails spaced 1 foot apart in each row in a staggered pattern; nail sizes shall be sixteenpenny when skids are 2 × 4 inches and twentypenny for 3– by 4– and 4– by 4–inch skids.

(*c*) *End headers.* Two headers spaced 2 feet apart shall be bolted to each end of the skids as shown in Figure 6–32 with ⅜–inch diameter carriage bolts. The end headers shall be the same cross section as the skids. When crate ends have 2– by 4–inch struts, bolts in the outer headers shall be placed to clear the struts.

(*d*) *Load-bearing floorboards.* When concentrated loads occur, load-bearing floorboards shall be used to transfer the load to skids. The sizes shall be as specified in Table 6–4. When end headers are used as a load-bearing member, the end header size shall be chosen from the load-bearing floorboard width specified in Table 6–4. Floorboards 2 inches or less in thickness shall be nailed to each skid in patterns as shown in Figure 6–23 and floorboards over 2 inches thick shall be bolted to each skid with ⅜–inch diameter carriage bolts. Two bolts shall be used for floorboards over 6 inches wide.

(*e*) *Diagonals and Floorboards.* Diagonals shall be used between headers and load-bearing floorboards or other crossmembers and shall be placed at an angle as close to 45 degrees as possible. Diagonals and floorboards other than load-bearing floorboards shall be 1– by 4–inch members for net loads up to 500 pounds and outside widths not exceeding 3 feet, and shall be 1– by 6–inch members for all other conditions.

(3) *Sides.* Sides shall be as shown in Figures 6–33, 6–34, and 6–35. Single-panel sides shall be used for heights over 6 feet. An intermediate longitudinal member shall be added for heights over 4 feet. Double-panel sides shall be used for heights over 6 feet and through 8 feet. Triple-panel sides shall be used for heights over 8 feet. Longitudinal members shall be in single pieces for lengths not exceeding 16 feet, and may be spliced as shown in Figure 6–24 for lengths greater than 16 feet. Splice locations shall be alternated. Member sizes and spacing shall be as specified in Table 6–9.

(4) *Ends.* Ends shall be as shown in Figures 6–36 and 6–37. All members shall be 1 by 4 inches in size for net loads up to 500 pounds, and 1 by 6 inches for net loads over 500 pounds, with the following exceptions:

(*a*) Struts shall be 2 by 4 inches in size when the crate height is over 5 feet.

(*b*) The lower frame member shall be 1 by 6 inches in size when the end headers of the base are 2–inch thick members and 1 by 8 inches in size when larger end headers are used.

(5) *Top.* The top shall be as shown in Figure 6–38. The spacing of the crossmembers shall be the same as the spacing of the side struts. Diagonals shall be nailed to the inner faces of the crossmembers. The longitudinal members shall be 1 by 4 inches in size for loads up to 500 pounds and widths to 4 feet, and 1 by 6 inches for all other conditions. Crossmembers and diagonals shall be 1 by 4 inches for loads to 1,000 pounds and widths to 4 feet, and 1 by 6 inches for all other conditions. Splicing of longitudinal members shall be as shown in Figure 6–24 and as specified in 6–10,a,(3).

(*a*) *Top reinforcing joists.* When the gross weight of the crate is over 500 pounds or the inside width is over 3 feet 6 inches, a 2– by 4–inch top-reinforcing joist shall be nailed to the top at the loaded center of balance as shown in Figure 6–38 to prevent the top of the crate from being crushed when the crate is lifted with a single set of grab-hooks. The joist shall be placed flat and the ends shall contact the inner face of the upper longitudinal members of the side when the crate is assembled. The joist shall be fastened to the longitudinal and diagonal members of the top with

Figure 6–32. Bases for Type V, style B crates (MIL-C–52950).

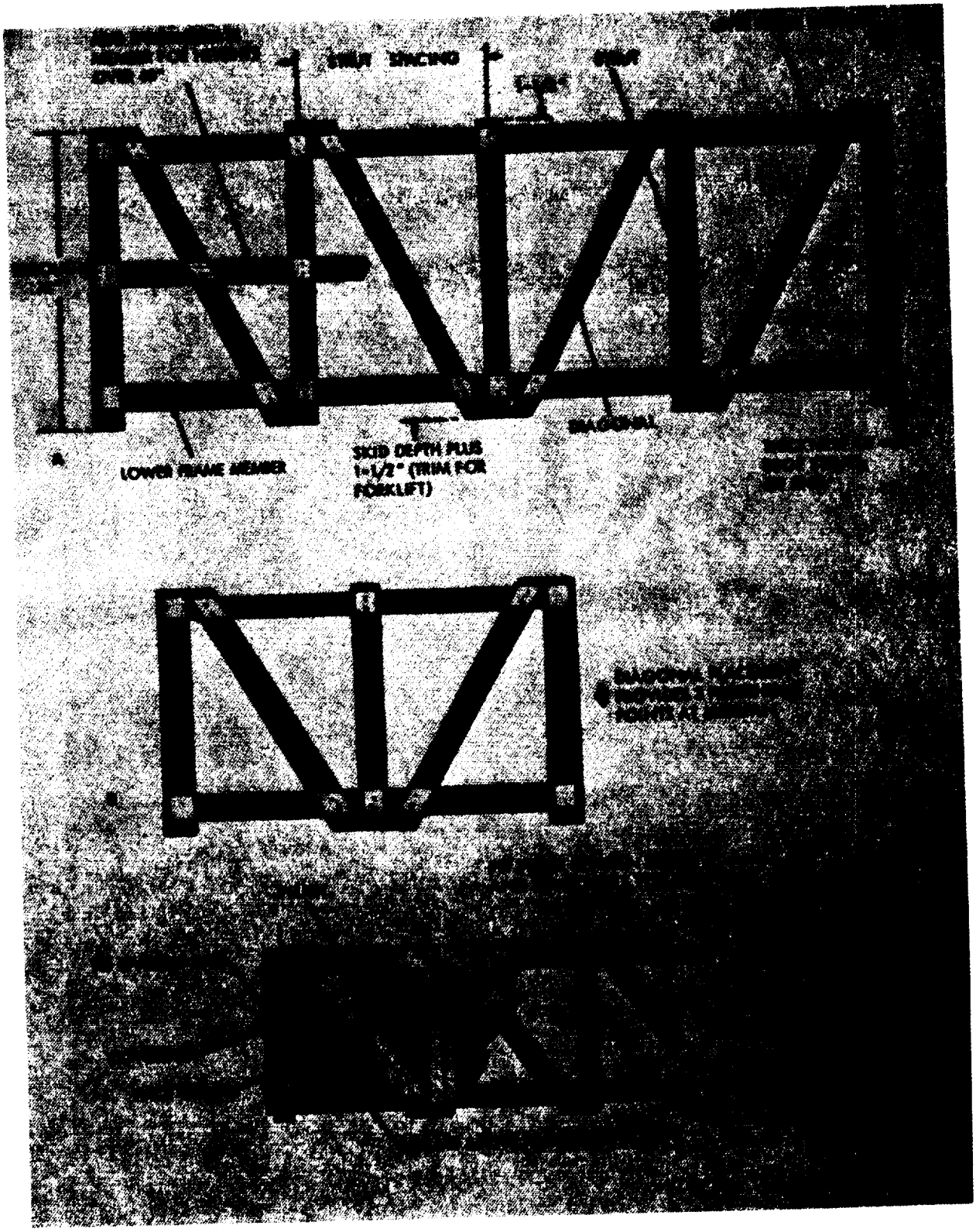


Figure 6–33. Single-panel sides for type V, style B crates (MIL-C–52950): A, side of long crate; B, side of short crate; C, covered side.

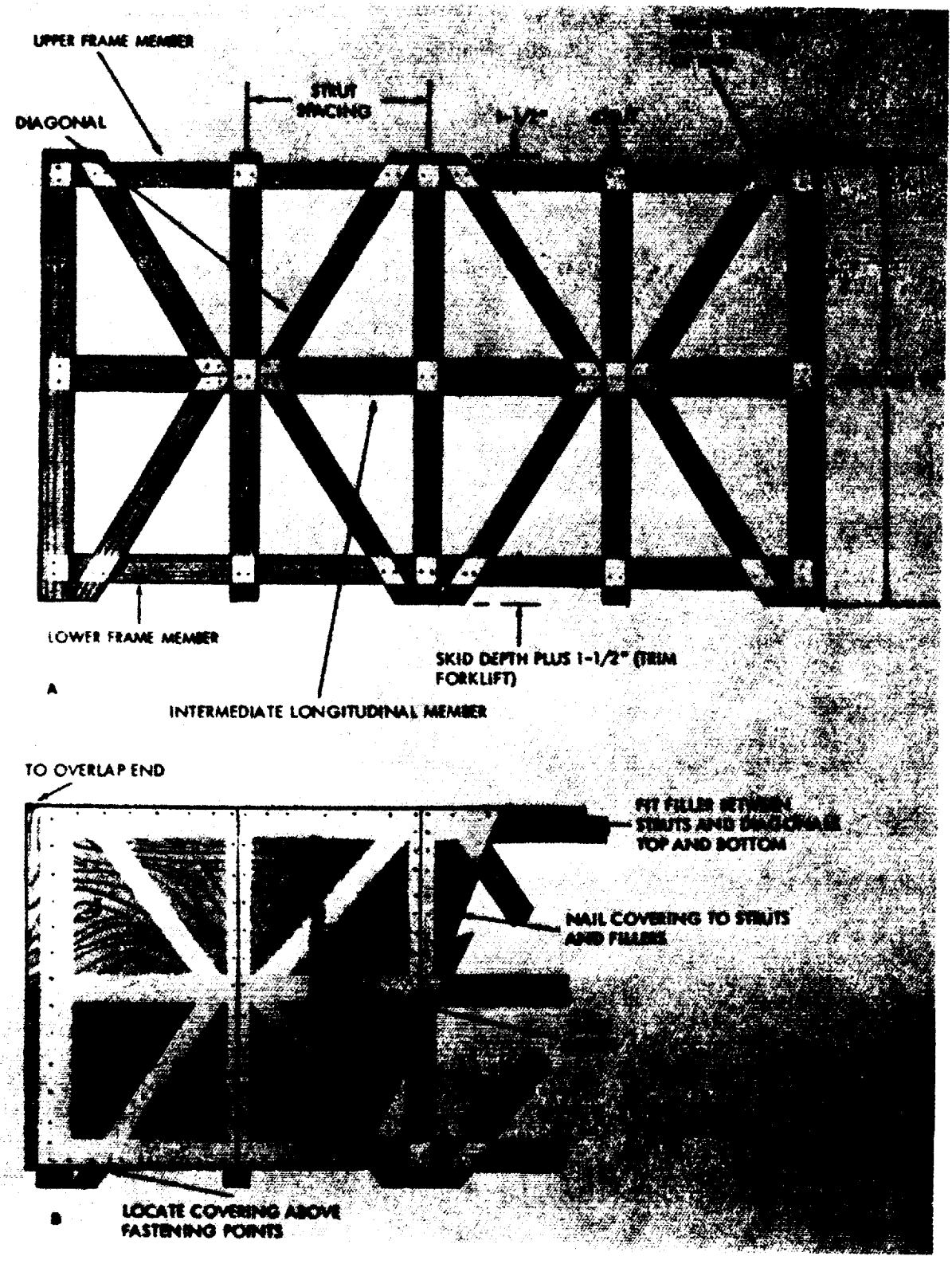


Figure 6–34. Double-panel sides for type V, style B crates for heights through 96 inches (MIL-C–52950): A, open side; B, covered side.

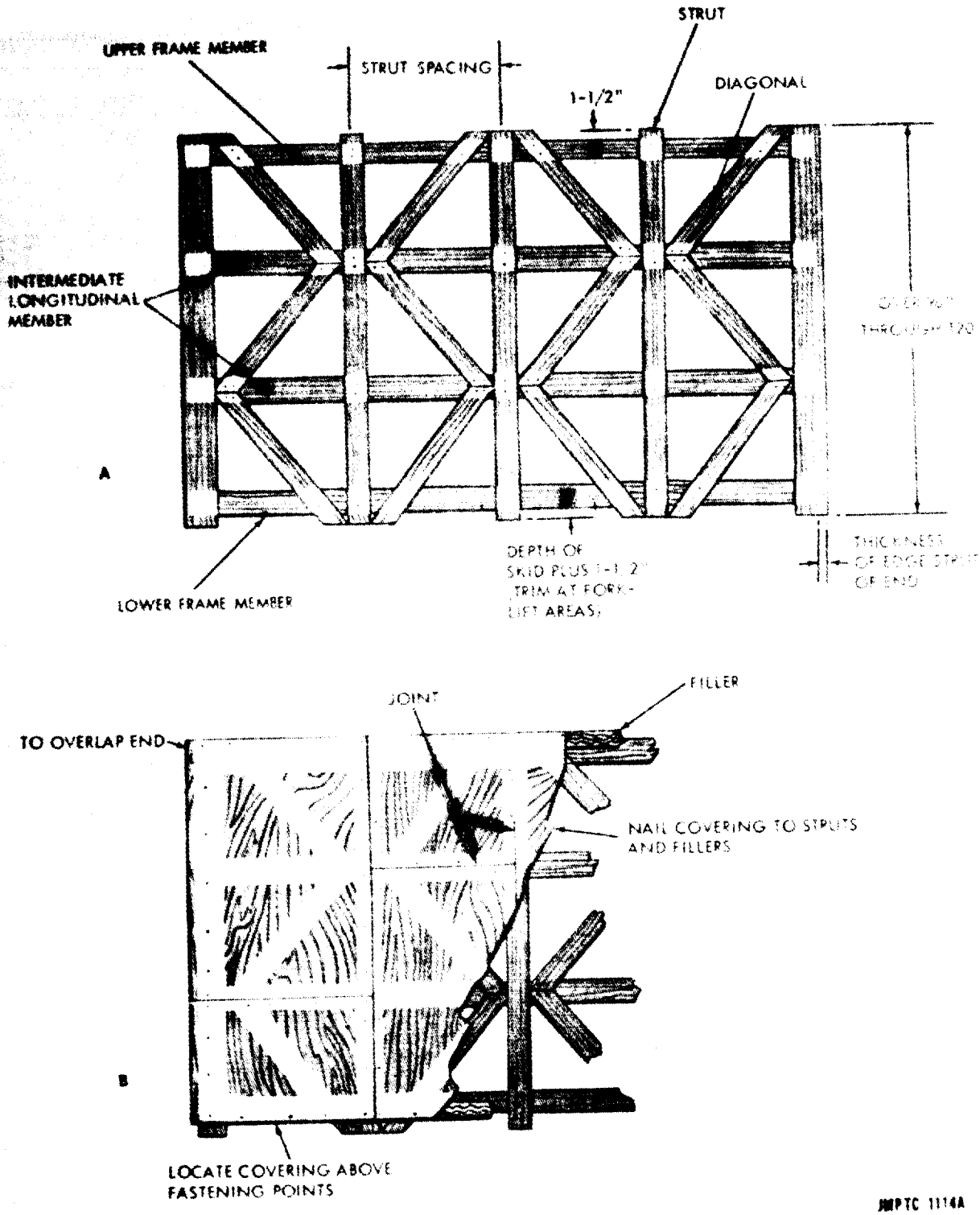


Figure 6–35. Triple-panel sides for type V, style B crates for heights over 96 inches (MIL-C–52950): A, open side; B, covered side.

Table 6-9. Frame Member Sizes for Sides of Type V, Style B Crates

Limits of Dimensions and Net Loads				Member Sizes (nominal)				
		Max. Strut. Spacing (on center)		Longitudinals				
Length	Net Load	Single Panel	Double & Triple Panel	Upper	Lower	Intermediate	Struts	Diagonals
(foot)	*(pound)*	*(inch)*	*(inch)*	*(inch)*	*(inch)*	*(inch)*	*(inch)*	*(inch)*
12	300	42	42	1×4	1×3	1×3	1×3[1]	1×4
32	500	48	54	1×6	1×4	1×4	1×4[1]	1×4
28	1000	42	54	1×6	1×4	1×4	1×4[1]	1×4
24	2000	36	48	1×6	1×6	1×6	1×6	1×6
20	3000	36	48	1×8	1×6	1×6	1×6[2]	1×6
16	4000	36	42	1×8	1×8	1×8	1×8	1×8

[1] For edge struts use 1×4 except that 1×6 members shall be used when edge struts of edges are 2×4 inches in size.
[2] For edge struts use 1×8 members.

sevenpenny nails placed as shown in Figure 6-23 and to the upper longitudinal members of the sides with two tenpenny nails in each end.

(*b*) *Assembly.* Unless demountability is specified, the crate shall be assembled by nailing. When demountability is specified, the sides, ends, and top as a unit shall be secured to the base with lag bolts. Eightpenny nails, spaced 8 to 10 inches apart, shall be used to fasten: (1) the edge struts of the sides to the edge struts of the ends; (2) the longitudinal members of the top to the upper frame members of the sides; (3) the end crossmembers of the top to the upper frame members of the ends; and, (4) the lower frame members of the ends to the end header of the base. Eightpenny nails as shown in Figure 6-23 nailing patterns shall be used to fasten: (a) the upper ends of the side struts and diagonals to the longitudinal members of the top; and (b) the ends of upper and lower frame members, horizontal members, and diagonals of the ends to the edge struts of the sides. The bottom ends of struts and diagonals of the sides shall be secured to the skids with eightpenny nails as follows: A minimum of three nails shall be used for each 3- and 4-inch wide member, four nails for each 6-inch wide member, and five nails for each 8-inch and wider member. Nails shall be staggered and shall be placed in two rows whenever possible. For demountable crates, each strut and diagonal of the sides shall be fastened to the skids with a minimum of one lag bolt. The size of lag bolts and the total number required shall be not less than that specified in Table 6-10. When more than one lag bolt is required in each strut or diagonal, the additional lag bolts shall be placed in the wider members, near the load-bearing points, and in a staggered pattern when possible. One-half the total number of lag bolts required shall be used for each side. For demountable crates, the lower frame members of the ends shall be fastened to the end headers of the base with 5/16- by 3-inch lag bolts, spaced 12 inches apart.

(*c*) *Covered Crates.* The structural framework of the covered crates shall be as specified in 6-10,a. The covered crates shall also be as shown in Figures 6-33 through 6-38a. Unless otherwise specified, the covering shall consist of plywood or paper-overload veneer with a minimum thickness of 1/8 inch. When joints are required in the covering they shall butt over the centerline of struts or crossmembers. Covering shall be fastened with two rows of nails or staples, spaced 8 inches apart in each row, staggered, and unclinched. Filler pieces between struts, diagonals, and crossmembers of sides, ends, and top shall be fastened with two rows of nails, spaced 10 inches apart in each row, staggered, and clinched. Filler pieces shall be the same thickness as adjacent panel framing members.

1. Sides. Four-inch wide filler pieces shall be fastened to the upper and lower frame members between the struts and diagonals. Fillers shall extend beyond the edge of the upper frame member so as to be flush with the ends of the struts and diagonals. The lower edges of the fillers shall be flush with the bottom edge of the lower frame member.

2. Ends. Three-inch wide filler pieces shall be nailed to the edge struts as shown in Figures 6-36 and 6-37. When specified, end ventilation shall be provided in accordance with MIL-C-104.

3. Tops. Two-inch wide filler pieces shall be fastened to the longitudinal members. The dovering of the top shall be extended to overlap the covering of the sides and ends. During nailing, a 4-inch wide strip of waterproof barrier material conforming to PPP-B-1055, class suitable for crate liners, shall be placed under each covering joint. The strip shall extend across the full width of the top.

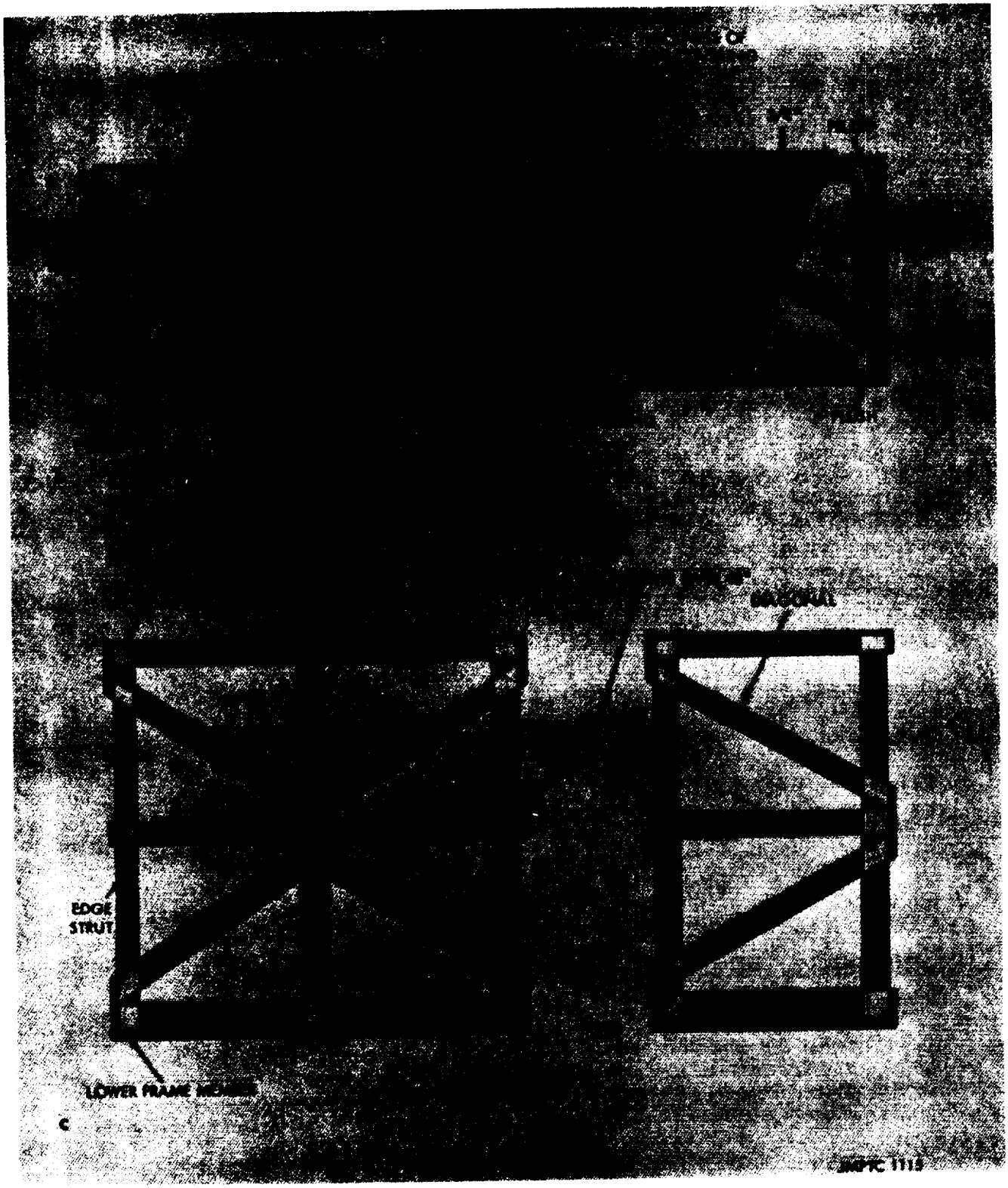


Figure 6–36. Ends for type V, style B crates (MIL-C–52950): A, two-panel horizontal; B, single-panel (covered); C, four-panel; D, two-panel vertical.

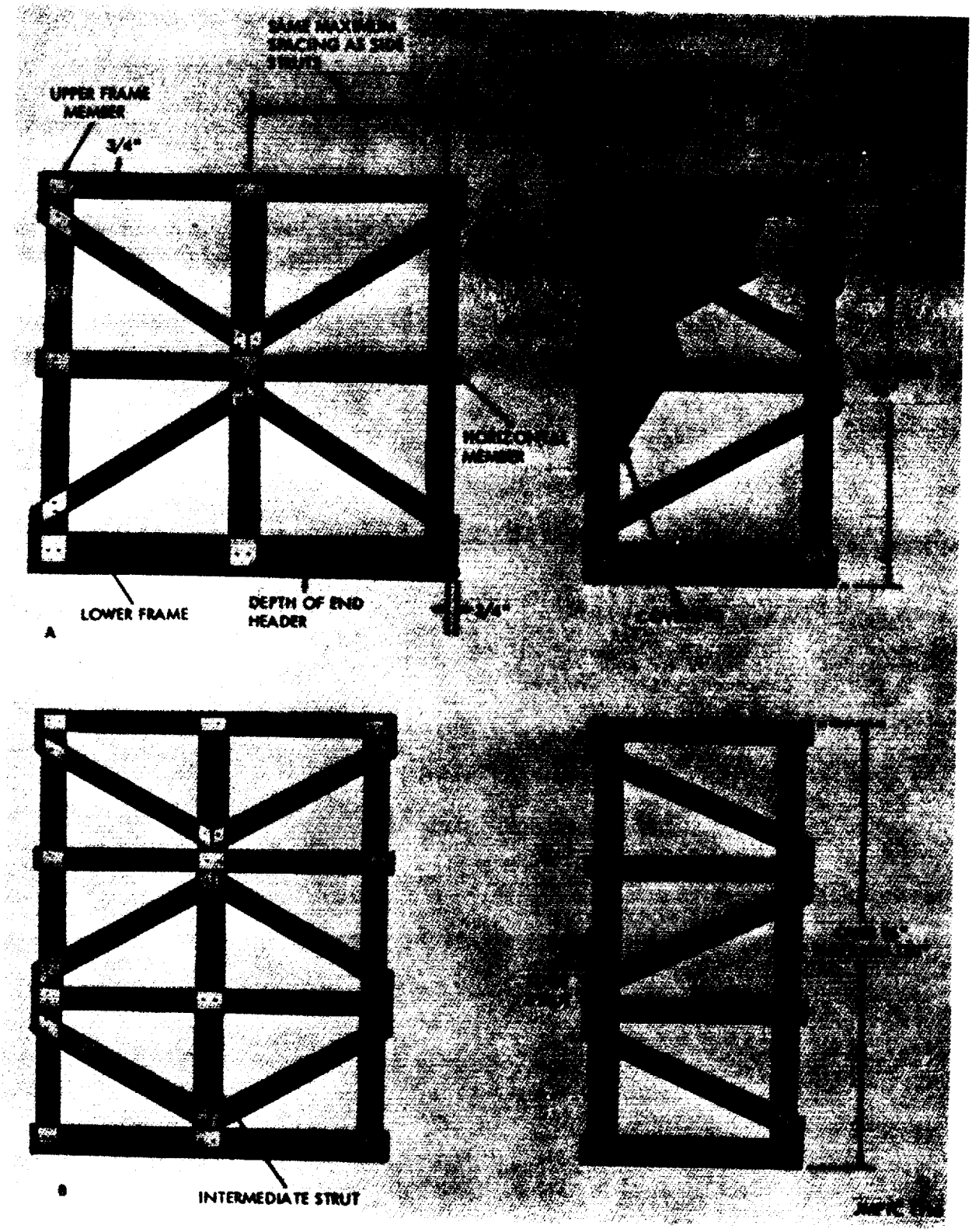


Figure 6–37. Ends for type V, style B crates (MIL-C–52950): A, wide and narrow double-panel ends; B, wide and narrow triple-panel ends.

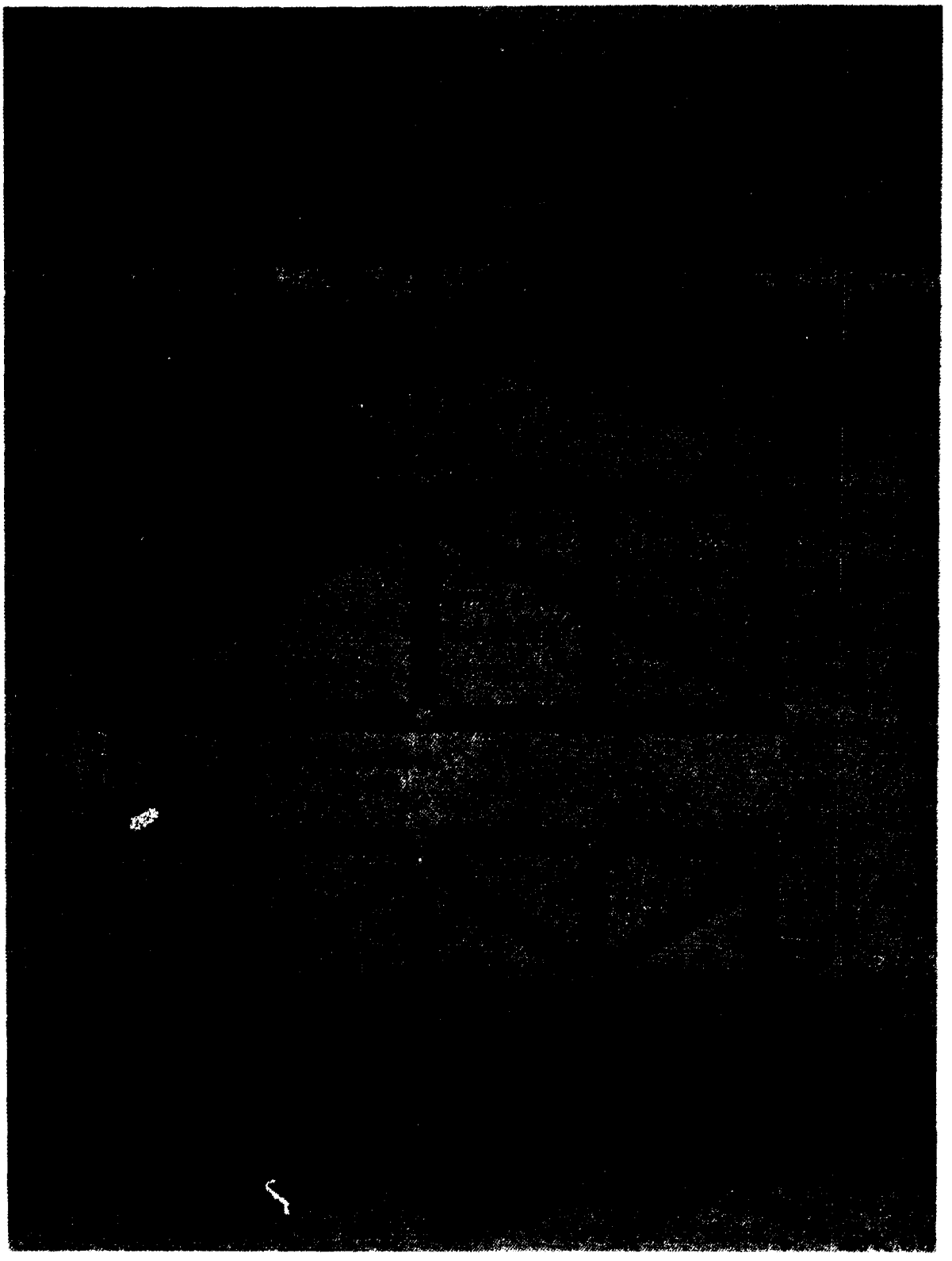


Figure 6–38. Tops for Type V, style B crates (MIL-C–52950): A, narrow top; B, medium-wide top; C, wide top.

Figure 6–38a. Type V, style B crate (MIL–C–52950)

Table 6–10. Number and Size of Lag Bolts Required to Assemble Sides to Base (Demountable Base) Of Type V, Style B Crates

Total Minimum Number of Lag Bolts

Gross Weight (crate and contents)	Size of Bolt for Each Skid Size		
	5/16- × 3 inch Bolt for 2- × 3- or 2- × 4-inch Skid (flat)	3/8- × 3-inch Bolt for 3- × 3-inch Skid	1/2- × 3 1/2-inch Bolt for 4- × 4-inch or two 2- × 4-inch Skids (on edge and laminated)
(pounds)			
1000	8	8	6
2000	14	10	10
3000	18	16	12
4000	24	20	14
5000	30	26	18

(*d*) *Covered crate assembly.* The assembly of covered Type V, Style B crates shall be as shown in Figure 6–38a and the assembly requirements specified in 6–10,b, except for the following: Ninepenny nails, spaced 8 to 10 inches apart, shall be used through the covering to fasten the edge struts of the sides to the edge struts of the ends; the struts, diagonals, and fillers of the sides to the edge longitudinal members of the top; the end crossmembers of the top to the upper frame members of the ends; the upper, lower, and horizontal members, diagonals, and fillers of the ends to the edge struts of the sides; the lower frame members of the ends to the end headers of the base; and, the struts, diagonals, and fillers at the lower edge of the sides to the skids of the base. The covering of the top shall be nailed to the filler of the sides with fourpenny nails spaced 4 to 6 inches apart. When demountability is specified, the sides and ends shall be fastened to the base with lag bolts as specified in 6–10,b.

6–11. Assembly Instructions (MIL-C–52950).

When specified, the contractor shall furnish applicable assembly instructions.

a. Tolerances. A tolerance of plus or minus 1/8 inch is allowable on the overall length and width of individual crate panels. Out-of-square deviations of individual panels shall be not more than 3/16 inch (3/8 inch difference in diagonals).

b. Workmanship. Crate panels shall be clean and free of slivers and protruding nail points. Crate panels be square and free of cracks, splits, or other damage which would prevent easy and correct assembly.

6–12. Open Wood Crates, MIL-C–3774 (General)

a. Crate Design. The open crates covered by Specification MIL-C–3774 consist of framing members partially sheathed in specific areas. This sheathing is applied to protect the enclosed item and acts as a reinforcement to the sides, ends, and top of the crate. These crates are designed to carry large or heavy items. A minimum of 1–inch clearance is required between the item and the nearest framing member of the sides, ends, and top.

b. Classification. Crates designed under this specification may be either bolted or nailed (table 6–15).

(1) *Open bolted crates (demountable).* These crates are designed to withstand a superimposed load of 200 pounds per square foot on the top, including dunnage. These crates may be used as reusable containers.

(2) *Open nailed crates (nondemountable).* Crates designed under this classification are considered to be "one trip" containers. This type may be constructed with a skid-or sill-type base.

c. Material Requirements.

(1) *Wood.* The requirements for lumber are stated in paragraph 6–2*a*.

(2) *Plywood.* Requirements for plywood are stated in paragraph 6–2*b*.

(3) *Fasteners.* Nails, strapping, bolts, etc.,

Table 6–15. Classification of MIL–C–3774 Crates

Assembly	Maximum net load (lb)	Maximum dimensions (ft)		
		Length	Width	Height
Type I, Nailed[1]	12,000	16	8	8
Type II, Bolted[2]	16,000	40	8	16

[1] Nailed assembly—nondemountable.
[2] Bolted assembly—demountable.

listed in paragraph 6-2*c* through *h* will be used as applicable.

6-13. Open Bolted Crates (MIL-C-3774)

a. Design Requirements. Demountable crates are designed and constructed so that the major components may be readily assembled or disassembled without damage to the component parts. This accomplished through the use of lag bolts or bolts (fig 6-5).

Table 6-16. Skid Sizes for Bolted MIL-C-3774 Crates

Maximum net load	Maximum length of crate	Size of skids
Pounds	*Feet*	*Inches*
2,000	12	3 x 3
4,000	[1] 40	4 x 4
5,000	20	4 x 4
10,000	16	4 x 4
5,000	32	4 x 6 (on edge)
16,000	20	4 x 6 (one edge)

[1] For lengths over 32 feet, crate heights shall be not less than 8 feet.

b. Fabrication of Open Bolted Crates.

(1) *Skid base.*

(*a*) *Skids.* The size of the skids is based upon the net load and the outside length of the crate, as stated in table 6-16. The number of skids is dictated by the item being packed. However, the clear distance between any adjacent skid is limited to 48 inches center to center (fig 6-39).

1. To prevent splitting, place one carriage bolt crosswise to two to three inches back from each end of the skid (fig 6-39).

2. When necessary, splice and laminate skids according to the details shown on figures 6-50 and 6-51.

(*b*) *Rubbing strip.* Rubbing strips are required on all 4 × 4-inch skids and must be at least 2-inch material, approximately as wide as the skid. Bevel these members at a 45° angle and set back approximately 8 inches from the ends of the skids. Bevel the inner ends of the notches at a 45° angle. These areas will serve as sling points and for forklift entries.

(*c*) *Headers.* The sizes of end headers and bolts are outlined as follows:

Skid Size (inches)	*Header size (inches)*	*Bolt diameter (inches)*
3 x 3	3 x 3	3/8
4 x 4	4 x 4	1/2
4 x 6 (on edge)	4 x 4	1/2

Extend headers beyond the outside faces of the outer skids three-fourths of an inch to support the lower frame members of the sides.

(*d*) *Load bearing floorboards.* Place load bearing floorboards where the concentrated load of the contents occur. Determine the size of load bearing floorboards from table 6-4. Set the end floorboards back from the end of the skids a distance equal to the thickness of the end sheathing.

1. Space floorboards three-fourths inch apart for drainage.

2. Nail floorboards up to two inches thick to the skids with three or more sixteenpenny coated or etched nails at each intersection with a skid.

3. Bolt floorboards up to 4 inches wide with one bolt in each skid. Boards over 4 inches wide require two bolts in each skid.

(*e*) *Forklift area.* The forklift area extends over the area of 42 inches in from the ends of the skids and may consist of the following:

1. Forklift headers spaced 20 to 40 inches in from each end header.

2. 2-inch-thick boards extending 42 inches in from each end.

3. Plywood for narrow crates.

(*f*) *Diagonals.* 1 × 6-inch diagonals are used between forklift areas and loadbearing members. The diagonals are nailed to the skids and to each other where they intersect.

(2) *Sides.* The sides consist of upper, lower, and intermediate members, vertical struts, diagonals, and corner sheathing.

Table 6-17. Frame-Member Sizes (Sides of Bolted Crates)

Limits		Size of members		
Length	Net load	Upper frame members	Lower frame members	Horizontal braces [1]
Feet	*Pounds*	*Inches*	*Inches*	*Inches*
[2] 12	500	[3] 5/8 x 4	[3] 5/8 x 4	[3] 5/8 x 4
10	2,000	1 x 4	1 x 4	1 x 4
16	4,000	1 x 6	1 x 6	1 x 6
12	8,000	1 x 6	1 x 6	1 x 6
[4] 40	4,000	2 x 4	2 x 6	2 x 4
16	10,000	2 x 4	2 x 6	2 x 4
20	10,000	2 x 6	2 x 8	2 x 6
20	16,000	2 x 8	2 x 10	2 x 8

[1] For crate heights of 48 inches and over.

[2] Size limits of crate. In addition to the 12-foot length and 500-pound gross weight limitations, this crate having 5/8-inch members shall be limited to 4-foot widths and 6-foot heights maximum.

[3] Actual thickness of members equals 5/8-inch.

[4] Crates over 32 feet in length shall be not less than 8 feet in height. Open bolted crates cannot be fabricated in lengths over 32 feet if the height is less than 8 feet. Long crates less than 8 feet high shall be fabricated in accordance with the requirements of Specification MIL-C-104.

(*a*) *Side panels.* The design of the side panel is illustrated in figure 6-40. The number of diagonals will depend upon the size of the crate.

(*b*) *Member selection.* The sizes of the upper, lower, and intermediate longitudinal members are based upon the gross weight and length of the crate as stated in table 6-17.

(*c*) *Diagonals.* Use 5/8 × 6-inch diagonals for crates not exceeding 12 feet in length, four feet in width and six feet in height, with a maximum net load of 500 pounds. Use 1 × 8-inch for crates exceeding 32 feet in length and 12 feet in height. Use 1 × 6-inch for all other conditions. See table 6-18 for the spacing of the diagonals. One-half of the diagonals shall be nailed to the outside of the longitudinal frame members and the other half shall be nailed to the inside of the same members, sloped in the opposite direction. The points of fastening of the diagonals, except at the end ones, to the longitudinal members shall be the same for inside and outside diagonals to permit the same lag bolts or bolts to pass through both diagonals. At the ends of the upper and lower frame members where no diagonal is present on the inside surface of the member, a filler block 12 inches long, the same thickness as one diagonal and the same width as the frame member, shall be used to provide continuous bearing. The number of diagonals is determined by the spacing of the diagonals.

Table 6-18. Spacing of Diagonals for MIL-C-3774 Crates

Maximum spacing	Thickness of longitudinal members	Crate size	
		Height	Width
Inches	*Inches*	*Feet*	*Feet*
24	2	to 6	to 6
18	2	6-12	6-8
[1]18	2	12-16	to 5
24	1	to 6	to 4
18	1	6-12	4-8

[1] For crates over 32 feet in length.

1. Both inner and outer diagonals shall be nailed to each 2-inch horizontal member with sevenpenny nails in patterns as shown on figure 6-54.

2. The outer diagonals shall be nailed to each 1-inch horizontal member with six nails, three driven from each side, and clinched.

3. The inner diagonals shall be nailed to each horizontal member with sevenpenny nails as shown on figure 6-54. When 5/8-inch frame members are used, the nail sizes shall be reduced as required.

(*d*) *Vertical struts or corner posts.* Fabricate these members from not less than 3 × 3-inch material. These pieces must be continuous from the upper longitudinal frame member of the side to both the lower longitudinal frame member of the side and the end floorboard member.

1. Notch the members when the top of the end floorboard does not come even with the top of the lower longitudinal member of the side.

2. Corner posts or vertical struts are designed to receive the lag bolts from the ends of the crate.

(*e*) *Corner sheathing.* Locate this material on the outside at each corner of the crate. Boards used at each end of the sides must be at least 1 × 8-inch pieces, except when diagonals and are 5/8-inch-thick, the sheathing is 5/8 × 8-inch material.

1. Nail sheathing boards to the vertical struts and corner posts with two rows (staggered pattern) of ninepenny nails. Space 8 inches apart within each row.

2. Nail sheathing boards to 2-inch longitudinal members with clinched eightpenny nails, five at each joint. Secure to 1-inch longitudinal members with clinched nails. Use pattern shown in figure 6-54.

(3) *Ends.* The ends consist of the upper, lower and intermediate longitudinal members which are the same size as the corresponding members of the sides (fig 6-41).

(*a*) Intermediate longitudinal members are required only when crates are 48 inches high or higher.

(*b*) Vertical struts of the ends are one continuous piece.

(*c*) All diagonal members of the ends are not less than 1 × 6-inch material. An X frame pattern is required when the width of the crate is not more than 1 1/2 times the height. When this limit is exceeded, a two-X frame pattern is required.

(*d*) Partial sheathing (corner). The outside vertical sheathing boards are not less than 1 × 6-inch for net loads up to 3,000 pounds, and not less than 1 × 8-inch boards for net loads over 3,000 pounds. Nail the corner board to the struts with two rows of sixpenny nails (staggered pattern). Space them 8 inches apart in each row and clinch.

(4) *Top panels. (fig 6-42).* Determine the number of panels to use by the length and width of the crate. Place the diagonal frame members as near to 45° angles as possible.

(*a*) *Frame members.*

1. Use 2 × 4-inch (one edge) or 3 × 3-inch members for contents up to 4,000 pounds. Over 4,000 pounds, use 4 × 4-inch pieces.

Figure 6-39. Skid base for bolted crate (MIL-C-3774).

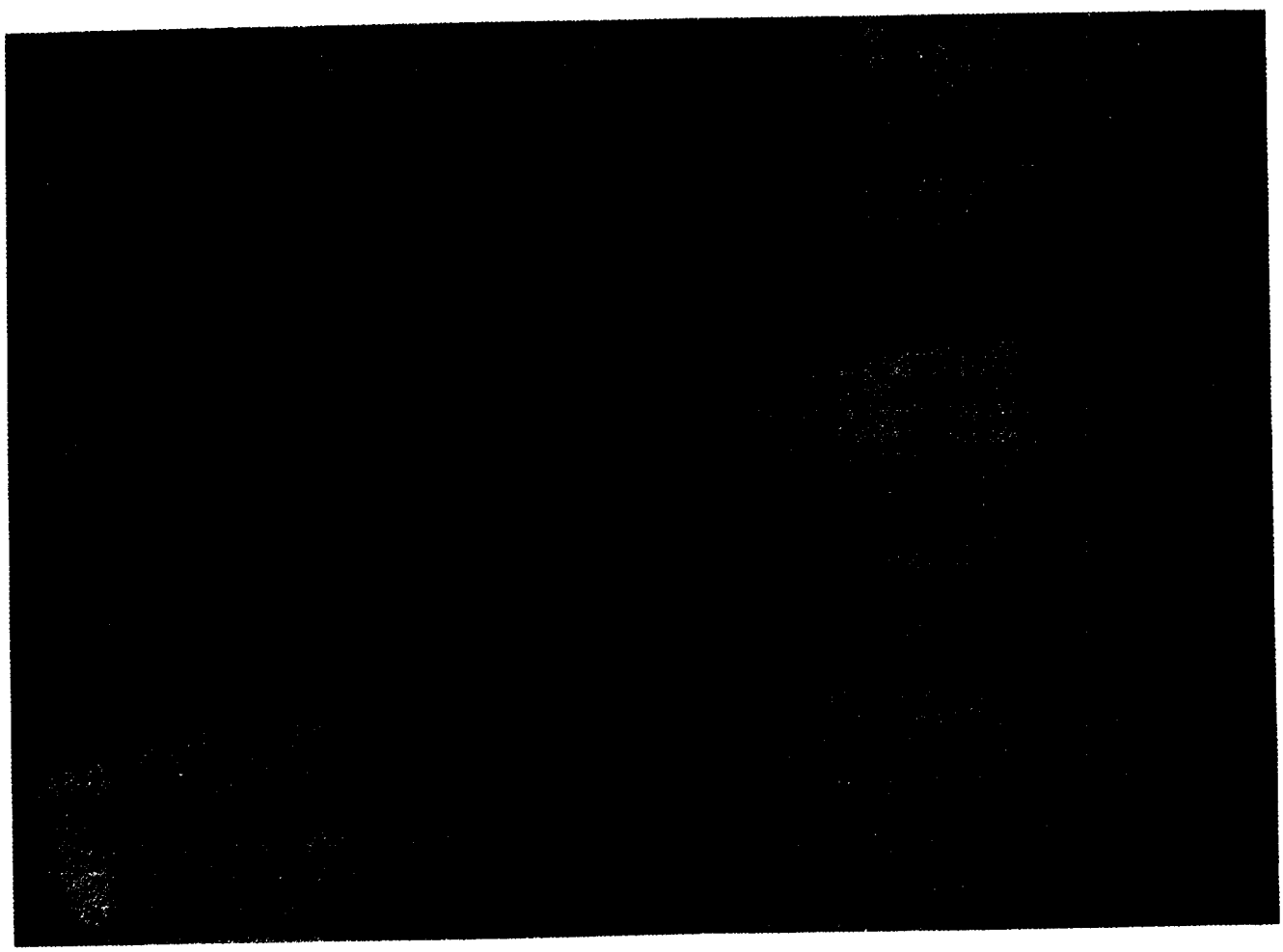


Figure 6-40. Side for bolted crate (MIL-C-3774).

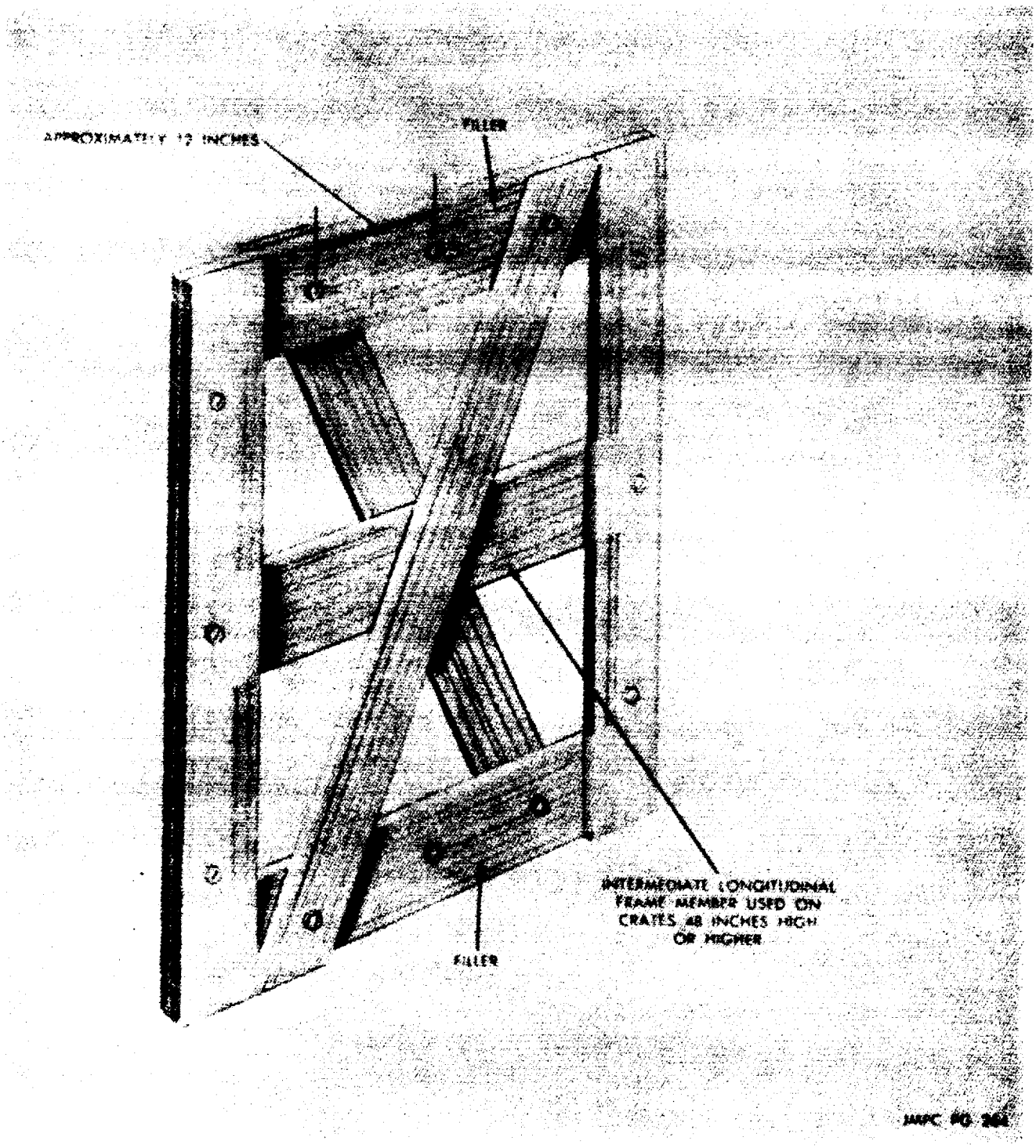


Figure 6-41. End for bolted crate (MIL-C-3774).

2. Nail 2-inch crosswise end members with twelvepenny nails, three at each joint. Nail through the side grain of the edge member into the end grain of the end member.

3. Nail 3 × 3-inch and 4 × 4-inch crosswise end members with twelvepenny nails, three at each joint, toenailed from the edge member into the crosswise end member.

(*b*) *Diagonal members.* All diagonal members are 1 x 6-inch boards

1. Nail diagonals to longitudinal members with eightpenny nails.

2. Where diagonals cross each other, use sevenpenny nails, five at each crossing, and clinch.

(c) *End sheathing boards.* All end sheathing boards of the top are 1 x 8-inch in size.

1. Nail the end sheathing boards to the frame member of the top with two rows of eightpenny nails spaced 4 inches apart in a single line for 2 x 4-inch frame members. For larger members the nails are staggered.

2. Nail sheating boards to longitudinal members with eightpenny nails.

(d) *Filler strips.* Fabricate filler strips from 1 x 4-inch material. Place them between the diagonals and nail. This will level the top in order to accommodate superimposed loads. Secure these strips with sixpenny nails spaced 6 inches apart.

(e) *Top joists.* Determine the size of the top joists by the width of the crate and the net weight of contents, as specified in table 6-19. An single joist shall be placed between the longitudinal frame members and at the center of balance. For long crates or for crates over 10,000 pounds in weight, two sets of joists shall be used and placed not more than 43 inches on each side of the center of balance. Nail through the 2-inch longitudinal members into the end grain of the top joist with twelvepenny coated nails, three in each joist. For 4-inch joist, use five nails. Toenail joist with twelve-penny coated nails.

Table 6-19. Joist Sizes

Size of joist	Limits	
	Gross load	Length (crate width)
Inches	*Pounds*	*Inches*
2 x 4	1,000	72
2 x 4	2,000	60
2 x 4	3,000	48
2 x 4	5,000	36
4 x 4	10,000	[1]96
[2]4 x 4	16,000	96

[1] Use two joists for greater widths of top.
[2] Use two joists.

c. *Assembly of Bolted Crates.*

(1) *Requirements for lag bolts or bolts.*

(a) Lag bolts may be used as fasteners for assembling the various panels of a bolted crate (fig 6-5).

(b) When a single diagonal occurs on the inside of a longitudinal member, use a three-fourths inch shorter lag bolt or bolt.

(c) When the diagonal is on the outside of the frame member, use a 3/4-inch filler strip between the frame member and the member to which the part is being fastened (fig 6-41).

(d) If bolts are used, they must be machine bolts with washers placed under both the head and the nut. Use washers under the heads of all lag bolts.

(e) Space 3/8-inch lag bolts or bolts not more than 24 inches apart. Space 1/2-inch lag bolts or bolts not more than 30 inches apart. Space 5/8-inch lag bolts or bolts more than 36 inches apart.

(2) *Assembly of the panels (fig 6-43).*

(a) *Fastening the sides to the base.*

1. The size and number of lag bolts used to fasten the side panels to the base are determined by the weight contents, the wood group used, and the width and thickness of the members as specified in table 6-17. The number of lag bolts or bolts specified in the tables are given for both side panels, one-half the number to be used on each side.

2. Connector plates may be used between the diagonals and skids. When used, use only half the number of lag bolts or bolts specified in tables 6-20 and 6-21. As an example, if the gross load is

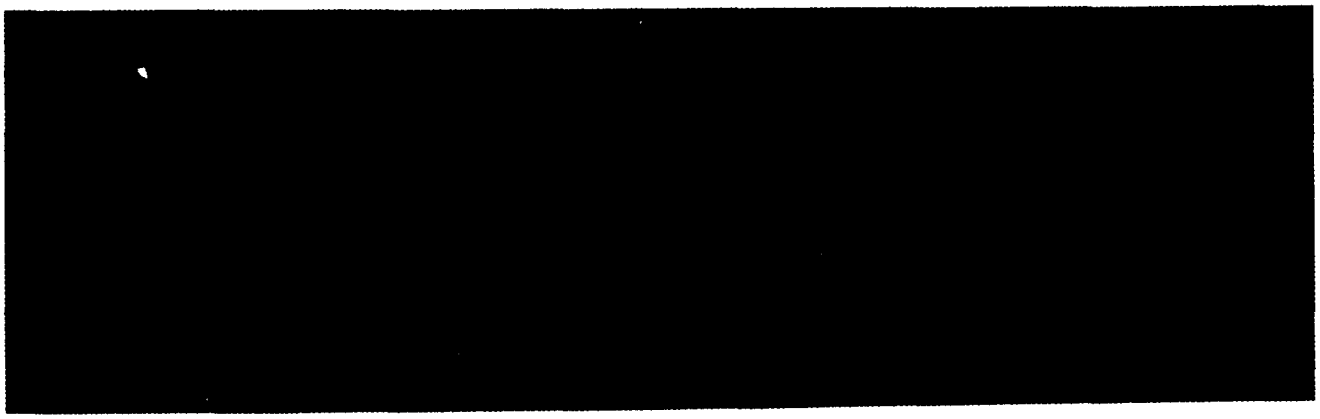


Figure 6-42. Top for bolted crate (MIL-C-3774).

Table 6-20. Number of Lag Bolts for Assembling Sides to Base of Bolted Crates; Where Nominal 1-inch Longitudinal Members Are Used in Sides and Nominal 4-Inch Wide Skids Are Used

Net weight of load	1/2 by 6 inch lag				1/2 by 5-1/2 inch lag				3/8 by 6 inch lag				3/8 by 5-1/2 inch lag			
	G I	G II	G III	G IV	G I	G II	G III	G IV	G I	G II	G III	G IV	G I	G II	G III	G IV
8,000	28	24	22	18	32	28	24	22	32	28	26	22	36	32	30	26
7,000	24	22	18	16	28	24	22	18	28	24	22	20	32	28	26	22
6,000	20	18	16	14	24	20	18	16	24	22	18	16	28	24	22	18
5,000	18	16	14	12	20	18	16	14	20	18	16	14	22	20	18	16
4,000	14	12	10	10	16	14	12	10	16	14	12	10	18	16	14	12
3,000	10	10	8	6	12	10	10	8	12	10	10	8	14	12	10	10
	1/2 by 5 inch lag								3/8 by 4-1/2 inch lag							
3,000	18	16	14	12					20	18	16	14				
2,500	14	12	12	10					16	14	12	10				

Note. G refers to the wood group and applies to the skids. If bolts are used, they shall be the same number and diameter as given above for lag bolts.

Table 6-21. Number of Lag Bolts for Assembling Sides to Base of Bolted Crates; Where Nominal 2-Inch Longitudinal Members Are Used in Sides and Nominal 4-Inch Wide Skids Are Used

Net load	5/8 by 7-inch lag				1/2- by 7-inch lag				1/2- by 6-1/2-inch lag				1/2- by 6-inch lag			
	G[1] I	G II	G III	G IV	G I	G II	G III	G IV	G I	G II	G III	G IV	G I	G II	G III	G IV
Pounds																
16,000	48	44	36	32	56	48	44	36	64	56	48	44	74	68	60	52
14,000	40	36	32	28	48	44	36	32	56	48	44	36	64	60	52	44
12,000	36	32	28	24	40	36	32	28	48	40	36	32	56	52	44	40
10,000	30	26	24	20	34	30	28	24	40	34	32	26	46	42	38	32
9,000	26	24	22	18	30	28	24	22	36	32	28	24	42	38	34	28
8,000	24	22	18	16	28	24	22	18	32	28	24	22	38	34	32	26
7,000	20	18	16	14	24	22	18	16	28	24	22	18	32	30	28	22
6,000	18	16	14	12	20	18	16	14	24	20	18	16	28	26	22	20
5,000	14	14	12	10	18	16	14	12	20	18	16	14	24	20	18	16
4,000	12	10	10	8	14	12	10	10	16	14	12	10	18	16	14	12
3,000	10	8	8	6	10	10	8	8	12	10	10	8	14	12	12	10

[1] Refers to the wood group and applies to the skids.
Note. If bolts are used, they shall be the same number and diameter as given for lag bolts.

8,000 pounds, use the number of bolts required in tables for 4,000 pounds.

3. Use the correct diameter and length of fasteners specified in tables 6-20 or 6-21, through each pair of diagonals, through the lower longitudinal member of the side, and into the sides of the skids.

(*b*) *Fastening the side panels to the top.*

1. Determine the size and number of lag bolts or bolts used to fasten the side panels to the top from the thickness of the diagonals and top frame members of the side, and the width of the longitudinal frame member of the top.

2. Use 1/2-inch lag bolts or bolts when the combined thickness of the diagonals, the upper edge member of the side, and the longitudinal member of the top, is 4 3/4 inches or more; use 3/8-inch fasteners when the sum is less.

3. The length of the lag bolt should be approximately equal to the sum of the three or four thicknesses. Bolts should be long enough to accommodate the nut and washers (under head and nut).

4. Secure the side panel to the top by using a lag bolt or bolt through each pair of diagonals and upper longitudinal member of the side, and into the longitudinal member of the top. This is required around the perimeter of the crate (fig 6-5).

(*c*) *Fastening the end panels.* The diameter and length of the lag bolts or bolts for fastening the ends of the crate to the top, bottom, and sides, is determined in a manner similar to that for fastening the sides to the top.

1. End panels to the top. The size and length of fastener will depend upon the thickness

of one or two diagonals or fillers, the top horizontal frame member of the end, and the width of the crosswise frame member to the top.

2. End panels to the base. The size and length of fasteners for securing the end panels to the base is the same as above.

3. End panels to the side panels. The size and length of fasteners to secure the end panels to the side panels is as specified for fastening the sides to the top. For 5/8-inch frame in the end, for loads not exceeding 500 pounds, use 5/16-inch diameter lag screws or bolts.

(*d*) *Corner strapping.* Use corner strapping on all nailed and bolted crates carrying a net load of 3,000 pounds or over, to reinforce the corners and to reinforce the crate at the junction of the panel (fig 6-4).

1. Fabricate all corner straps from 1 1/4 x .035-inch steel banding, 12 inches in length.

2. Apply three steps on each of the four upper corners of the crate and secure to the frame members with sixpenny nails, four in each leg of the strap. Space approximately 2 inches center to center.

3. Apply single straps at 36-inch intervals from the corners in all directions and nail to the frame members.

6-14. Open Nailed Crates (MIL-C-3774)

a. Design Requirements. Nondemountable crates may be designed with either a sill- or skid-type base, depending upon the requirements for the item being packed.

(1) *Skid bases.* Skid bases for open nailed crates are constructed almost identical to the bases used for bolted crates (fig 6-39).

(*a*) *Skids and rubbing strips.* The requirements for skids and rubbing strips are found in paragraph 6-31*b*(1). The size of skids depends upon the net load and the length of the crate (table 6-22).

Table 6-22. Skid Sizes for Nailed MIL-C-3774 Crates

Maximum net load	Maximum length of crate	Size of skids
Pounds	*Feet*	*Inches*
500	12	2 x 4
2,000	12	3 x 3
10,000	16	4 x 4
12,000	16	4 x 6 (on edge)

(*b*) *Headers.* Headers are bolted to the skids with carriage bolts. The sizes of end headers and bolt sizes are as follows:

Skid size (inches)	*Header size (inches)*	*Bolt diameter (inch)*
2 x 4	2 x 4	3/8
3 x 3	3 x 3	3/8
4 x 4	4 x 4	1/2
4 x 6 (on edge)	4 x 4	1/2

1. Set the headers or end floorboards back from the ends of the skids the thickness of the end sheathing.

2. When necessary, notch the headers at their ends down flush with the top of the floorboards. These notches will then accommodate and support the lower edge members of the sides.

3. Extend the headers to the outside faces of the outer skids.

4. The end of the base will be similar to the base of the MIL-C-104 crate (fig 6-53).

(*c*) *Load bearing floorboards.* See table 6-IV for sizes and paragraph 6-13*b*(1) (*d*) for requirements.

(*d*) *Forklift area.* Refer to the requirements stated in paragraph 6-13*b*(1) (*e*).

(*e*) *Nonload bearing floorboards (diagonals).* Refer to the requirements stated in paragraph 6-13*b*(1) (*f*).

(2) *Sill bases.* Sill bases are designed for loads to be transmitted to the sides by means of intermediate sills or by the end sills. The size of the side sills is based upon the weight of the contents and the length of the crate. However, sill spacing shall not exceed 48 inches center to center, whether required for transmitting loads or for bracing (fig 6-44).

(*a*) *Side and end sills.* The size of the side sills is obtained from table 6-23. End sills are the same size as the side sills.

1. Overlap the side sills over the end sills and nail at the corners using twentypenny coated nails.

2. When necessary, laminate the sills (fig 6-51).

(*b*) *Intermediate sills.* Apply intermediate sills either crosswise or lengthwise of the crate. These members are always required when the width of the crate exceeds 48 inches. Determine the size by the length of the sill and the actual weight supported by the sill. Refer to table 6-33 to calculate the intermediate sill size.

1. Attach intermediate sills at their ends to the side or end sills by a combination of nailing and metal hangers (strap or stirrup) (fig 6-17).

2. Metal hangers are not required for fastening nonload bearing intermediate sills.

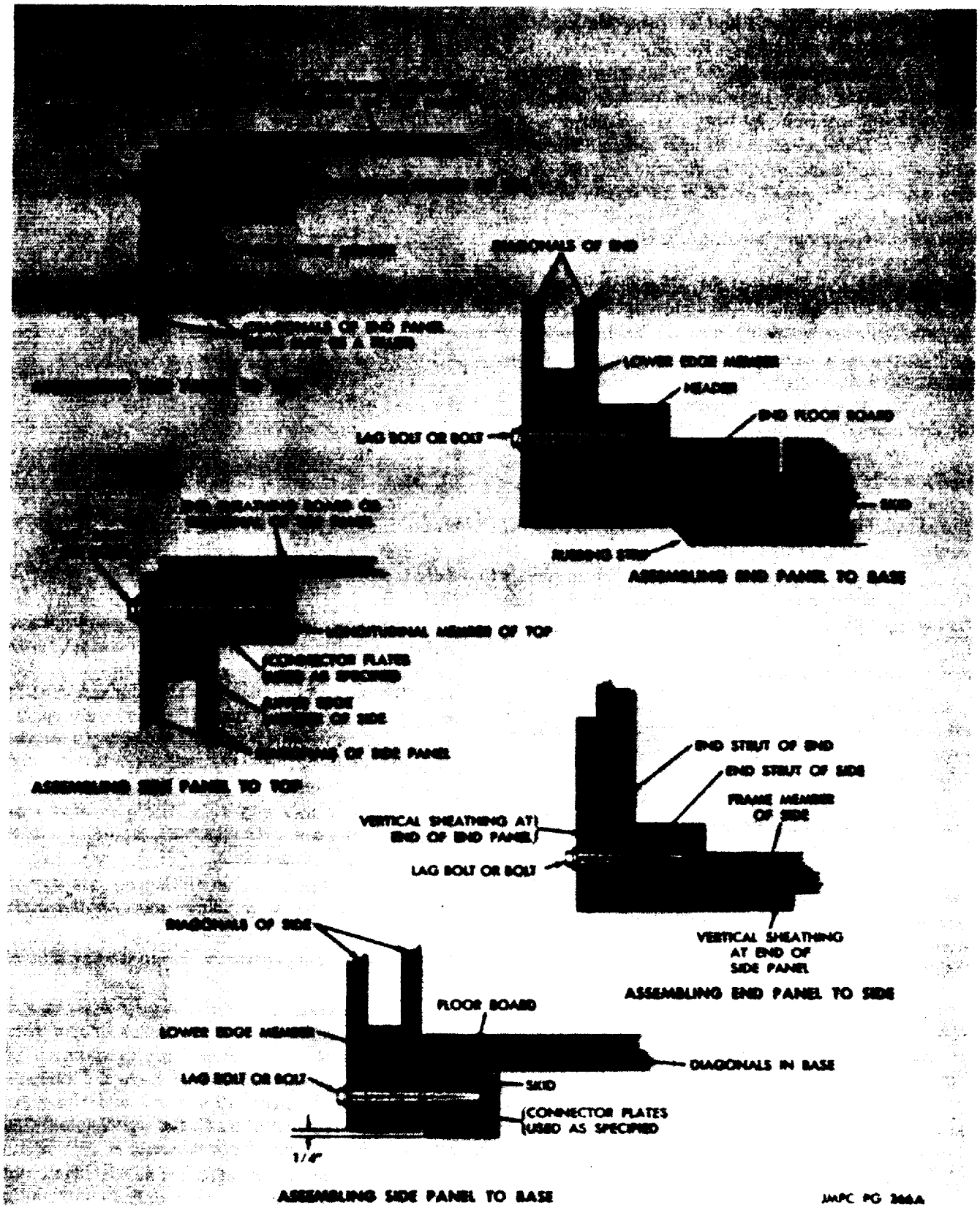


Figure 6-43. Assembly details for bolted crates (MIL-C-3774).

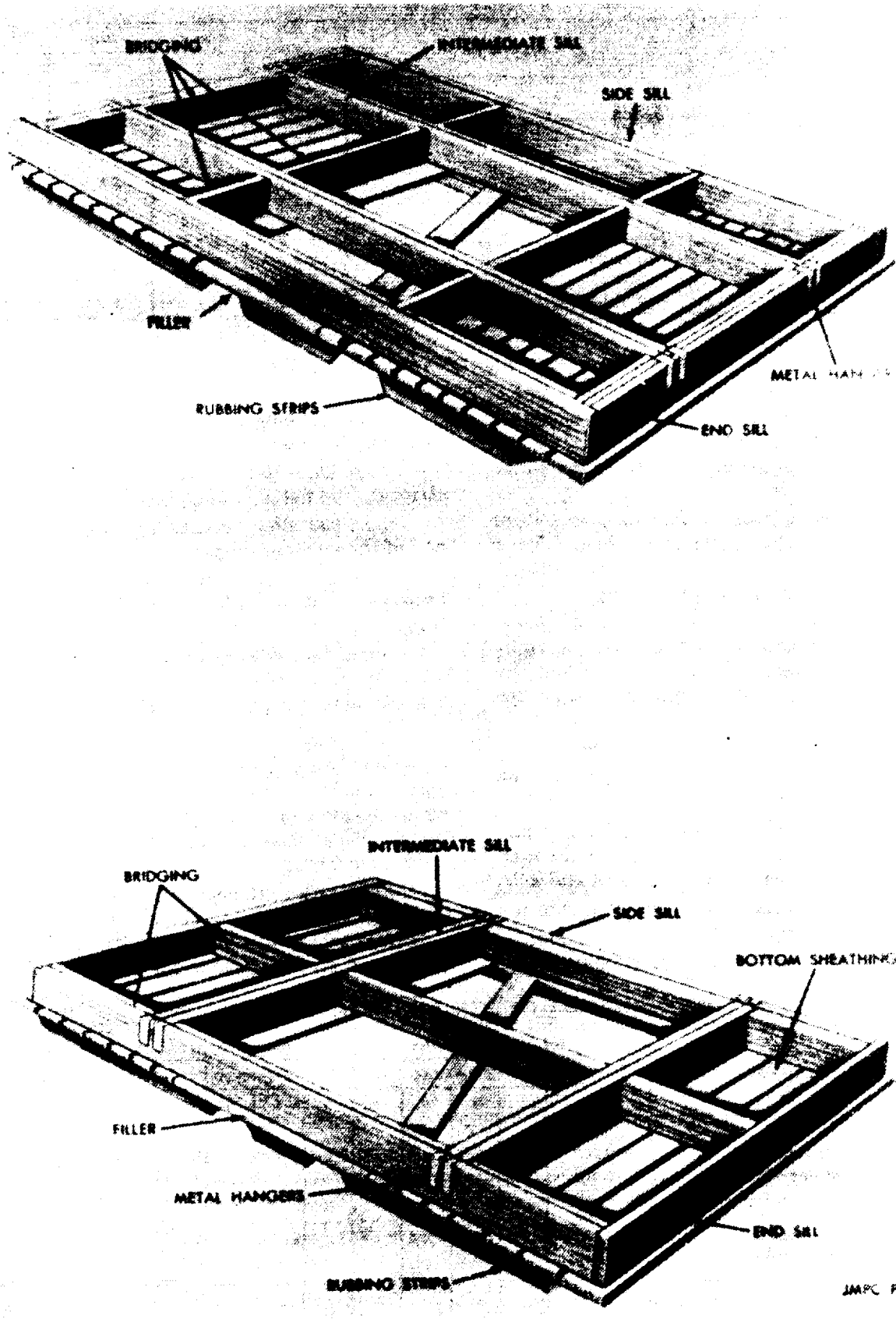


Figure 6-44. Sill base for nailed crate (MIL-C-3774).

Table 6-23. Size of Side and End Sills

Net weight of contents	Height in feet	Length of crate (feet)			
		4	8	12	16
Pounds					
2,500 to 4,000	Over 3	2 x 4	2 x 4	2 x 6	2 x 6
	3 or under	2 x 8	2 x 8	2 x 6	2 x 6
4,001 to 6,000	Over 3	2 x 4	2 x 6	2 x 6	2 x 6
	3 or under	2 x 8	2 x 6	2 x 6	2 x 6
6,001 to 8,000	Over 3	2 x 6	2 x 6	2 x 6	2 x 8
	3 or under	2 x 6	2 x 6	2 x 6	2 x 10
8,001 to 10,000	Over 3	2 x 6	2 x 8	2 x 8	2 x 8
	3 or under	2 x 6	2 x 10	2 x 10	2 x 10
10,001 to 12,000	Over 3	2 x 8	2 x 8	2 x 10	2 x 10
	3 or under	2 x 10	2 x 10	2 x 12	2 x 12

(*c*) *Bridging.* Use bridging to prevent the sills from buckling and to strengthen the base.

1. Bridge intermediate sills at their ends, except when positioned on their flat faces, with 1-inch lumber of the same depth. Nail to the inner face.

2. Reinforce spans 5 feet or over (either length or width of the crate) with 2-inch lumber the same depth as the sills. Position the reinforcing members at right angles to the sills.

(*d*) *Bottom sheathing.* Position bottom sheathing and nail crosswise to the base (at right angles to the direction of the side sills). Space the boards one-fourth to three-eighths inch apart for drainage.

1. Use boards 4 to 10 inches wide.

2. For the forklift area (42 in. from each end of the base) use 2-inch lumber.

3. Use one piece sheathing boards and extend them one-half to five-eighths of an inch beyond the outside faces of the side and end sills.

4. Place at least one diagonal in the unsheathed portion of the base.

(*e*) *Rubbing strips.* Position rubbing strips lengthwise to the crate under each longitudinal sill.

1. Rubbing strips are always two inches thick and not less than 4 inches wide.

2. The clear distance between rubbing strips should not exceed 30 inches.

3. Cut sling notches 8 inches long in each end of the rubbing strip.

4. Use filler strips in the unsheathed area between the sill and the rubbing strip where voids occur.

(3) *Sides.* The sides consist of upper and lower frame members, vertical struts, horizontal braces, diagonals, and gusset plates (fig 6-45).

(*a*) *Design of the side panels.* Determine the design of the side panel from the inside length and inside height of the crate. For crates up to 48 inches inside height use an X-type frame and for crates with an inside height of over 48 inches use a HK-type frame.

(*b*) *Member selection.* Determine the sizes of the upper and lower members, struts, and diagonals from tables 6-24 and 6-25 with the exception of the end strut or corner post. Loads referred to

Table 6-24. Panel Member Selection (6,000, 8,000, and 10,000 Pounds Net Load)[1]

Length	Members	Net load	4-foot width				6-foot width				8-foot width			
			Height (feet)				Height (feet)				Height (feet)			
			2	4	6	8	2	4	6	8	2	4	6	8
Feet		*Pounds*												
6	Upper frame member	6,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower fram members	6,000				2 x 4				2 x 4				2 x 4
	Struts	6,000				2 x 4				2 x 4				2 x 4
	Diagonals	6,000				2 x 4				2 x 4				2 x 4
8	Upper frame member	6,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	6,000				2 x 4				2 x 4				2 x 4
	Struts	6,000				2 x 4				2 x 4				2 x 4
	Diagonals	6,000				2 x 4				2 x 4				2 x 4
10	Upper frame member	6,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	6,000				2 x 4				2 x 4				2 x 4
	Struts	6,000				2 x 4				2 x 4				2 x 4

Table 6-24. Panel Member Selection (6,000, 8,000, and 10,000 Pounds Net Load)[1]—Continued

Length	Members	Net load	4-foot width				6-foot width				8-foot width			
			Height (feet)				Height (feet)				Height (feet)			
			2	4	6	8	2	4	6	8	2	4	6	8
Feet		*Pounds*												
	Diagonals	6,000				2 x 4				2 x 4				2 x 4
12	Upper frame member	6,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower fram member	6,000				2 x 4				2 x 4				2 x 4
	Struts	6,000				2 x 4				2 x 4				2 x 4
	Diagonals	6,000				2 x 4				2 x 4				2 x 4
16	Upper frame member	6,000	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4
	Lower frame member	6,000				2 x 4				2 x 4				2 x 4
	Struts	6,000				2 x 4				2 x 4				2 x 4
	Diagonals	6,000				2 x 4				2 x 4				2 x 4
6	Upper frame member	8,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	8,000				2 x 4				2 x 4				2 x 4
	Struts	8,000				2 x 4				2 x 4				2 x 4
	Diagonals	8,000			1 x 6	2 x 4			1 x 6	2 x 4			1 x 6	2 x 4
8	Upper frame member	8,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	8,000				2 x 4				2 x 4				2 x 4
	Struts	8,000				2 x 4				2 x 4				2 x 4
	Diagonals	8,000			1 x 6	2 x 4			1 x 6	2 x 4			2 x 4	2 x 4
10	Upper frame member	8,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	8,000				2 x 4				2 x 4				2 x 4
	Struts	8,000				2 x 4				2 x 4				2 x 4
	Diagonals	8,000			1 x 6	2 x 4			1 x 6	2 x 4			1 x 6	2 x 4
12	Upper frame member	8,000	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4
	Lower frame member	8,000				2 x 4				2 x 4				2 x 4
	Struts	8,000				2 x 4				2 x 4				2 x 4
	Diagonals	8,000			1 x 6	2 x 4			1 x 6	2 x 4			1 x 6	2 x 4
16	Upper frame member	8,000	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4
	Lower frame member	8,000				2 x 4				2 x 4				2 x 4
	Struts	8,000				2 x 4				2 x 4				2 x 4
	Diagonals	8,000			1 x 6	2 x 4			1 x 6	2 x 4			1 x 6	2 x 4
6	Upper frame member	10,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	10,000				2 x 4				2 x 4			2 x 4	2 x 4
	Struts	10,000				2 x 4			1 x 6	2 x 4		1 x 6	2 x 4	2 x 4
	Diagonals	10,000			1 x 6	2 x 4			1 x 6	2 x 4	1 x 6		2 x 4	2 x 4
8	Upper frame member	10,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower framemember	10,000			2 x 4	2 x 4			2 x 4	2 x 4				2 x 4
	Struts	10,000			2 x 4	2 x 4			2 x 4	2 x 4		1 x 6	2 x 4	2 x 4
	Diagonals	10,000		1 x 6	2 x 4	2 x 4	1 x 6	1 x 6	2 x 4	2 x 4	1 x 6	1 x 6	2 x 4	2 x 4
10	Upper frame member	10,000	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4	2 x 4
	Lower frame member	10,000				2 x 4				2 x 4				2 x 4
	Struts	10,000			1 x 6	2 x 4			1 x 6	2 x 4			1 x 6	2 x 4
	Diagonals	10,000		1 x 6	1 x 6	2 x 4	1 x 6	1 x 6	1 x 6	2 x 6	1 x 6	1 x 6	1 x 6	2 x 6
12	Upper frame member	10,000	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4	2 x 6	2 x 4	2 x 4	2 x 4
	Lower 10,000					2 x 4			2 x 4	2 x 4			2 x 4	2 x 4
	Struts	10,000			1 x 6	2 x 4			2 x 4	2 x 4			2 x 4	2 x 4
	Diagonals	10,000		1 x 6	1 x 6	2 x 4	1 x 6	1 x 6	2 x 4	2 x 4	1 x 6	1 x 6	2 x 4	2 x 4
16	Upper frame member	10,000	2 x 8	2 x 6	2 x 4	2 x 4	2 x 8	2 x 6	2 x 4	2 x 4	2 x 8	2 x 6	2 x 4	2 x 4
	Lower frame member	10,000				2 x 4			2 x 4	2 x 4			2 x 4	2 x 4
	Struts	10,000				2 x 4			2 x 4	2 x 4		1 x 6	2 x 4	2 x 4
	Diagonals	10,000	1 x 6	1 x 6	1 x 6	2 x 4	1 x 6	1 x 6	2 x 4	2 x 4	1 x 6	1 x 6	2 x 4	2 x 6

[1] All blank spaces are 1 x 4's.

Note. See text for size of end struts of sides.

in the table are based on the net weight of the contents and the inside dimensions of the crate. If the exact size of the crate is not given in the table, use the member size for the crate of the next longer length, the neat greater width, and next smaller height.

1. Use 1 x 4-inch lumber for members and diagonals and 2 x 4-inch lumber for upper edge members when the height of the crate is 6 feet or less and the load does not exceed 4,000 pounds.

2. Use 1-inch lumber for the lower edge members, struts and diagonals, and 2-inch lumber for the upper edge members and end struts when the height of the crate is under 6 feet and the load is over 4,000 pounds.

3. Use 2 x 4-inch lumber for the upper and

Table 6-25. Panel-Member Selection (12,000 Pound Net Load)[1]

Length	Members	Net load	4-foot width			6-foot width			8-foot width		
			Height (feet)			Height (feet)			Height (feet)		
			4	6	8	4	6	8	4	6	8
Feet		*Pounds*									
6	Upper frame member	12,000									
	Lower frame member	12,000									
	Struts	12,000									
	Diagonals	12,000			(*)			(*)		(*)	(*)
8	Upper frame member	12,000									
	Lower fram member	12,000									
	Struts	12,000									(*)
	Diagonals	12,000		(*)	2 x 6		(*)	2 x 6		(*)	2 x 6
10	Upper frame member	12,000									
	Lower frame member	12,000									
	Struts	12,000						(*)			2 x 6
	Diagonals	12,000		2 x 6	2 x 6		2 x 6	2 x 6		2 x 6	2 x 6
12	Upper frame member	12,000									
	Lower frame member	12,000									
	Struts	12,000						2 x 6		2 x 6	2 x 6
	Diagonals	12,000			2 x 6		2 x 6	2 x 6		2 x 6	2 x 6
16	Upper fram member	12,000									
	Lower frame member	12,000									
	Struts	12,000						2 x 6			2 x 6
	Diagonals	12,000			2 x 6			2 x 6	2 x 6	2 x 6	2 x 6

[1] All blank spaces are 2 x 4's.

* *Note.* The above sizes are for uniform loads but apply also to concentrated loads where an asterisk is shown. When an asterisk is shown, increase the member size to 2 x 6 for concentrated load.

lower edge members, struts and diagonals, when the height of the crate is over 6 feet.

(c) *Upper, lower, and intermediate members.* The members are required to be a single continuous piece. If splicing is required, splice the members according to the details shown in figure 6-50. All splicing should be made under or over a strut whenever possible. Splicing 1-inch material is not permitted. The size of these members is based upon the gross weight and length of the crate. Intermediate members (horizontal braces) are used only for crates of the HK type.

(d) *Vertical struts and diagonals.* All vertical struts and diagonals are continuous from the lower frame member to the upper frame member. Cut the diagonal and horizontal braces to fit between the vertical struts.

(e) *End struts or corner posts.* The end vertical strut or corner post of the side is not less than 2 inches in thickness in order to provide sufficient nailing space when fastening the ends.

(f) *Partial sheathing boards.* Always apply the sheathing boards vertically. These boards are located at the corners and at various intervals based upon the design of the crate.

1. *Lumber sheathing.* The sheathing boards are of one piece material, 1 inch thick, and from 4 to 10 inches wide. All end boards are at least 6 inches wide, preferably wider. Ten percent of the boards may be 4 inches wide, but no narrow boards may be adjacent to each other.

2. *Plywood sheathing.* Plywood strips, three or five ply material, may be substituted for lumber sheathing in the sides, ends, or tops. This material must be the same width as the lumber sheathing. For loads up to 5,000 pounds, use 7/16 inch plywood of group I woods; 3/8-inch of group II woods; 5/16-inch of group III and IV woods. For loads over 5,000 pounds, use 1/2-inch plywood of group I woods; 7/16-inch of group II woods; 3/8-inch of group III and IV woods.

(g) *Gusset plates.* Gusset plates are required for crates using 1-inch frame members. Place the gusset plates where the diagonals, struts, or horizontal braces intersect. Plywood gusset plates are not required when plywood sheathing is used. Use 12 x 12 x 1/4-inch gusset plate for 1 x 4-inch frame members. Use 18 x 18 x 1/4-inch gusset plate for 1 x 6-inch frame members. Secure the gusset plates to frame members using sevenpenny nails and clinch (fig 6-56).

(h) *Nailing lumber sheathing.* Nail 4 to 6 inches wide sheathing boards of horizontal and diagonal members with three rows of ninepenny clinched nails. Use three nails in sheathing boards 4 to 6 inches wide and four nails in wider boards. Nail sheathing boards over 6 inches wide to horizontal and diagonal members with four rows of

ninepenny clinched nails. Nail sheathing boards 4 to 6 inches wide to vertical struts with two rows of ninepenny nails, spaced 6 inches apart in each row and clinch.

(*i*) *Nailing plywood sheathing.* Nail plywood sheathing to 4-inch wide frame members with two rows of nails, spaced 6 inches apart in each row, and clinch. Use three rows of nails in frame members over 4 inches wide. The nailing requirements are identical to those illustrated in figure 6–54 except for the spacing.

(4) *Ends.* The end frame members are identical to those of the sides. The design of the end panels is also based upon the inside length and inside height of the crate. The panel design will be either X or HK framing (fig 6–45).

(*a*) *Member selection.* The frame members of the ends are the same size as the corresponding members of the sides.

(*b*) *Nailing (para 6–14a93)(h) and (i).*

(5) *Top panels.* The top panels consist of framing members, partial sheathing boards, gusset plates and joists. Tops are classified according to types (table 6–26 and fig 6–46).

Table 6–26. Type of Tops (MIL–C–3774)

Type framing pattern	Width of top (in.)
N	Up to 40
X	Over 40 through 60
HK	Over 60 through 96

(*a*) *Number of panels.* To determine the number of panels for N, X or HK type of top, divide the crate length by the crate width and use the nearest whole number.

(*b*) *Frame members.* All top frame members are 1 x 6-inch material. When the width of the top is 24 inches or less use 1 x 4-inch material.

(*c*) *Gusset plates.* Use gusset plates at the intersection of the frame members of the top. They are the same size and nailed in the same manner as those for the side and end panels (para 6–14*a*(3) (*g*)).

(*d*) *Top joists.* Determine the size of the joists by the weight of the contents and the length of the joists (table 6–19). Space the joists not more than 48 inches center to center. Extend all joists from the upper longitudinal member of one side to the upper longitudinal member of the other side. Fasten each joist with three twelvepenny coated sinkers through the upper edge members of the side into the end of the joist when the framing is one inch thick. Use three twentypenny nails per joint for 2-inch upper frame members. This nailing is accomplished as the crate is being assembled.

b. Fabrication of Open Nailed Crates.

(1) *Sheathing to the horizontal and diagonal frame members.* Use nails for securing the sheathing to the frame members (up to and including 2-in. thickness) long enough to permit clinching at least one-fourth of an inch. Use three rows of nails to secure the sheathing. Use a minimum of three nails in each sheathing board up to 6 inches wide. Use not less than four nails in wider boards.

(2) *Sheathing to the vertical frame members.* Use two rows of nails, placed on 6-inch centers, in each row and stagger (table 6–28 and fig 6–46).

(3) *Plywood sheathing to the frame members.* The nails for fastening plywood to framing members shall be long enough to pass through the plywood and the frame member and be clinched not less than one-fourth of an inch. Stagger all nails in two parallel rows in each frame member up to $^{35}/_{8}$ inches wide, and in three rows in wider frame members. Place the nails not less than one-half of an inch from the edge of the frame members. The distance between rows of nails is not less than one inch, and the distance between adjacent nails in any row is not to exceed 6 inches.

(4) *Sheathing to the side frame members of the top.* Use two rows of nails. One row three-fourths inch from the inside edge of the frame member, and one row three-fourths of an inch from the outside edge. Stagger the nails between rows with a minimum of two clinched nails in each sheathing board at each longitudinal member.

(5) *Sheathing to the end frame members of the top.* Place one row of nails in three-fourths of an inch from the inside edge of the frame member. Place the other row in the center of the frame members. Space the nails 9 inches apart in each row and clinch.

(6) *Sheathing to the longitudinal and diagonal members of the top.* Use three rows of nails, with not less than three nails in sheathing boards 6 inches wide. Use not less than four nails in wider boards.

(7) *Sheathing to the struts of the top.* Two rows of nails are required not less than three-fourths inch from the edges of both the frame members and the sheathing. Space the nails on 9-inch centers in each row and clinch.

(8) *Plywood sheathing to the frame members of the top.* If plywood is substituted for lumber, stagger the nails in two parallel rows and space them 6 inches apart in each row. Position the nails

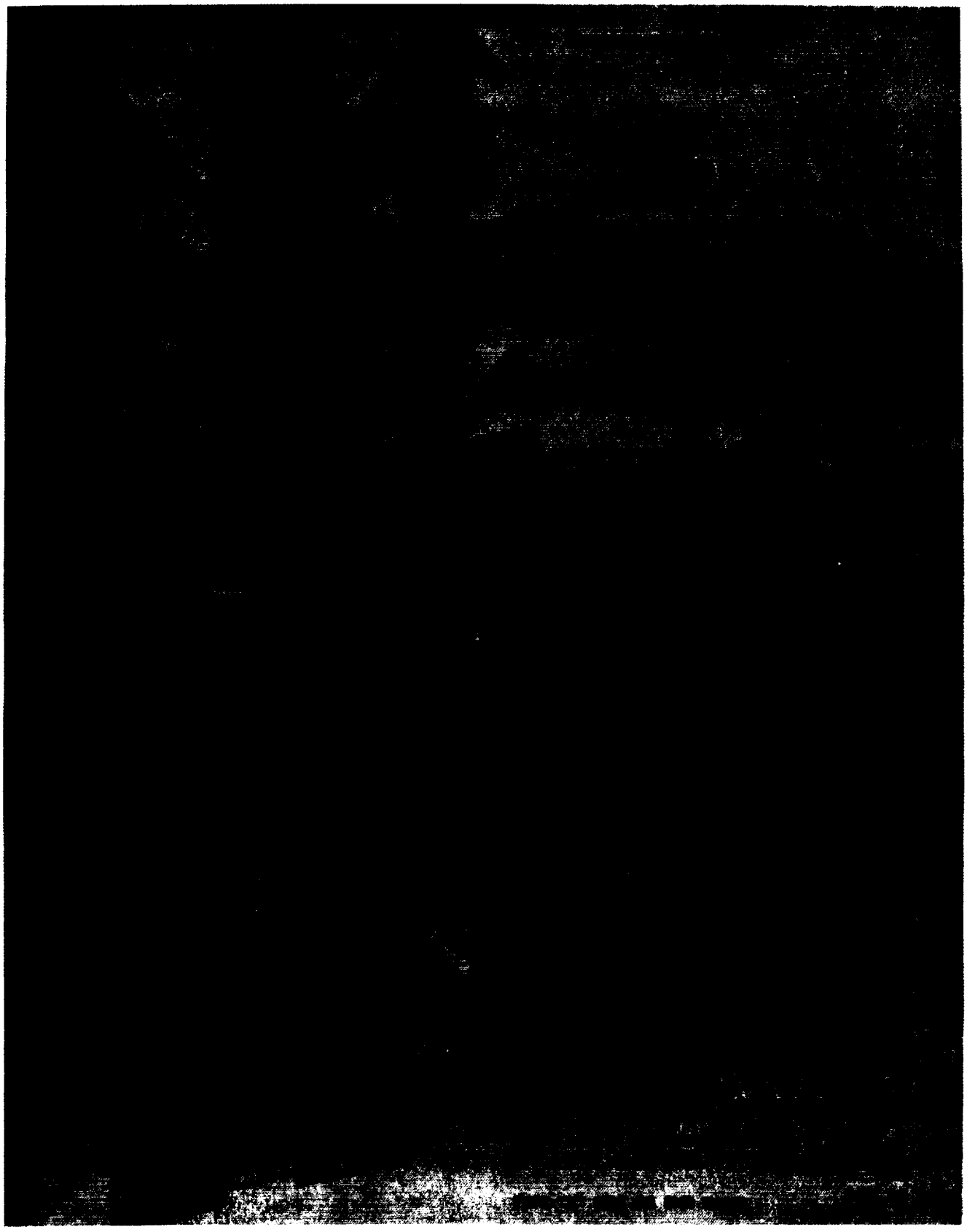


Figure 6-45. Side or end panel for nailed crate (MIL-C-3774).

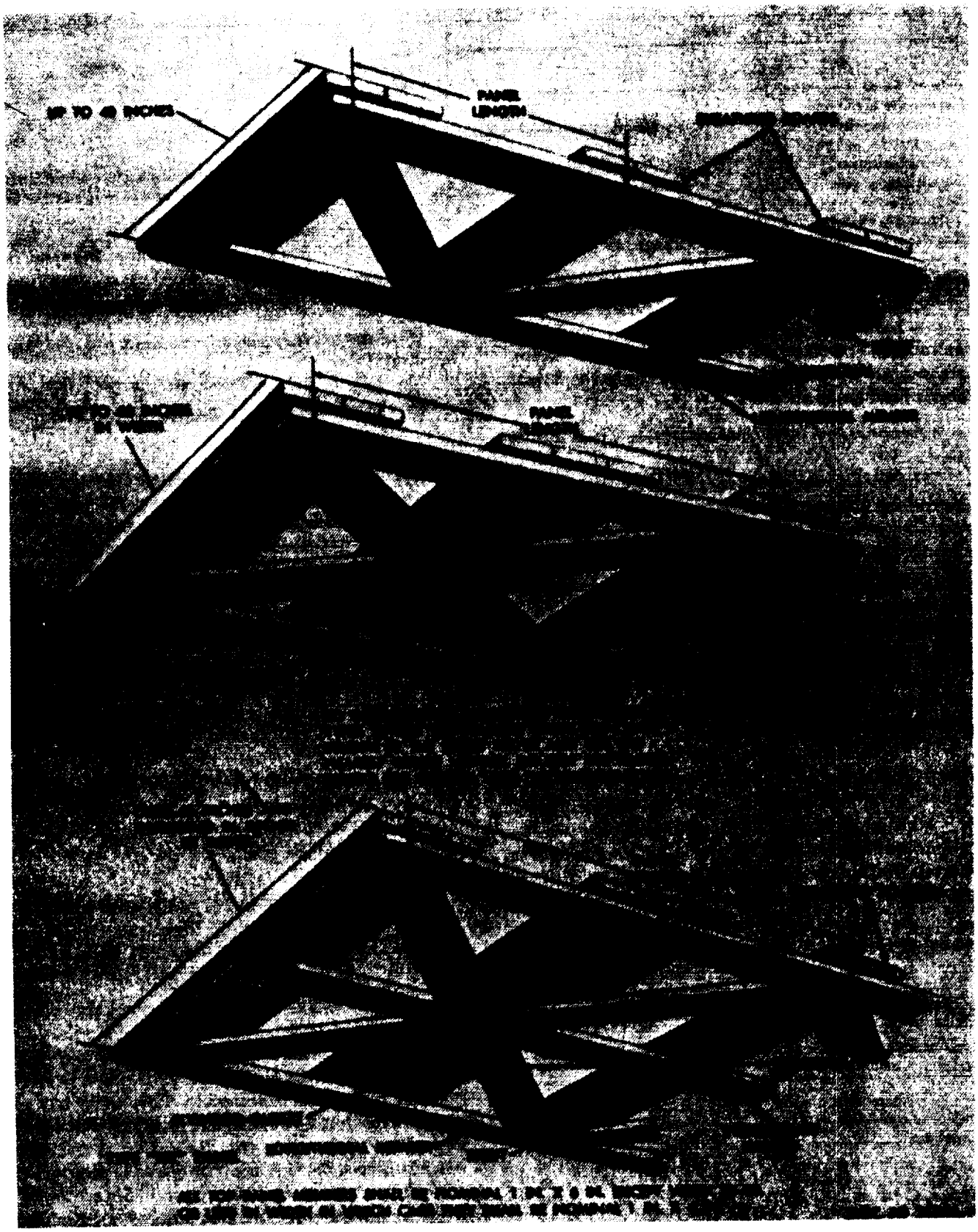


Figure 6-46. Types of top panels (MIL-C-3774).

Table 6-27. Nailed Crate Assembly (MIL-C-3774).

Fasten		Size type of nail	Maximum spacing	Notes
Part	To part			
			Inches	
Corner strut of end—(1-inch member).	Corner strut of the side	12d	12	
Corner strut of end—(2-in. member).	Corner strut of the side	20d	12	Predrill through sheathing of end and corner strut of end.
Sheathing of side	Corner strut of the end	8d	6 to 8	
Edge frame member of top—(through sheathing).	Upper framemember of sides	12d	6 center to center.	Stagger.
Edge frame member of top	Upper frame member of sides	8d	6 to 8	Space nails between top sheathing.
End strut of top	Upper frame member of end	12d	6	Stagger.

three-fourths inch from the edge of the frame members. The nails must be long enough to penetrate both the members and be clinched at least three-fourths of an inch.

c. Assembly of Open Crates (fig 6-4, 6-47 and 6-48).

(1) *Nailing requirements.* The nailing requirements for fastening the base, sides, ends, and top together are found in tables 6-27 and 6-28.

(2) *Nailing procedures.*

(*a*) When attaching the sides and ends to the skids, use one row of nails (staggered) for 2-inch-deep skids, two rows for 3- and 4-inch-deep sills and three rows for deeper members.

(*b*) Secure the corner struts of the end to the corner struts of the side with twentypenny nails spaced 12 inches apart.

(*c*) Nail the partial sheathing of the side to the corner strut of the end using eightpenny nails, spaced 6 to 8 inches apart, and staggered.

(*d*) Nail through the top sheathing into the upper edge members of the side using twelvepenny nails, spaced 6 inches apart, center to center.

(*e*) Nail the top sheathing to the top joists using twelvepenny nails, spaced 8 inches apart.

Table 6-28. Nails Per Each 1,000-Pound Gross Load; Nailing Side Sheathing to Skids or Sills and End Sheathing to Headers and Sills

Nail		Wood groups of skids		
Type	Penny size	II	III	IV
Common	7	20	21	16
Do	8 or 9	16	17	13
Do	10	13	14	11
Sinker or cooler	7	23	26	19
Sinker or cooler	8 or 9	19	21	16
Sinker or cooler	10	18	19	14
Corker	8 or 9	17	19	14
Do	10	15	16	12

(3) *Corner strappings (para 6-13c (2) (d) and fig 6-4 and 6-18.*

6-15. Sheathed Wood Crates, MIL-C-104 (General)

a. Crate Design. Fully sheathed crates conforming to Specification MIL-C-104 are for weights up to 30,000 pounds. These crates are used to provide protection to items that are susceptible to damage from outside forces, or for items that are too large or too heavy to fall within the weight and dimensional limitations of an open crate or a nailed wood box. Usually items shipped in sheathed crates need this additional protection. These crates are designed to support the weight of the item only when their ends and sides are fastened in place.

b. Classification. Eight crate designs are possible through the combination of the types, classes, and styles given in table 6-29. For example, a type I (nailed), class 2 (plywood sheathed), Style A (skid base) crate may be used.

Table 6-29. Classification of Crates (MIL-C-104)

Types	Classes	Styles
I (Nailed)	1 (Lumber sheathed)	a (Skid base)
II (Bolted)	2 (Plywood sheathed)	b (Sill base)

(1) *Weight limitations.* The gross weight of these crates should not be more than 11,200 pounds, whenever practicable. This weight is recommended in order to permit handling with ship's gear. However, when this limitation is not possible, the gross weight may be greater than 11,200 pounds but less than 20,000 pounds for crates with Style b (sill) bases, or 30,000 pounds for crates with Style a (skid) bases.

(2) *Dimension limitations.* The exterior dimensions of the crate are limited to 30 feet in

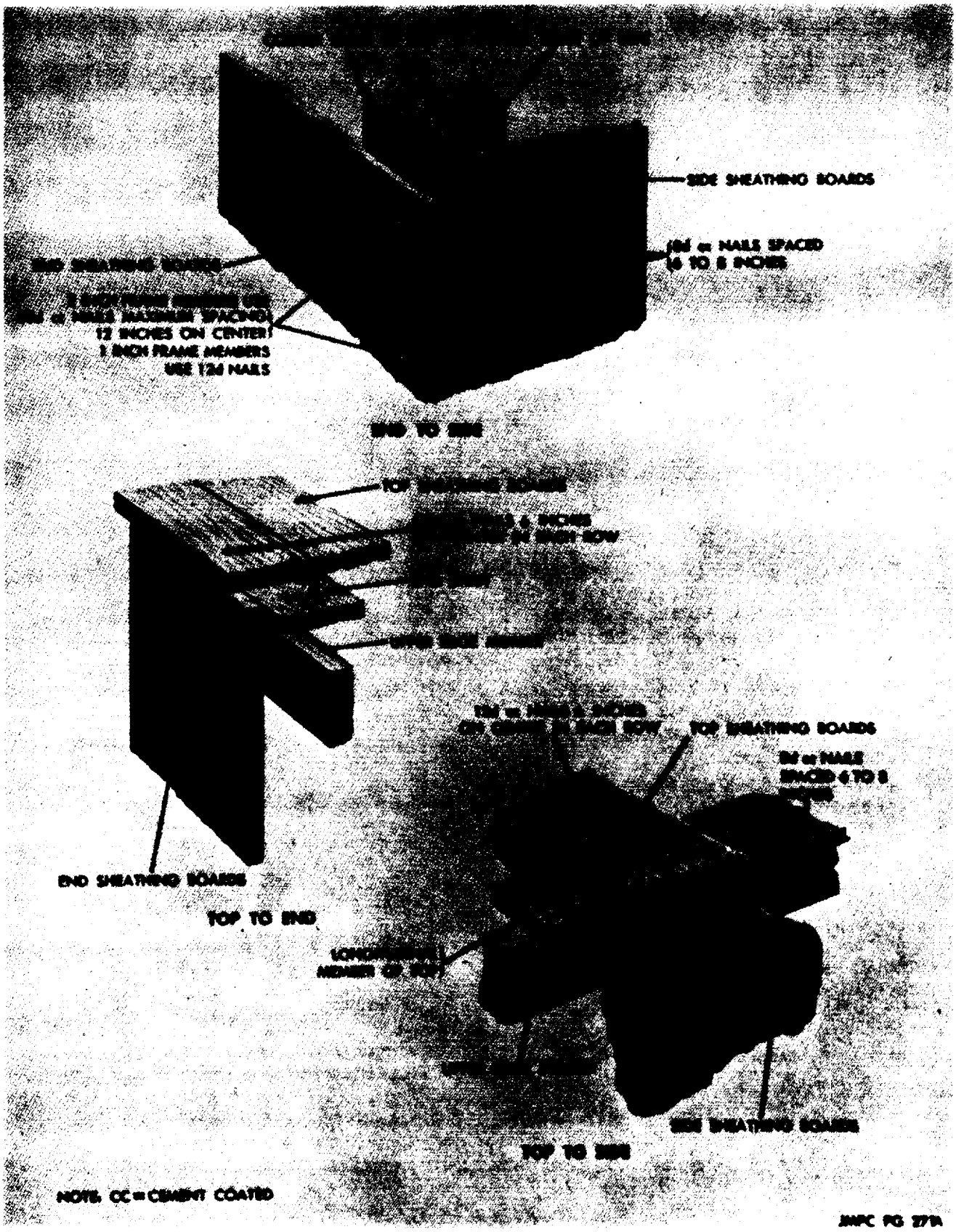


Figure 6-47. Assembly of open nailed crates.

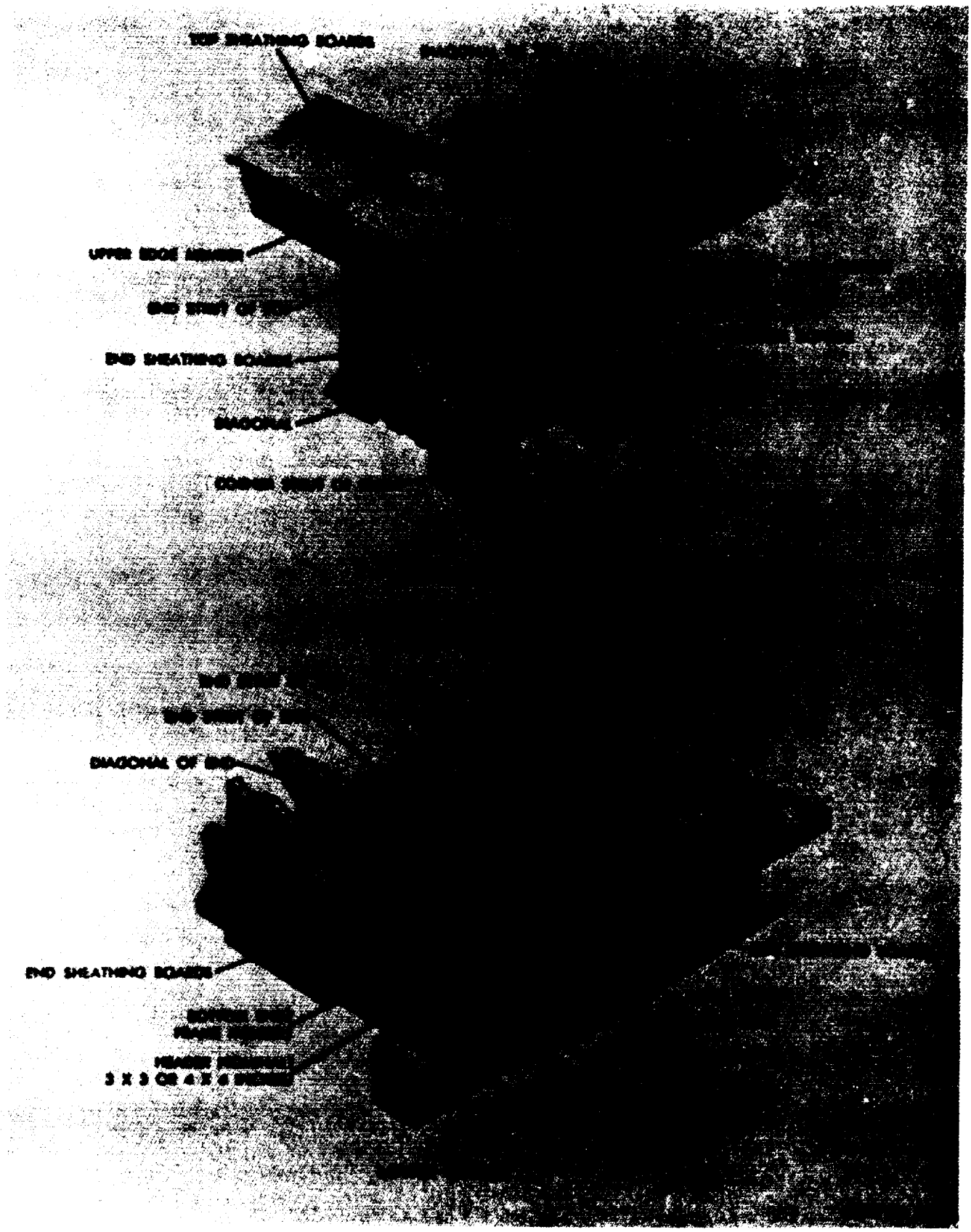


Figure 6-48. Assembly details for nailed crates (MIL-C-3774).

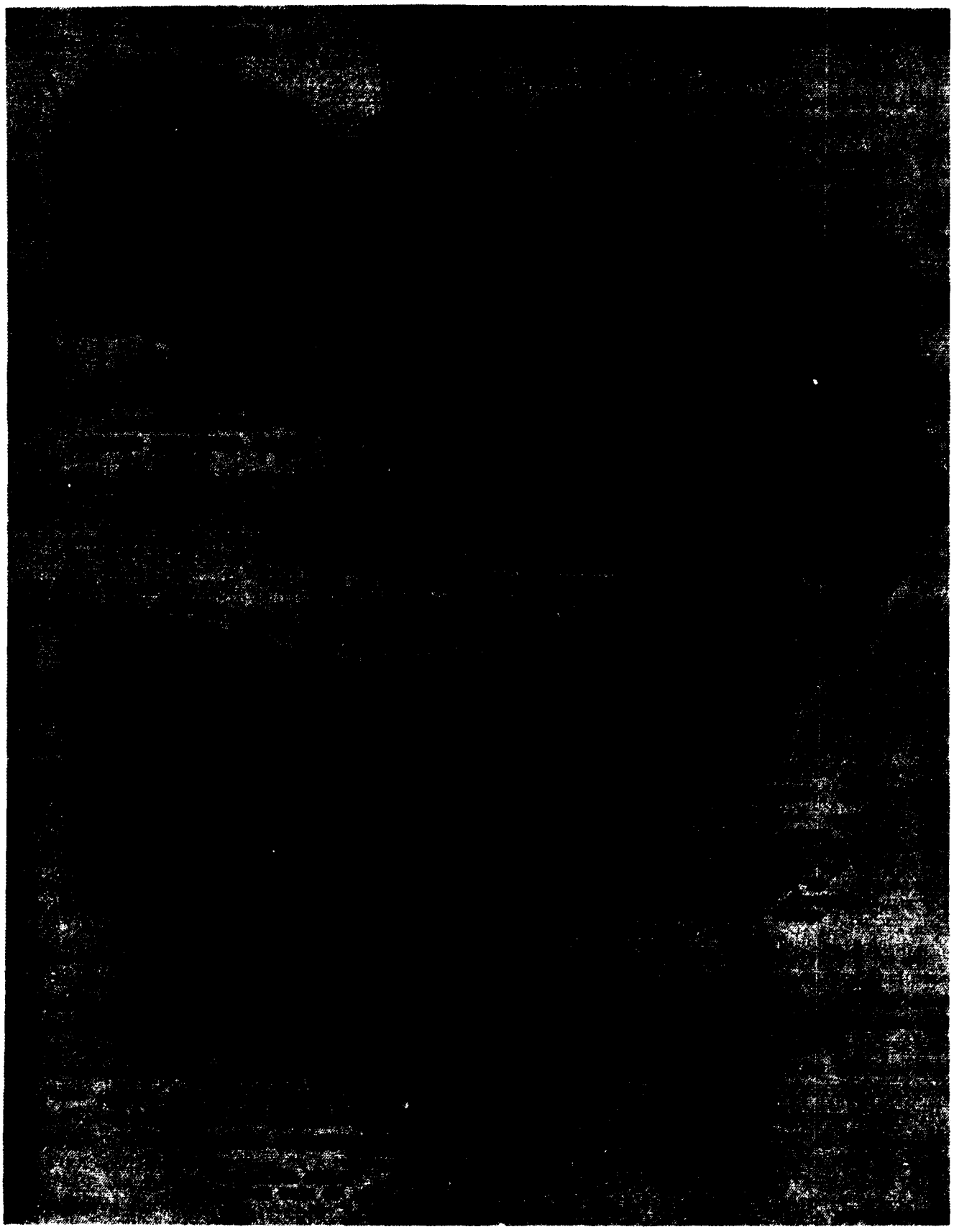


Figure 6-49. Ventilation and screening of sheathed crates.

length, 9 feet in width, and 10 feet in height, unless different dimensions are required under special circumstances.

c. Material Requirements.

(1) *Lumber.* The requirements for lumber are as stated in paragraph 6-2*a*, with the following additions:

(*a*) At least one surface of the lumber sheathing (the surface to be placed on the outside of the crate) should be dressed to permit legible markings.

(*b*) Crates containing items packed within floating bags will have all load bearing members and floor members coming in contact with the barrier material dressed.

(2) *Plywood.* All plywood for sheathing will conform to Specification NN-P-530 (para 6-2*b*).

(3) *Inspection doors (para 6-2l and fig 6-21).*

d. Ventilation (fig 6-49). All sheathed crates will be ventilated with clusters of holes located at each end, or at the ends and sides of lumber sheathed crates, or slots cut in the ends of plywood sheathed crates. Do not cut holes or slots in any frame member.

(1) *End ventilation.* Provide ventilating holes three-fourths of an inch in diameter in each end and space 2 inches on center. Place them in one or more clusters, near the upper frame members and provide with a baffle. No baffles are required for perimeter ventilation holes. In small crates, locate the holes so that the struts or diagonals can be utilized in parts as cleats for the baffle plates. In crates over 10 feet in length, divide the ventilation holes equally between the ends and sides of the crate, and provide a baffle for each group of holes. Located the cluster of holes as near the midpoint of the side and end as practical. Base the minimum number of holes for end (or end and side) and ventilation on the volume of the crate (table 6-30).

(2) *Perimeter ventilation.* Use perimeter ventilation as an alternate to end (or side) ventilation. Space 3/4 inch ventilation holes evenly (in a single line) around the perimeter of the crate just below the top frame member. Drill the holes at a 45° angle to drain outward. The total number of holes should comply with table 6-30.

(3) *Slotted ventilation (plywood sheathed).* Provide ventilation for pylwood sheathed crates by means of a horizontal slot at each end with a screen and baffle. The maximum size of a single slot is 4 x 12 inches. In small crates, 3/4-inch-diameter holes may be substituted for the ventilating slots in the proportion of two holes per square inch of required area. The required ventilating area should comply with table 6-30.

Table 6-30. Ventilation holes and area required (MIL-C-104)

Volume of crate (cuft)	Lumber-sheathed crates		Plywood-sheathed crates
	End ventilation minimum number of 3/4 in. diameter holes required in each end (place in clusters and use baffle)	Perimeter ventilation (alternate) total minimum number of 3/4 in. diameter holes required around perimeter (space evenly and slope to drain out)	Area required in each end (use baffle and screen) (sq in.)
0-100	3	6	7
100-150	4	8	10
150-200	5	10	14
200-400	9	18	27
400-600	14	27	40
600-800	18	36	52
800-1,000	22	44	66
1,000-1,200	27	54	80
1,200 and over	33	66	100

Note 1. In long crates (over 10 feet) when specified by the procuring agency the ventilation holes may be divided equally between the ends and the sides but the total required area or number of holes shall not be less than listed.

Note 2. In large crates, when a large ventilating area is required, two or more slots or clusters of holes may be used in each panel.

6-16. Lumber Sheathed (Class 1) Crates (MIL-C-104)

a. Design Requirements. Lumber sheathed crates may be either nailed or bolted for assembly. Nailed crates are fabricated and assembled with nails and straps and are not designed for reuse. Bolted crates are fabricated with nails and the panels are assembled with lag bolts for ease of disassembly or reassembly. Bases for lumber and plywood sheathed crates may be of Style A (skid) or Style B (sill) construction.

(1) *Skid bases (Style A).* Style a bases consist of longitudinal skids, rubbing strips, headers, load bearing floorboards, and flooring. The details of construction are the same for bolted and nailed crates (fig 6-11 and 6-52).

(*a*) *Skids.* Any species of wood, except Group I, may be used for the skids. Space skids no farther apart than 48 inches center to center, measured across the width of the crate. Skid sizes are based on the maximum net load and the maximum length of the crate (table 6-31). When either the length or the net load exceeds the limitation shown in table 6-31, use the next larger skid size.

1. Splicing of members. When necessary, skids made of lumber larger than 2 x 4-inch material may be spliced and laminated according to the details shown in figures 6-50 and 6-51. When 2 x 4-inch skids are used, each should be of one piece.

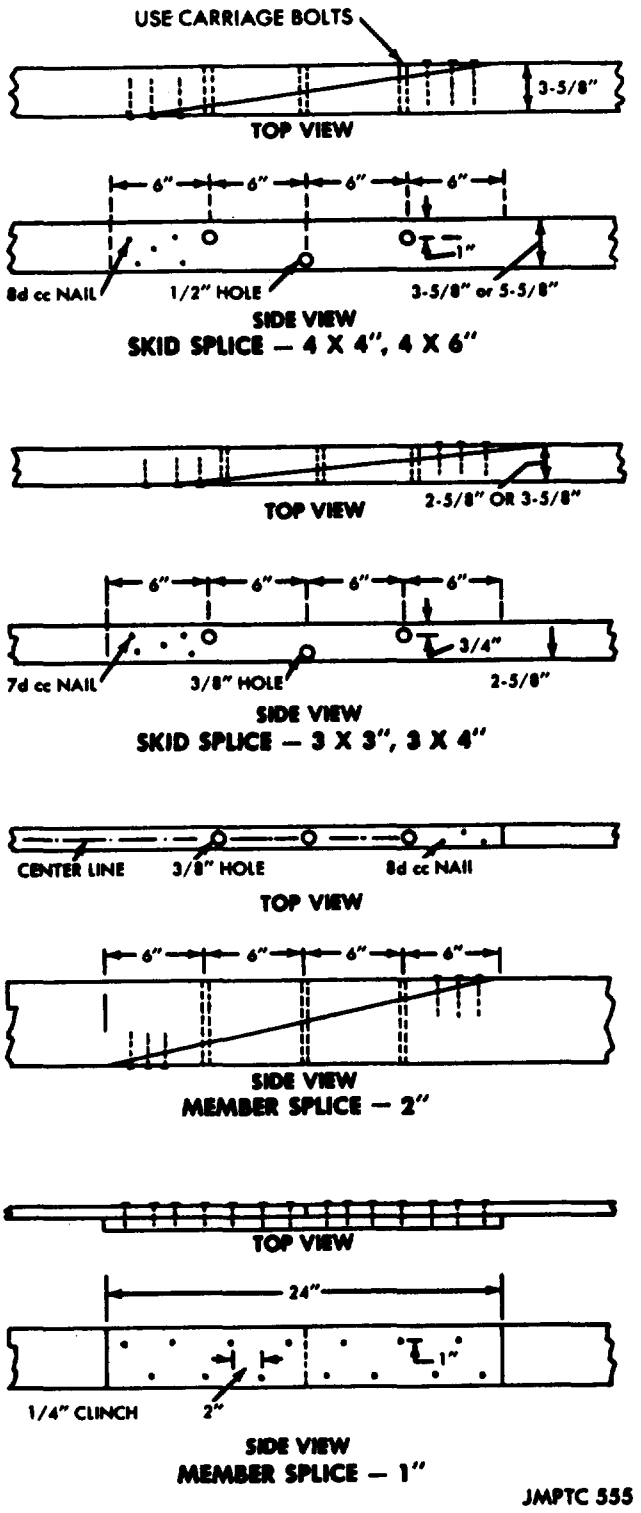


Figure 6-50. Splicing of members.

Table 6-31. Skid, Header, and Bolts Sizes (MIL-C-104)

Maximum net load (lbs.)	Maximum length of Crate (ft.)	Nominal size of skid (in.)	Nominal size of header (in.)	Bolt diameter (in.)
300	16	2 × 4 (flat)[1]	2 × 4[3]	3/8
1,000	12	2 × 4 (flat)[1]	2 × 4[3]	3/8
2,000	20	3 × 3 or 3 × 4 (flat).[2]	3 × 3 or 3 × 4 (flat).[4]	3/8
10,000	32	4 × 4	4 × 4	1/2
30,000	20	4 × 6 (on edge)	4 × 4	1/2

[1]For nailed crates only.
[2]For crates with 2-inch thick lower frame members or 2-inch end struts.
[3]For nailed crates only in width to 48 inches. For wider crates or bolted crates, use 3 × 3 inch.
[4]When 2 inches thick, end struts are required.

2. Bolts. To prevent skids from splitting out at the ends, place one carriage bolt crosswise and 2 to 3 inches in from each end of the skids.

(b) Rubbing strips. Fabricate rubbing strips for skid bases from 2-inch lumber the same width as the skid. Attach them to the skids with two rows (staggered pattern) of twelvepenny coated nails spaced 12 inches apart in each row.

1. Forklift openings. Provide sling openings for forklift entry in the rubbing strips. These openings are 12 inches in length and 28 inches center to center. Position them to straddle the center of balance of the loaded crate. Center pieces of the rubbing strips must be at least 16 inches in length.

2. Sling openings. Provide sling openings not less than 4 inches in length, but preferably 8 inches, at the ends of the rubbing strips where permitted by the length of the crate and by the location of the worklift access openings. Bevel the ends of all rubbing strips at an angle of 45° at sling and forklift openings. For bases less than seven feet long, provisions for forklift openings may be omitted.

(c) Headers. Headers are placed at each end of the base. Header sizes are based upon skid sizes.

1. Place headers used with lumber flooring directly on the skids, back from the ends a distance equal to the thickness of the end sheathing. Notch the ends of the headers equal to the thickness of the flooring to receive the lower edge members of the sides. Bolt these members to each skid with one carriage bolt. The sizes of the headers and bolt diameters are found in table 6-31.

2. Place the headers used with plywood flooring on top of the plywood and set back from

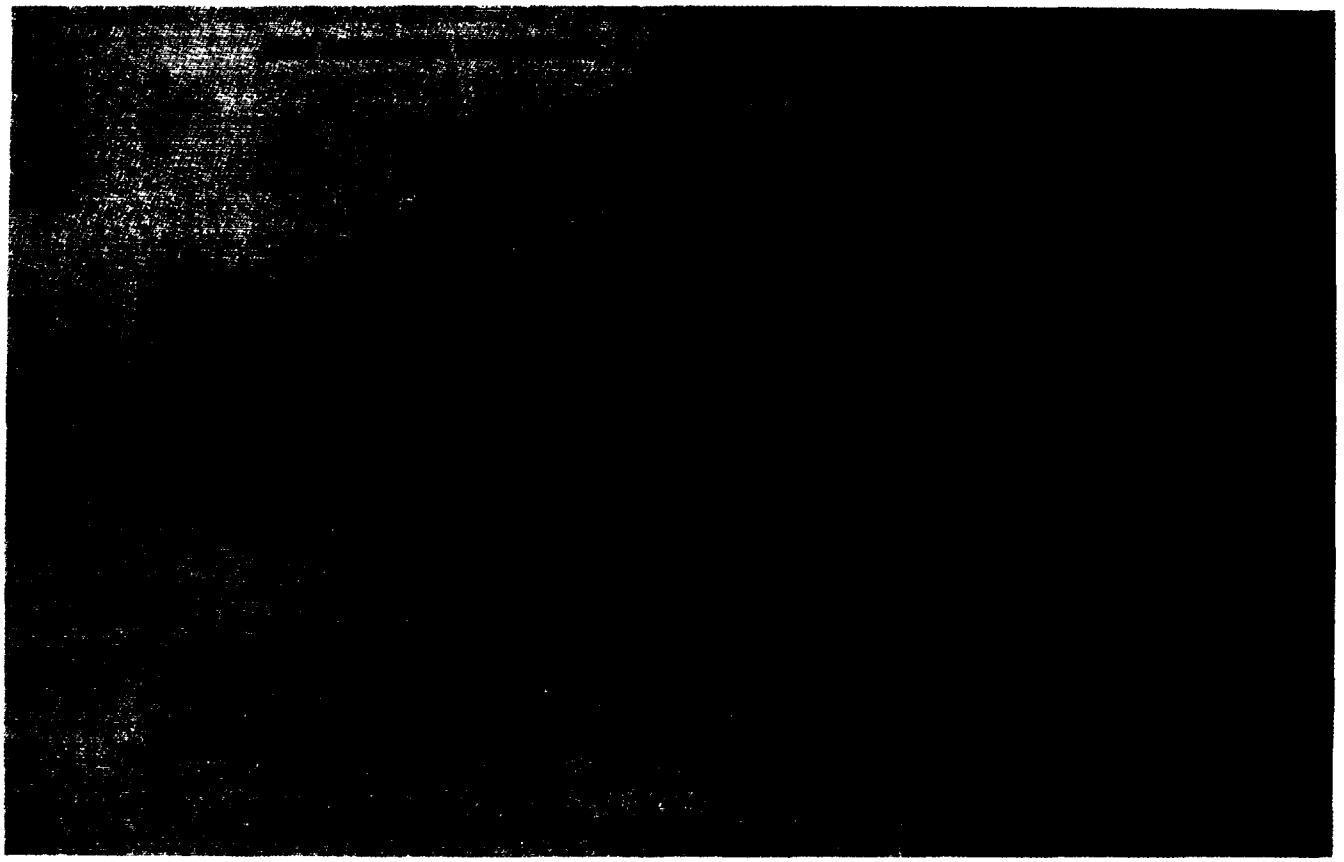


Figure 6-51. Lamination of skid or sill members.

the ends of the skids the same as required for lumber flooring. Cut off the ends of the headers a distance equal to the thickness of the lower edge members of the sides so that the lower edge members will rest on top of the plywood flooring. The size of the headers and bolt diameters are found in table 6-31.

(*d*) *Forklift area.* The forklift area consists of the headers and two more members of equal size, spaced 20 and 40 inches (on center) from each end of the skids and bolted to the skids.

1. When crates are short or narrow, or the above arrangement will interfere with the loading of the item, use 2-inch lumber throughout the 42-inch forklift area.

2. Space lumber flooring one-fourth of an inch apart for drainage. Nail the flooring to the outer skids and bolt to the intermediate skids when required.

(*e*) *Load bearing floorboards.* Load bearing floorboards are members placed across the width of the base where the concentrated load of contents occur. They also serve to distribute and transfer the load to the skids. Calculate the thicknesses of the load bearing members on the basis of the distance between the outer skids and the concentrated load per linear inch of floorboard width. The load per inch of floorboard width is equal to the weight of the item at the heaviest concentration area in pounds, divided by the length of the concentrated area in inches. The result of this computation will give the actual load per inch in pounds. See table 6-4 for the thickness of load bearing floorboards; see figure 6-22 for use of table 6-4. When using table 6-4 if either the length between the outer skids or the weight is less than required, use the next greater length or higher poundage to determine the thickness of the load bearing floorboards.

1. The forklift members and any other 1- or 2-inch flooring may be considered as load bearing floorboards within their assigned values.

2. The length of the load bearing floorboards is the same as the headers.

3. Fasten load bearing floorboards four inches wide to each skid with one carriage bolt. Fasten load bearing floorboards over four inches wide to each skid with two bolts. The diameter of the bolts are the same as those specified for the

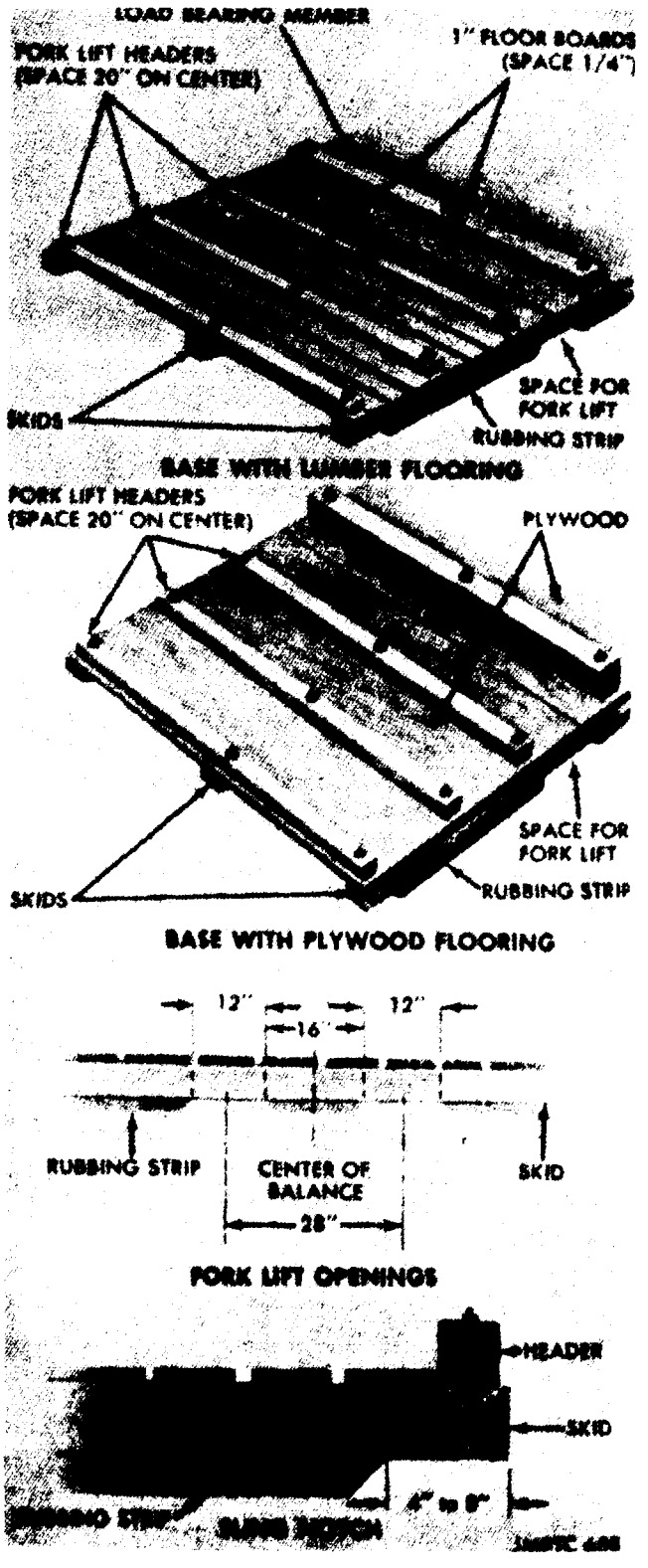


Figure 6-52. Headers, forklift openings, and sling notches on skid bases.

headers. When intermediate skids are required, the same rules apply.

(*f*) *Lumber flooring.* Lumber flooring must be at least 1-inch thick, not less than 4 inches in width and placed at right angles to the skids. Space the boards one-fourth of an inch apart for drainage, and place the ends flush with the outside faces of the skids. If part of the base is floored with 2-inch lumber and the rest with 1-inch lumber, use filler strips 2 inches wide along each side over the thinner flooring to equal the thickness of the 2-inch flooring (fig 6-53). Nail filler strips with two rows (staggered pattern) of sixpenny nails spaced 10 inches apart.

(*g*) *Plywood flooring.* Plywood of Group I or II woods, three-eights of an inch in thickness, may be used in lieu of 1-inch lumber flooring, but not as load bearing floorboards. Lay plywood flooring flush with the outer edges of the skids with the face grain perpendicular to the skid length. Space each piece of plywood one-fourth of an inch apart for drainage and nail to each skid with two rows (staggered pattern) of sevenpenny nails, spaced 6 inches apart in each row. When one-third to one-half the area of the base is floored with 2-inch lumber, use plywood flooring between those areas and nail 2-inch filler strips over the plywood (fig 6-53). Drill a drainage hole one-half of an inch in diameter adjacent to each header or load bearing member. Locate the holes on the outer edge of each plywood floored section (a "section" being an unjoined portion of plywood located between two members) of the base where water might be trapped. Locate the holes so that they will not be covered when the contents are placed on the base of the crate.

(2) *Sill bases* (*style b*). Style b bases consist of side, end, and intermediate sills, load bearing headers, bridging, bottom sheathing, and rubbing strips. These bases are designed for the weight of contents to be transmitted to the side sills through the intermediate sills or by the item itself. Details of construction are the same for nailed and bolted assembly (fig 6-10).

(*a*) *Side and end sills.* The size of the side sills is based on the gross weight of crate and contents and length of the crate. The end sills are the same dimensions as the side sills (table 6-32). The side sills should overlap the end sills. When necessary, the sills may be spliced and laminated (fig 6-50 and 6-51).

(*b*) *Intermediate sills.* Apply intermediate sills crosswise to the length of the base and parallel to the end sills. Attach the intermediate sills at their ends to the side sills with a combina-

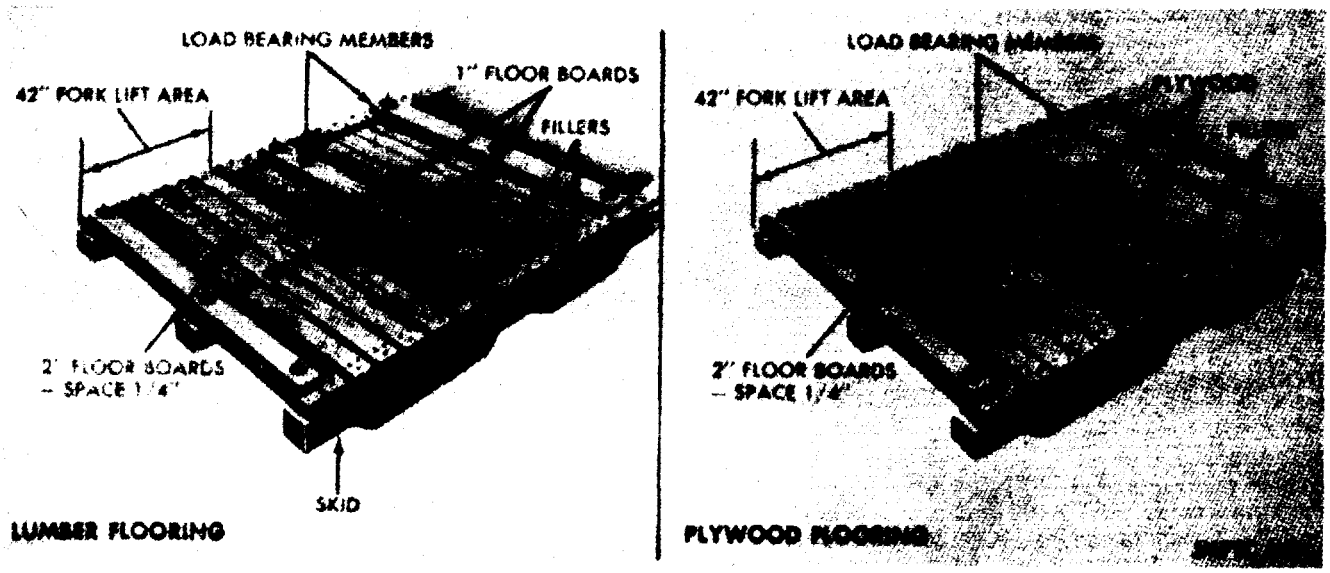


Figure 6-53. Skid base—partial 2-inch flooring.

tion of nails and meter strap hangers. Fabricate hangers from 1½ x 0.035-inch nail-on strapping (fig 6-17). Determine the size of the intermediate sill by using the length of the sill and the amount of weight actually supported by that sill (table 6-33).

(*c*) *Load bearing members.* Load bearing headers are pieces of lumber placed between a set of intermediate sills, when necessary, to support the contents. Load bearing headers are the same size as the intermediate sills. These members are not required when all the load is supported by the side sills. Attach the load bearing headers at their ends to the intermediate sills in the same manner as described in (b) above.

(*d*) *Bridging.* Use 1-inch lumber to bridge intermediate sills at the ends. The nail size depends upon the thickness of the side sills. Use 2-inch lumber the same depth as the intermediate sills at intervals not to exceed 4 feet. This material will add strength and rigidity to the base structure (fig 6-10).

(*e*) *Bottom sheathing.* Style B bases are sheathed with lumber laid at right angles to the side sills and secured with nails. Use boards from 4 to 10 inches wide and not less than 1 inch thick for spans of less than 30 inches between side sills. Use boards 2 inches thick for spans of 30 inches or more. Lay the bottom sheathing flush with the outside edges of the sills and space one-fourth of an inch apart for drainage. Secure 1-inch sheathing boards with eightpenny nails and 2-inch boards with twelvepenny nails in accordance with the nailing pattern (fig 6-54).

(*f*) *Rubbing strips.* Fabricate the rubbing strips from 2-inch lumber at least 4 inches wide. Place these members lengthwise beneath the bottom sheathing under each side sill. Locate intermediate rubbing strips of the same size between the outer rubbing strips so that the clear distance

Table 6-32. Nominal Sizes of Side Sills (MIL-C-104)

Gross weight of crate lb	Length of crate (ft)							
	4	8	12	16	20	24	28	32
To 2,000	2 × 4	2 × 4	2 × 4	2 × 4	2 × 4	2 × 6	2 × 6	2 × 6
2,000-4,000	2 × 4	2 × 4	2 × 4	2 × 4	2 × 6	2 × 6	2 × 6	2 × 8
4,001-6,000	2 × 4	2 × 4	2 × 4	2 × 6	2 × 6	2 × 6	2 × 8	2 × 8
6,001-8,000		2 × 4	2 × 6	2 × 6	2 × 6	2 × 8	2 × 8	2 × 8
8,001-10,000		2 × 6	2 × 6	2 × 6	2 × 8	2 × 8	2 × 8	2 × 10
10,001-12,000		2 × 6	2 × 6	2 × 8	2 × 8	2 × 8	2 × 10	2 × 10
12,001-,000		2 × 6	2 × 8	2 × 8	2 × 8	2 × 10	2 × 10	2 × 10
14,001-16,000		2 × 8	2 × 8	2 × 8	2 × 10	2 × 10	2 × 10	2-2 × 8
16,001-18,000		2 × 8	2 × 8	2 × 10	2 × 10	2 × 10	2-2 × 8	2-2 × 8
18,001-20,000		2 × 8	2 × 10	2 × 10	2 × 10	2-2 × 8	2-2 × 8	2-2 × 8

Note. The above sizes are for crates with a height of over 3 feet. For heights of three feet or under, increase 2 × 4 sizes to 2 × 6; increase 2 × 6 sizes to 2 × 8; increase 2 × 8 sizes to 2 × 10; and increase two 2 × 8 sizes to two 2 × 10.

Table 6-33. Allowable Load for Intermediate Sills in Pounds Per Inch of Sill Width

Length of Sill (ft)	Sill depth (inch) Groups I and II wood						
	1-1/2 in	2-1/2 in	3-1/2 in	5-1/2 in	7-1/2 in	9-1/2 in	11-1/2 in
	POUNDS						
4	71	150	290	720	1250	2000	3000
5	57	120	234	580	1000	1640	2400
6	48	100	195	480	840	1320	2020
7	41	85	167	399	710	1170	1730
8	35	75	140	350	630	1020	1500
9	34	66	130	300	560	910	1350
10	30	60	117	270	500	820	1200

between strips does not exceed 36 inches. Normally, these members are placed underneath a sill, providing they are within the 36-inch span requirement. The requirements for fork-life openings, sling points, and nailing of rubbing strips, are the same as specified for Style A, skid base.

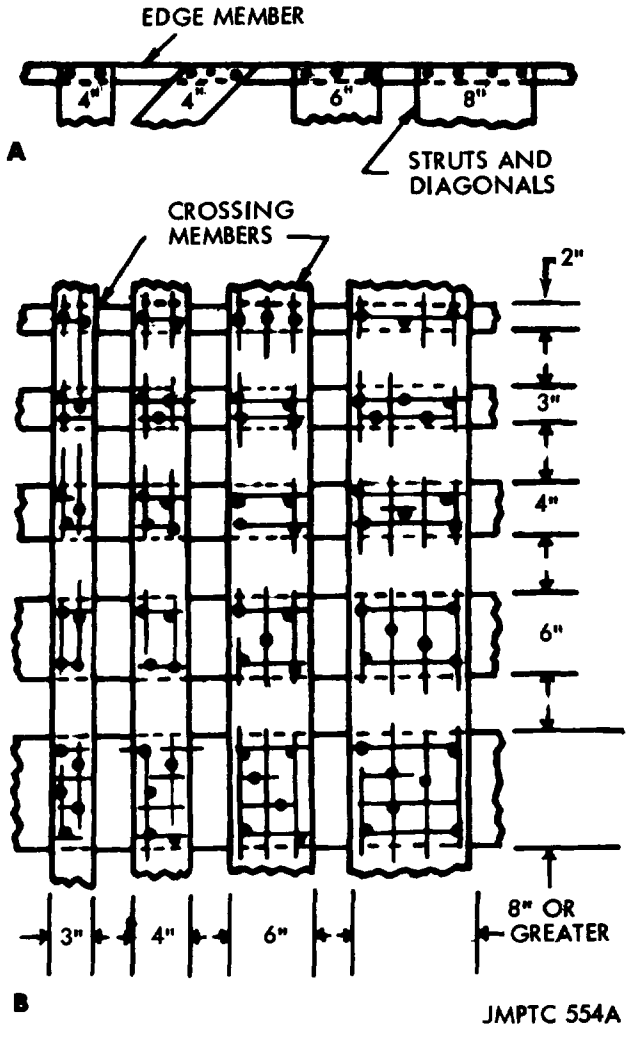


Fig. 6-54 Nailing patterns.

(3) *Sides.* The sides for class 1 (lumber sheathed) crates consist of the upper and lower frame members, vertical struts, diagonals, joist supporters, horizontal braces, liners, gusset plates, and lag bolts reinforcing straps when the crates are bolted (fig 6-55).

(a) Type and number of panels.

1. The types of side panels (A, B, or C) are based on the inside height of the crate (table 6-34).

Table 6-34. Types of Side Panels for Lumber Sheathed Crate (MIL-C-104)

Inside height of crate	Type of panel	Framing pattern
Over 24-60 inches	A	fig 6-5
Over 60-108 inches	B	fig 6-55
Over 108-144 inches	C	fig 6-55

2. The number of panels for each side is computed by dividing the inside crate length by the inside crate height, and using the nearest whole number.

Examples: A crate that is 12 feet long and 9 feet high requires only one type B panel for a full length side. A crate that is 14 feet long and 5 feet high would require three type A panels for a full length side.

(b) Selection of members. Determine the sizes of the upper and lower frame members, struts, and diagonals from tables 6-43 through 6-52. Loads referred to in the tables are based on the net weight of contents and the inside dimensions of the crate. Member sizes are based on group II woods. When using the tables, if the exact size of the crate is not given in the tables, use the member sizes given for the crate of the next longer length, the next greater width, and the next smaller height.

(c) Upper and lower frame members. Upper frame members for crates over 54 inches wide

require 2-inch members. The members must be a minimum of 2 x 4-inch size, except when vertical joist supports are required. These members may be spliced, providing they are spliced over or under a strut. Splicing of the members must be in accordance with the details shown in figure 6-50. Determine the sizes of the upper and lower frame members from tables 6-43 through 6-52.

(d) Vertical struts. Vertical struts must be a single continuous piece from the lower to the upper frame member. Base the size of the end vertical struts on the net load and the type of crate (nailed or bolted) (table 6-35). Determine the intermediate strut sizes from tables 6-43 through 6-52.

Table 6-35. Nominal Size of End Struts for Sides (MIL-C-104)

Net load (lb)	Nailed crate (in.)	Bolted crate (in.)
1,000 or under	2 x 4	2 x 4
Over 1,000 but under 5,000	2 x 4	3 x 3
Over 5,000	2 x 4	4 x 4

(e) Diagonals. The size of diagonals are found in tables 6-43 through 6-52. When frame members are 1-inch lumber and the height is over 36 inches, use gusset plates fabricated from plywood one-fourth of an inch thick, and at least 12 inches in the shortest dimension, at the intersection of the diagonals. The corners of the gusset plates should coincide with the center line of the diagonals (fig 6-56). Secure gusset plates with a minimum of three sevenpenny nails in each member. Clinch nails on the sheathing side.

(f) Horizontal braces. Use horizontal braces only in the construction of Type B and C panels. T hey are the same thickness as the struts and are 4 inches wide.

(g) Joists supports. Use these members in conjunction with the upper frame members of the sides to support the top. When crates are 6 feet wide and 12 feet high, or 8 feet wide and 10 feet high, with struts 1 inch thick, 2 x 4-inch supports are required. Place the supports over the framing under each joist of the top, extending down to the base. Secure them with two tenpenny nails at each horizontal frame member and one tenpenny nail at each diagonal frame member. When securing joist supports, use ninepenny nails on plywood sheathing and tenpenny on lumber sheathing.

(h) Liners (para 6-2i and fig 6-10).

(i) Sheating. Apply the sheathing boards always vertically on the sides and ends on both skid and sill base crates. Extend the boards to the bottom of the skids on skid bases and to the bottom of the sills on sill bases.

1. The sheathing boards may be either tongue-and-groove, square, or Linderman-jointed. Two or more pieces that are Linderman-jointed are considered as one piece (para 3-2*e*(2) and fig 3-11).

2. Boards five-eights of an inch thick may be used for sheathing for net loads less than 300 pounds, and nominal 1-inch for net loads over 300 pounds.

3. Boards must not be less than 4 inches wide and only 10 percent of the boards used (not more than one out of 10 boards) may be of the minimum width.

4. Boards used at the corners must be full length and at least 6 inches wide. At least every second board must be full length also.

5. Short boards, not less than 2 feet long, may be used. Cut the boards at right angles and locate the center of the short boards at the approximate center of the width of a diagonal. Have complete coverage of the diagonal, or join in the center of a horizontal member (fig 6-57). Butt joints are not permitted to be adjacent to each other.

(j) Nailing lumber sheathing. Drive the nails all the way through the sheathing and into the framing members and clinch a minimum of one-fourth of an inch (fig 6-57).

1. Horizontal and diagonal. Use three rows of nails, three nails minimum per board crossing, to secure the sheathing to horizontals and diagonals 4 to 6 inches wide. Use a minimum of four nails in wider boards. Use four rows of nails, four nails minimum per board crossing, to secure sheathing to horizontals and diagonals 4 to 8 inches wide. Use a minimum of five nails in wider boards.

2. Struts. Use two rows of nails for nailing the sheathing to struts 4 to 6 inches wide. Space the nails approximately 8 inches apart in each row in a staggered pattern. Use three rows of nails for nailing the sheathing to struts over 6 inches wide. Space the nails approximately 12 inches apart in each row in a staggered pattern.

3. Gusset plates. Use sevenpenny nails driven from the gusset plates and clinch on the sheathing.

4. Vertical joist supports. Secure the vertical joist supports with tenpenny nails. Use two at each horizontal frame member crossing, one at each diagonal crossing, and two rows of nails, 30 inches on center, where the vertical joists coincide with the struts.

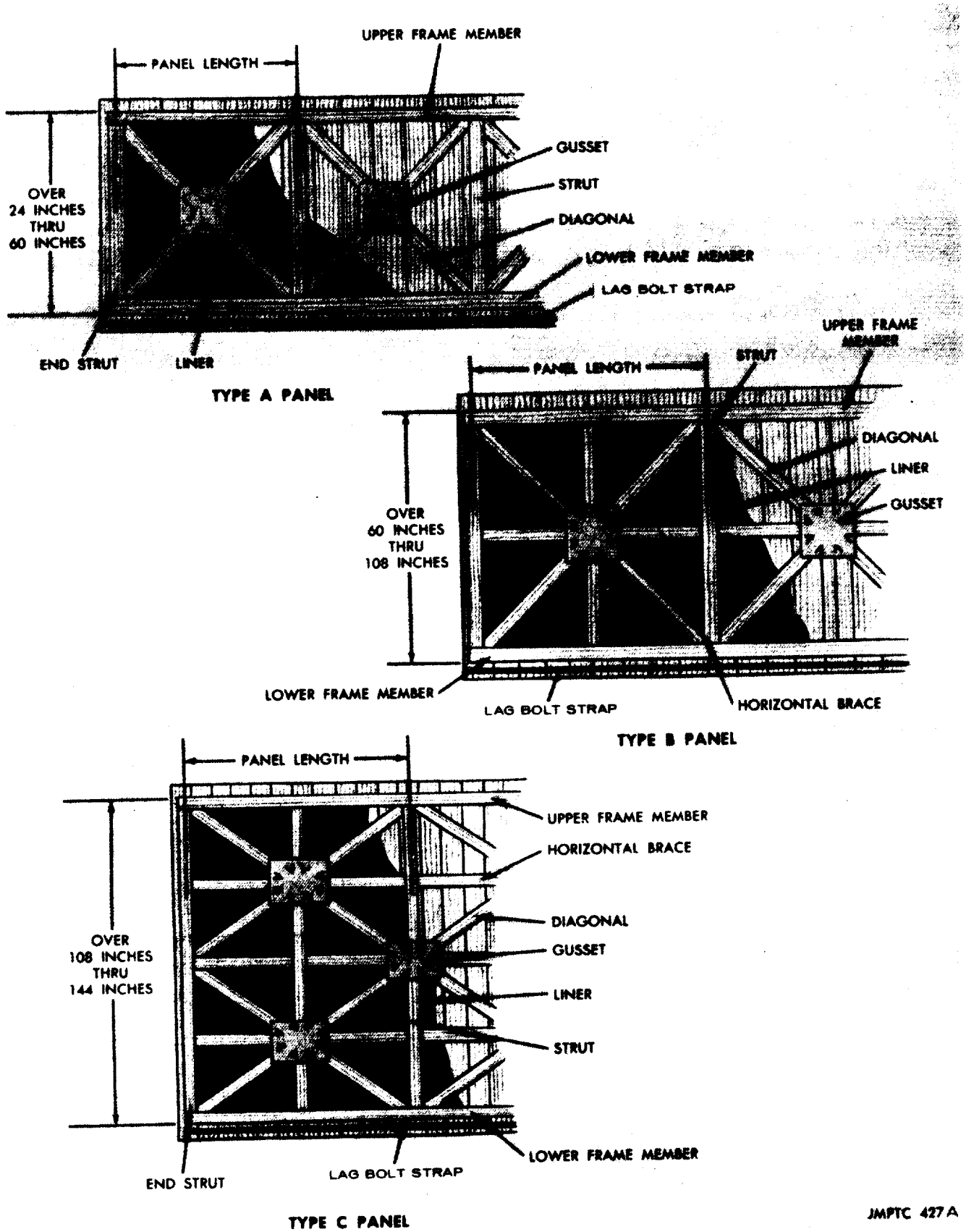
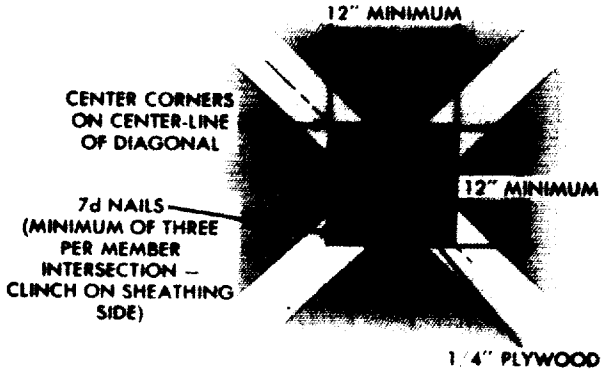
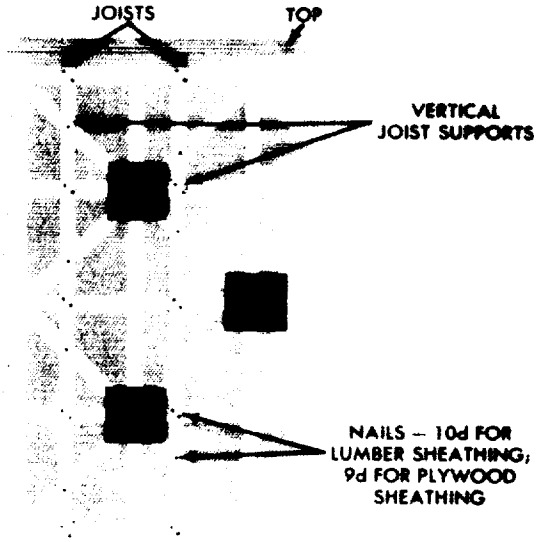


Figure 6-55. Types and number of lumber panels for sides.



PLYWOOD GUSSET PLATE



VERTICAL JOIST SUPPORTS

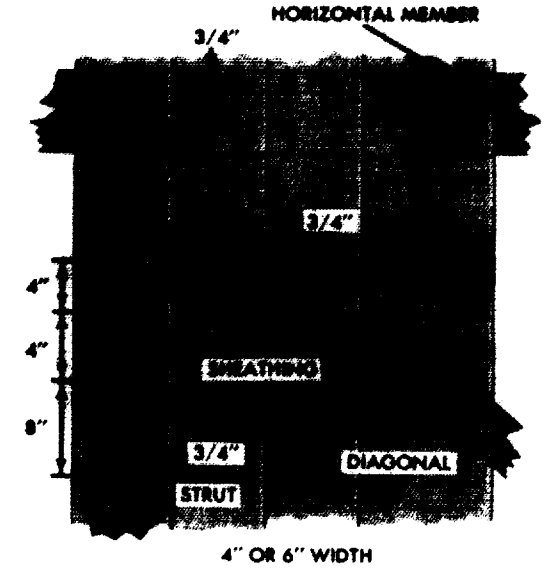
JMPTC 643

Figure 6-56. Joist supports and gusset plates.

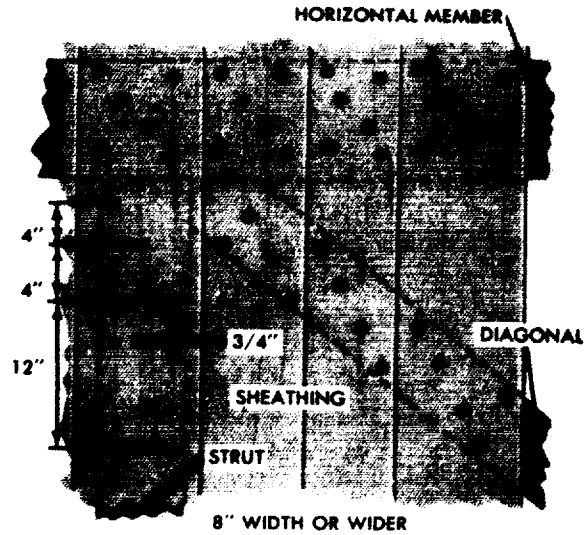
(k) Lag bolt reinforcing straps. Use lag bolt reinforcing straps on all bolted crates as illustrated in figure 6-16. These straps run the full length of each panel on all bolted crates.

1. Nail galvanized steel straps, punched or drilled (1¼ x 0.035-in. strap for ⅜-in. lag bolts and 2 x 0.050-in. strap for ½ and ⅝-in. lag bolts) to the inner face of the sheathing, between the lower edge of the lower frame member and the bottom of the sheathing.

2. Locate the straps to coincide with the center of the skids on the sides and center of the headers on the end. Secure the straps to the sheathing with clout or similar nails and space a maximum of two inches on centers. Clinch the nails at least three-eighths of an inch on the sheathing side.

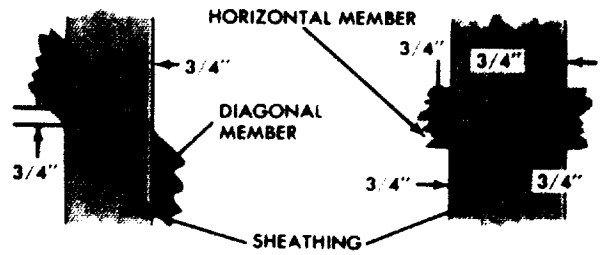


4" OR 6" WIDTH



8" WIDTH OR WIDER

FRAME MEMBER WIDTHS



NOTE: USE 3 NAILS FOR EACH 1" x 4" AND 1" x 6" MEMBER, AND 4 NAILS FOR 1" x 8" MEMBER AND WIDER

BUTT JOINTS
DIAGONALS AND HORIZONTAL MEMBERS

JMPTC 632

Figure 6-57. Fabrication nailing.

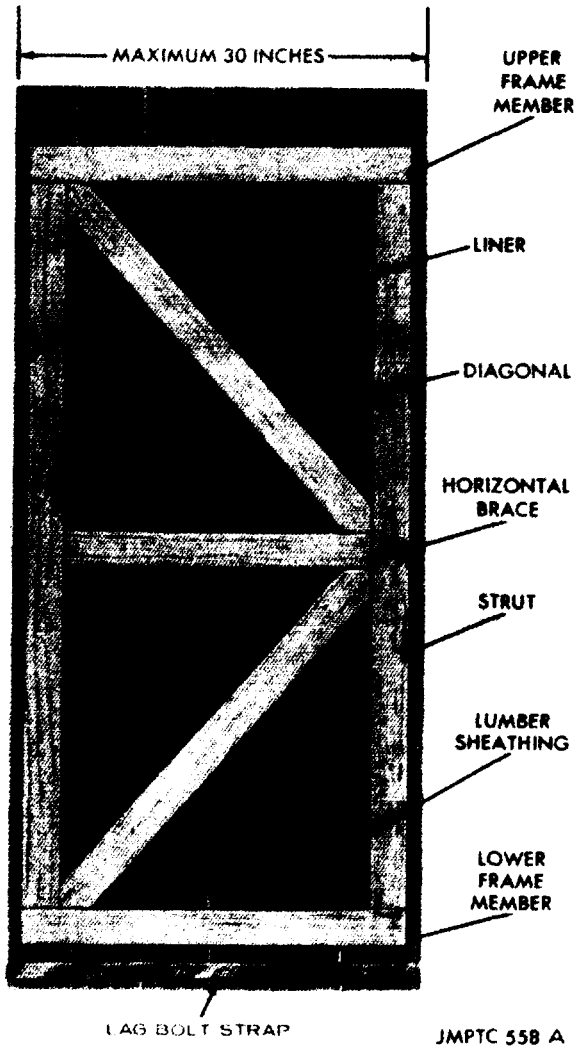


Figure 6-58. Narrow and panel.

(4) *Ends (lumber sheated).* The types of end panels and the size of the framing members for crates over 30 inches wide are determined in the same manner as for the sides. The thickness of the supper and lower edge frame members are always the same as for the struts (tables 6-43 and 6-52 and fig. 6-55). When the crate is less than 30 inches wide, use single diagonals and 1 x 4-inch framing (fig 6-58). The requirements for sheathing, liners, nailing, and the use of lag bolt reinforcing straps for bolted crates are the same as for the sides.

(5) *Tops (lumber and plywood sheathed).* The tops for both lumber and plywood sheathed crates are constructed in the same manner. They consist of framing members and three additional layers of material; a plywood underlayer, roofing felt, and an upper layer of lumber sheathing (fig 6-59). The plywood must be weather-resistant and one-fourth of an inch thick. Place the face grain of the plywood parallel to the width of the top, and flush with the outside of the framing members. Make the joints in the plywood over a joist or other frame members. Apply roofing felt, or polyethylene film not less than 4 mils thick, on the top of the plywood and extend to the outside edges of the framing members a distance equal to the thickness of the side and end sheathing, minus one-eighth of an inch. Overlaps in roofing felt must be at least 4 inches and sealed with nonhardening caulk or mastic compound. Lap the top sheathing boards over the top framing members a distance equal to the thickness of the sheathing minus one-eighth of an inch. Tops for these crates are classified according to the width of the crate (inside measurement from sheathing to sheathing) (table 6-3*b*).

(a) Narrow tops. Frame narrow tops on 2 x 4-inch framing members placed flat. When joints are required in the plywood, use a 2 x 3-inch member on the frame side of the top. Apply top sheathing boards across the width of the crate. When required, place grabhook reinforcing joist to coincide with the center of balance of the loaded crate. Determine the size of the reinforcing joist from table 6-38.

(b) Intermediate tops. Frame intermediate tops on 2 x 4-inch end joists (flat) and 2 x 6-inch intermediate joist (flat). Hold them in place at their ends with ¾- x 2-inch headers. Space intermediate joists as follows: 24 inches from the outer edge of one end joist to the center of the first intermediate joist, and 24 inches (maximum) from center to center on additional intermediate joists.

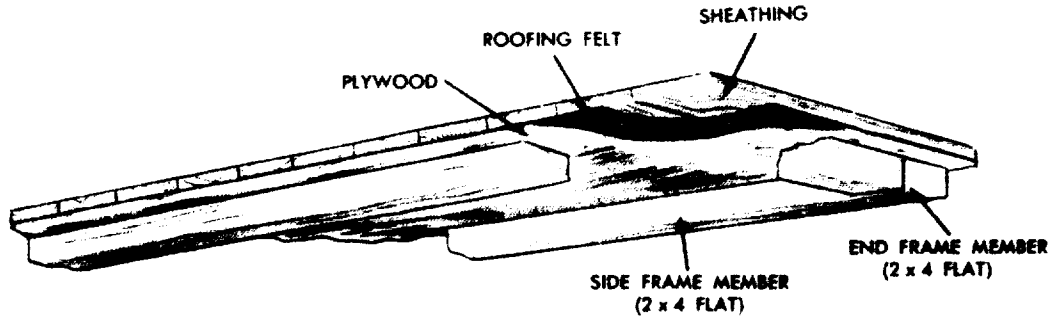
1. Apply top sheathing parallel to the length of the top.

2. For crates over 10 feet long, the sheathing boards may be butt joined over the joists. Joints are not permitted to be adjacent to each other, and not more than one-third of the joints should be made over any one joist.

3. When an intermediate joist does not coincide with the center of balance, select the appropriate size from table 6-38 and place the joist at the center of balance.

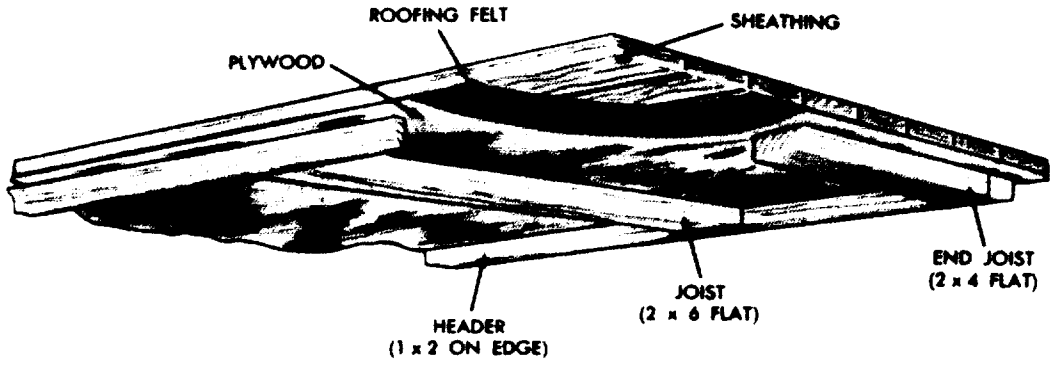
(c) Wide tops. Wide tops are constructed similar to intermediate tops, except the size of joist will vary depending upon the width of the crate. Place all joists on edge and space them not more than 24 inches on center (see table 6-37). Figure 6-59 shows the size of joists for spans of 90 through 120 inches.

1. When joists are given as nominal 2-inch and a nominal 1-inch piece combined, a nominal 3-



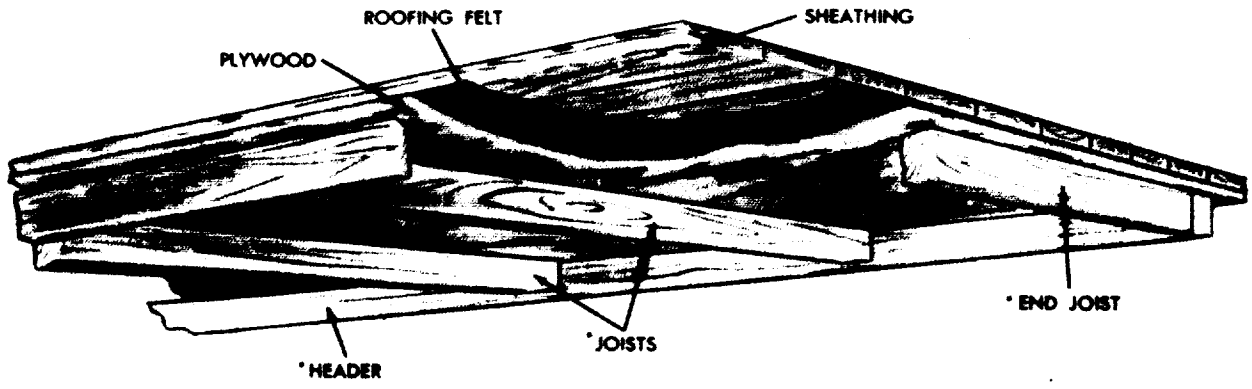
NARROW CRATE TOP

WIDTH UP THRU 54 INCHES



INTERMEDIATE CRATE TOP

WIDTH OVER 54 INCHES THRU 60 INCHES



*SIZE DEPENDS UPON CRATE WIDTH

WIDE CRATE TOP

WIDTH OVER 60 INCHES THRU 120 INCHES

JMPTC 4268

Figure 6-59. Top construction (MIL-C-104).

Table 6-36. Classification of Tops (MIL-C-104)

Width of top (in.)	Kind of top
Up through 54	Narrow
Over 54 through 60	Intermediate
Over 60 through 120	Wide

inch or actual 2⅜-inch of the same depth may be used.

2. A nominal 4-inch piece, or actual 3¼-inch, may be substituted for two 2-inch pieces of the same depth.

3. If joists are not used, or when a joist does not coincide with the center of balance, place a reinforcing joist at the center of balance to distribute the load when the crate is lifted with a single set of grabhooks (table 6-38). When the gross load exceeds 22,000 pounds, or the width exceeds 96 inches for any load over 10,000 pounds, place two 4 x 4-inch joists 2 to 3 feet each way from the center of balance. This arrangement will provide for the use of two sets of grabhooks.

4. When two members 1 and 2 inches thick are nailed together for joists, use sevenpenny nails, with the heads in the thinner piece. If two members are 2 inches thick, use twelvepenny nails to secure the members. Stagger the nails in two rows at least 1 inch from the edges and 18 inches apart in each row.

(d) Alternate plywood sheathed top. For tops not exceeding 96 inches wide, single sheathing of ½-inch-thick plywood may be used rather than the double sheathed top. Face grain of the plywood will be parallel with the width of the top. Framing members and joists will be the same as for double sheathed tops. When joists do not coincide with plywood joints, a joint cover of 1 x 4 inch lumber will be used on the inside of the top. Before the plywood is fastened to the joists or joint cover, a continuous bead of nonhardening caulk is applied between the plywood panels at the butt joint, and between the plywood and joint cover or joist on either side of the butt joint.

b. Fabrication of Lumber Sheathed (Class 1) Crates.

Table 6-37. Size of Joists for Wide Tops (MIL-C-104)

Span	Nominal size (in.)
Over 60 through 66	2 x 4
66 through 78	2 x 4 plus 1 x 4 or [1]3 x 4
78 through 90	2-2 x 4's or [1]4 x 4
90 through 102	2 x 6
102 through 120	2 x 6 plus 1 x 6 or [1]3 x 6

Note. All headers are 3/4 of an inch thick and the same depth as the joists.

[1]End joists are single 2-inch members and the same depth as the joists.

Table 6-38. Grabhook Reinforcing Joist (MIL-C-104)

Size of reinforcing joist (in.)	Gross loads not exceeding (lbs)	Length of joist not exceeding (in.)
2 x 4	1,000	72
2 x 4	2,000	60
2 x 4	3,000	48
2 x 4	5,000	36
4 x 4	10,000	96
4 x 4	15,000	72
4 x 4	22,000	60

(1) *Skid bases (fig 6-11, 6-52, and 6-53).*

(a) Headers to the skids.

1. Place the headers on the skids and set back on the skids a distance equal to the thickness of the sheathing.

2. The clear distance between the skids (center to center) is not more than 48 inches.

3. Determine the bolt size from the size of the skid and the header size.

4. Drill the bolt holes through the headers and skids the same diameter as the bolt shank.

5. Install the carriage bolts, apply the washers and nuts, and tighten the nuts, forcing the square necks of the bolts into the wood.

6. Apply P-1 or P-19 preservative or paint to the threads above the nuts to prevent loosening.

7. Cut the headers to extend between the lower edge members if plywood flooring is used.

8. Install the correct size of carriage bolts crosswise to the grain of the skids, 2 to 3 inches from each end of each skid to prevent splitting.

(b) Loading bearing floorboards to the skids.

1. Place the load bearing floorboards at right angles to the skids.

2. Select the correct size and number of bolts and drill the required holes through the floorboards and skids (table 6-31).

3. Install the carriage bolts, apply washers and nuts, and tighten the nuts to force the square necks of the bolts into the wood.

4. Apply paint or P-1 or P-19 preservative to the threads to prevent the nuts from loosening.

(c) Forklift members to the skids.

1. Use two members of equal size, preferably the size of the header or larger.

2. Place the members at right angles to the skids and space them 20 inches and 40 inches (on center) from the ends of the skids.

3. Select the correct size carriage bolt and drill the holes the same diameter as the shank in each member and skid.

4. Bolt the members to the outer skids, and to

the intermediate skids, if they are used.

(d) Forklift floorboards to the skids.

1. Use 2-inch boards to cover the 42-inch area between the skids when the shape of the item makes the use of forklift members impractical.

2. Space the boards one-fourth inch apart for drainage and nail them to the outer skids with twelvepenny coated nails (fig 6-54).

3. Bolt the floorboards to the intermediate skids with one carriage bolt, using the same size bolt as for the header.

(e) Load bearing floorboards to the skids.

1. Place the load bearing floorboards at right angles to the skids at points where the load will rest.

2. Notch the floorboards or set them back from the edge of the skids (as required for the headers).

3. Use the same size of bolts as used for the headers. Locate and drill the holes through the floorboards and skids.

4. Use one carriage bolt on each end of headers 4 inches wide. For those over 4 inches wide, use two bolts in each end.

5. Install the bolts, washers, and nuts, and tighten.

(f) Nonload bearing floorboards to the skids.

1. Use boards no less than 1 inch thick and not less than 4 inches wide.

2. Position the boards at right angles to the skids and space them one-fourth of an inch apart for drainage.

3. With the ends flush with the outside faces of skids, nail them together using coated nails long enough to penetrate 1½ inches into the skids.

4. Determine the number of nails for securing the floorboards to the skids by adding the width of the two pieces together and dividing the sum by two. Subtract one from the result and this will give the number of nails to use. For example, nailing a board 6 inches wide to a skid 4 inches wide would be: 6 + 4 = 10 ÷ 2 = 5 - 1 = 4. Four nails would be used on each end of the board.

5. Use filler strips 2 inches wide and place over the ends of the floorboards (parallel to the skids) to level the floor. Secure the filler strips with two rows of sixpenny nails in a staggered pattern and space 10 inches apart in each row.

(g) Plywood flooring to the skids.

1. Position the plywood flooring with the face grain at right angles to the length of the skids and the edges flush with the outer edges of the skids.

2. Secure the plywood with two rows of sevenpenny nails staggered 6 inches apart.

3. Use filler strips, when required, and nail the same as lumber flooring.

4. Drill ½-inch holes in the corners of the plywood floored section next to the headers and the forklift members to permit drainage.

5. Place the headers, forklift members, and load bearing members of top of the plywood flooring and bolt to the skids.

(h) Rubbing strips to the skids.

1. Remove the base from the jig and turn skid side up.

2. Cut pieces of 2-inch lumber, the same width as the skids, 8 to 16 inches shorter than the skids, to provide sling notches 4 to 8 inches long at each end of the skids.

3. Forklift openings (when used) are 12 inches long and spaced 28 inches center to center.

4. Position the pieces so the openings straddle the center of balance of the crate with the center pieces no less than 16 inches long. Bevel the ends of all pieces at a 45 degree angle.

5. Nail the pieces to the skids with two rows of twelvepenny nails spaces 12 inches apart in each row. Use a staggered pattern.

(2) *Sill bases (fig 6-10).*

(a) Side sills to the end sills.

1. Place the side sills to overlap the end sills.

2. Nail the side sills to the end sills using three coated nails in each end. The nails must be of sufficient length to penetrate the end grain of the end sill a depth equal to twice the thickness of the side sill.

(b) Intermediate sills to the side sills.

1. Place the intermediate sill in the jig at right angles to, and between the side sills.

2. Install the preformed metal strap hanger (para 6-16*a*(2)(*b*) and fig 6-17).

3. Drive three coated nails through the metal hanger, through the side sill, and into the end grain of the intermediate sill.

4. Nail the metal hanger to the underside of the intermediate sill with four eightpenny coated nails, and to the upper edge of the side with one eightpenny coated nail.

(c) Load bearing headers.

1. Cut the load bearing headers from lumber of the same width as the intermediate sill.

2. Position the load bearing headers at right angles to the intermediate sills and parallel to the side sills.

3. Install the metal hangers on the ends of the load bearing headers, over the intermediate sills.

4. Drive three twentypenny coated nails through the metal hanger, through the intermediate sill, and into the end grain of the load bearing header.

5. Nail the metal hanger to the underside of the load bearing header with four eightpenny coated nails, and to the upper edges of the intermediate sills with one eightpenny coated nail.

(*d*) *Bridging.*

1. Cut 1-inch pieces, the same width or depth as the side sills, to fit between the intermediate sills and the end sills.

2. Position the pieces at the ends of the intermediate sills against the inner faces of the side sill and nail to the side sills with two rows of eightpenny coated nails spaced 12 inches apart in a staggered pattern.

3. Cut 2-inch pieces, the same width or depth as the side sills, to fit between the intermediate sills and the end sills.

4. Position the pieces on edge, every 4 feet along the length of the intermediate sill.

5. Nail through the intermediate sill into the end grain of the bridging using a minimum of three twelvepenny coated nails at each end.

(*e*) *Bottom sheathing.*

1. Remove the sill frame from the jig and turn bottom side up.

2. Position the bottom sheathing at right angles to the length of the side sills, with the ends flush with the outside edge of the sills and spaced one-fourth of an inch apart for drainage.

3. Nail the bottom sheathing to the sills and bridging (para 6-16*a*(2)(*e*) and fig 6-54).

(*f*) *Rubbing strips.*

1. Cut the rubbing strips from 2-inch lumber not less than 4 inches wide and 8 to 16 inches shorter than the crates. Bevel the ends at a 45° angle.

2. Position the rubbing strips lengthwise to the crate, under each lengthwise member.

3. Adjust the location of the pieces to provide 4- to 8-inch notches at each end of the crate.

4. Use an intermediate rubbing strip when the clear distance between strips exceeds 36 inches.

5. Nail the rubbing strips to the bottom sheathing and the frame members with two rows of twlevepenny coated nails, spaced 12 inches apart in each row.

(3) *Side panels.*

(*a*) Position the precut frame members in a temporary jig in the proper relationship to each other and unroll Specification PPP-B-1055 barrier material. Type E-2, C-2, or L-2, horizontally over the frame members (para 6-2*i*).

(*b*) Arrange the sheathing boards in place over the frame members with the dressed side of the board on the outside (fig 6-57).

(*c*) Use a chalk line to snap a centerline on the top of sheathing over each frame member. If preferred, snap a line on top of the sheathing over the two edges of each frame member.

(*d*) Use nails long enough to penetrate the sheathing and framing and clinch one-fourth inch. Bright (uncoated) nails may be used (para 6-16*a*(3)(*j*) and fig 6-57).

(*e*) Attach the vertical joist supports to the frame members (when required).

1. Remove the panel from the jig and turn the panel over.

2. Cut the pieces to the proper size to extend from the upper edge of the upper frame member to the lower edge of the lower frame member.

3. Locate these pieces along the upper and lower frame members, at right angles to the upper frame member at points where the top joist will bear.

4. Nail the joist supports to each horizontal member with two tenpenny nails and clinch. Nail to each diagonal with one clinched tenpenny nail.

5. When joist supports coincide with the struts, use two rows of tenpenny nails spaced 30 inches apart.

(*f*) Attach the lag bolt reinforcing strap (when required).

1. Locate the strap on the side sheathing near the lower edge panel, at the center line of the skids (para 6-16*a*(3)(*k*) and fig 6-16).

2. Nail the strap to the sheathing with clout nails, spaces 2 inches apart, and clinch a minimum of three-eights inch on the outside of the sheathing.

(*g*) Attach the gusset plates (when required) (fig 6-56). Nail through the gusset plate, frame members, and sheathing, with sevenpenny nails and clinch. Use at least three nails in each member.

(*h*) Install crate ventilation (table 6-30, para 6-15*d*(1) and (2) and fig 6-49).

1. *Cluster of holes and baffle.* Locate the area for the holes and drill a cluster of 3/4-inch diameter holes on 2-inch centers. Clean the chips and barrier material away from the hole, then cut a baffle from a piece of 1/4-inch plywood or metal, large enough to cover the holes. Nail a 2 x 2-inch batten below and on the sides of the holes, using

Table 6-39. Assembly Nailing of Nailed Crate (MIL-C-104)[1]

Fasten		Nail size and spacing		Notes
Part	To part	Lumber sheathing	Plywood sheathing	
Sheathing of side and end.	Skid and end header (skid base).	Eightpenny minimum size 3-inch maximum spacing.	Sevenpenny minimum size 3-inch maximum spacing.	See table 6-40 for number of nails required.
	End and side sills (sill base).	Two rows up to 4 x 4 skids Three rows for 4 x 6 skid (on edge). Three rows for all sill bases.	Two rows up to 4 x 4 skids Three rows for 4 x 6 skid (on edge). Three rows for all sill bases.	
Corner strut of end	Corner strut of side	Twentypenny-predrill 12-inch spacing.	Twelvepenny 12-inch spacing.	Predrill holdes for twentypenny nails, 75 percent of shank diameter.
Sheathing of side --	Corner strut of end	Eightpenny minimum size 6- to 8-inch spacing.	Sevenpenny minimum size 6- to 8-inch spacing.	

[1] For fastening top to sides and ends use strapping in paragraph 6-2*h* and illustrated in figure 6-15.

sevenpenny nails. Finally, nail the baffle to the battens using sevenpenny nails.

2. Holes around the perimeter. Drill 3/4-inch diameter holes 2 inches below the upper frame member spaced evenly around the perimeter of the crate. Drill the holes from the inside out, at a 45° angle to drain outward, then clean the chips and the barrier material from the holes.

3. Horizontal slots. Cut the slots one to four inches wide and not over 12 inches long. Cover the opening with 1/4 or 3/8-inch mesh screen cloth and tack or staple hardware cloth in place. Cut from 1/4-inch plywood or metal a piece of material large enough to cover the area of the slot. Nail a 2 x 2-inch batten below and on each side of the slot, using sevenpenny nails. Nail the baffle plate to the battens using sevenpenny nails.

(4) *End panels.* The end panels are constructed in the same manner as the sides. Refer to figure 6-55 if the end is over 30 inches wide and figure 6-56 if the end is 30 inches or less (para 6-16*b*(3)).

(5) *Tops (para 6-16a(5) and fig 6-59).*

(*a*) *Positioning the frame members.* Position the precut top frame members in a temporary jig in the correct relation to each other.

1. Narrow tops. Lay the 2 x 4-inch members flat, with the end frame members inside the side frame members.

2. Intermediate tops. Nail the headers to the joists, positioned on their wide faces, with twelvepenny coated nails spaced 2 inches on center. Nail through the headers into the end grain of the top joists.

3. Wide tops. Nail the headers to the joists, positioned on edge, with twelvepenny coated nails. Use two nails for 2 x 4's and three nails for 2 x 6's. Nail through the headers into the end grain of the top joists.

(*b*) *Plywood to the top frame members.* Place a sheet of 1/4-inch of the required plywood over the frame members, with the face grain parallel with the width of the top. Nail the plywood on at least three edges to the frame members with fivepenny coated nails spaced eight inches apart. When joints are required, make them over the frame members or the joists.

(*c*) *Application of the roofing felt.* Roofing felt, conforming to Specification SS-R-501, should be applied over the plywood and should overlap the edges and ends by a distance equal to the thickness of the end or side sheathing less 1/8 inch. There should be a minimum 4-inch tape with mastic when a joint is necessary.

(*d*) *Attachment to the top sheathing boards.*

1. Narrow tops. Place the sheathing boards parallel to the width of the top. Nail the sheathing through the plywood to the framing with eightpenny coated nails spaced 3 inches apart.

2. Intermediate and wide tops. Place the sheathing boards lengthwise to the top and nail the same as for narrow tops.

c. Assembly of Lumber Sheathes (Class 1) Crates.

(1) *Nailed crates.* Type I (nailed) crates are assembled with coated or etched nails and metal straps (table 6-39 and fig 6-60).

(*a*) *Fastening the sheathing around the perimeter of the base.* The number of nails to be used for fastening the sheathing around the perimeter of the base is based on each 1,000 pounds of gross weight and the wood group used (table 6-40).

Table 6-40. Number of Nails per Each 1,000 Pounds Gross Load for Nailing Sheathing to Base Around Perimeter of Nailed Crate (MIL-C-104)

Type of nail	Size of nail	Wood group of skid		
		II	III	IV
Sinker or cooler	7d	23	26	19
	8d or 9d	19	21	16
	10d	18	19	14
	12d	15	16	12
Corker	7d	24	26	19
	8d or 9d	17	19	14
	12d	15	16	12
	12d	15	16	12

Note. Nails shall not be less than 2 per board (lumber sheathing) and shall be not less than 1-1/2 inches apart nor more than 3 inches apart.

(b) Fastening of the tops to the sides and ends. The tops are fastened to the sides and ends with corner straps and to the sides with tension straps held by anchor plates (fig 6-15). Fabricate the corner straps long enough to permit nailing into the frame members of the sides and ends.

(2) *Bolted crates.* Type II (bolted) crates are assembled with lag bolts or nut sleeve assemblies and metal straps (fig 6-14 and 6-60).

(a) Fastening the sides and ends to base using lag bolt reinforcing straps. The size of lag bolts is based upon the gross weight of crate and the size of the skids (table 6-41). Use half the total number on each side and space them evenly along the length of the skids (fig 6-16).

(b) Fastening the sides to the top. Use ⅜-inch lag bolts 3½ inches long for fastening the sides to the top (fig 6-61).

1. Place the lag bolts in the end of each joist, as near the center of the joist as possible.

2. For tops without joists, place the lag bolts at the approximate center of the side frame members of the top and space not more than 24 inches apart.

(c) Fastening of the ends to the top, sides, and bases. Use ⅜-inch lag bolts, 2½ inches long for fastening the ends to the top, and the ends to the sides (fig 6-64).

6-17. Plywood Sheathed (Class 2) Crates (MIL-C-104)

a. Design Requirements. Plywood sheathed crates may be constructed of either nailed or bolted assembly.

(1) *Bases.* The construction of bases for plywood sheathed (class 2) crates will adhere to the same requirements for lumber sheathed (class 1) crates (para 6-16*a*(1) and (2) and fig 6-10 and 6-11).

Table 6-41. Lag Bolts Required to Assemble Sides to Base of Bolted Crates Using Lag Bolt Reinforcing Strap Skids to Group II, III, or IV Woods (MIL-C-104)

Weight of crate and contents (lb)	Size and number of lag bolts[1]		
	3/8 x 3-inch (3 x 3 or 3 x 4-inch skids)	1/2 x 4-inch (4 x 4-inch skids)	5/8 x 4-inch (4 x 6-inch skids)
2,000	6	6	6
3,000	10	6	6
4,000	14	8	6
6,000	20	12	8
8,000	.....	16	10
10,000	.....	18	12
12,000	.....	22	14
14,000	.....	26	16
16,000	.....	30	18
18,000	.....	32	22
20,000	.....	36	24
24,000	.....	.....	28
28,000	.....	.....	32
32,000	.....	.....	36
36,000	.....	.....	42
40,000	.....	.....	46

[1]Use one-half the number on each side:
Maximum spacing—3/8 x 3—16 inches on center
1/2 x 4—20 inches on center
5/8 x 4—20 inches on center
Minimum number—three per side, two per end.

(2) *Sides.* The sides of plywood sheathed (class 2) crates consist of upper and lower frame members, vertical struts, horizontal braces, joist supports, and lag screw reinforcing straps, when the crate is of bolted assembly construction.

(a) Type and number of panels. Determine the type of side panels from the side height of the crate. The number of panels depends upon the length of the crate (table 6-42 and fig 6-62).

(b) Selection of members. Calculate the requirements for the upper and lower frame members in the same manner as for lumber sheathed crates (see para 6-16*a*(3) *(b)* and tables 6-35 and 6-43 through 6-52 for the sizes).

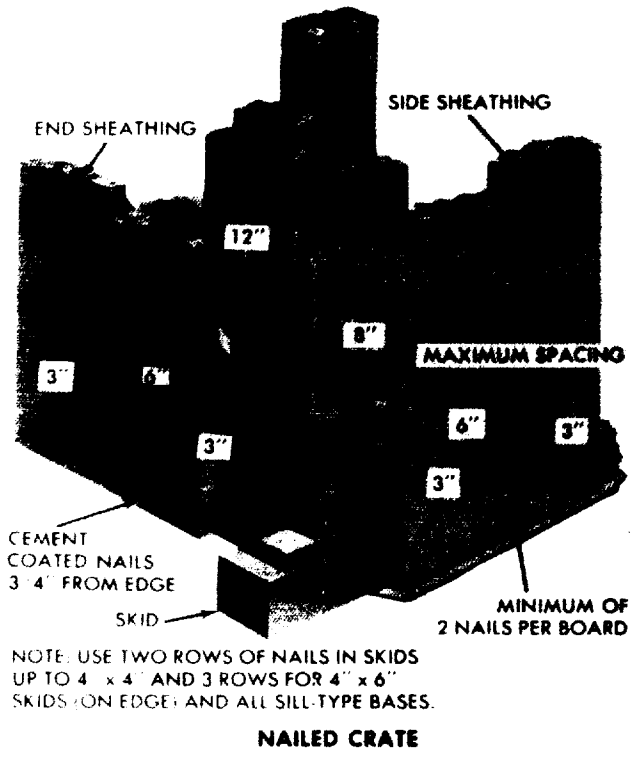
1. Diagonals. Diagonals are not required for plywood sheathed crates.

2. Horizontal braces. Horizontal braces for type B and C panels are the same thickness as the struts and are four inches wide.

3. Joist supports, (para. 6-16a(3) (g)and fig 6-56).

(c) Liners. Liners are not required for plywood sheathed crates.

(d) Sheathing. Use ¼-inch plywood sheathing for net loads up to 300 pounds: ⅜-inch for net loads up to 10,000 pounds; and ½-inch for net loads over 10,000 pounds. Apply plywood with the face grain vertically. When specified, the face grain may be placed horizontally on crates 4 feet



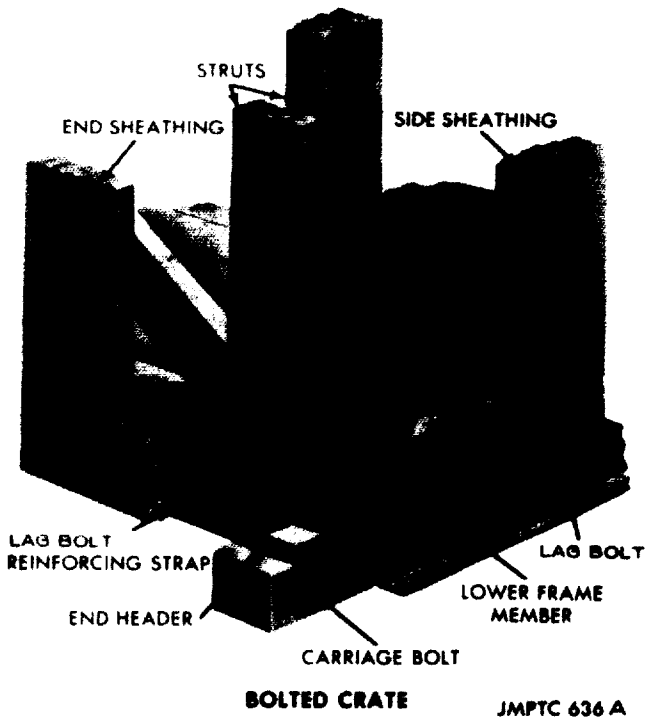
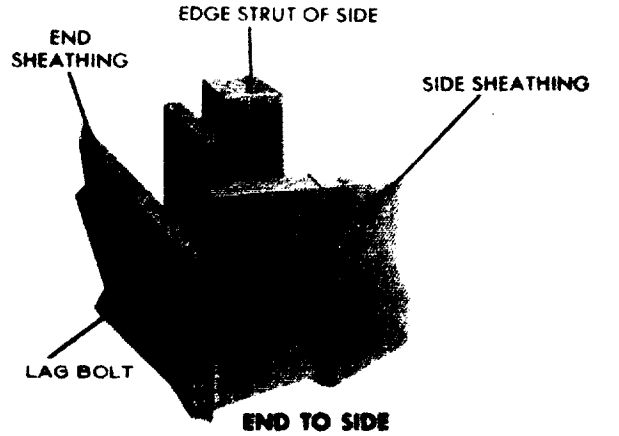
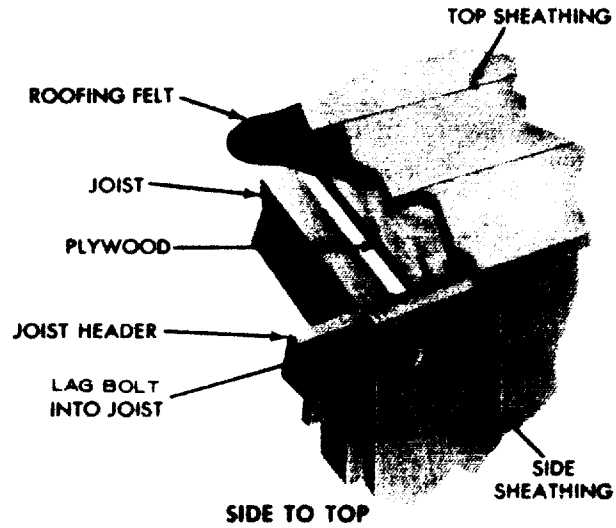


Figure 6-60. Detail view of lower corners of nailed and bolted crates.





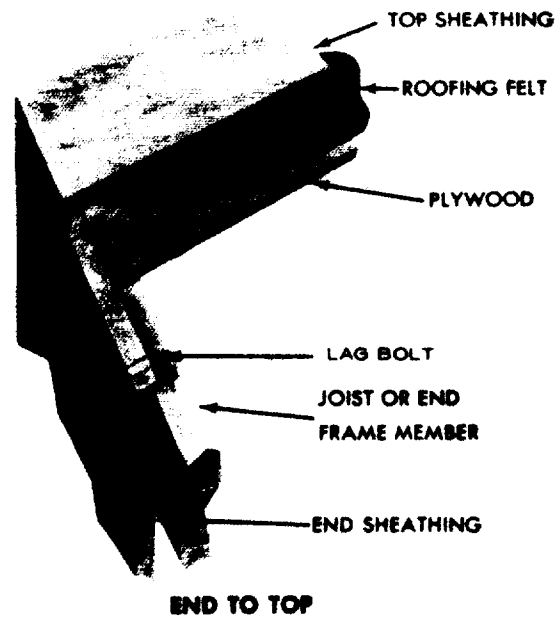


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Figure 6-61. Detail assembly of bolted crate.

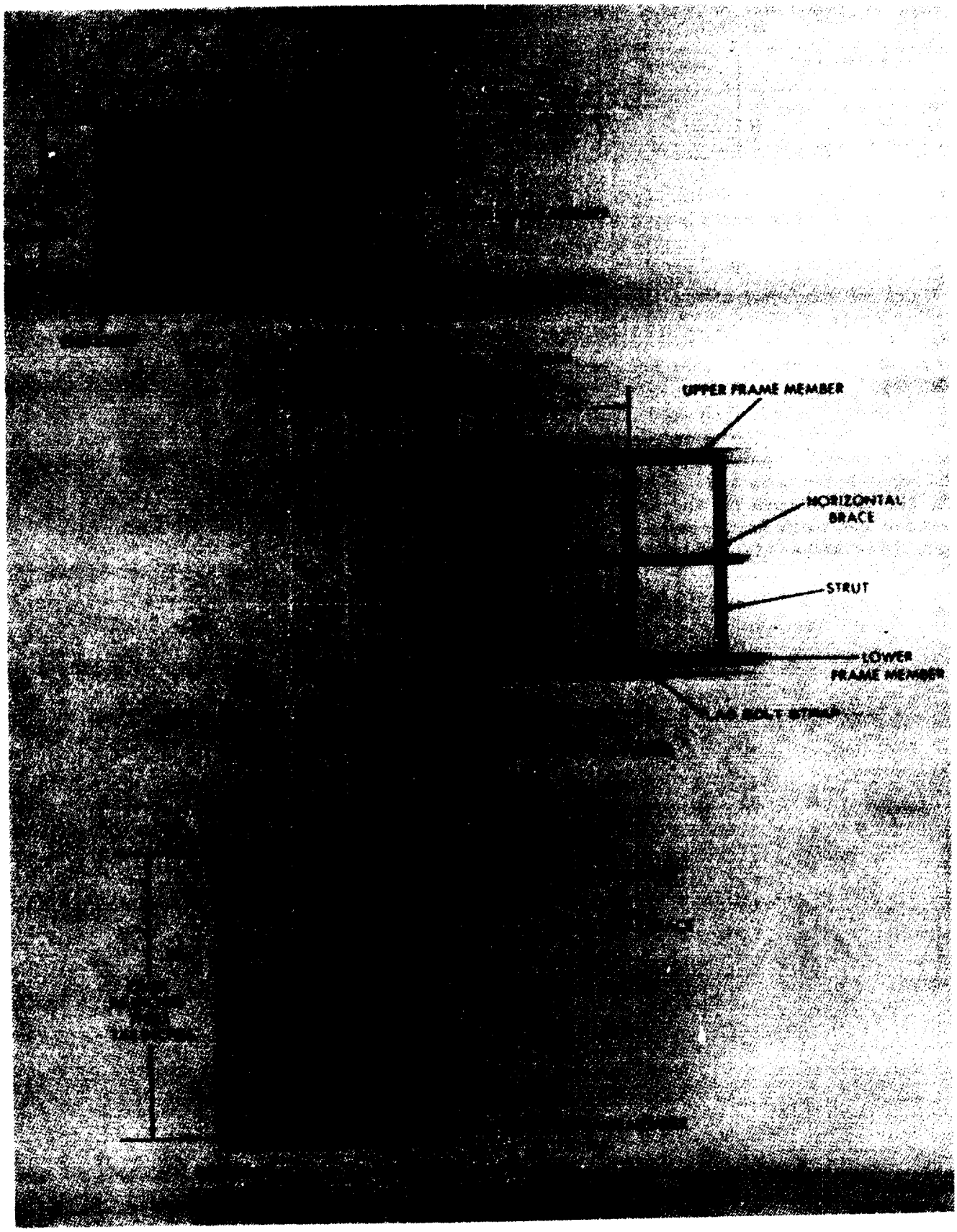

Figure 6-62. Type and number of plywood panels.

Table 6-42. Type of Panels for Plywood Sheathed Crates (MIL-C-104)

Inside height of crate	Type of panel	Framing pattern
Over 24-60 inches inches	A	Fig 6-62
Over 60-96 inches	B	Fig 6-62
Over 96-144 inches	C	Fig 6-62

or less in height. Horizontal joints in plywood sheathing are not permitted in type A side panels; not desirable, but permitted in type B panels; and shall be permitted in type C panels.

e. Lag bolt reinforcing straps. Use lag bolt reinforcing straps on all bolted (demountable) crates (fig 6-16). These straps should extend the full length of each panel of the sides and ends (para 6-16*a*(3)(*k*).

(3) *Ends.* The ends of plywood sheathed (Class 2) crates consists of the same members as indicated for sides. Compute the type and number of end panels in the same way as for the sides (fig 6-62). The requirements for the upper and lower members and struts are the same as for the sides (para 6-16*a*(3) (*c*) and (*d*) and tables 6-35 and 6-43 through 6-52).

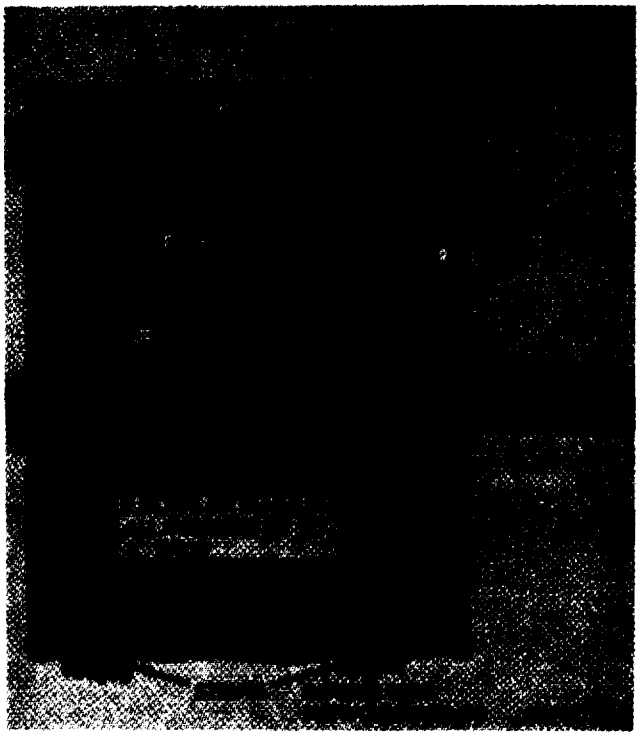

Figure 6-63. Fabrication nailing (plywood sheathing).

Figure 6-64. Assembly of the bolted crate.

b. Fabrication of Plywood Sheathed (Class 2) Crates. Secure the sheathing to the framing members with nails driven through the plywood into the framing members (fig 6-63). Use a nail long enough to allow a minimum 1/2-inch clinch. For nailing joist supports, refer to paragraph 6-16*a*(3)(*j*) and use ninepenny nails as illustrated in figure 6-56.

c. Assembly of Plywood Sheathed (Class 2) Crates.

(1) *Nailed assembly.* Assemble plywood sheathed nailed crates in the same manner as lumber sheathed (class 1) crates (para 6-16*c*(1) and fig 6-60). Nail sizes are specified in table 6-39.

(2) *Bolted assembly.* Assemble plywood sheathed bolted crates in the same manner as lumber sheathed (Class 1) Type II (bolted) crates (para 6-16*c*(2) and fig 6-60, 6-61, and 6-64).

6-18. Crate, Slotted Angle, Steel or Aluminum (MIL-C-9897)

a. Design Requirements. The slotted angle crate is designed to permit rapid fabrication of a crate through assembly of slotted angle steel or aluminum with nuts, bolts, and lockwashers and disassembly and reuse of component material.

b. Classification. The following classifications have been established for this crate (fig 6-8):

(1) *Types.*

(*a*) *Type I*—crate, slotted angle, steel or aluminum, open.

(*b*) *Type II*—crate, slotted angle, steel or aluminum, fully inclosed or sheathed with solid material.

(2) *Styles.*

(*a*) *Style A*—crate, slotted, angle, steel, or aluminum, without skids or rubbing strips.

(*b*) *Style B*—crate, slotted angle, steel, with skid blocks or skids with rubbing strips and provisions for forklift truck handling.

(3) *Grades.*

(*a*) *Grade 1.* Crate for domestic and oversea shipments intended for outside or indeterminate storage.

(*b*) *Grade 2.* Crate for domestic and oversea shipments intended for inside or protected storage.

c. Use. These crates are suitable for—

(1) Packing lightweight, bulky items, including airframe components.

(2) Oversea and domestic air and surface shipments.

(3) Packing items requiring rigid blocking and bracing assemblies, such as support panels, cushioned saddles, solid and slat cradles, specially designed brackets, yoke panel assemblies, etc.

(4) Adaptation of suspension systems or shock mounts for shock absorption.

(5) Packing repairable, returnable items where a desirable light-weight, reusable container is specified.

d. Materials.

(1) *Slotted metal angles.*

(*a*) This material comes in either steel or aluminum. There are three different sizes of slotted metal angles, variations being based on the size of the flanges and the thickness of the metal used in fabricating the angles. The slotted angle material shall conform to Specification MIL-S-21041, use table 6-35 as a guide for the selection of slotted angle based on size of crate and weight of load.

(*b*) Steel slotted angle material for Grade 1 crates shall have a zinc protective coating. Steel slotted angle material for Grade 2 crates shall be treated with a primer or a phosphatized base and a baked-on synthetic enamel of high grade commercial quality. The color shall be DOD Gray, unless otherwise specified, in accordance with Federal Standard 595.

(*c*) The hole pattern for the 1 1/2-inch by 1 1/2-inch angle shall be of such a design as to provide one line of holes or slots in each flange. The 1 1/2-inch by 2 1/4-inch angle shall have one line of holes or slots in the narrow flange and two lines of holes or slots in the wide flange. The 1 1/2-inch by 3-inch angle shall have one line of holes or slots in the narrow flange and three lines of holes or slots in the wide flange. The hole patten shall be of continual repetition and shall be visually indexed at 3-inch intervals.

(*d*) Occasionally, it may be necessary to splice pieces. When this occurrs, either the lap or butt splice may be made. The bolting pattern shown in figure 6-65 will be followed, when possible, in making the splices.

(2) *Bolts and nuts.*

(*a*) Bolts and nuts used in joining slotted angle frame members of the crate shall conform to Specification MIL-S-21041, except that nuts shall conform to MS51922 with the exception that 5/16 nuts shall be .551 to .564 inches across the flats.

(*b*) Bolts and nuts used in attaching sheathing and wood members of the crate (and any wood blocking and bracing therein) shall be

Table 6-43. Panel Member Selection Table for 1,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)						Height (ft)[1]						Height (ft)[1]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
6	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
8	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
10	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
12	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
16	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	2x4	----	1x6	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
20	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	2x4	----	1x6	----	1x8	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	1x6
	Upper frame member	(2)	----	----	----	----	----	(2)	----	----	----	----	----	(2)	----	----	----	----	2x4	(2)	----	----	----	2x4	2x4
24	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	1x6	----	----	----	1x6	----	1x6	----	2x4	----	1x6	----	1x8	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	1x6
	Upper frame member	(2)	----	----	----	----	----	(2)	----	----	----	----	----	(2)	----	----	----	----	2x4	(2)	----	----	2x4	2x4	2x4
28	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	1x6	----	----	----	1x6	----	1x8	----	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	1x6	----	----	----	2x4	1x6	1x4
	Upper frame member	(2)	----	----	----	----	----	(2)	----	----	----	----	----	(2)	----	----	2x4	----	2x4	(2)	1x6	----	2x4	2x4	2x4
32	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	1x6	----	----	----	1x6	----	2x4	----	2x4	----	1x6	1x6	2x4	2x4	2x4
	Diagonal	----	----	1x6	----	----	----	----	----	----	1x6	----	1x6	----	----	----	2x4	----	2x4	----	----	----	2x4	1x6	2x4

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-44. Panel Member Selection for 2,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)						Height (ft)[1]						Height (ft)[1]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
8	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
10	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	----
12	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	----
16	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	2x4	----	1x6	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	1x6
20	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	2x4	----	2x6	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	1x6	----	----	----	2x4	----	1x6
24	Upper frame member	(2)	----	----	----	----	----	(2)	----	----	----	----	----	(2)	1x6	----	2x4	----	2x4	(2)	1x6	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x
	Struts	----	----	----	----	----	----	----	----	----	1x6	----	----	----	1x6	----	2x4	----	2x4	----	2x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	1x6	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	2x4	2x4
28	Upper frame member	(2)	----	----	----	----	----	(2)	----	----	----	----	----	(2)	1x6	----	2x4	----	2x4	(2)	1x6	1x6	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	1x6	----	----	----	1x6	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	1x6	----	1x6	----	----	----	2x4	----	2x4	----	----	----	2x4	1x6	2x4
32	Upper frame member	(2)	1x6	----	----	2x4	----	(2)	1x6	----	2x4	----	----	(2)	1x6	1x6	2x4	----	2x4	(2)	2x4	1x6	2x4	2x4	2x4
	Lower frame member	----	----	----	----	2x4	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	2x4	----	----	----	----	2x4	----	----	----	1x6	----	2x4	----	2x4	----	1x6	1x6	2x4	2x4	2x4
	Diagonal	----	----	----	----	2x4	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	2x4	----	----	1x6	2x4	2x4	2x4

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-45. Panel Member Selection Table for 4,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)						Height (ft)[1]						Height (ft)[1]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1x6	----	----
8	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	2x4	2x4
	Diagonal	----	----	----	----	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	1x6
10	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	1x6	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	----
12	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	----	----	----	----	2x4	----	1x6
16	Upper frame member	1x6	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	----	1x6
	Diagonal	----	----	----	1x6	----	----	----	----	----	1x6	----	----	2x4	----	----	2x4	----	2x4	2x6	----	----	2x4	2x4	2x4
20	Upper frame member	1x6	----	----	----	----	----	1x6	----	----	----	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	1x6	----	----	(2)	1x6	1x6	2x4	----	2x4	(2)	1x6	1x6	2x4	2x4	2x4
24	Upper frame member	(2)	1x6	----	----	----	----	(2)	1x6	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	----	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	2x4	----	1x6	(2)	1x6	1x6	2x4	----	2x4	(2)	1x6	1x6	2x4	2x4	2x4
28	Upper frame member	(2)	1x6	----	----	----	----	(2)	1x6	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	----	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	2x4	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	2x4	----	----	----	1x6	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	2x4	----	----	1x6	2x4	2x4	2x4
32	Upper frame member	(2)	2x4	----	2x4	----	----	(2)	2x4	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	1x6	----	2x4	----	2x4	----	1x6	1x6	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	2x4	----	1x6	1x6	2x4	1x6	2x4	----	----	1x6	2x4	2x4	2x6

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-46. Pound Member Selection Table for 6,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)						Height (ft)[2]						Height (ft)[2]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	1x6	----	----	----	----	----	1x6	----	----	----	----	----	1x6	----	2x4	----	----	----	2x4	----	----
8	Upper frame member	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	----	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	1x6	----	1x6	----	----	----	2x4	----	1x6	----	----	1x6	2x4	----	1x6	----	----	1x6	2x4	----	2x4
10	Upper frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	----	1x6	----	----	----	2x4	2x4	2x4
12	Upper frame member	1x6	----	----	2x4	----	----	1x6	----	----	2x4	----	----	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	1x6	----	----	1x6	2x4	1x6	2x4
16	Upper frame member	2x6	----	----	2x4	----	----	2x6	----	----	2x4	----	----	2x6	----	----	2x4	----	2x4	2x6	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	1x6	----	----	1x6	2x4	1x6	2x4
20	Upper frame member	2x6	1x6	----	2x4	----	----	2x6	1x6	----	2x4	----	----	2x6	1x6	----	2x4	----	2x4	2x6	1x6		----	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	1x6	1x6	----	----	----	2x4	1x6	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	1x6	----	----	1x6	2x4	----	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4
24	Upper frame member	(2)	2x4	1x6	2x4	----	----	(2)	2x4	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	2x4	2x4	(2)	2x6	1x6	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	1x6	2x4	----	1x6	----	2x4	2x4	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	2x4	2x4	----	----	1x6	2x4	2x4	2x4
28	Upper frame member	(2)	2x4	1x6	2x4	----	----	(2)	2x4	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	2x4	2x4	(2)	2x6	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	1x6	----	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	2x4	wx4	----	----	2x4	2x4	2x4	2x6
32	Upper frame member	(2)	2x6	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	----	2x4	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x6	----	1x6	2x4	2x6	2x6	2x6

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-47. Panel Member Selection for 8,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)[1]						Height (ft)[1]						Height (ft)[1]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	----	1x6	----	----	1x6	2x4	1x6	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4
8	Upper frame member	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	----	2x4	1x6	----	2x4	2x4	----	2x4	1x6	----	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	----	2x4	----	----	1x6	2x4	----	2x4	----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	----	2x4
10	Upper frame member	1x6	----	----	2x4	----	----	1x6	----	----	2x4	----	----	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	1x6	----	----	----	2x4	1x6	2x4	----	----	----	2x4	2x4	2x4
	Diagonal	----	----	----	2x4	----	1x6	----	----	1x6	2x4	----	1x6	----	----	1x6	2x4	1x6	1x6	----	----	2x4	2x4	1x6	2x4
12	Upper frame member	2x6	----	----	2x4	----	----	2x6	----	----	2x4	----	2x4	2x6	----	----	2x4	----	2x4	2x6	----	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	1x6	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	1x6	2x4	----	----	1x6	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x4
16	Upper frame member	2x6	----	----	2x4	----	----	2x6	1x6	----	2x4	----	2x4	2x6	1x6	----	2x4	----	2x4	2x6	1x6	2x4	1x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	----	----	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	1x6	2x4	----	----	----	2x4	1x6	2x4	----	1x6	----	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	1x6	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	1x6	1x6	2x4	2x4	2x4
20	Upper frame member	2x8	1x6	----	2x4	----	----	2x8	1x6	----	2x4	----	1x6	2x8	1x6	2x4	2x4	2x4	2x4	2x8	2x4	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	----	----	----	----	2x4	----	----	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	----	----	----	----	2x4	1x6	1x6	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	1x6	----	----	1x6	2x4	1x6	1x6	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x6
24	Upper frame member	(2)	2x6	1x6	2x4	----	2x4	(2)	2x6	1x6	2x4	2x4	2x4	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	1x6	2x4	----	----	----	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x6
	Diagonal	----	----	1x6	2x4	1x6	2x4	----	1x6	1x6	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x6	2x6	2x6
28	Upper frame member	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x6	2x4	1x6	1x6	(2)	2x6	2x6	2x6	2x4	2x4
	Lower frame member	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x6	----	1x6	2x4	2x4	2x4	2x6	----	1x6	2x4	2x6	2x6	2x6
32	Upper frame member	(2)	2x8	1x6	2x4	----	2x4	(2)	2x8	2x6	2x4	2x4	2x4	(2)	2x8	2x6	2x6	2x4	2x4	(2)	2x8	2x6	2x6	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x6	2x6	2x6	----	1x6	2x4	2x6	2x6	2x6

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-48. Panel Member selection Table for 10,000 Pounds, Net Load (MIL-C-104)

Length (ft)	Members	4 ft width						6ft width						8 ft width						10 ft width					
		Height (ft)						Height (ft)[1]						Height (ft)[1]						Height (ft)					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	1x6	2x4	2x4	1x6	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	----	2x4	2x4	1x6	2x4	----	1x6	2x4	2x4	2x4	2x4
8	Upper frame member	1x6	----	2x4	2x4	----	2x4	1x6	----	2x4	2x4	----	2x4	1x6	----	2x4	2x4	----	2x4	1x6	----	2x4	2x4	2x4	2x4
	Lower frame member	----	----	2x4	2x4	----	2x4			2x4				----	----	2x4	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	2x4	2x4	1x6	2x4	----	----	2x4	2x4	1x6	2x4	----	1x6	2x4	2x4	1x6	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	2x4	2x4	1x6	2x4	1x6	1x6	2x4	2x4	1x6	2x4	1x6	1x6	2x4	2x4	1x6	2x4	1x6	1x6	2x4	2x4	1x6	2x6
10	Upper frame member	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	----	2x4	1x6	----	----	2x4	----	2x4	2x4	1x6	----	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	----	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	----	1x6	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	1x6	2x4	1x6	2x4	1x6	1x6	1x6	2x6	1x6	2x4	1x6	1x6	1x6	2x6	1x6	2x4	1x6	1x6	2x4	2x6	2x4	2x4
12	Upper frame member	2x6	----	----	2x4	----	2x4	2x6	----	2x4	2x4	2x4	2x4	2x6	----	2x4	2x4	2x4	2x4	2x6	----	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	2x4	----	----	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	1x6	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	1x6	2x4	1x6	2x4	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x4	2x4	2x4
16	Upper frame member	2x8	1x6	----	2x4	----	2x4	2x8	1x6	2x4	2x4	2x4	2x4	2x8	1x6	2x4	2x4	2x4	2x4	2x8	1x6	2x4	2x4	2x4	2x4
	Lower frame member	----	----	----	2x4	----	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4
	Struts	----	----	----	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4
	Diagonal	1x6	1x6	1x6	2x4	1x6	2x4	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x6	2x4	2x4	1x6	1x6	2x4	2x6	2x6	2x4
20	Upper frame member	2x10	2x4	2x4	2x4	----	2x4	2x10	2x6	2x4	2x4	2x4	2x4	2x10	2x6	2x4	2x4	2x4	2x4	2x10	2x6	2x4	2x4	2x4	2x4
	Lower frame member	1x6	----	2x4	2x4	----	2x4	1x6	----	2x4	2x4	2x4	2x4	1x6	----	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Struts	----	----	2x4	2x4	1x6	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x6
	Diagonal	1x6	1x6	2x4	2x4	1x6	2x4	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x6	2x4	2x6	1x6	2x4	2x4	2x6	2x6	2x6
	Upper frame member	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x6	2x4	2x4	2x4	(2)	2x6	2x6	2x4	2x4	2x4	(2)	2x8	2x6	2x4	2x4	2x4
	Lower frame member	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4
	Struts	----	----	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x6	2x6	----	2x4	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x6	2x6	2x6		----	1x6	2x4	2x6	2x6	2x6	----	2x4	2x4	2x6	2x6	2x6
	Upper frame member	(2)	2x6	2x4	2x4	2x4	2x4	(2)	2x6	2x6	2x4	2x4	2x4	(2)	2x8	2x6	2x6	2x4	2x4	(2)	2x8	2x6	2x6	2x6	2x4
	Lower frame member	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4
	Struts	----	----	2x4	2x4	2x4	2x4	----	----	ts4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x6	2x6	2x6	----	2x4	2x4	2x6	2x6	2x6	----	2x4	2x4	2x6	2x6	2x6
	Upper frame member	(2)	2x8	2x6	2x6	2x4	2x4	(2)	2x6	2x6	2x6	2x4	2x4	(2)	2x10	2x6	2x6	2x4	2x4	(2)	2x10	2x6	2x6	2x4	2x4
	Lower frame member	----	----	2x4	2x4	2x4	2x4	----	----	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4
	Struts	----	1x6	2x4	2x4	2x4	2x4	----	1x6	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	----	2x4	2x4	2x4	2x4	2x4	2x4
	Diagonal	----	1x6	2x4	2x6	2x4	2x6	----	1x6	2x4	2x6	2x6	2x6	----	2x4	2x4	2x6	2x6	2x6	----	2x4	2x6	2x6	2x6	2x6

[1]Crates 12 feet high in 6-foot widths and crates 10 feet high in 8-foot widths require 2x4 vertical joist supports when struts are 1 inch thick; all other sizes use horizontal joist supports.

[2]Crates require special design.

Note. All blank spaces are 1x4's.

Table 6-49. Panel Member Selection Table for 15,000 Pounds, Net Load[1] (MIL-C-104)

Length (ft)	Members	4 ft width Height (ft)					6 ft width Height (ft)[1]					8 ft width Height (ft)[1]					10 ft width Height (ft)				
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
6	Upper frame member																				
	Lower frame member																				
	Struts														2x6	2x6			2x6	2x6	2x6
	Diagonal			(*)	2x6	2x6			(*)	2x6	2x6		(*)	(*)	2x6	2x6		(*)	(*)	2x6	2x6
8	Upper frame member																				
	Lower frame member																				
	Struts									(*)	2x6			(*)	2x6	2x6		(*)	2x6	2x6	2x6
	Diagonal		(*)	2x6		2x6		(*)	2x6		2x6		(*)	2x6		2x6		(*)	2x6	(*)	2x6
10	Upper frame member																				
	Lower frame member																				
	Struts								(*)	2x6	2x6			2x6	2x6	2x6		2x6	2x6	2x6	2x6
	Diagonal		2x6	2x6	(*)			2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6
12	Upper frame member																				
	Lower frame member																				
	Struts					2x6			2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6
													2x6	2x6	2x6	2x6	(*)	2x6	2x6	2x6	2x6
16	Upper frame member											2x6					2x6				
	Lower frame member																				
	Struts				2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6
	Diagonal			2x6	2x6	2x6			2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
20	Upper frame member	2x6					2x6					2x6					2x6				
	Lower frame member																				
	Struts				2x6	2x6				2x6	2x6				2x6	2x6				2x6	2x6
	Diagonal		2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
24	Upper frame member	**2x6	(*)				**2x6	2x6				**2x6	2x6	2x6	2x6		**2x6	2x6	2x6	2x6	2x6
	Lower frame member																				
	Struts				2x6	2x6				2x6	2x6		(*)		2x6	2x6		(*)		2x6	2x6
	Diagonal		2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
28	Upper frame member	**2x6	2x6	(*)			**2x6	2x6	2x6			*2x8	2x6	2x6	2x6		*2x8	2x6	2x6	2x6	2x6
	Lower frame member																				
	Struts								(*)					(*)					(*)		
	Diagonal		(*)	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8
32	Upper frame member	**2x8	2x6	2x6			**2x8	*2x6	*2x6			**2x8	*2x6	*2x6	2x6	(*)	**2x8	*2x6	*2x6	2x6	2x6
	Lower frame member	(*)					(*)					(*)					(*)				
	Struts								(*)					(*)			(*)		(*)		
	Diagonal	(*)	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x8	2x8	2x8

[1] The above are for uniform loads, but apply also to concentrated loads except where an asterisk is shown. Where one asterisk is shown, increase the member size to the next larger size as a blank (standing for a 2x4) to a 2x6, a 2x6 to a 2x8, etc., and where two asterisks are shown increase the member size to the second larger size as a 2x6 to a 2x10 or a 2x8 to a 2x12.

Note. All blank spaces are 2x4's.

Table 6-50. Panel Member Selection Table for 20,000 Pounds, Net Load[1] (MIL-C-104)

Length (ft)	Members	4 ft width					6 ft width					8 ft width					10 ft width				
		Height (ft)					Height (ft)[1]					Height (ft)[1]					Height (ft)				
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
6	Upper frame member																				
	Lower frame member																				
	Struts	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
	Diagonal	2x6	2x6	2x6	2x6	*2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6
							(*)	(4)				2x6	2x6				2x6	2x6			
	Struts				2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
	Diagonal				2x6	*2x6	2x6	2x6	2x6	2x6	2x8	2x6	*2x6	2x8	2x6	2x8	2x6	2x8	2x8	2x6	2x8
	Upper frame member	2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6		
10	Lower frame member																				
	Struts		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6
	Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6
	Upper frame member	2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6		
12	Lower frame member																				
	Struts		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6
	Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	*2x6	2x6	2x6	2x6	2x6	2x8	*2x6
	Upper frame member	2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6		2x6	2x6	2x6	2x6	
16	Lower frame member																				
	Struts	(*)		2x6	2x6	2x6	(*)		2x6	2x6	2x6	(*)		2x6	2x6	2x6	(*)		2x6	2x6	2x8
	Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x8	2x6	2x6	2x6	2x8	2x8	2x6
	Upper frame member	*2x6	2x6	2x6	2x6	2x6	*2x6	2x6	2x6	2x6	2x6	*2x6	2x6	2x6	2x6	2x6	*2x6	2x6	2x6	2x6	2x6
20	Lower frame member																				
	Struts				2x6	2x6				2x6	2x6				2x6	2x8				2x8	2x8
	Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x8	2x6	2x6	2x8	2x8	2x8
	Upper frame member	**2x8	*2x6	2x6	2x6	2x6	**2x8	*2x6	2x6	2x6	2x6	*2x8	*2x6	2x6	2x6	2x6	**2x8	*2x6	2x6	2x6	2x6
24	Lower frame member						(*)					(*)					(*)				
	Struts	(*)	(*)		2x6	2x6	(*)	(*)		2x6	2x6	(*)	(*)		2x6	2x8	(*)	(*)		2x8	2x8
	Diagonal	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x8	*2x6	2x6	2x6	2x8	2x8	2x8	2x6	2x6	2x8	2x8	2x8
	Upper frame member	**2x8	*2x6	*2x6	2x6	2x6	**2x8	*2x6	*2x6	2x6	2x6	*2x6	*2x6	*2x6	2x6	2x6	**2x8	*2x6	*2x6	2x6	2x6
28	Lower frame member						(*)					(*)					(*)				
	Struts			(*)					(*)					(*)					(*)		
	Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x8	2x8	2x6	2x6	2x8	2x8	2x8	2x6	2x6	2x8	2x8	2x8
	Upper frame member	2x10	*2x6	*2x6	2x6	2x6	2x10	2x8	*2x6	2x6	2x6	2x10	*2x8	**2x6	2x6	2x6	2x10	*2x8	*2x8	2x6	2x6
32	Lower frame member																				
	Struts			(*)					(*)					(*)					(*)		
	Diagonal	2x6	2x6	2x8	2x6	*2x6	2x6	2x6	2x8	2x8	2x8	2x6	2x8	2x8	2x8	2x8	2x6	2x8	2x8	2x8	*2x8

[1] The above sizes are for uniform loads, but apply also to concentrated loads except where an asterisk is shown. Where one asterisk is shown, increase the member size to the next larger size as a blank (standing for a 2x4) to a 2x6, a 2x6 to a 2x8, etc., and where two asterisks are shown increase the member size to the second larger size as a 2x6 to a 2x10 or a 2x8 to a 2x12. Where figure appear in bold faced type, a special design is required for a concentrated load.

Note. All blank spaces are 2x4's.

Table 6-51. Panel Member Selection Table for 25,000 Pounds, Net Load[1] (MIL-C-104)

Length (ft)	Members	4 ft width					6 ft width					8 ft width					10 ft width				
		Height (ft)					Height (ft)[1]					Height (ft)[1]					Height (ft)				
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
	Upper frame member	2x6	2x6	----	----	----	2x6	2x6	----	----	----	2x6	2x6	----	----	----	----	2x6	2x6	----	----
6	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x8	2x8	2x8	2x6	2x6	2x8	2x8	2x8
	Diagonal	2x6	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x6	2x8	2x8	2x8	2x8	2x6	2x8	2x8	2x8	2x8
	Upper frame member	2x6	2x6	(*)	----	----	2x6	2x6	(*)	----	----	2x6	2x6	(*)	----	----	2x6	2x6	(*)	----	----
8	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x8	2x6	*2x6	2x8	2x8	2x8	2x6	2x8	2x8	2x8	2x8
	Diagonal	2x6	2x8	2x8	2x6	2x8	2x6	2x8	2x8	2x6	2x8	2x6	2x8	2x8	2x8	2x8	2x6	2x8	2x8	2x6	2x10
	Upper frame member	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----
10	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	----	2x6	2x6	*2x6	2x8	----	2x6	2x8	2x8	2x8	----	2x8	2x8	2x8	2x8	----	2x8	2x8	2x8	2x8
	Diagonal	2x6	2x6	*2x8	2x6	2x6	2x6	2x6	*2x8	2x8	2x8	2x6	2x6	*2x8	2x8	2x8	2x8	2x8	*2x8	2x8	2x8
	Upper frame member	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----	2x6	2x6	2x6	----	----
12	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	----	*2x6	2x6	2x8	2x8	----	*2x6	2x8	2x8	2x8	----	2x8	2x8	2x8	2x8	----	2x8	2x8	2x8	2x8
	Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x8	2x8	2x8	2x8	*2x6	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8
	Upper frame member	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6
16	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	(*)	----	2x8	2x8	2x8	(*)	----	2x8	2x8	2x8	(*)	----	2x8	2x8	2x8	(*)	----	2x8	2x8	2x8
	Diagonal	2x6	2x6	2x8	2x8	2x8	2x6	2x6	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x10	2x8	2x8
	Upper frame member	*2x8	2x6	2x6	2x6	2x6	*2x8	2x6	2x6	2x6	2x6	*2x8	2x6	2x6	2x6	2x6	*2x8	2x6	2x6	2x6	2x6
20	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	----	----	----	2x8	2x8	----	----	----	2x8	2x8	----	----	----	2x8	2x8	----	----	----	2x8	2x8
	Diagonal	2x6	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8
	Upper frame member	2x8	**2x6	2x6	2x6	2x6	2x10	*2x8	2x8	2x8	2x6	2x10	*2x8	2x8	2x8	2x6	2x10	*2x8	2x8	2x8	2x6
24	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	----	(*)	----	2x8	2x8	----	(*)	----	2x8	2x8	----	(**)	----	2x8	2x8	----	(**)	----	2x8	----
	Diagonal	2x6	2x8	2x8	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x10	2x8	2x10	2x8	2x10	2x10	2x10
	Upper frame member	2x10	*2x8	*2x6	2x6	2x6	2x10	*2x8	*2x8	2x8	2x6	2x10	*2x8	*2x8	2x8	2x6	2x8	*2x8	*2x8	2x8	2x6
28	Lower frame member	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	Struts	----	----	(*)	----	----	----	----	(**)	----	----	----	----	(**)	----	2x6	----	----	(**)	2x6	2x6
	Diagonal	2x8	2x8	2x8	*2x6	2x8	2x8	2x8	2x8	*2x6	2x8	2x8	2x8	2x10	*2x6	2x8	2x8	2x8	2x10	*2x8	2x10
	Upper frame member	2x12	*2x8	*2x8	2x6	2x6	2x12	*2x8	*2x8	2x8	2x6	2x12	*2x8	*2x8	2x8	2x6	2x12	2x10	*2x8	2x8	2x6
32	Lower frame member	2x6	----	----	----	----	2x6	----	----	----	----	2x6	----	----	----	----	2x6	----	----	----	----
	Struts	----	----	(**)	----	----	----	----	(**)	----	----	----	----	(**)	----	2x6	----	----	(**)	2x6	2x6
	Diagonal	2x8	2x8	*2x8	2x8	2x8	2x8	2x8	2x10	2x8	*2x8	2x8	2x8	2x10	2x10	2x10	2x8	2x8	2x10	2x10	2x10

[1] The above sizes are for uniform loads, but apply also to concentrated loads except where an asterisk is shown. Where one asterisk is shown, increase the member size to the next larger size as a blank (standing for a 2x4) to a 2x6, a 2x6 to a 2x8, etc., and where two asterisks are shown increase the member size to the second larger size as a 2x6 to a 2x10 or a 2x8 to a 2x10. Where figures appear in bold faced type, a special design is required for a concentrated load.

Note. All blank spaces are 2x4's.

Table 6-52. Panel Member Selection Table for 30,000 Pounds, Net Load[1] (MIL-C-104)

Length (ft)	Members	4 ft width					6 ft width					8 ft width					10 ft width				
		Height (ft)					Height (ft)[1]					Height (ft)[1]					Height (ft)				
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
	Upper frame member	2x6	2x6				2x6	2x6	(*)			2x6	2x6	2x6			2x6	2x6	2x6		
6	Lower frame member																				
	Struts	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8
	Diagonal	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x10
	Upper frame member	2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6		
8	Lower frame member																				
	Struts	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8
	Diagonal	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x8	2x10	2x8	2x10	2x10	2x8	2x10
	Upper frame member	2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6		
10	Lower frame member																				
	Struts		2x8	2x10	2x8	2x8		2x8	2x10	2x8	2x8		2x8	2x10	2x8	2x8		2x8	2x10	2x8	2x8
	Diagonal	2x6	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x8	2x8
	Upper frame member	2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6			2x6	2x6	2x6		
12	Lower frame member																				
	Struts		2x8	2x7	2x8	2x8		2x8	2x8	2x8	2x8		2x8	2x8	2x8	2x8		2x8	2x8	2x8	2x8
	Diagonal	2x8	2x8	2x8	2x10	2x10	2x8	2x8	2x8	2x10	2x10	2x8	2x8	2x10	2x10	2x10	2x8	2x8	2x10	2x10	2x10
	Upper frame member	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6	2x8	2x6	2x6	2x6	2x6
16	Lower frame member																				
	Struts	(**)		2x10	2x8	2x8	(**)		2x10	2x8	2x8	(**)		2x10	2x8	2x8	(**)		2x10	2x10	2x10
	Diagonal	2x8	2x8	2x10	2x8	2x8	2x8	2x8	2x10	2x10	2x8	2x8	2x8	2x10	2x10	*2x8	2x8	2x8	2x10	2x10	2x10
	Upper frame member	**2x8	2x8	2x6	2x6	2x6	**2x8	2x8	2x6	2x6	2x6	**2x8	2x8	2x6	2x6	2x6	*2x10	2x10	2x6	2x6	2x6
20	Lower frame member											(*)					(*)				
	Struts				2x8	2x8				2x8	2x8			2x6	2x8	2x10			2x6	2x10	2x10
	Diagonal	2x8	2x8	2x10	2x8	*2x8	2x8	2x10	2x10	2x8	2x10	2x8	2x10	2x10	2x10	2x10	2x8	*2x10	2x10	2x10	2x10
	Upper frame member	2x10	*2x8	2x8	2x8	2x6	2x10	**2x8	2x8	2x8	2x6						2x10	**2x8	2x8	2x8	2x8
24	Lower frame member							(*)				2x10	**2x8	2x8	2x8	2x8		(*)			
	Struts		(**)	(*)	2x8	2x8		(**)	(*)	2x8	2x10		*2x6	2x6	2x10	2x10		*2x6	2x6	2x10	2x10
	Diagonal	2x8	2x8	2x10	2x10	2x10	2x8	2x8	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10
	Upper frame member	2x12	*2x8	*2x8	2x8	2x6	2x12	*2x10	*2x8	2x8	2x6	2x12	*2x10	*2x8	2x8	2x8	2x12	*2x10	*2x8	2x8	2x8
28	Lower frame member	2x6					2x6	(*)				2x6	(*)				2x6	(*)			
	Struts			(**)		2x6			*2x6	2x6	2x6		2x6	*2x6	2x6	2x6		2x6	*2x6	2x6	2x6
	Diagonal	2x8	2x8	2x10	2x10	2x10	2x8	2x8	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10
	Upper frame member	2x12	*2x10	*2x8	*2x6	2x6	2x8	*2x10	*2x8	2x8	2x8	2x12	*2x10	2x10	2x8	2x12	2x12	*2x10	2x10	2x8	2x8
32	Lower frame member	2x6	(*)	(*)			2x12	(*)	(*)			2x8	(*)	(*)			2x8	(*)	(*)		
	Struts			(**)	2x6	2x6			2x6	2x6	2x6		2x6	*2x6	2x6	2x6		2x6	*2x6	2x6	2x6
	Diagonal	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x10	2x10	2x10	2x8	2x10	2x12	2x10	2x12

[1] The above sizes are for uniform loads, but apply also to concentrated loads except where an asterisk is shown. Where one asterisk is shown, increase the member size to the next larger size as a blank (standing for a 2x4) to a 2x6, a 2x6 to a 2x8, etc., and where two asterisks are shown increase the member size to the second larger size as a 2x6 to a 2x10 or a 2x8 to a 2x12.

Note. All blank spaces are 2x4's.

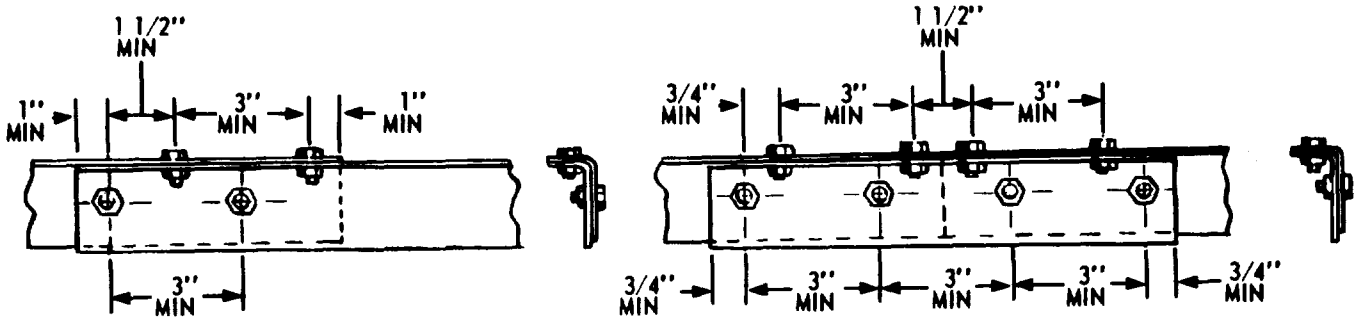

Figure 6-65. Methods of splicing.

zinccoated and shall conform to Specification FF-B-584 or FF-B-575.

(3) *Wood components* Skids, skid blocks, rubbing strips, load-bearing members, filler strips etc., should be made of Group II, III, or IV wood, meeting the requirements of Military Standard MIL-STD-731 and treated in accordance with TT-W-571.

(4) *Plywood.* The plywood used shall conform to Specification NN-P-530. Plywood for Grade 2 crates shall conform to PS-51, Type II, Grade 3-4 or PS-1 standard and be treated with wood preservatives in accordance with TT-W-571.

(5) *Paper-overlaid veneer.* Paper-overlaid veneer used for sheathing and covering shall conform to type II as specified in Specification PPP-V-205.

(6) *Fiberboard.* Fiberboard for sheathing and covering crates shall conform to Specification PPP-F-320, type SF class weather-resistant, grades V2s, V3s, or V4s.

(7) *Steel strapping.* Steel strapping used for either banding or tension braces should conform to type I finish B of Specification QQ-S-781.

e. Assembly.

(1) *General.*

(*a*) *Diagonal bracing.* Using slotted angle, full diagonal bracing should extend from one corner to the diagonally opposite corner, being cut on an angle on the ends to permit maximum contact of flanges. Corner braces, when used, should be placed in each corner. Diagonal and corner braces should be installed at an angle of 45° or as close to that angle as possible. A minimum of one bolt should be used at each end of a brace. Flat steel strapping, not less than 1¼-inch wide and 0.032 inch thick, may be used for bracing in lieu of slotted angle steel or aluminum when it is adequate to the bracing requirements or where frame members, vertical or horizontal, side or end panel, prevent the use of the slotted angle.

(*b*) *Joints.*

1. Corner joints formed by the upper and lower horizontal crate members for the sides and ends with the vertical crate members at the ends should be bolted together as shown in figure 6-66.

2. Intermediate vertical members (struts), upper and lower horizontal members, and upper and lower intermediate lateral members should be bolted together to effect the joints as shown in figure 6-67.

3. When additional members are added for the purpose of using shock or vibration mounts, the joints formed with other crate members should be formed by using a minimum of two bolts in the wide flange and one in the narrow flange. Short pieces of slotted angle steel or aluminum may be necessary to effect this type of joint (fig 6-67 and 6-68).

(*c*) *Bolting.* When bolting metal portions of the crate together consideration should be given to the maximum utilization of round holes in the metal angle. All bolts and nuts shall be drawn tight by the assembler and the nuts shall be secured against loosening by the use of lockwashers or locknuts. Self-locking nuts or serrated nuts of the type described in *d*(2)(*a*) above may be used in lieu of lockwashers or locknuts.

(*d*) *Sheathing.* Plywood; paper-over-laid veneer, or fiberboard may be used for sheathing of Type II crates. Figure 6-69 shows methods which may be employed in sheathing or covering crates. Figure 6-70 shows methods of attaching sheathing to slotted metal angle. Sheathing should be

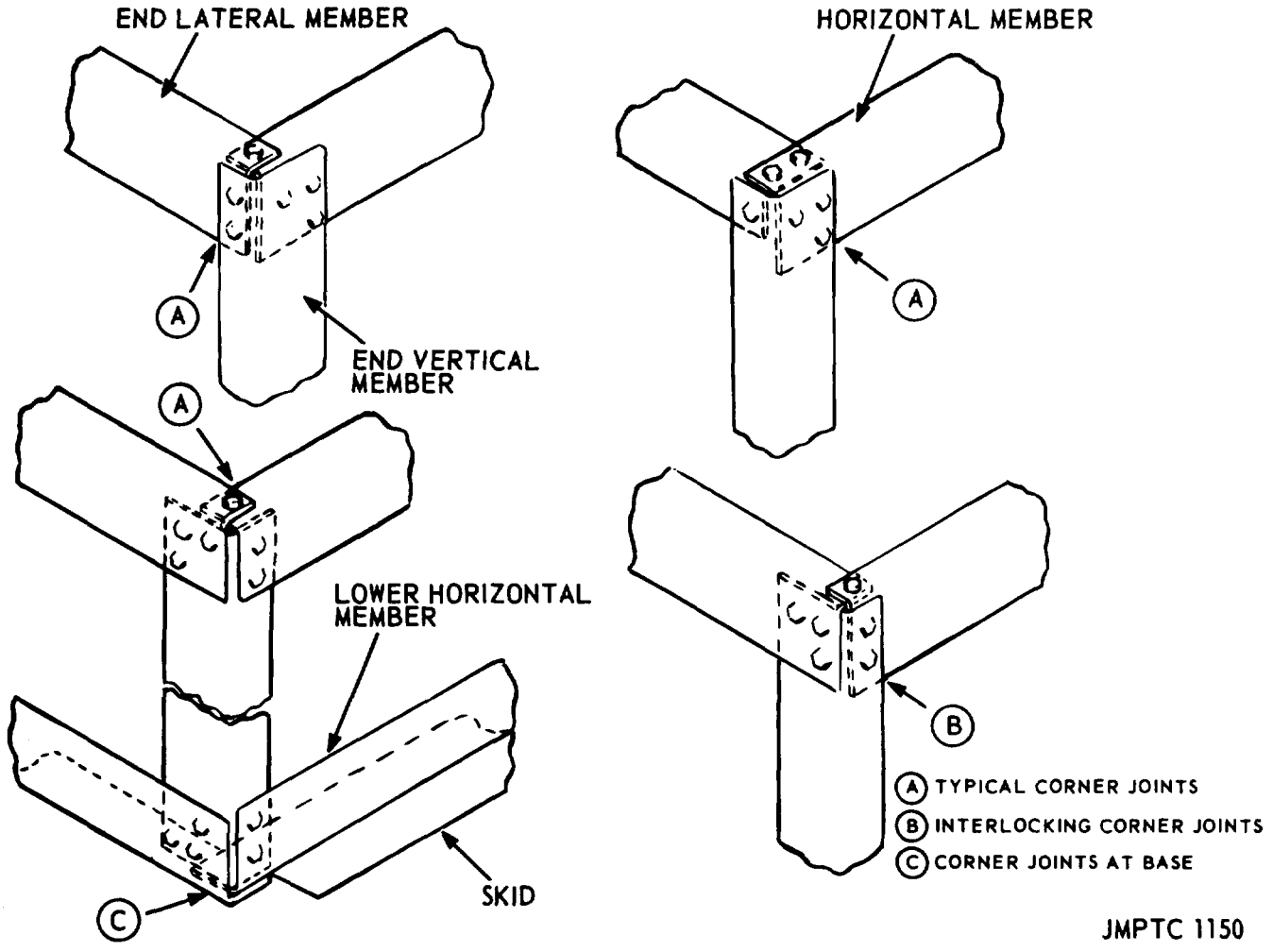

Figure 6-66. Corner joints.

fastened to a slotted angle material with not less than two bolts on each panel edge, with additional bolts being employed, if necessary, to maintain the interval between bolts at not more than 12 inches. When sheathing is attached to the top by nailing to a wooden strip which is secured to the slotted angle portion of the crate by bolts spaced not less than 24 inches apart, the nailing strip will be at least 1 by 2 inches and the nails will be at least sixpenny in size, spaced not more than 5 inches apart.

(*e*) *Ventilation.* Crates completely inclosed or sheathed with plywood or paper-overlaid veneer will be ventilated. Ventilation will be accomplished by means of holes or slots in the ends or ends and sides around the perimeter of the crate. They shall be placed immediately below the tip frame members of the ends and sides. When crates are over 10 feet in length, the ventilation holes or slots will be divided equally between both ends and both sides and located as near the midpoint of the sides and ends as practicable. Place baffles or shields inside the crate to deflect the water blown into the crate, thus preventing the water from coming in contact with the contents. The following table establishes the area of the holes or slots required to provide ventilation for graduated range of volume for a crate (table 6-53).

(*f*) *Panels for marking open crates.* To provide sufficient area for placing required markings on open crates, a panel of 1/4-inch plywood will be bolted to the crate.

(2) *Specific crates.*

(*a*) *Type 1, style A.* This crate is of simple construction, usually consisting of one panel in each section, requiring minimum bracing and used for light, bulky, and small items not exceeding 200 pounds. Either the slotted angle aluminum or the smaller slotted angle steel is usually strong enough for this crate. Unless specifically

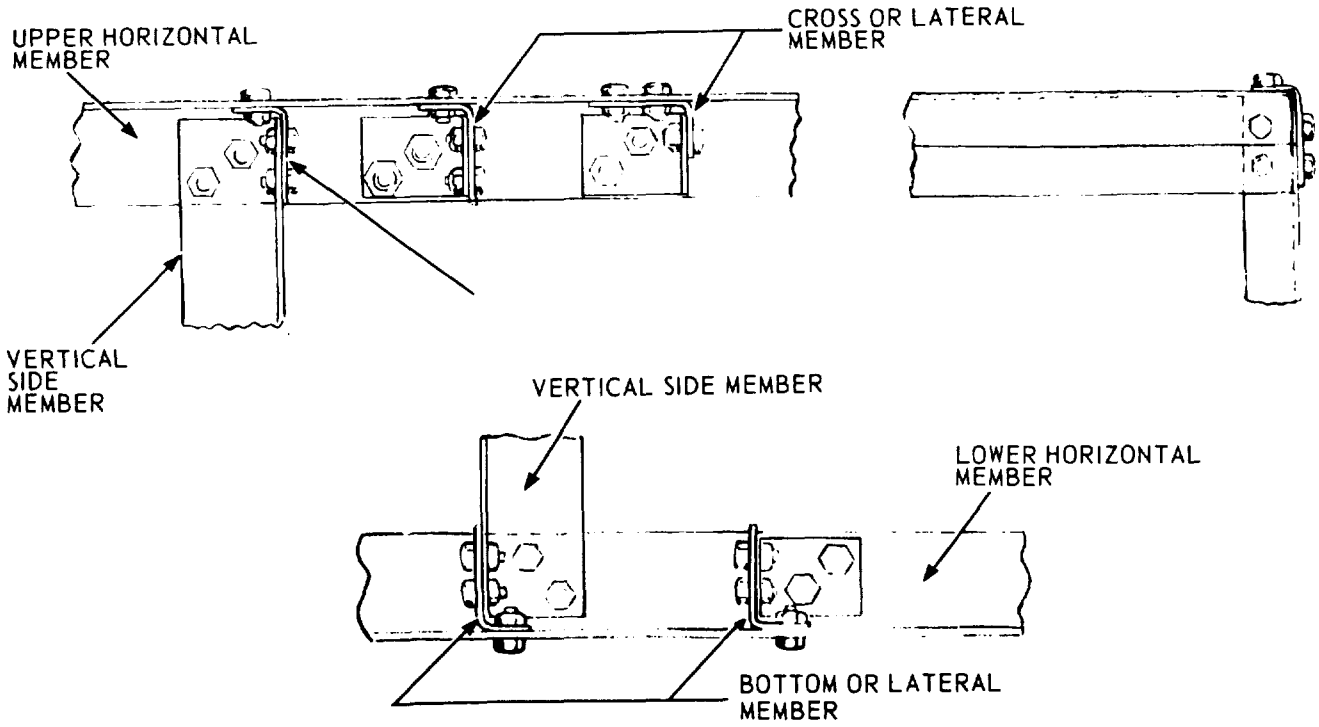

Figure 6-67. Attachment of intermediate members.

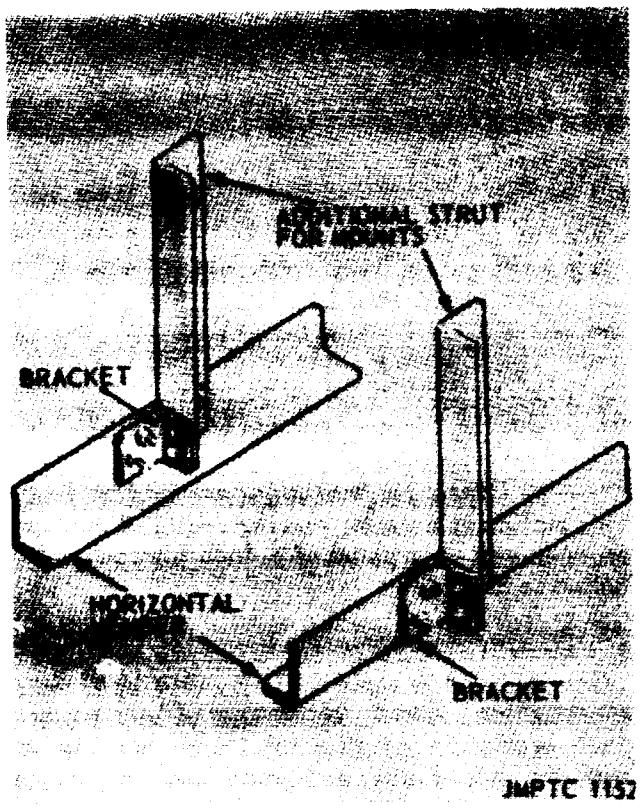

Figure 6-68. Alternate methods of attaching members.

excepted, it is limited to maximum dimensions of 80 inches in width.

1. Sides. The metal angle used for the side rails (horizontal members) should be positioned with the wider flange parallel to the plane or surface of the side. The bottom rail should be positioned so that the wide flange points up, while the top rail should have the wide flange pointing down. Vertical members (struts) should be equal in length and be positioned so that they are within horizontal rails when the crate is assembled. "Vertical members should not exceed 48 inches in length and distance between vertical members (struts and intermediate struts) shall not exceed 1⅓ the height of the crate. Where greater side strength or special mounting provisions are required along the side of the crate, extra vertical members may be added with the wide flange against the wide flange of the horizontal members (side rails) of the crate. Additional or intermediate vertical members should be added where the length-to-height ratio dictates."

2. Ends. The crate ends shall consist of slotted angle crossmembers joining the two crate sides. Additional crossmembers or intermediate struts to provide mounting or attaching points within the crate for specific items may be added to crate end as required. The distance between the

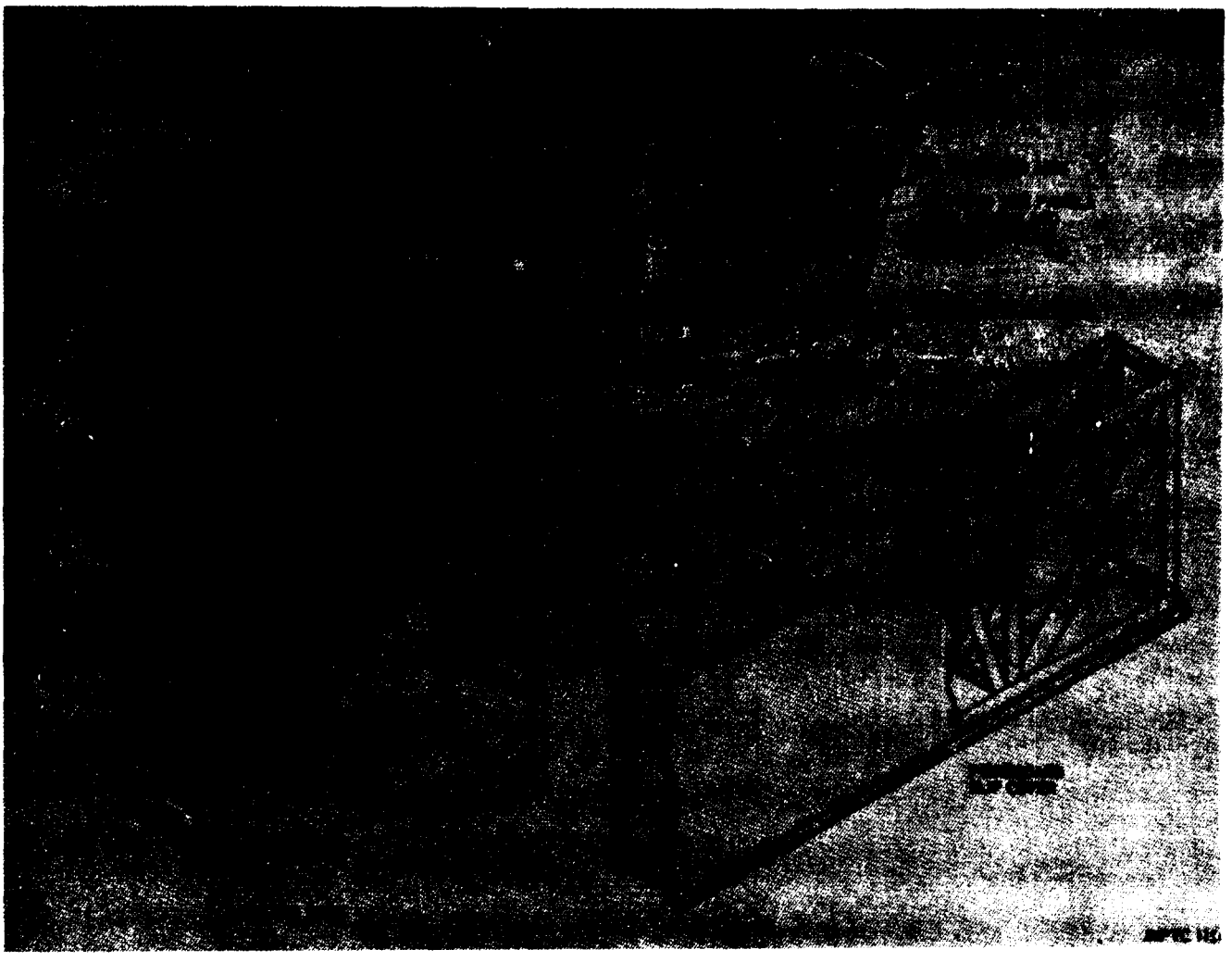

Figure 6-69. Methods of sheathing or covering crates.

Table 6-53. Ventilation Requirements

Area of holes or slots for ventilation	
Volume of crate in cubic feet	Cumulative area in square inches of ventilation holes or slots
0-100	7
101-150	10
151-200	14
201-400	27
401-600	40
601-800	52
801-1000	66
1001-1200	80
1201 and over	100

lateral members (crossmembers and intermediate struts) shall not exceed 1⅓ the width of the crate.

3. Base. The base is not a separate panel which is bolted to the sides and ends, but is formed by the addition, as necessary, of crossmembers, (loadbearing members, flooring, and braces).

(a) *Flooring.* The crate will be sufficiently floored to protect the contained item. The flooring need not be continuous throughout the base; however, it will be placed in such locations that will provide protection to the areas of the contained item that are subject to damage by forklift trucks or other material handling equipment. Plywood flooring (except loadbearing floorboards) will be a minimum of ¼ inch thick for crates through 12 inches wide, ⅜ inch for crates over 12 inches wide and through 24 inches wide, and ¾ inch thick for crates over 24 inches wide. Flooring will be cut to fit snugly in place and securely bolted to the lower side rails of the crate. Each piece of flooring shall be bolted in place with a minimum of two bolts in each lower side rail. The distance between bolts used to secure the flooring shall not exceed 12 inches. When the flooring is ⅜ inch or less in thickness it is reinforced on top by an additional strip of wood 1 inch by 2 inches, through which the holddown bolt will

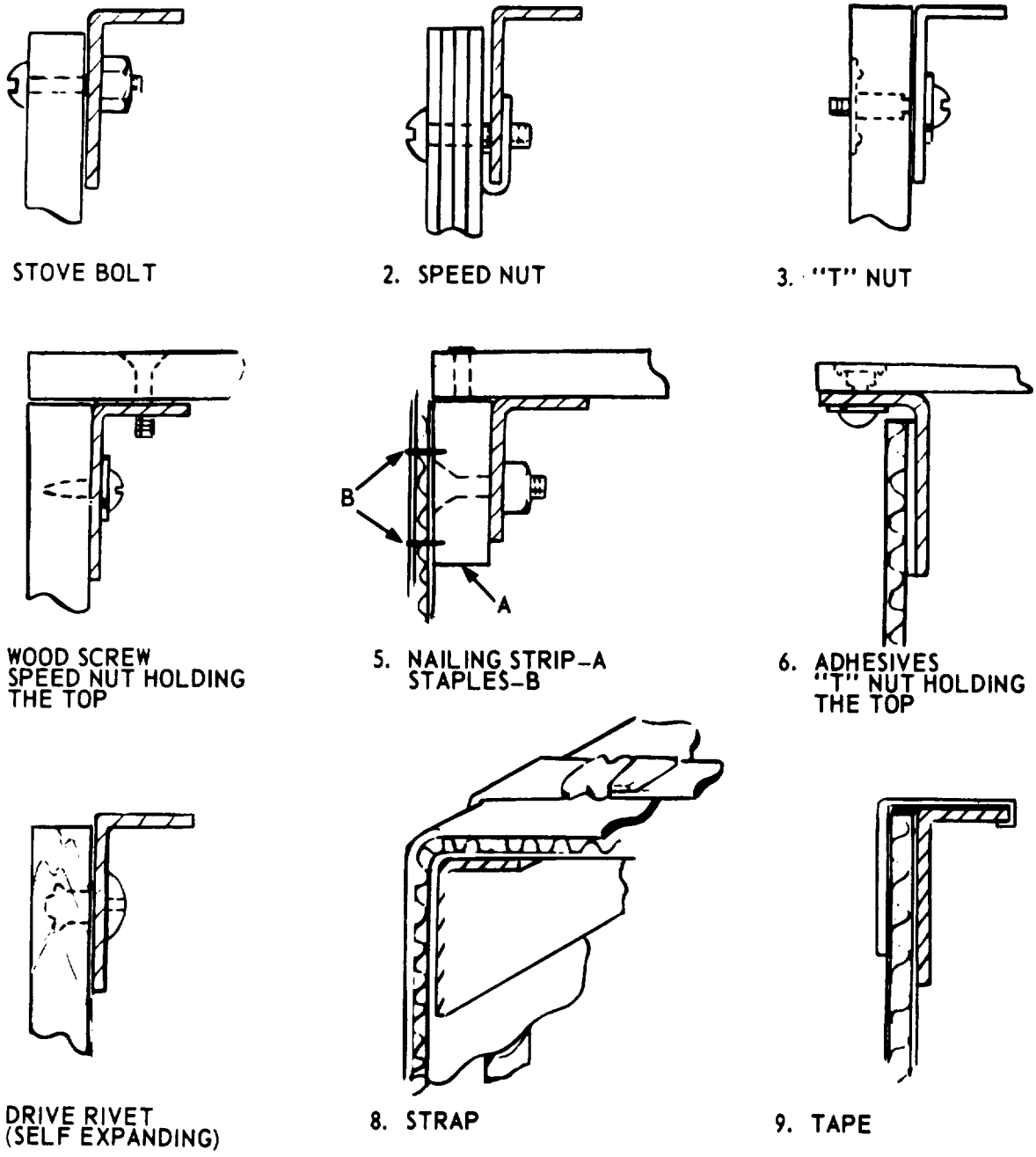

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Figure 6-70. Methods of attaching sheathing.

pass. Bolts used for securing floorboards shall not be less than 5/16 inch in diameter.

(b) *Loadbearing members.* Loadbearing members shall be located within the crate base to carry the load of the contained item, except when suspension systems are used or when the item is attached to the side structure. The size of wood members shall be determined from table 6-54. The size of steel members shall be determined from Table 6-55.

(c) *Crossmembers.* Crossmembers will be of the same strength and quality as the slotted angle used for the side rails and struts. Crossmembers in the base will be spaced not more than 24 inches apart. If loadbearing members are employed, they should be included in the considerations for base crossmembers.

(d) *Braces.* The base should be reinforced with braces of the same slotted angle as the crossmembers. These braces should be used in

Table 6-54. Allowable Load per Inch of Floorboard Width for Groups I and II Woods

Distance between outside skids	Actual thickness of floorboards (Inches)			
	3/4	1-5/8	2-5/8	3-5/8
(inches)	(pounds)	(pounds)	(pounds)	(pounds)
12	48	220	574	1,095
18	32	147	382	731
24	24	110	287	548
30	19	88	229	438
36	16	73	192	365
42	14	63	164	313
48	12	55	144	274
60	9	44	115	219
72	8	37	96	182

If group III or IV woods are used, the above allowable loads may be increased 20 percent.

unfloored areas of the crate. When one-third of the base is floored with 12-inch or wider floor panels, braces are not required.

4. Crate top. The top, like the base, is not a separate panel which is attached to the sides and ends. It is formed by crossmembers, crosstie members, and braces installed between the two crate sides. The crossmembers are placed perpendicular to the sides and are placed at each point where a vertical strut is bolted to the side rail, being bolted as shown in figure 6-67. The crosstie members are slotted angle members placed at intermediate points between, and parallel to, crossmembers with the distance between the crossmembers and crossties not exceeding 1⅓ the width of the crate. Braces of the same type slotted angle material as that used for crossmembers are placed diagonally in the rectangle formed by the side rails and the crossmembers and crossties. The ends will be cut at an angle to give maximum contact of the flanges being bolted together.

5. Use of corner braces for light crates. Where crates are intended for net loads not in excess of 200 pounds and limited to the maximum dimensions of 60 inches in length, 30 inches in width, and 48 inches in height, corner bracing may be utilized in lieu of full diagonal bracing.

(a) *Type II, Style A crate.* This crate is identical to the Type I, Style A crate, except that it is fully closed or sheathed using plywood, paper-overlaid veneer, or fiberboard, as specified in *d*(4), (5), and (6) above. Sheathing should be added in accordance with provisions of *e*(1)(d) above.

(b) *Type I, Style B crate.* The Style B (skidded) crate is intended for use in crating larger and/or heavier items, employing a skidded base; braced sides, ends and top; loadbearing and attaching members; and provisions for truck and cargo sling handling. Only slotted angle steel (not aluminum) will be used in fabricating this style crate. Unless specific approval is given for a larger size crate, the maximum dimensions are 360 inches in height (see fig 6-71 for a typical crate).

1. Sides. Crate sides consist of horizontal members (side rails), vertical members (struts), and full diagonal braces.

(a) *Intermediate horizontal members.* When a crate exceeds 48 inches in height, an intermediate horizontal member should be placed between the top and bottom side rails and should run the full length of the crate. In addition to the requirement for additional intermediate horizontal members because of the height, extra strength requirements may demand additional horizontal members.

(b) *Intermediate vertical struts.* Intermediate struts shall be evenly and systematically spaced throughout the length of the crate side between the end or corner vertical struts. The spacing of intermediate struts for crates with sides not provided with an intermediate horizontal member shall be determined by the height and length. The distance between the vertical struts shall not exceed 1¼ the height of the crate. The spacing of intermediate struts for crates with sides provided with intermediate horizontal members shall be determined by the same method as above, except that the height shall be considered as the distance between the two adjacent horizontal members.

2. Ends. The ends are not assembled panels which are bolted to the sides but are formed by the upper and lower crossmembers, intermediate crossmembers, and braces which join the sides. In addition to the upper and lower crossmembers, intermediate crossmembers are required when the height of the crate exceeds 48 inches or when the height of the crate exceeds 1¼ width of the crate. The maximum interval between any two adjacent crossmembers is 48 inches. Intermediate crossmembers shall be installed with the wider flange of the angle in a vertical position. Intermediate vertical members may be added to the ends for special mountings and special blocking and bracing. Bracing of the ends may be done either with slotted angle material equal to that used for side bracing or with flat steel strapping (as in *e*(1)(a) above). When a crate is in excess of 60 inches long, 18 inches wide, or subject to being pushed by forklift trucks or other equipment, it should be equipped with push plates to protect the crate and contents (fig 6-72). The push plates are positioned across the lower part of

Table 6-55. Load Table For Slotted Angle.

SLOTTED ANGLE (STEEL) 14 GAUGE (.074) 1-1/2" x 1-1/2"
VERTICAL SUPPORTING SECTIONS

(Length of Column in Feet - Load in Pounds)

	3'	4'	5'	6'
Recommended Load	1480	1180	940	742
Recommended Load	3830	3475	2970	2475
Recommended Load	3900	3565	3170	2620

SLOTTED ANGLE (STEEL) 14 GAUGE (.074) 1-1/2" x 2-1/4"
VERTICAL SUPPORTING SECTIONS

(Length of Column in Feet - Load in Pounds)

	3'	4'	5'	6'	7'
Recommended Load	2490	1850	1530	1280	940
Recommended Load	5500	5000	4350	3800	3350
Recommended Load	5600	5390	5000	4480	4150

SLOTTED ANGLE (STEEL) 12 GAUGE (.104) 1-1/2" x 3"
VERTICAL SUPPORTING SECTIONS

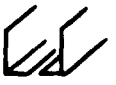
(Length of Column in Feet - Load in Pounds)

	3'	4'	5'	6'	7'
Recommended Load	3450	2870	2360	1670	1150
Recommended Load	7960	7040	6240	5400	4500
Recommended Load	8900	7940	6700	5800	4650

Table 6-55. (Cont.) Load Table For Slotted Angle.

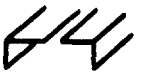
SLOTTED ANGLE (STEEL) 12 GAUGE (.104) 1-1/2" x 3"

(Length of Beam in Feet - Load in Pounds)

	2'	3'	4'	5'	6'
Recommended Load 	1450	980	740	500	350
Recommended Load 	4500	3100	2100	1200	1000
Recommended Load 	10400	7500	5300	4350	3500
Recommended Load 	1550	1000	760	580	490

SLOTTED ANGLE (STEEL) 14 GAUGE 1-1/2" x 2-1/4"

(Length of Beam in Feet - Load in Pounds)

	2'	3'	4'	5'	6'
Recommended Load 	1260	850	610	400	200
Recommended Load 	2400	1700	1150	820	625
Recommended Load 	5190	3350	2700	2100	1700
Recommended Load 	800	510	390	300	250

SLOTTED ANGEL (STEEL) 14 GAUGE 1-1/2" x 1-1/2"

(Length of Beam in Feet - Load in Pounds)

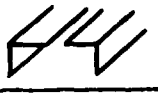
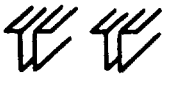
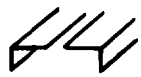
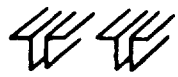
	3'	4'	5'	6'
Recommended Load 	495	270	190	145
Recommended Load 	590	395	297	190
Recommended Load 	1335	1035	693	540

Table 6-55. (Cont.) Load Table For Slotted Angle.

SLOTTED ANGLE (ALUM) 13 GAUGE (.089) 1-1/2" x 2-1/4"

	(Length of Beam in Feet - Load in Pounds)				
	3'	4'	5'	6'	
Recommended Load 	450	350	260	180	
Recommended Load 	950	600	*400	*350	
Recommended Load 	2200	1600	1240	940	
Recommended Load 					

*On spans of this length, cross barcing gives a better structure, higher recommended load.

SLOTTED ANGLE (ALUM) 13 GAUGE 1-1/2" x 2-1/4"
VERTICAL SUPPORTING SECTIONS

	(Length of Column in Feet - Load in Pounds)				
	3'	4'	5'	6'	7'
Recommended Load 	1000	900	700	600	
Recommended Load 	3100	2730	2430	2170	1750
Recommended Load 	3500	3100	2700	2400	2100

the end panel with the lower part of plate flush with top of the skids and shall be bolted to the corner struts with a minimum of two bolts in each end of the plate. Group II, III, or IV wood or plywood may be used for crates having a gross weight up to 500 pounds. They shall be Group III or IV wood when the gross weight exceeds 500 pounds. They shall be Group III or IV wood when the gross weight exceeds 500 pounds. When push plates are made from wood they shall be a minimum $1^{5}/_{8}$ inches thick and $7^{1}/_{2}$ inches wide. Plywood push plates shall be a minimum $^{3}/_{4}$ inch thick and 12 inches wide.

s. Top. The top, like the ends, is formed by joining the two sides together, through the use of crossmembers, crossties, and braces of slotted angle material. The end crossmembers serve also as the top crossmembers of the ends. Additional crossmembers are bolted as shown in figure 6-67, the wider flange being vertical and the narrow flange at the top. When the distance between the crossmembers is greater than $1^{1}/_{4}$ times the width of the crate, intermediate crossmembers (crossties) should be used, placing them equidistant between the crossmembers. Sufficient crossties should be used to maintain an interval not in

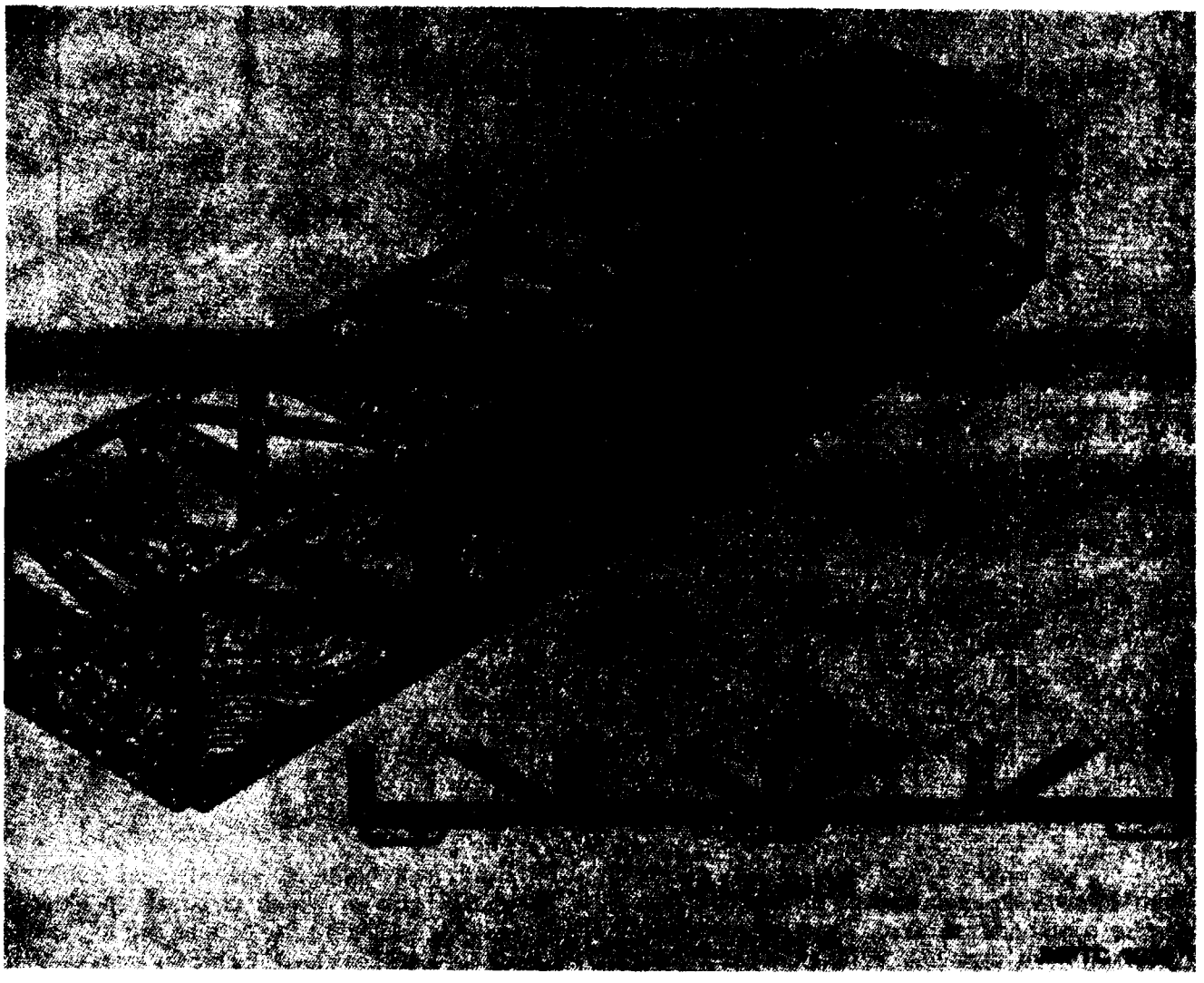


Figure 6-71. Type 1, Style B crate.

excess of 1¼ times the width of the crate between any two adjacent crossmembers and/or crossties. (See fig 6-67 for the bolting pattern.) Full diagonal braces should be used in the interval between adjacent crossmembers and/or crossties. Tension braces of steel strapping may be used in lieu of slotted angle material (e(1)(a) above).

4. Base. Crossmembers and crossties tying the side panels together at the bottom of the crate plus required loadbearing members, forklift truck handling members, skid blocks, full skids, headers, and flooring comprise the base.

(a) *Skid blocks and full skids.* When the load contained by the crate exceeds 500 pounds, full skids running the length of the crate shall be used. Full length skids may be used for lesser contained weights, but are not mandatory. Full length skids shall be fabricated from minimum nominal 2 x 4-inch lumber for net loads up to 1,000 pounds and 4 x 4-inch lumber for net loads exceeding 1,000 pounds. They shall be provided with 2 x 4-inch rubbing strips. When full length skids are not used, 2 x 4-inch skid blocks 16 inches long are used. Skids and skid blocks shall be beveled 45 degrees on each end. Skid blocks located at the ends of the crate shall be set 2½ to 4 inches from each crate end to permit the use of slings. Rubbing strips on full length skids shall be set back an equal distance from each crate end. Intermediate skid blocks shall be placed in locations that will support loads transferred to the lower side rails by loadbearing members and struts. The center of balance of the loaded crate shall be the determining factor in locating intermediate skid blocks to provide the forklift entry. The maximum distance between skid blocks shall not exceed 48 inches. Skid blocks, skids, and rubbing strips shall be bolted to the lower side rails with minimum ⅝-inch diameter bolts (fig 6-72).

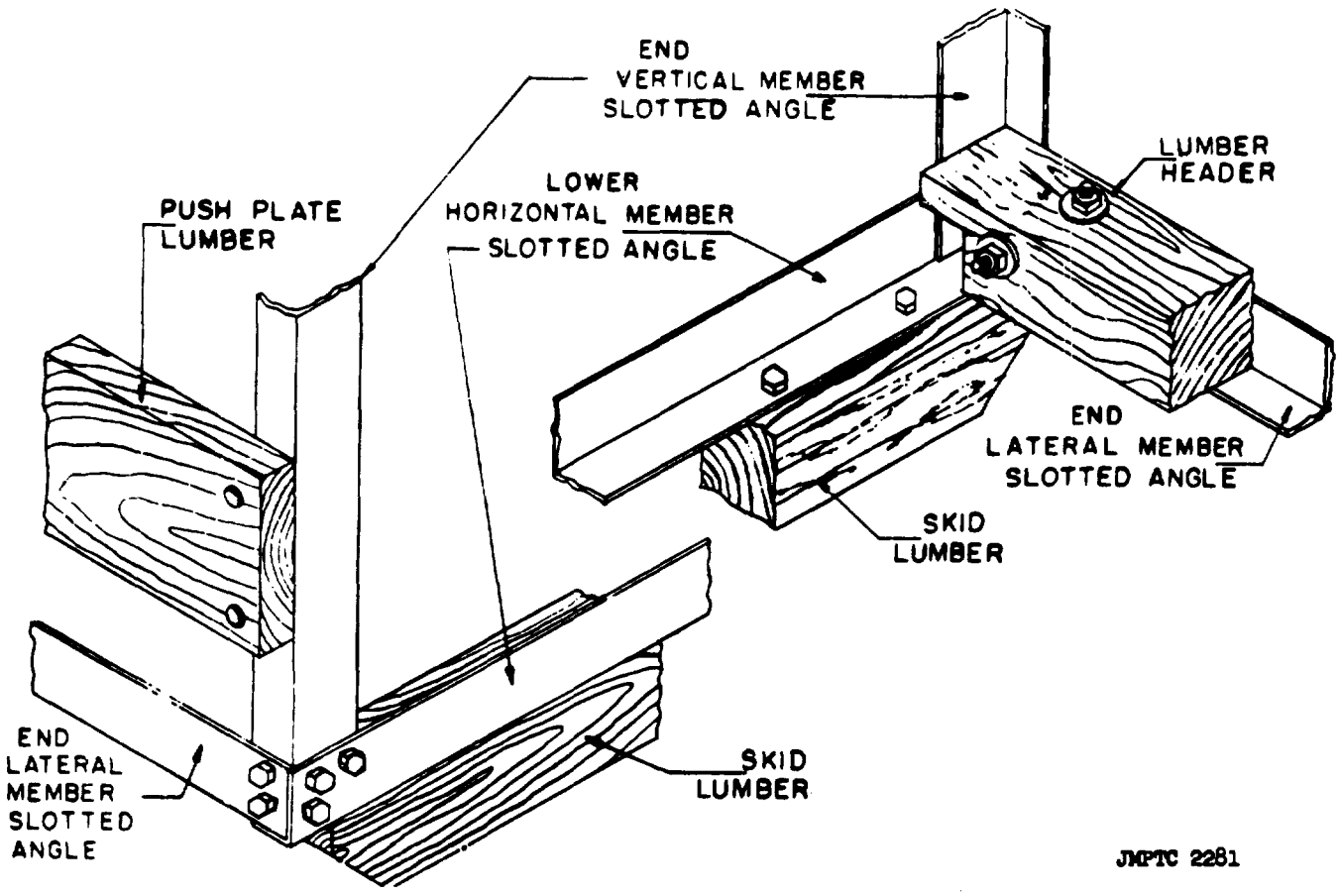


Figure 6-72. Method of attaching push plates, skids, and headers.

(b) *Loadbearing members.* To provide direct support to loads resting on the base, loadbearing members are used. These members may be either wood, plywood, metal, or a combination of wood and metal and are placed at right angles to the length of the crate, being bolted to both of the lower side members. See tables 6-54 and 6-55 for tabulated data to be used in determining the size, etc., of material for loadbearing members.

(c) *Flooring.* Flooring may be lumber or plywood and need not be continuous throughout the base; however, it shall be placed in such locations as will provide protection to the areas of the contained item that is subject to damage by forklift trucks or other material handling equipment. The flooring should be cut to fit snugly in place and should be bolted to both of the lower side each end of each piece of flooring with a minimum of two bolts to a rail. Plywood flooring shall have a minimum thickness of 3/8 inch for crates through 12 inches wide, 1/2 inch for crates 12 to 24 inches wide, and 3/4 inch for crates over 24 inches wide. Lumber flooring shall have a minimum thickness of 3/4 inch.

(d) *Forklift truck handling members.* Forklift truck handling members of lumber or metal, the size of which is based on strength required as applied to the data shown in tables 6-54 and 6-55, will be placed 24 inches from each end of the crate and at right angles to the length, being bolted to both of the lower side rails. When the crate is in excess of 36 inches in width, forklift truck handling members should be placed at the location provided for side entry of forklifts and, if the crate is over 8 feet in length, they should be in addition to those placed 24 inches from the end. Loadbearing members, if suitably located, may serve as forklift truck handling members.

(e) *Type II, Style B crate.* Except for the sheathing, this crate is fabricated in the same manner as the Type I, Style B crate. The sheathing is accomplished in the manner described in (1)(*d*) above.

(6) *Crossties and headers.* When the distance between loadbearing members exceeds the width of the crate and the flooring is less than 3/4 inch thick, intermediate crossties should be installed, being bolted to both of the flanges of both lower side rails (fig 6-67).

CHAPTER 7

CONSOLIDATION AND UNITIZATION FOR SHIPMENT AND USE OF CARGO CONTAINERS

7-1. Consolidation and Unitization for Shipment

Consolidation is the bringing together of like or unlike items for shipment. Once the items are assembled, they must be kept together as a single unit until they reach a break-bulk point or the ultimate consignee. Unitization results in economy through reduction in handling and documentation, one unit taking the place of several units.

a. Advantages. Figure 7-1 gives advantages of unitizing loads which are as follows:

(1) Eliminates laborious and expensive manual handling of individual items.

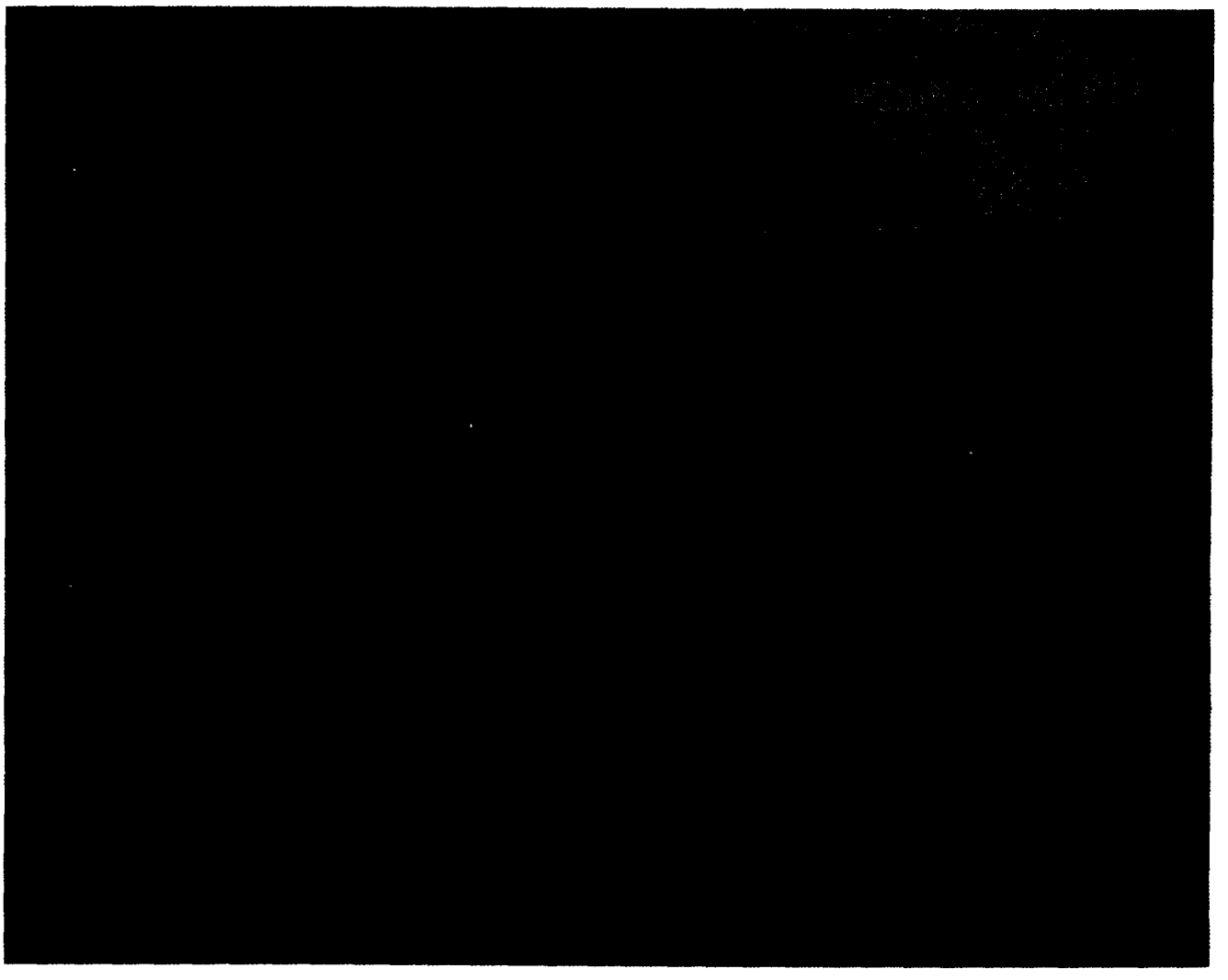


Figure 7-1. Advantages of cargo unitization.

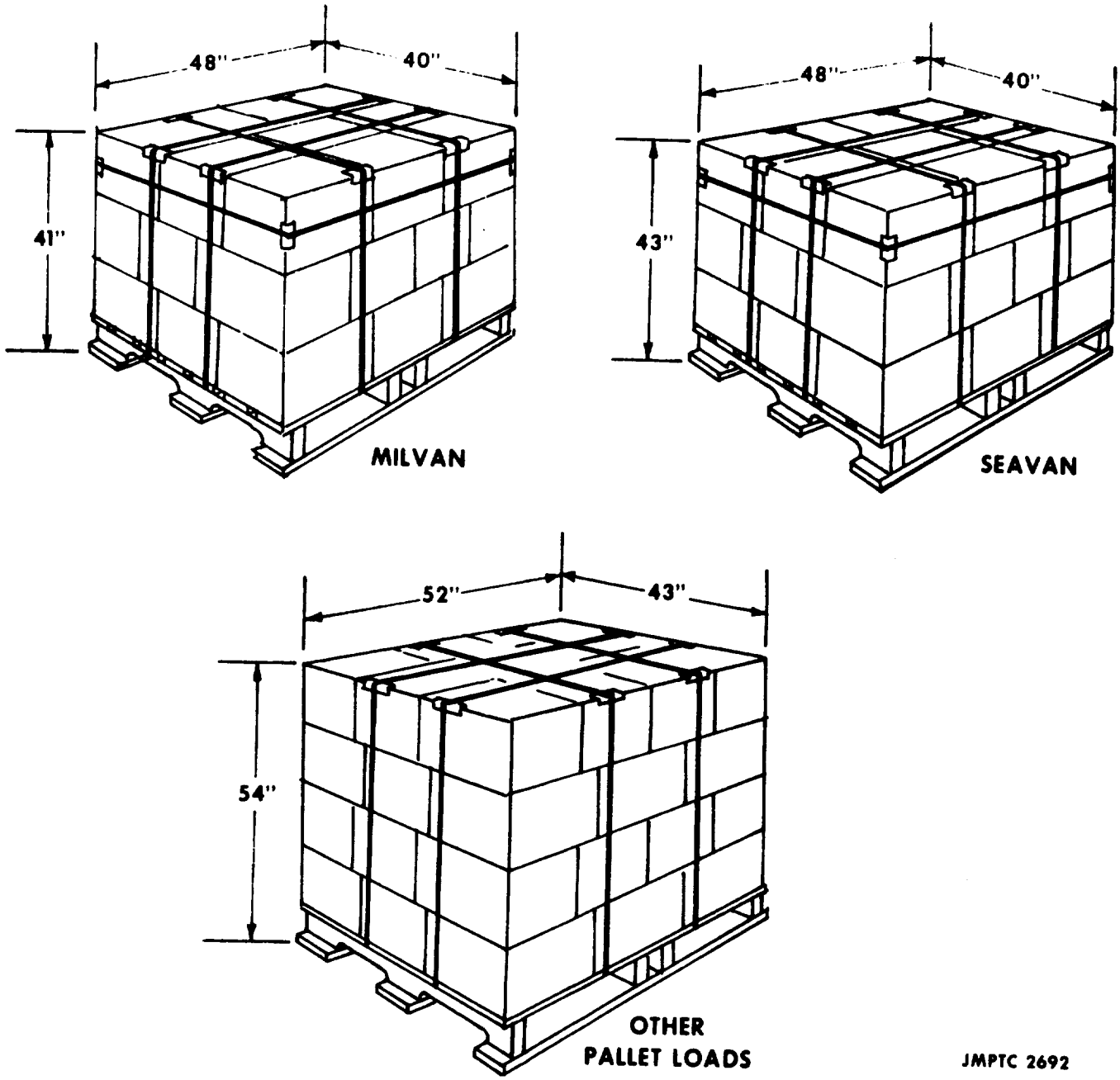


Figure 7-2. Pallet size limitations.

(2) Reduces damage to items by eliminating manual handling.

(3) Permits savings in handling costs.

(4) Reduces personnel accidents by eliminating manual handling and lifting.

(5) Simplifies inventorying and reduces inaccuracies.

(6) Utilizes storage heights not possible by manual means.

(7) Reduces pilferage because of unitization of items by steel straps and other bonding methods.

(8) Permits faster movement of supplies and equipment and provides greater utilization of carrier equipment.

(9) Reduces marking requirements on individual containers.

b. Forms of Unitization. The two basic forms of unitization are—

(1) *Palletization.* This is the placing of a number of packages on a low, portable platform of wood, metal, or fiberboard, or a combination of these materials.

(2) *Containerization.* This is the placing of a number of packages into a container, which not only reduces the number of units and documentation, but provides additional protection to the packages.

7-2. Palletizing Unit Loads (MIL-STD-147)

Military Standard MIL-STD-147 gives the palletized unit load requirements for Department of Defense material using the pallets discussed in paragraphs 3-10 and 3-11. The standard establishes loading patterns for various types of commodities, listing the pattern for stacking containers and the methods of unitizing to be used.

a. Limitations. The following size and weight limitations apply to the complete load including the pallet and the bonding and storage aids (fig 7-2).

(1) Unless otherwise specified by the procuring activity, load units prepared for shipment in MILVANS and SEAVANS shall not exceed 40 inches in length. All other loads shall not exceed 43 inches in length, which permits an overhang of 1½ inches at each end of the pallet.

(2) Unless otherwise specified by the procuring activity, load units prepared for shipment in MILVANS and SEAVANS shall not exceed 48 inches in width. All other loads shall not exceed 52 inches in width, which permits an overhang of 2 inches at each side of the pallet.

(3) Load units prepared for shipment in containerization media such as SEAVANS, etc. shall not exceed 43 inches in height and in MILVANS, 41 inches. All other loads shall not exceed 54 inches in height, except as permitted for loads of compressed gases in cylinders.

(4) The maximum gross weight of a load shall not exceed 3,000 pounds per single pallet load for domestic, intercoastal, or oversea shipments.

b. Types of Palletized Loads. Types of supplies that can be palletized are

(1) Items which are identical and identified by the same stock number.

(2) Items uneconomical or impractical to pack otherwise.

(3) Rugged and durable items that require minimum physical protection.

(4) Boxed items uniform in size requiring additional protection.

(5) Items that are moved in large quantities.

c. Load Arrangement. The arrangement of items to the pallet must provide a rigid, compact, uniform size load, strongly secured to prevent shifting, and capable of resisting impact, vibration, racking, and compression encountered during handling, storage, and shipment. Basic principles for arranging and securing loads to pallets are—

(1) Items should be interlocked, nested, or bundled whenever possible.

(2) The load pattern should eliminate or reduce void space.

(3) Wood separators or spacers are placed in voids between rows and layers of irregular-shaped items to insure a firm and stable load.

(4) The top surface of the loading pallet must be level, or made level for stacking purposes. This can be accomplished by applying a wood top frame or leveling boards with a supporting framework.

(5) Loads difficult to stabilize or which are compressible and not sufficiently firm to support superimposed loads, will be reinforced with a supporting framework as prescribed in (4) above.

(6) Boxed items are arranged on the pallet so that the markings on individual containers do not show on two adjacent sides of the palletized load. This will provide clear areas for unit load marking.

(7) The load is secured to the pallet, using the applicable size of strapping given in table 7-1 for applying lengthwise and crosswise strapping. Horizontal strapping is the same size as the tie-down strap size. The gross weight of the load, divided by the total number of tie-down straps to be used, determines the weight which must be borne by each strap. This weight is compared with the strap capacity listed in table 7-1. The strapping which has the same or next higher capacity is used. Non-metallic strapping is not authorized for the strapping of palletized loads of wooden, plywood, or metal shipping containers.

(8) Strapping is applied in a manner that will eliminate any possibility of slippage. Wood cleats, tie blocks, or braces are used under straps when necessary to insure stability or to bridge unsupported spans.

d. Loading. To properly load a pallet, consideration must be given to the type of item, its weight, and destination. It is recommended that Military Standard MIL-STD-147 be followed when loading 40- x 48-inch pallets. Figure 7-3 illustrates one common type of palletized load out of the many types illustrated in the standard.

7-3. Shrink Film and Stretch Film Palletization

a. Shrink Film. Plastic films such as polyethylene are now being used in accordance with the requirements of MIL-STD-147 as a means of

Table 7-1. Maximum Safe Working Capacities of Steel and Nonmetallic Strapping (para 7-2c(7))
Metal Strapping QQ-S-781

Flat Strapping			Round Strapping	
Nominal width and thickness Inch Size	Standard (Cold rolled)	High Tension Hot rolled (HR) Cold rolled (CR)	Wire Size	Safe Capacity Maximum per strand
(inches)	*(pounds)*	*(pounds)*	*(gage)*	*(pounds)*
3/8 x 0.015	112			
3/8 x 0.020	150			
3/8 x 0.23	150			
1/2 x 0.15	150			
1/2 x .020	200		16	107
5/8 x .020	250		15	140
5/8 x .023	300		14	175
3/4 x .023	350		13-1/2	200
3/4 x .025		575 (CR)	13	230
3/4 x .028	450	575 (HR)	12-1/2	265
3/4 x .031		725 (CR)	12	300
3/4 x .035	525	725 (HR)	11	375
1-1/4 x .031		900 (CR)	10	500
1-1/4 x .035		900 (HR)	9	600
1-1/4 x .044		1275 (CR)	8	720
1-1/4 x .050		1275 (CR)		
1-1/4 x .065		1700 (HR)		
2 x .044		2000 (CR)		
2 x .050		2000 (HR)		
2 x .065	2625 (HR)			

Nonmetallic Strapping PPP-S-760
Type II

Nominal width and thickness	
Inch Size	Safe Capacity Maximum per strap
(inches)	*(pounds)*
1/4 x 0.015	75
1/4 x .020	100
1/4 x .025	125
3/8 x .015	112
3/8 x .020	150
1/2 x .0125	120
1/2 x .015	150
1/2 x .020	200
1/2 x .025	250
1/2 x .030	300
5/8 x .015	190
5/8 x .020	250
5/8 x .025	310
5/8 x .030	375
1-1/4 x .035	900

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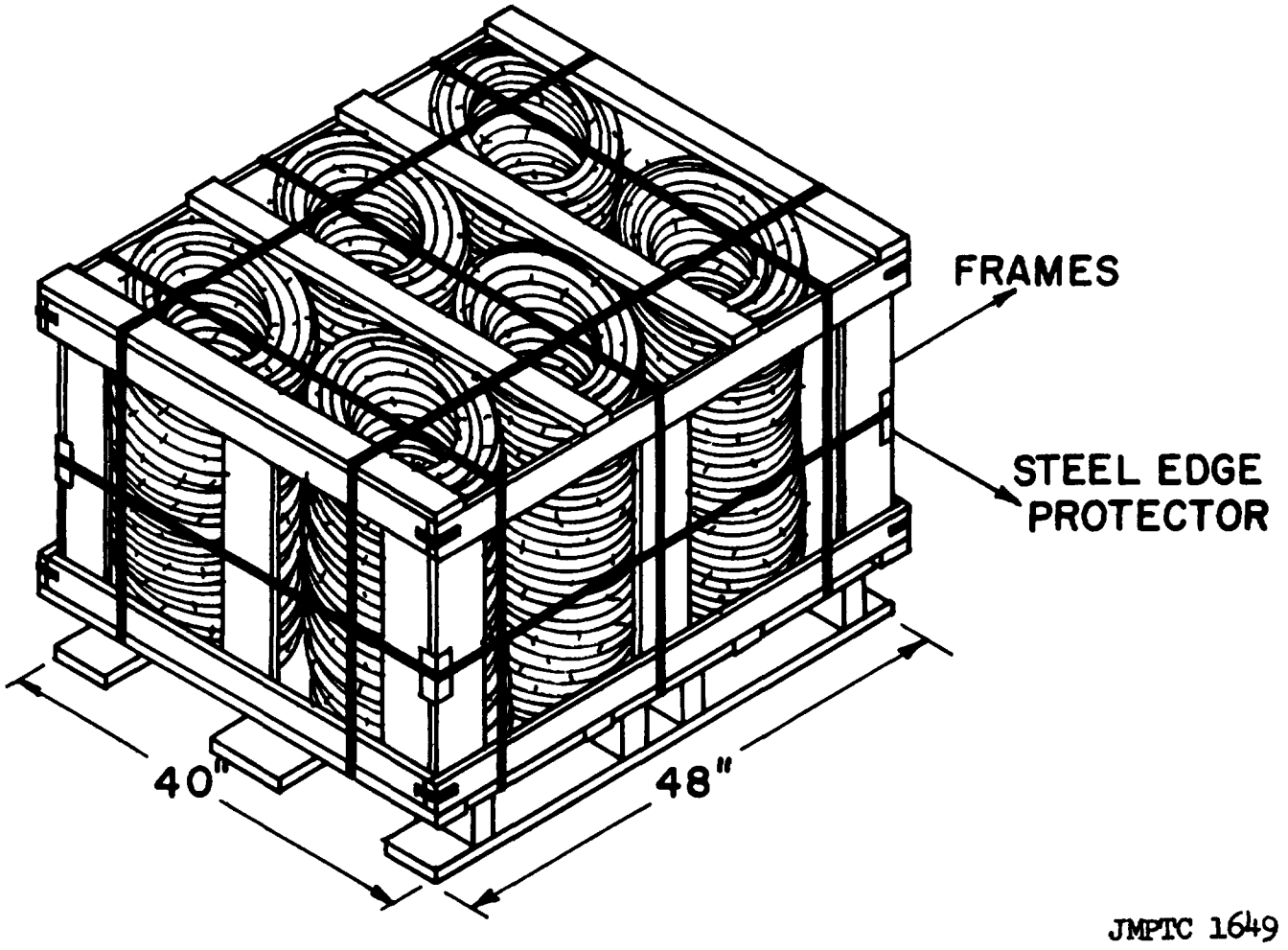


Figure 7-3. Example of palletized load.

bonding palletized loads. The plastic film is stretched in the manufacturing process; this is called "orientation." The stretched film shrinks when subjected to a controlled flow of heat air. The heated air is supplied by the use of a heat shrink cannon (fig 7-4) or a shrink film chamber (fig 7-5). The heat causes the film to shrink, conforming to the contour of the load. For this reason, it can be used for pallet loads containing a variety of items which form irregular shaped configurations that could not be palletized by conventional means. The tightly adhering film immobilizes the contents and provides stability. It also provides some weather protection for exposed cargo. Shrink film palletization provides a reduction of labor and material cost by the use of automatic equipment and eliminates the problem of damage caused by too tight strapping of containers.

b. Stretch Film. Stretch films can be used as a means of bonding palletized loads for many commodities shipped in the Continental United States (CONUS) or when shipped containerized. The stretch films are extruded polyethylene, polyvinyl chloride or ethylene vinyl acetate. The film is wrapped around the load in multiple layers from the top of the bottom deckboard to not less than two inches above the height of the load. The required thickness of the wrap is determined by the kind of film being used and the weight of the load. Additional bonding strength can be provided by placing a sheet of weather-resistant fiberboard, the same size as the top dimensions of the load, on top of the load prior to stretch wrapping.

7-4. Consolidation Containers (General)

Consolidation containers may be constructed of fiberboard, paper-overlaid veneer, plywood, or lumber. They may be demountable or non-demountable. They are usually secured to a pallet base or a skid base for handling purposes. Some containers are intended to be expendable, while others are intended to be reusable. Some consolida-

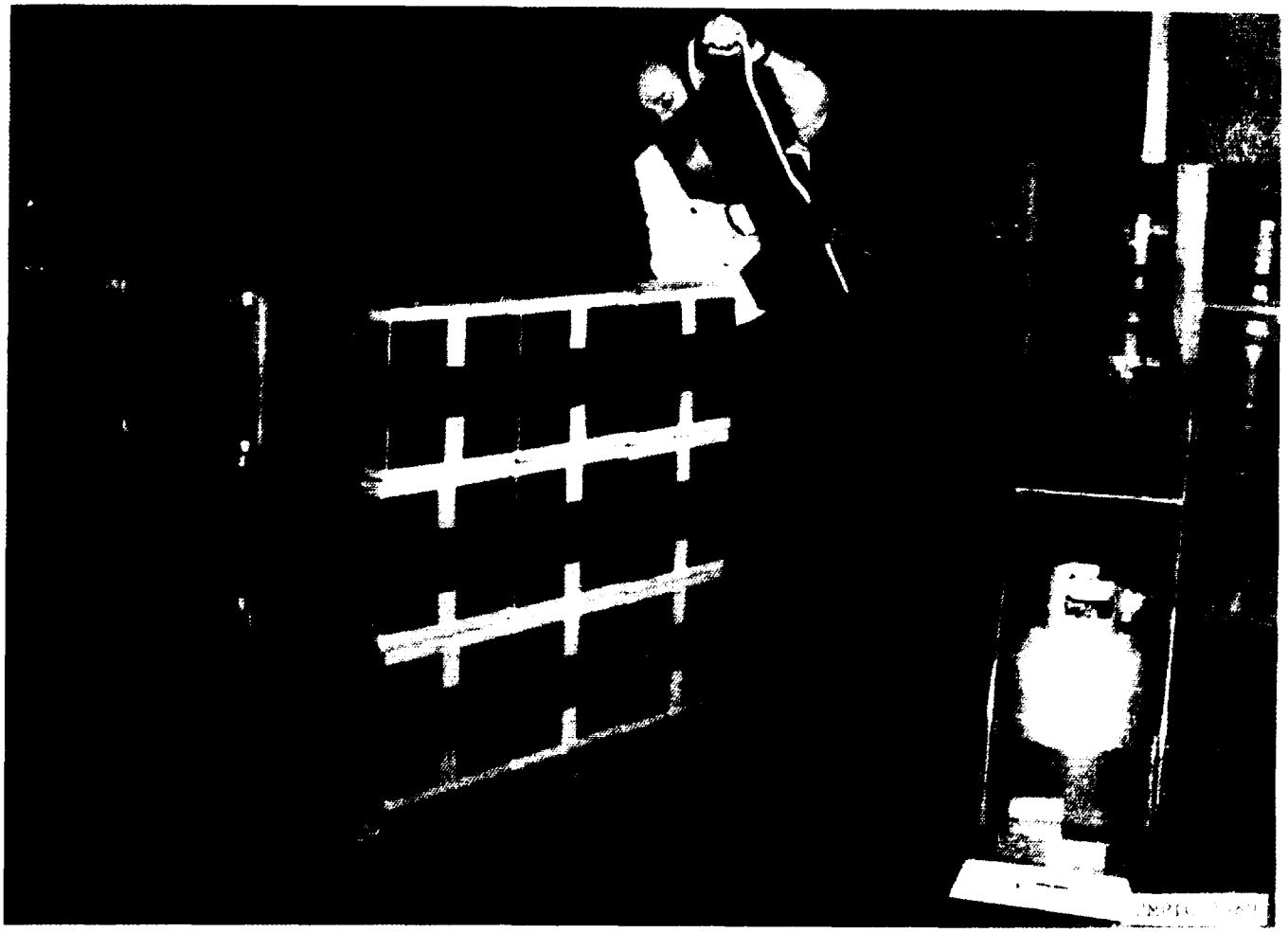


Figure 7-4. Use of cannon to heat shrink film around palletized load.

tion containers are designed to be compatible with the requirements of the 463L Materials Handling System of the Air Force. Others are designed to be used as inserts in transporters such as CONEXES, MILVANS, or SEAVANS, or to be used as separate shipping containers.

7-5. Expendable Fiberboard Pallet Boxes (MIL-P-26342)

Military Specification MIL-P-26342 covers the requirements for fabricating two classes of expendable fiberboard pallet boxes (fig 7-6).

a. Classification. These containers are classified as either domestic or weather-resistant.

b. Description. These containers are fabricated from fiberboard and consist of a pallet base, bottom tray with drainage holes, body, and top cap. The weather-resistant class of boxes has an auxiliary tray which fits inside and at the bottom of the box. This auxiliary tray may be specified for the domestic class also, when necessary. An interlocking top cap (fig 2-9) may be specified for either class of box, when necessary. Dividing inserts may also be specified for either class of box. Table 7-2 lists the size designations and applicable dimensions together with the weight capacities applicable to each size box. See table 7-3 for the number of inserts required for each size box.

c. Closure and Strapping Requirements.

(1) After the boxes are packed and closed, they are strapped with nailless flat steel strapping with formed edges conforming to Specification QQ-S-781. The minimum size should be ¾ x 0.015 inches with a minimum tensile strength of 80,000 psi.

Table 7-2. Size Designations, Dimensions, and Load Limitations (MIL-P-26342)

Size designation	Dimensions (inches)			Maximum load (lb)
	Length	Width	Depth	
A1	35	35	12	500
A2	35	35	24	500
A3	35	35	36	500
B1	40	48	12	800
B2	40	48	24	800
B3	40	48	36	800

Table 7-3. Number of Dividing Inserts Required for Each Size Designation of Expendable Fiberboard Pallet Box (MIL-P-26342)

Size designation	Length of insert (inches)		
	35	40	42
A1	5		
A3	10		
A3	15		
B1		3	2
B2		6	4
B3		9	6

Note 1. An insert is the single sheet of fiberboard cut to the interior dimension of either the width or length of the box, and notched to permit matching with other inserts running in a perpendicular direction.

Note 2. The lengths 35", 40", and 48" indicate the outside dimension of the box in which the insert is to be used, modified to allow for the thickness of the fiberboard utilized in manufacturing the box.

(2) Two girthwise straps shall be applied to sizes A-1, A-2, and A-3. The straps shall be perpendicular to each other on the top and bottom and placed approximately ½-inch from one edge of the center row of posts (fig 7-7).

(3) Three girthwise straps shall be applied to sizes B-1, B-2, and B-3. Two straps shall go around the top, sides, and bottom at the center of the forklift finger areas and one strap shall go around the top, ends, and bottom. This one strap shall be placed approximately ½-inch from one edge of the center row of post (fig 7-7).

(4) Straps shall be applied straight and sufficiently tensioned to imbed into the edges of the pallet box, but not to the extent of cutting, tear-

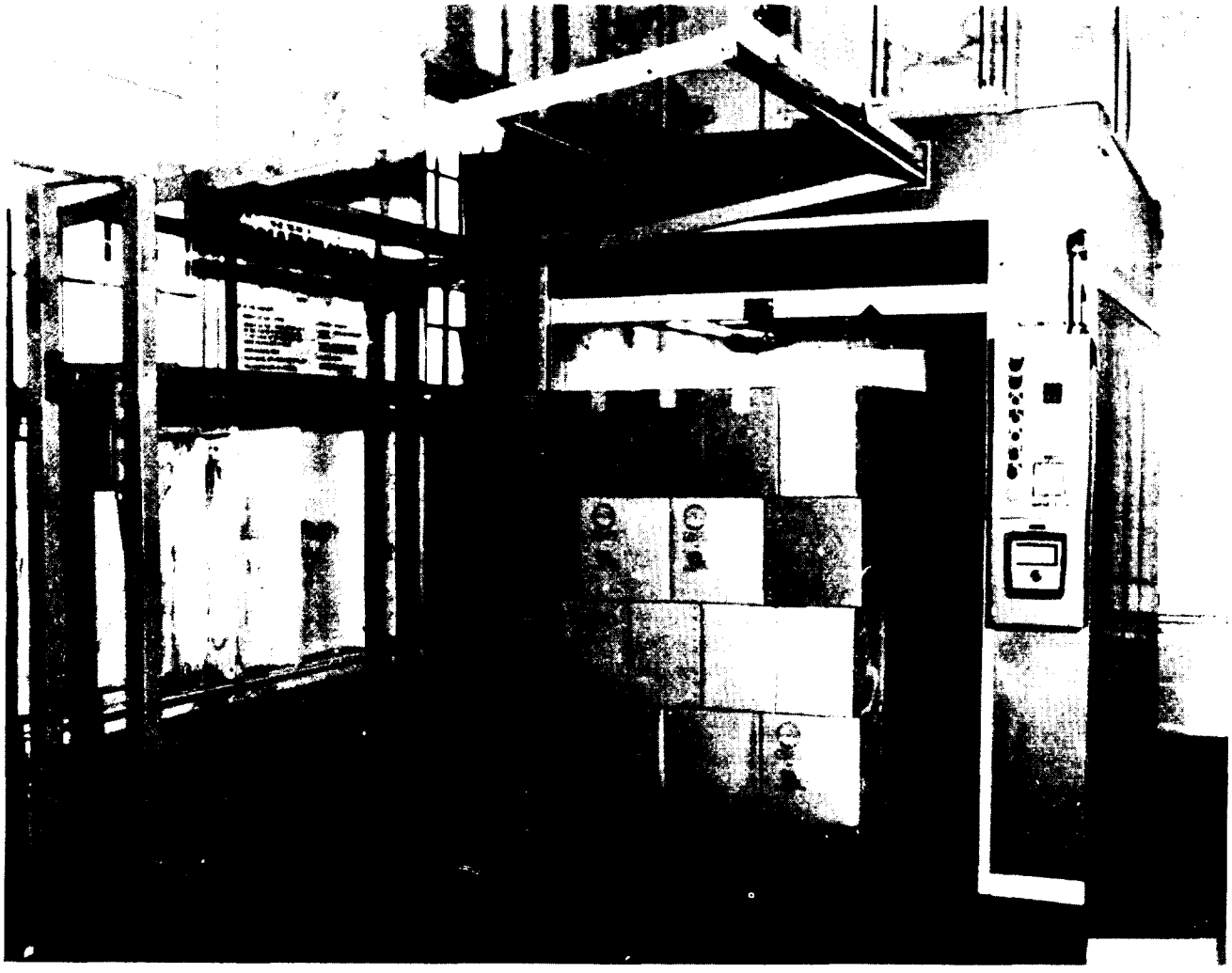


Figure 7-5. Shrink film chamber used for heat shrinking film around palletized load.

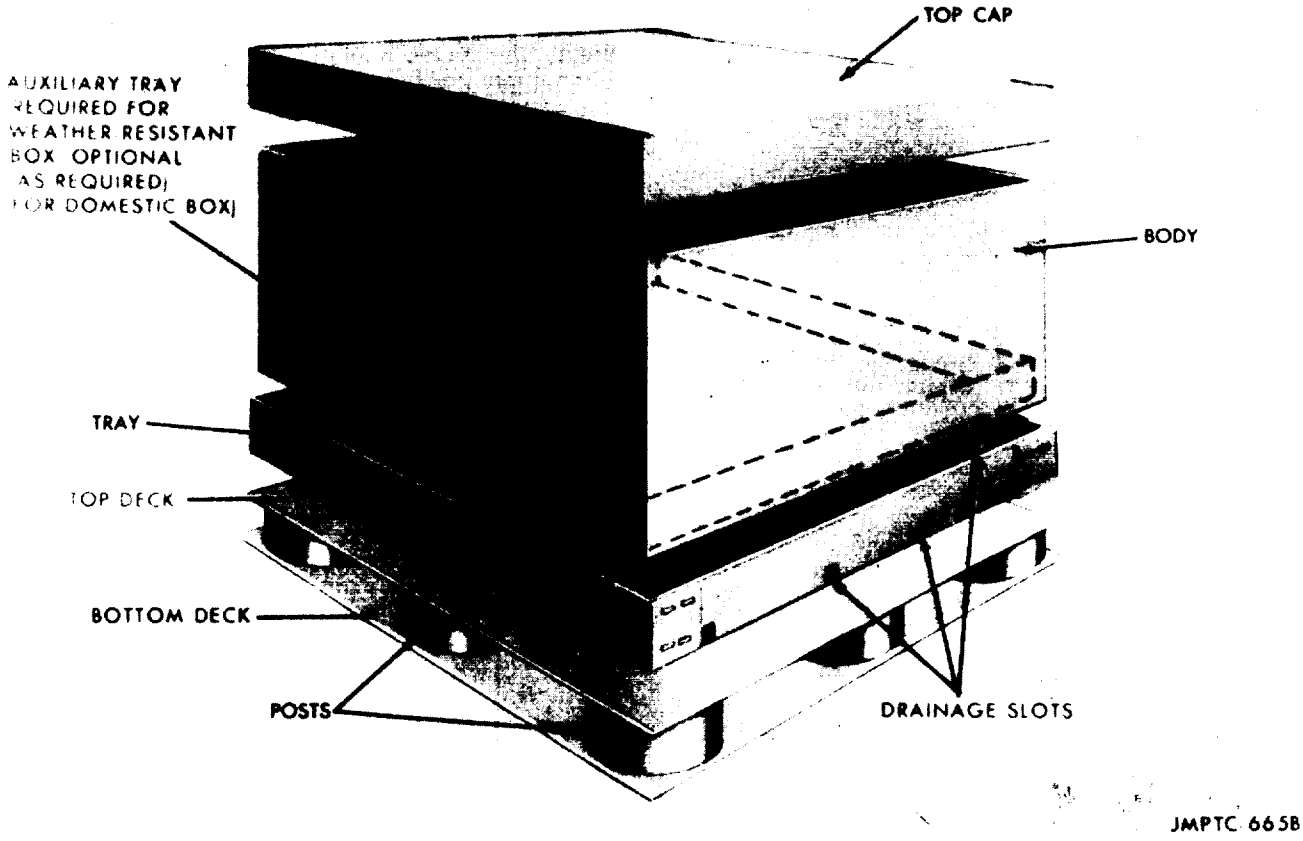


Figure 7-6. Expendable fiberboard pallet box (MIL-P-26342).

ing, or otherwise damaging the fiberboard or crushing the contents. Exposed ends of strapping shall not be of a hazardous length.

7-6. Fiberboard and Polyolefin Consolidation Containers (MIL-B-38721) (USAF) Deleted.

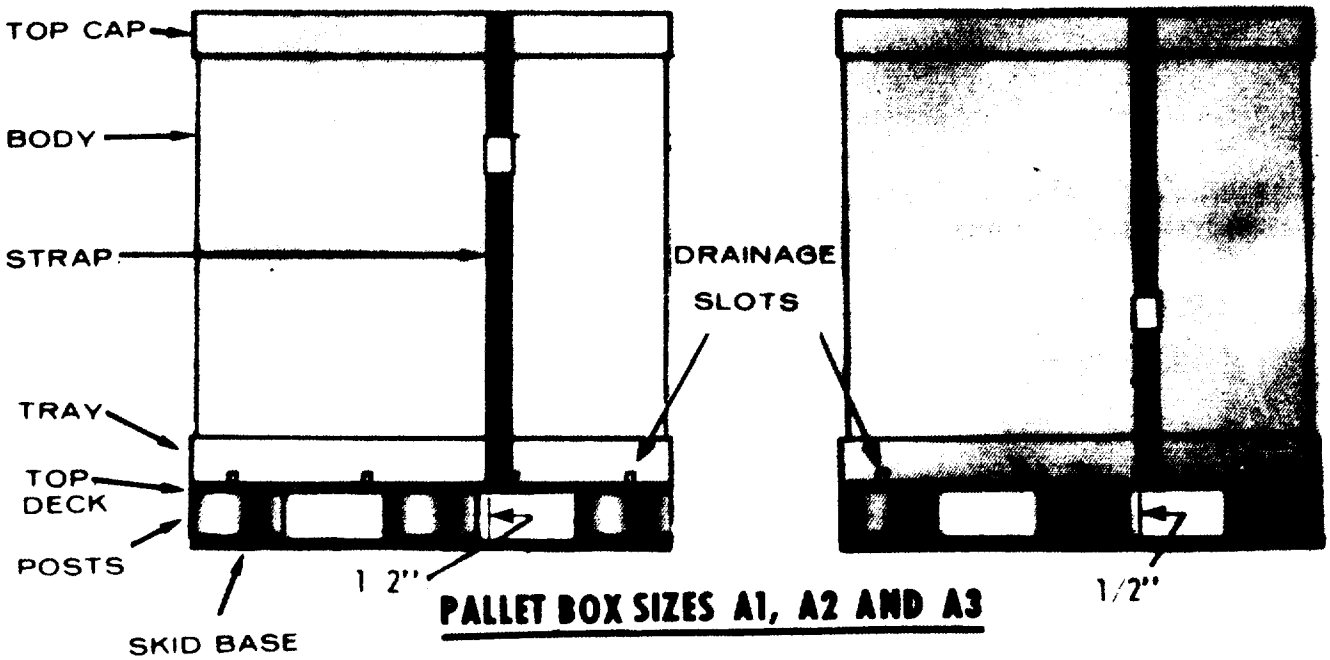
a. Selection and Use. Deleted.

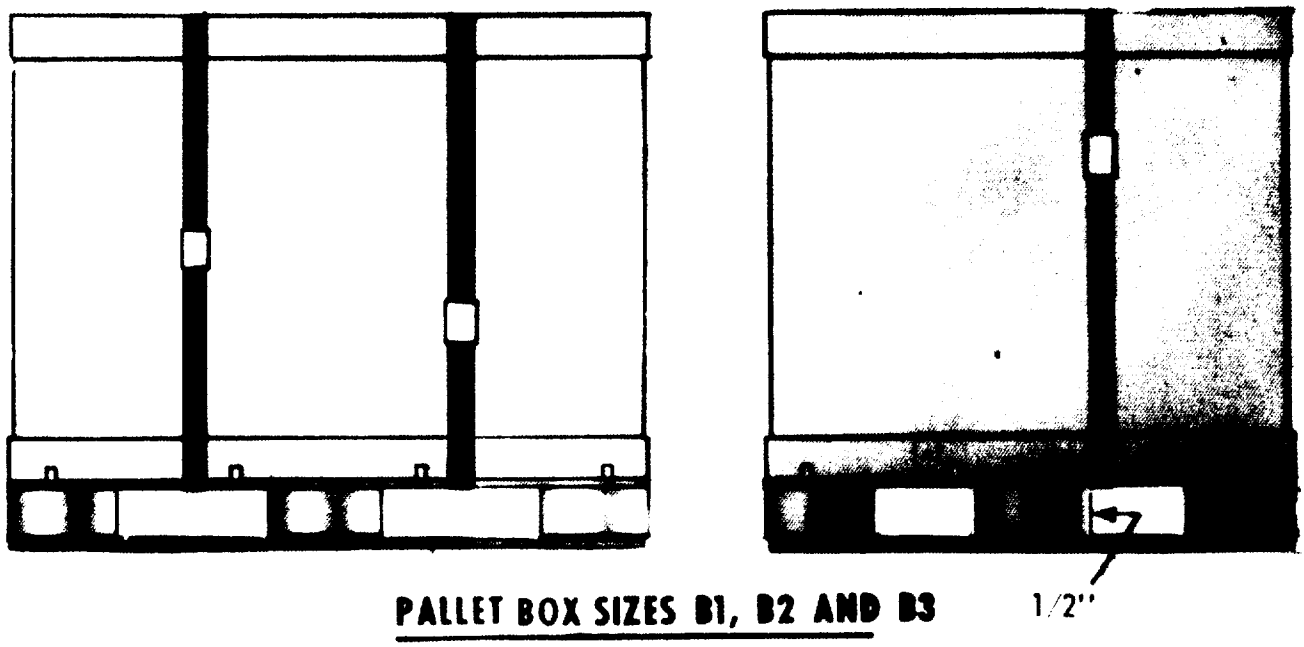
b. Classification. Deleted.

c. Size Limitations. Deleted.

Table 7-4. Fiberboard and polyolefin consolidation box sizes (MIL-B-38721). Deleted.

* U.S. G.P.O.:1991-311-773-86221





NOTE: USE NAILLESS FLAT STEEL STRAP CONFORMING TO QQ-S-781, SIZE 3 4"X 0.015"

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Figure 7-7. Strapping of expendable fiberboard pallet boxes (MIL-P-26342).

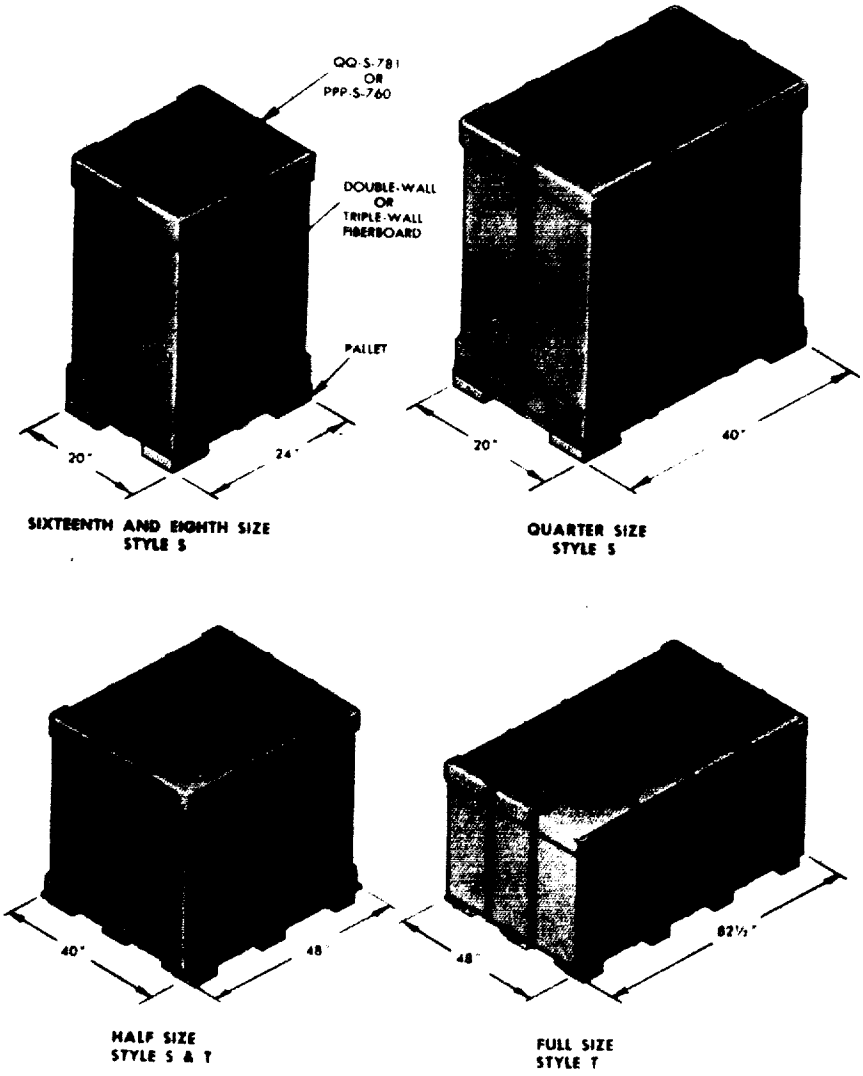


Figure 7-8. Box, consolidation, fiberboard (MIL-B-38721).

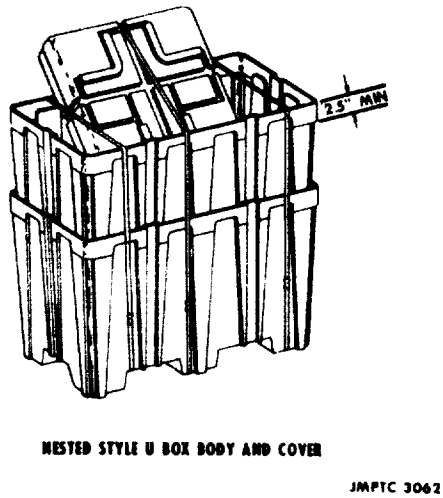


Figure 7-9. Box, consolidation, polyolefin.

d. Strapping Requirements. After the containers have been assembled and packed, they shall be strapped with ⅝-inch wide steel straps having a minimum thickness of 0.020 inches and conforming to Specification QQ-S-781 or with nonmetallic straps conforming to Specification PPP-S-760 of comparable tensile strength. Lengthwise straps shall first be applied, then girthwise straps (fig 7-8).

(1) Sixteenth and eighth size containers require one lengthwise and one girthwise strap.

(2) Quarter size containers require one lengthwise strap located in the center of the container, and two girthwise straps spaced one-third the distance between the ends of the container.

(3) Half size containers require two lengthwise straps spaced one-third the distance between the sides of the container and two girthwise straps spaced one-third of the distance between ends of the container.

(4) Full size containers require two lengthwise straps spaced approximately one-third the distance of the container width dimension, and three girthwise straps—one spaced approximately 18 inches in from each end and one in the center of the container.

7-7. Boxes, Shipping Insert Consolidation, MIL-B-43666 (General)

a. Description. These boxes are constructed of wood cleated plywood, plywood wirebound, double-wall fiberboard, or triple-wall fiberboard. They are mounted on pallet-type bases for ease of handling. Their construction varies widely depending upon the materials used. The sizes are such that they are modular in concept.

b. General Use. These boxes are intended for use as inserts in cargo transporters such as CONEX, MILVANS, or SEAVANS, or as separate exterior containers. They are to be used for Level A or B shipments.

c. Classification. There are three types of consolidation insert containers. Type I is of wood cleated plywood construction and has two styles depending upon the style of pallet base used. Type II is of plywood wirebound construction of the pallet base. Type III is constructed of double-wall or triple-wall fiberboard. Type III has four styles depending upon the construction features of the box.

d. Marking. The marking for shipment will be in accordance with MIL-STD-129.

7-8. Type I, Wood Cleated Plywood Consolidation Insert Box (MIL-B-43666)

a. Description. These containers are wood cleated plywood boxes similar in construction to the PPP-B-601 cleated plywood boxes. They are provided with a four-way entry pallet base (fig 7-10).

b. Use. These boxes may carry Type 1, 2, or 3 loads not exceeding a density of 37 pounds per cubic foot. Loads exceeding this density require additional box reinforcement. They may be used for domestic and oversea shipments. They are intended for consolidation of like and unlike stock numbered items. These containers may be used as inserts in SEAVANS or MILVANS, but should not be used as inserts in CONEX transporters.

c. Size and Weight Limitations. There are 15 sizes available in the wood cleated plywood consolidation insert containers. The outside length ranges from 29 to 86 inches. The outside width ranges from 31¾ to 45 inches. The outside height ranges from 20 to 52½ inches. For MILVAN shipments, the overall height shall be not more than 41 inches. The weight capacity for the various sizes ranges from 1,000 to 2,600 pounds. Table I and II of MIL-B-43666 specifies the length, width, height, and weight combinations for each of the 15 sizes.

d. Closure. Nail the top to the top cleats of the sides and ends using sixpenny cement-coated, chemically etched, or mechanically deformed nails spaced three inches apart. Do not drive the nails into the end grain of the vertical cleats.

e. Strapping Requirements.

(1) Each vertical corner shall be reinforced with two 8-inch pieces of ¾-inch flat steel strapping 0.023 inches thick.

(2) The strapping will be attached to the cleats with pneumatically driven galvanized staples 7/16 inches long or with 1-inch long nails pneumatically driven.

(3) As an alternate, ¾-inch wide flat, nail-on strapping, 0.025 or 0.028-inch in thickness, may be used. This strapping, which is perforated with holes spaced ½ to 1¾ inches apart, may be secured with large headed galvanized roofing nails, zinc coated steel roofing nails, or 1-inch mechanically driven nails.

(4) Each strap will be secured with four fasteners. Two will be driven into the through cleat on the end of the box and two will be driven into the filler cleat on the side of the box.

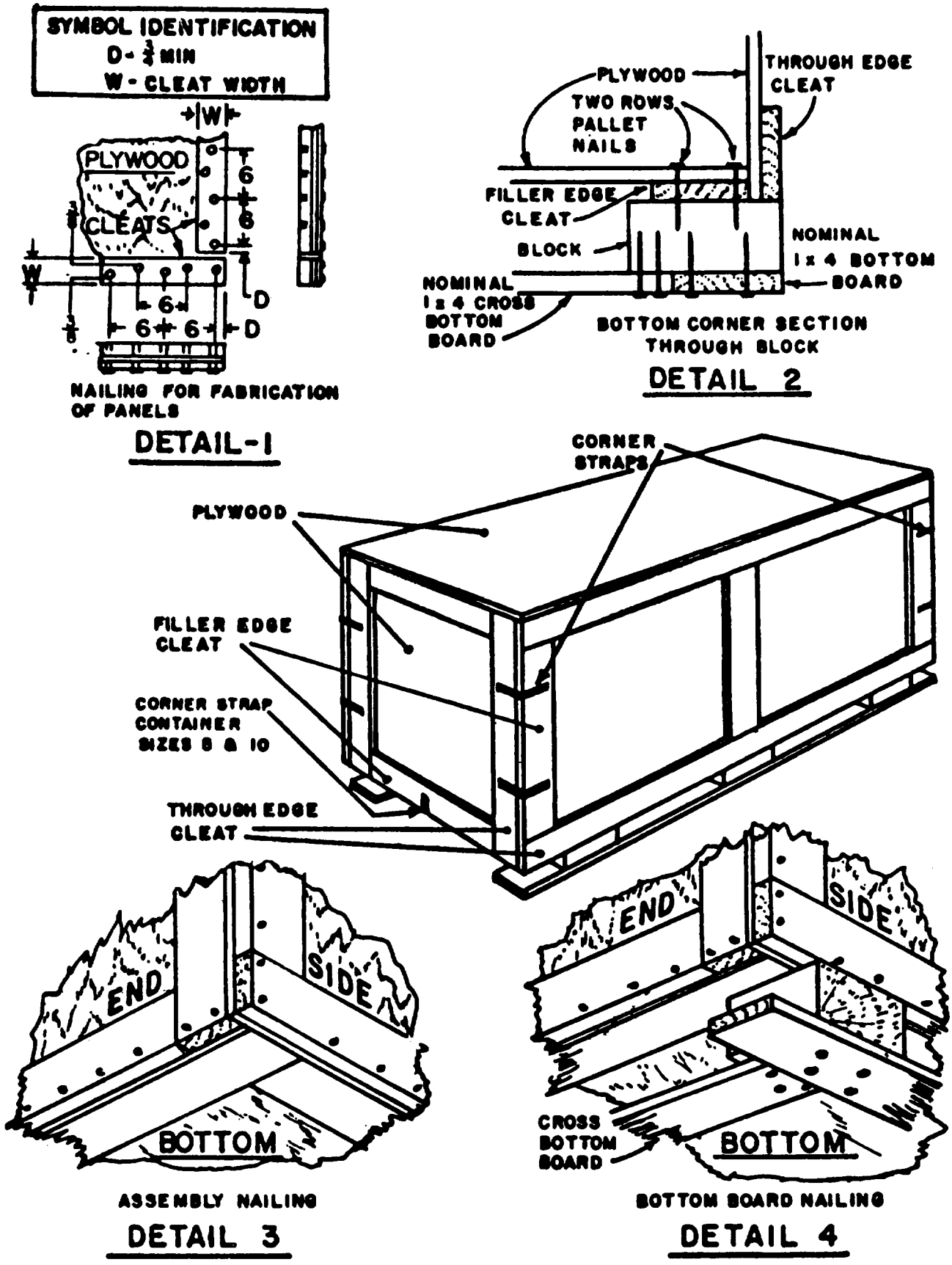


Figure 7-10. Type I, style 1, wood cleated plywood consolidation box (MIL-B-43666).

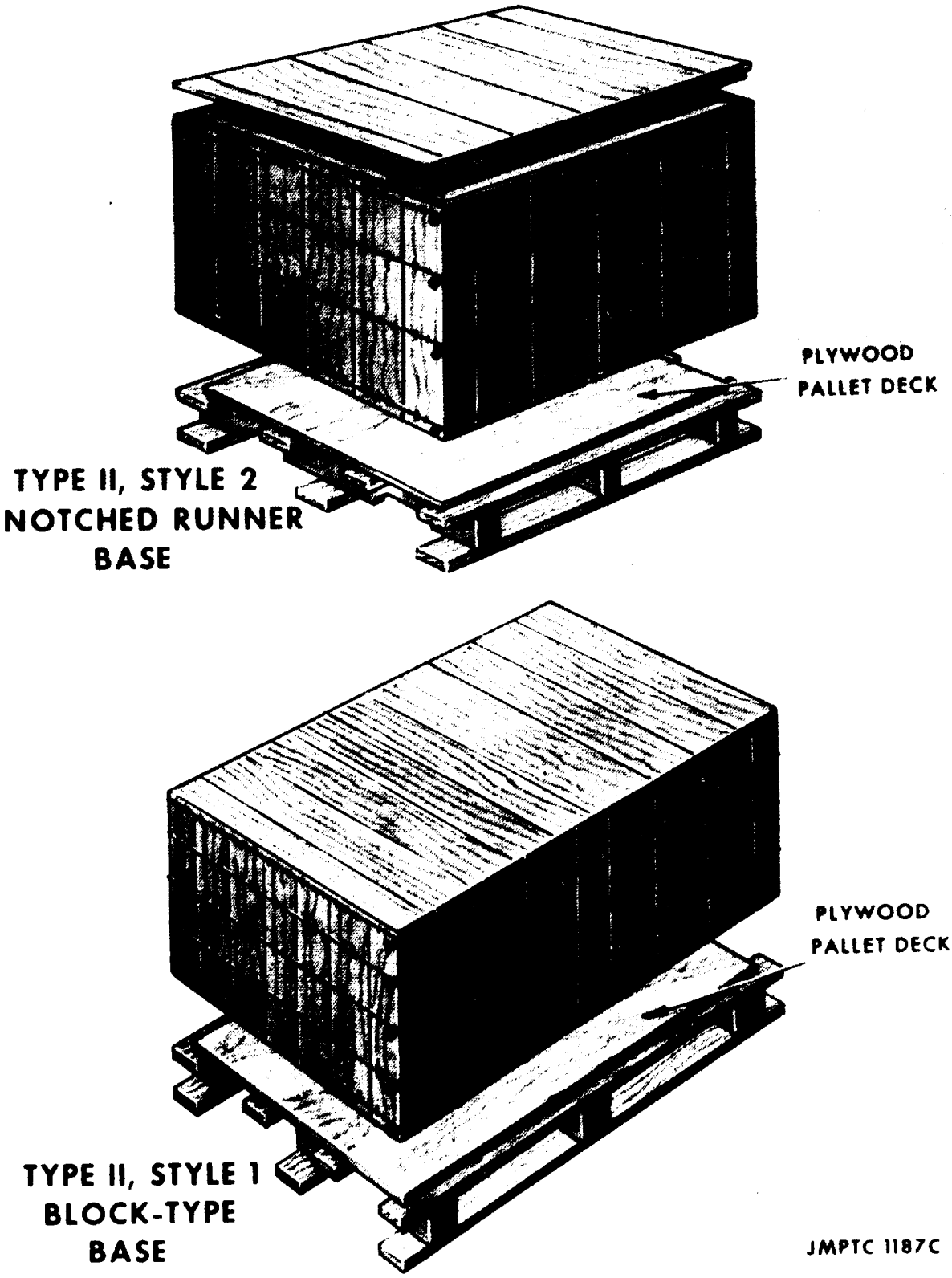


Figure 7-11. Type II, plywood wirebound consolidation boxes (MIL-B-43666).

(5) On boxes 41 inches high, strapping will be placed 13 and 26 inches from the top of the box.

(6) On boxes 20 inches high, strapping will be placed 2 and 15 inches from the top of the box.

(7) On box sizes 5 and 10, which are 43 inches wide, an additional strap shall be placed at the center of each corner formed by the bottom and end panels.

7-9. Type II, Plywood Wirebound Consolidation Insert Box (MIL-B-43666)

a. Description. The body and top of these boxes are constructed of plywood panels bound together with binding wires. The bottom panel is fabricated from ½-inch plywood which is secured to either a skid base or a pallet base (fig 7-11).

b. Use. The use of Type II plywood wirebound boxes is the same as Type I would cleated plywood boxes.

c. Classification. There are two styles of boxes available under the Type II classification.

(1) Style 1 box utilizes a double-wing, block-type pallet base (fig 7-11).

(2) Style 2 box utilizes a skid base having three lengthwise skids which are cut out to facilitate side entry by folklift trucks.

d. Size and weight limitations. There are several sizes available in the plywood wirebound consolidation containers. The range of outside dimensions and weight limitations are the same as those specified for the Type I, cleated plywood boxes. Tables I, and II, of MIL-B-43666 specify the length, width, and height combinations for each of the sizes.

e. Closure. After the box body is assembled by securing the wire loops with a sallee closure hand tool, or similar suitable alternate tool, and nailed to the base, make the closure by nailing the plywood top to the top cleats with threepenny nails. Space the nails 4½ inches apart. Complete the closure by applying lengthwise and girthwise straps.

f. Strapping Requirements. Requirements for the size, number, and location of straps vary for each style and size of Type II containers. Consult the Appendix of MIL-B-43666 for detailed requirements for reinforcing the particular plywood wirebound container being used.

7-10. Type III, Fiberboard Consolidation Insert Box (MIL-B-43666)

a. Description. These boxes are made of double-wall or triple-wall fiber board. The box design and construction differs for each of the four designated styles. Unless otherwise specified, they are furnished with a pallet base.

b. Use. Type III fiberboard insert boxes should be restricted to CONEX, MILVAN, or SEAVAN when used for level A oversea shipments. They may be used as shipping containers for Level B oversea shipments and as domestic consolidation containers. Style 3 should be used for items of assorted stock numbers to be loaded at origin as inserts only for shipment in CONEX, MILVAN, and SEAVAN to a single consignee address code. Style 5 should be used for unit loads of nonperishable subsistence as required by MIL-L-35078 and sized (in height) depending on the anticipated height of the contents.

c. Classification. There are four styles of boxes available under Type III classification.

(1) Style 3, regular slotted box (RSC), is the same as the alternate construction of the Style E PPP-B-640 fiberboard box with a 1½-inch overlap of the outer flaps (fig 7-12). The box may be furnished with or without a pallet base. When a pallet base is used, it may be either a double wing block-type or double wing notched runner-type.

(2) Style 4 half slotted container (HSC) with telescoping sleeve and cap, consists of a half slotted container bottom section without top flaps, a sleeve (with stiffening flaps) which fits over the bottom section, and a top cap which extends down six inches over the sleeve (fig 7-12). The requirements for the pallet base are the same as for Style 1.

(3) Style 5 flanged bottom tube with cap, pad, and pallet, consists of a fiberboard tube with 4-inch bottom flanges, a bottom pad, and a top cap which fits down over the body tube (fig 7-13). This style is furnished with a stringer type pallet base.

(4) Style 6, half slotted container (HSC) with cap and pallet base, consists of a body having a regular slotted bottom and a flanged top, and a top cap (fig 7-13). Unless otherwise specified, it is furnished with a pallet base.

d. Size and weight limitations. There are several sizes available in the fiberboard consolidation containers, depending upon the styles. The outside length ranges from 29 to 86 inches. The outside width ranges from 31¾ to 42 inches. The outside height ranges from 20 to 52 1/8 inches. The weight limit ranges from 1,500 to 2,600 pounds. Style 3 is available in sizes 1 through 10; Style 4 is available in sizes 23 and 24; Style 5 is available in sizes 16, 17, 18, and 24; and Style 6 is available in sizes 14 and 15. Tables I and II of MIL-B-43666 must be consulted for the various length, width, height, and weight combinations of each of the sizes specified for Type III boxes.

e. Closure. The closure requirements vary for each style of box. Type III boxes are constructed in accordance with Specifications PPP-B-640, PPP-B-1163, and PPP-B-43666. The boxes are closed in accordance with the Appendix of the applicable specification.

f. Strapping Requirements. Either metal or nonmetallic strapping may be used to reinforce Type III boxes. Requirements for the size, number, and location of straps vary for each style and size of box. Consult the Appendix of MIL-B-43666 for the detailed requirements for reinforcing the particular style and size of fiberboard consolidation box being used.

7-11. Packing Consolidation Container

a. Problems Involved in Consolidation. The main problem involved in consolidation of materials becomes one of shock mitigation.

(1) The packer must be skilled in placing packages in the container so that each package "wedges in" other packages.

(2) The packer must be able to block or brace the load as he progresses, in a minimum of time and with the cheapest and lightest material, yet strong enough to do the job.

(3) Essentially, the problem becomes one of converting a type 3 load to a Type 2 load for protection against shock and vibration.

b. Shock Mitigation. In order to meet the problem of shock mitigation relative to consolidation containers, there are certain basic procedures to follow:

(1) Try to maintain level layers.

(2) Fill all internal voids as the load progresses.

(3) Keep the center of gravity low and cen-

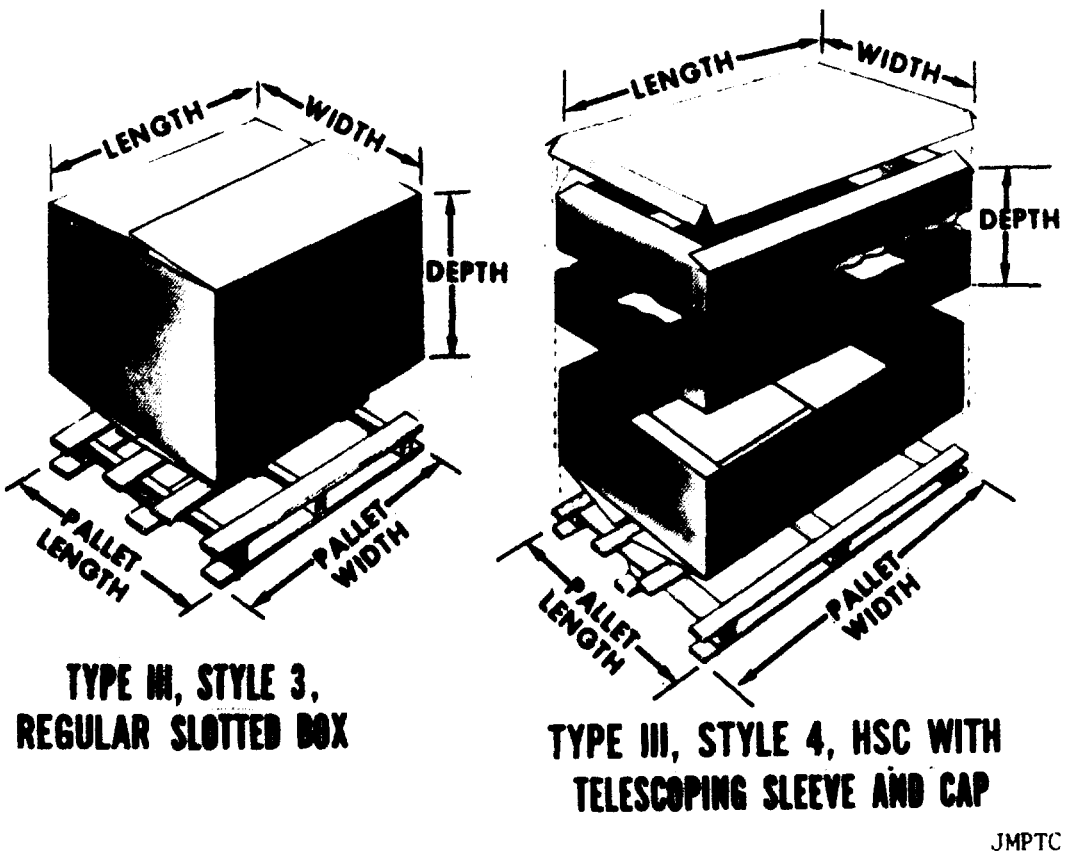
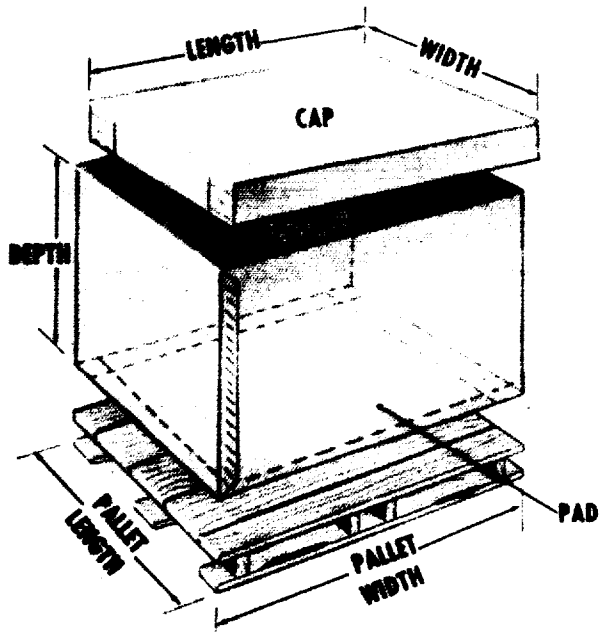
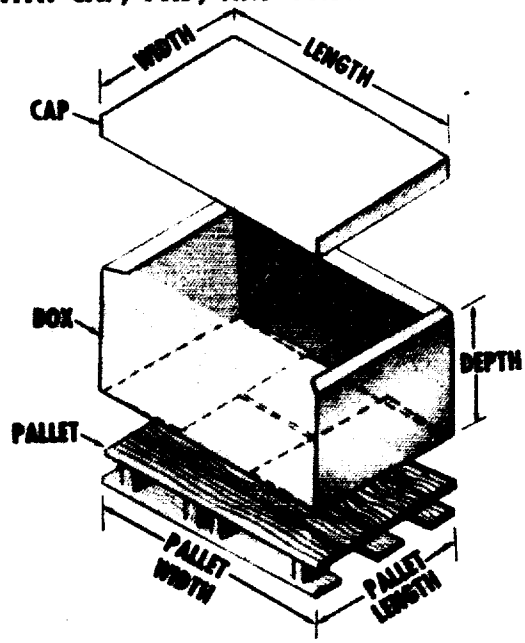


Figure 7-12. Type III, styles 3 and 4, fiberboard consolidation boxes (MIL-B-43666).



TYPE III, STYLE 5, FLANGED BOTTOM TUBE WITH CAP, PAD, AND PALLET



TYPE III, STYLE 6, HALF SLOTTED CONTAINER WITH CAP AND PALLET BASE

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Figure 7-13. Type III, styles 5 and 6, fiberboard consolidation boxes (MIL-B-43666).

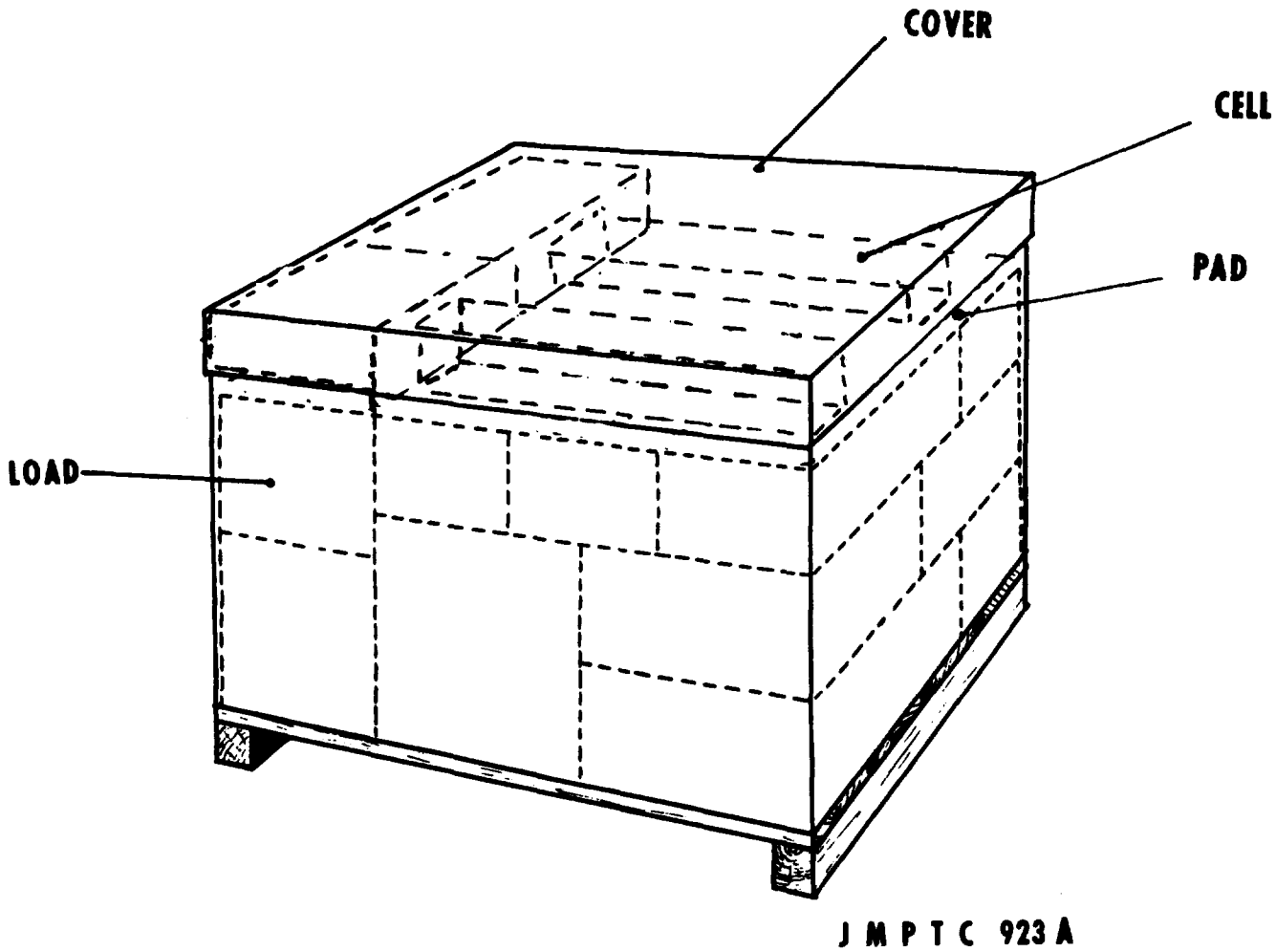

Figure 7-14. Blocking and bracing top voids.

tered by placing heavy items in the bottom portion of the container and centering them in the container as much as possible.

(4) Block and brace the interior load adequately to prevent movement caused by shock and vibration.

c. *Blocking and Bracing the Load.*

(1) The ideal conditions for full utilization of consolidation containers is to tailor a container to the size of uniform interior packages. Of course, the required consolidation containers are generally of standard dimension and are not related to product package sizes.

(2) These ideal conditions are not always present at the depot or base level, but with a variety of package sizes to place in consolidation containers most of the available space can be utilized in some instances.

(3) Voids that occur at the top of the pack are probably the most usual (fig 7-14). In order to provide holddown media for the load, first cover the packs with pad(s) and then place cells between the pads and the container cover. The use of adhesives will hold the cells in place. Cells should be located where strapping will be placed. Where feasible, the corners of the container may be split down to the top of the load and the excess portion of each side panel, above the top of the load, may be folded in, thus eliminating the need for cells.

(4) Voids that occur at the sides of the pack can be blocked with pads and cells, the same as top blocking and bracing (fig 7-15).

(5) Interior voids (fig 7-16) are the hardest to cope with and the most time-consuming. All voids that would permit shifting of the packages should be filled with cells or foamed-in-place materials as

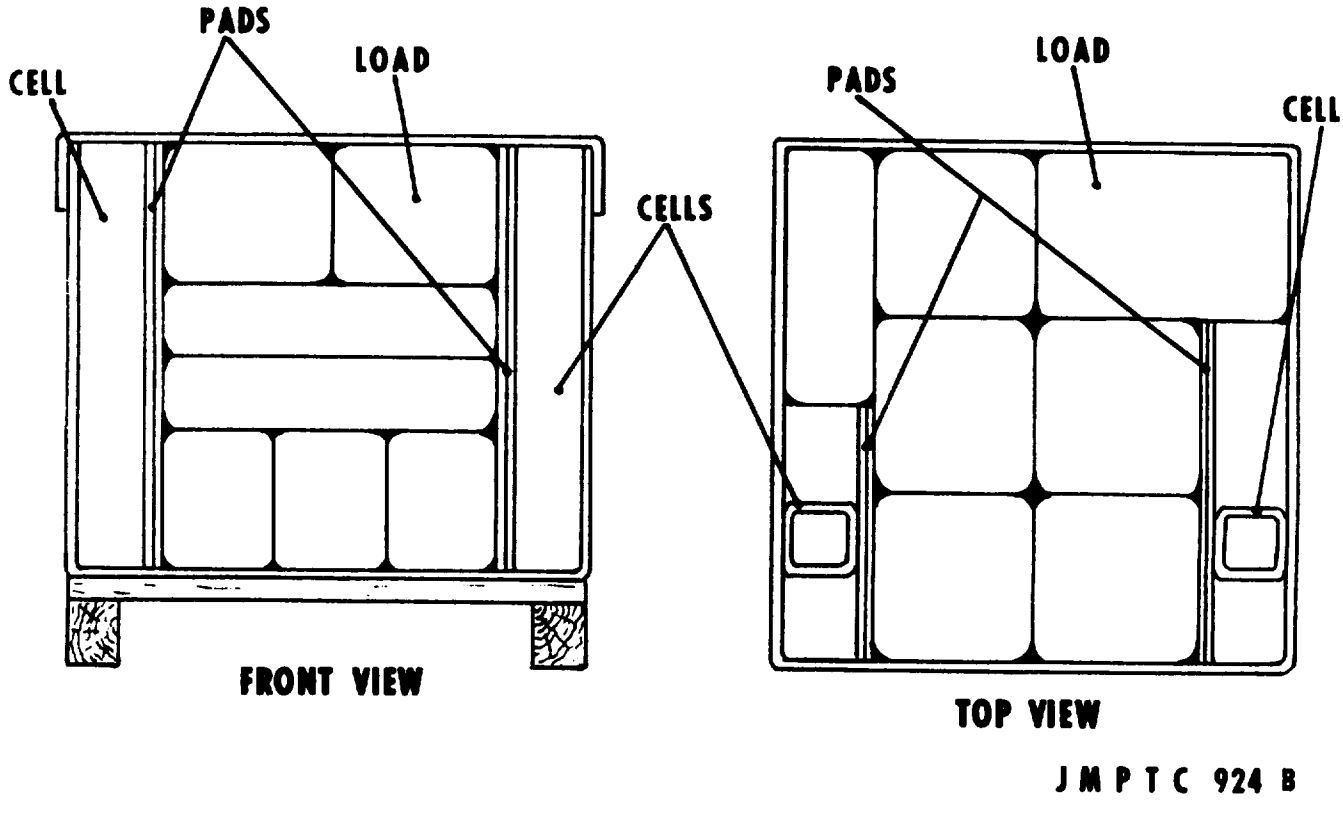

Figure 7-15. Blocking and bracing side voids.

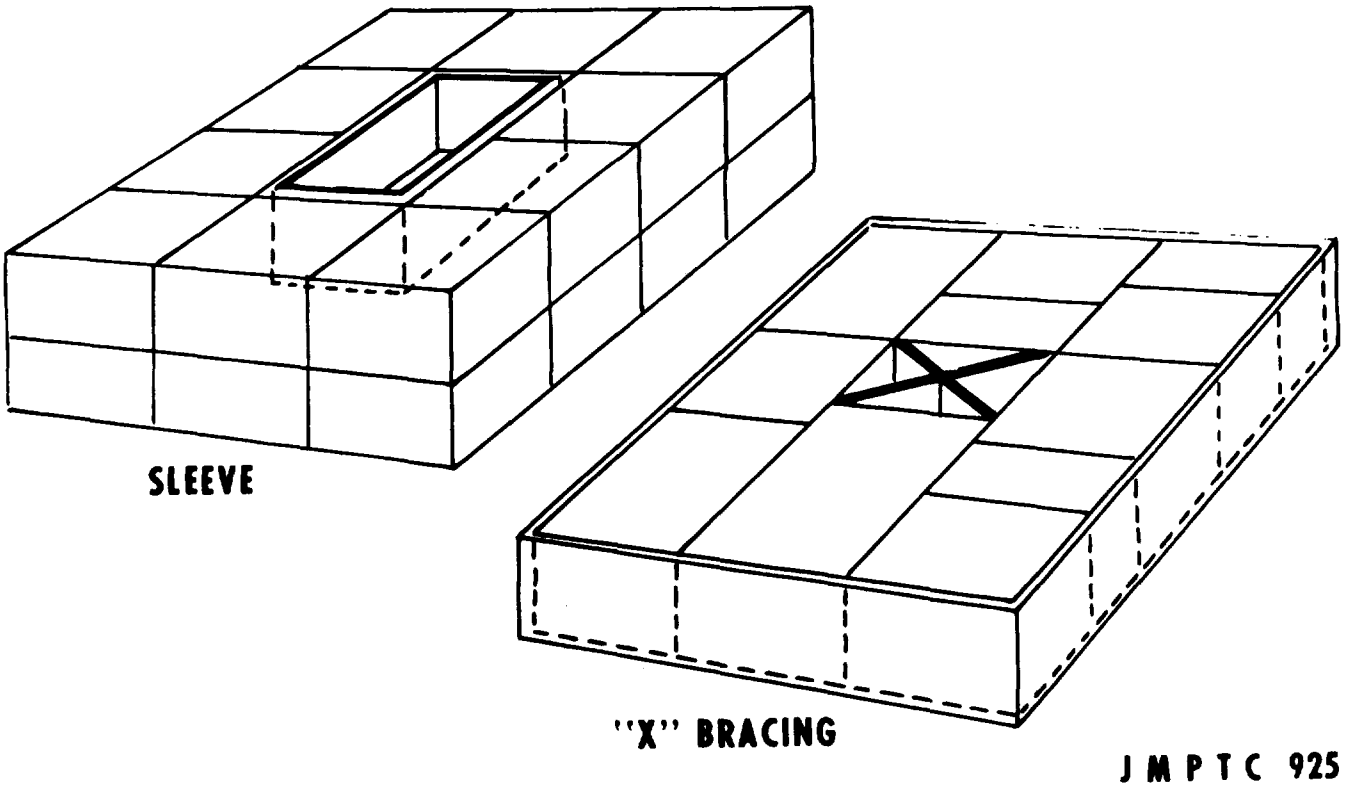

Figure 7-16. Blocking and bracing interior voids.

the layers progress. If the packages are uniform, one sleeve may fill the void for several layers of packages.

(6) Compound voids (top and side, two sides, etc.) may take a little more skill, but pads and cells can be used to block and brace the same as previously discussed.

7-12. Packing Nonperishable Subsistence Items

Unit loads of nonperishable subsistence items shall be prepared in conformance with Specification MIL-L-35078, Load, Unit: Preparation of Nonperishable Subsistence. This specification establishes patterns, methods, materials, and techniques applicable to the preparation of unit loads of nonperishable subsistence items by loading the shipping containers onto a pallet or within a consolidation container for shipment. The choice of unit load type and class based upon the level of protection provided can be determined from paragraph 6.1 of MIL-L-35078. Detailed specification sheets, MIL-L-35078/1 through MIL-L-35078/7, provide the requirements for each unit load type and class. The types and classes of unit loads are shown in table 7-5, below.

Table 7-5. Classification of Unit Loads of Nonperishable Subsistence Items (MIL-L-35078)

Types	Classes
I—Palletized unit load	A—Strapped or film bonded. B—Capped and strapped. C—Sheathed, capped and strapped. D—Shrouded, sheathed, capped and straped.
II—Containerized unit load	E—Capped and strapped fiberboard box. F—Wood cleated or wirebound, strapped plywood box.
III—Commercial load base	G—Palletized. H—Load base.

7-13. Cargo Containers (General)

a. Definitions.

(1) Transporter. A cargo container is a large shipping container in which packed or unpacked materiel is placed for movement to a break-bulk point or to an ultimate consignee.

(2) *CONEX.* The CONEX is a Government-owned noncollapsible, reusable metal shipping container equipped with skids and lifting lugs to facilitate handling.

(3) *MILVAN.* The MILVAN is a Government-owned or leased noncollapsible, reusable cargo container capable of being coupled to another container of like description. It can be lifted by top or bottom corner fittings; can be used either singly or coupled together; and can be carried by highway, rail or water modes of transportation.

(4) *SEAVAN.* A SEAVAN is a privately-owned container of various sizes and configurations which may be leased to the Government for the consolidated movement of materiel by highway, rail, or water modes of transportation.

Note—Cargo that is hard to handle in closed vans, such as large, heavy or bulky items, or machinery, may be shipped in flat racks. (see para 7-15b(3) for more information.)

(5) *AIR/LAND.* The M2 AIR/LAND container is a lightweight intermodal container that permits land and air freight transportation without re-handling of the contents. The container is 8 feet in height, 8 feet in width, and 20 feet in length. They have a gross weight capacity of approximately 45,000 pounds. The container and its contents must not exceed the structural limitations of the transporting aircraft.

(6) *Stuffing.* The term "stuffing," as related to cargo containers means the placing of cargo into cargo containers as distinguished from the process of loading containers on board ship. See MTMC

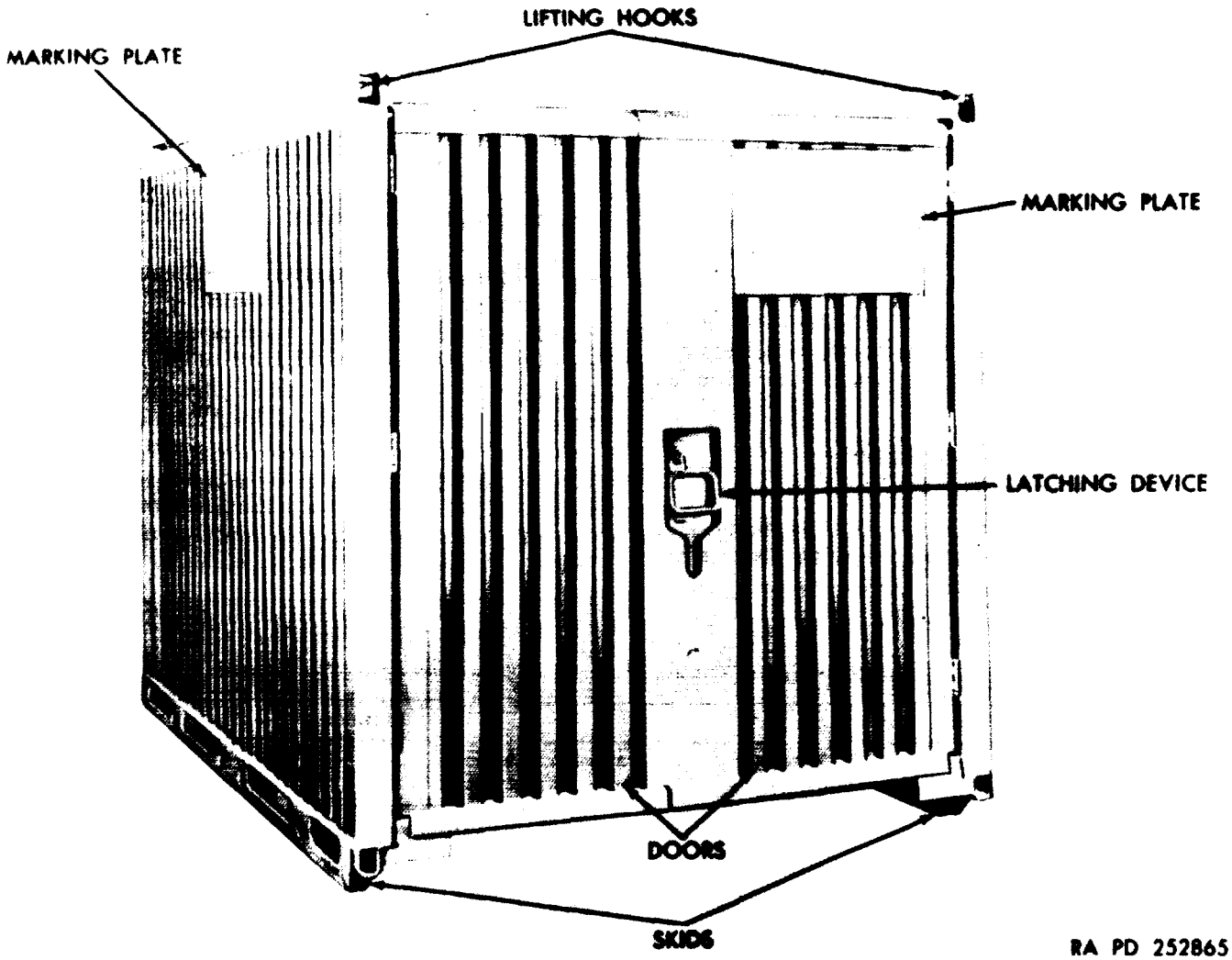

Figure 7-17. Type II CONEX.

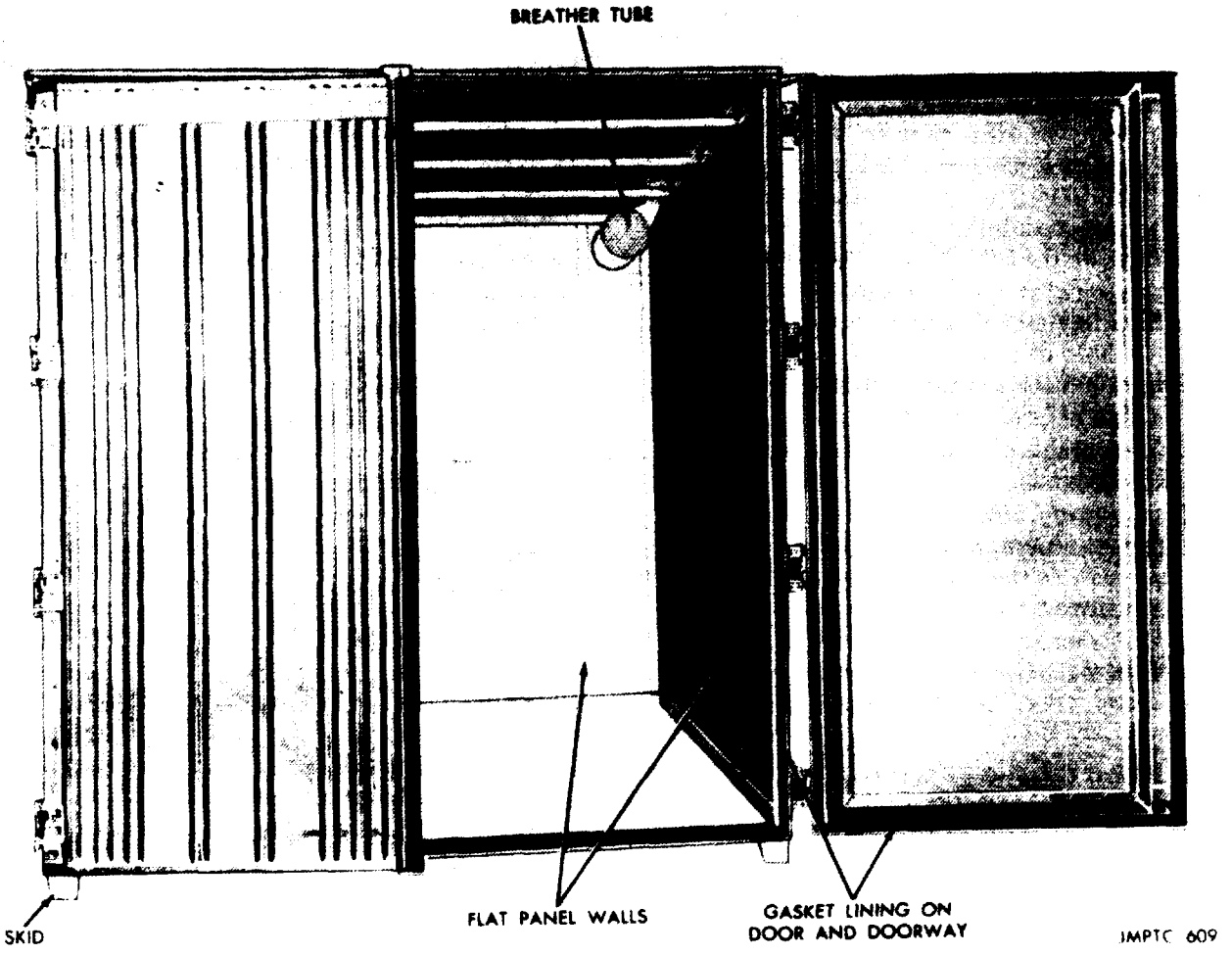

Figure 7-18. Controlled humidity (CH) CONEX.

Pamphlet No. 55-2 "Management and Stuffing of Containers."

b. Purpose and Advantages of Large Containers.

(1) *Purpose.* The purpose of cargo containers reduce the number of miscellaneous small package shipments to unit loads of the best possible size for the direct application of mechanical handling equipment.

(2) *Advantages.* The use of mechanical handling procedures increases the speed, security, accuracy, flexibility, and economy of supply and transportation operations.

(a) Use of cargo containers reduces the cost of handling and rehandling many small packages.

(b) Loss due to damage to containers and supplies during handling and shipping is reduced.

(c) Loss due to pilferaging and misplacement or misrouting of individual packs is reduced.

(d) The consolidation of packs within cargo containers reduces the need for marking and documentation of individual packs destined for one consignee.

(e) Savings are realized through the elimination or reduction of heavy or expensive shipping containers.

7-14. Use of CONEX Containers (MIL-B-11886)

a. Description (fig 7-17 and 7-18). The CONEX cargo containers are reusable metal shipping containers. With the exception of those which are designed to offer controlled humidity, they are weatherproof but not entirely waterproof. There are two types of CONEX containers.

(1) *Type I (Half-Size).* This type is four feet, 3 inches long and has a volume of 135 cubic feet. It has a weight carrying capacity of 9,000 pounds.

(2) *Type II (Standard Size).* This type is twice as long as the Type I. It has a volume of 295 cubic feet and has a carrying capacity of 9,000 pounds also.

(3) *Type II (Controlled Humidity).* Type II is also available in an airtight type construction which makes it water-vaporproof. It is provided with a free-breathing device which is connected to a desiccant cell. The desiccant cell breathes freely with temperature changes. All air entering or leaving the CONEX must pass through the desiccant, thus maintaining a safe level of relative humidity within the CONEX.

b. Utilization of Weight Capacity.

(1) Items having a density of 30 to 45 pounds per cubic foot should be shipped in a Type II CONEX.

(2) Items having a density of over 45 pounds per cubic foot should be shipped in a Type I CONEX.

(3) The contents of CONEX containers shall not exceed 9,000 pounds.

c. Utilization of Cubic Capacity.

(1) The maximum use of all internal space will normally preclude the use of dunnage. A workable guide is to utilize 80 percent of the usable space.

(2) Unnecessary dunnage adds to the gross weight of the CONEX. Eliminate it when possible.

(3) Large, irregular shaped items should not be stuffed in a CONEX because of the waste of cube.

d. Stuffing of Hazardous Materials

(1) Authorized hazardous materials may be shipped in a CONEX provided they are packed, marked, and stuffed in strict accordance with Department of Transportation and US Coast Guard regulations. Examples of materials prohibited by the US Coast Guard to be shipped in cargo containers alcohol, bombs, detonators, dynamite fuzes, gas projectiles, mortar ammunition, black powder, hand grenades, mines, rocket missiles, etc.

(2) Authorized hazardous materials must be kept separated from the rest of the load.

(3) Noncompatible hazardous materials must be kept separated in shipment.

e. General Rules for Stuffing CONEXES.

(1) *Sensitive and expensive items.* Stuff sensitive and expensive items in the rear of the CONEX to deter pilfering.

(2) *Heavy, rugged items.* Place heavy and more rugged items on the bottom in the CONEX. When necessary, block and brace these items to prevent shifting and damaging other items.

(3) *Sets and assemblies.* Whenever possible keep sets and assemblies together within the CONEX to facilitate keeping them together when the CONEX is unstuffed.

(4) *Items to be shipped to different consignees.* Whenever possible, if items within the CONEX are to be shipped to different consignees, they should be kept together and separated from the rest of the load.

(5) *Priority items.* Whenever possible, plan to load so that priority items will be readily available upon arrival at destination.

(6) *Securing the load.* The load within the CONEX must be secured so that it will not shift in transit.

(a) Place packages within the CONEX so that all available space is utilized. Prevent shifting of containers by cross-tiering, that is alternately fitting them together so that the boxes support each other.

(b) Place dunnage between the load and the sides of the CONEX to fill voids when the containers cannot be fitted snugly.

(c) Block and brace partial loads within the CONEX to prevent shifting by placing 2- by 4-inch lumber across the width of the CONEX, fitting the ends of the braces into the corrugations on the sides of the CONEX.

(d) Use flat steel strapping in the doorway area to prevent the load from spilling out when the CONEX doors are opened. Use two lengths of strapping for each application. Anchor one end of each length by threading the end through a slot in the doorpost, looping the end back against the length of the strap, and securing with a strapping seal. Bring the other two ends of the anchored lengths together at the center of the load, tension the two lengths together, and apply a strapping seal. If strapping is not sufficient to secure the load, fill the intervening spaces between the straps by placing additional strips of wood dunnage vertically or horizontally beneath the straps prior to tensioning the strapping.

f. Closure and Sealing.

(1) *Weatherproofing the doorway area.* Since the CONEX is not completely waterproof, secure waterproof barrier material in the doorway area when there is a danger that water may damage the contents in the CONEX.

(2) *Placing the shipping documents within the CONEX.* Place the shipping documents in a shipping document envelope and place the envelope in the packet located in the CONEX door, so that it is easily accessible when the CONEX is opened.

(3) *Closing the CONEX doors and securing the handle.*

(a) Close the CONEX doors and lock them in the closed position by turning the door handle 90° so that the hole in the handle is in line with the hole in the bracket which is located on the CONEX door.

(b) Secure the door handle with zero to five gage wire. Pass the wire through the holes in the door handle and the door bracket. Thread the wire through two holes drilled an inch apart in an 18-to-20-inch steel bar. Twist the bar several times,

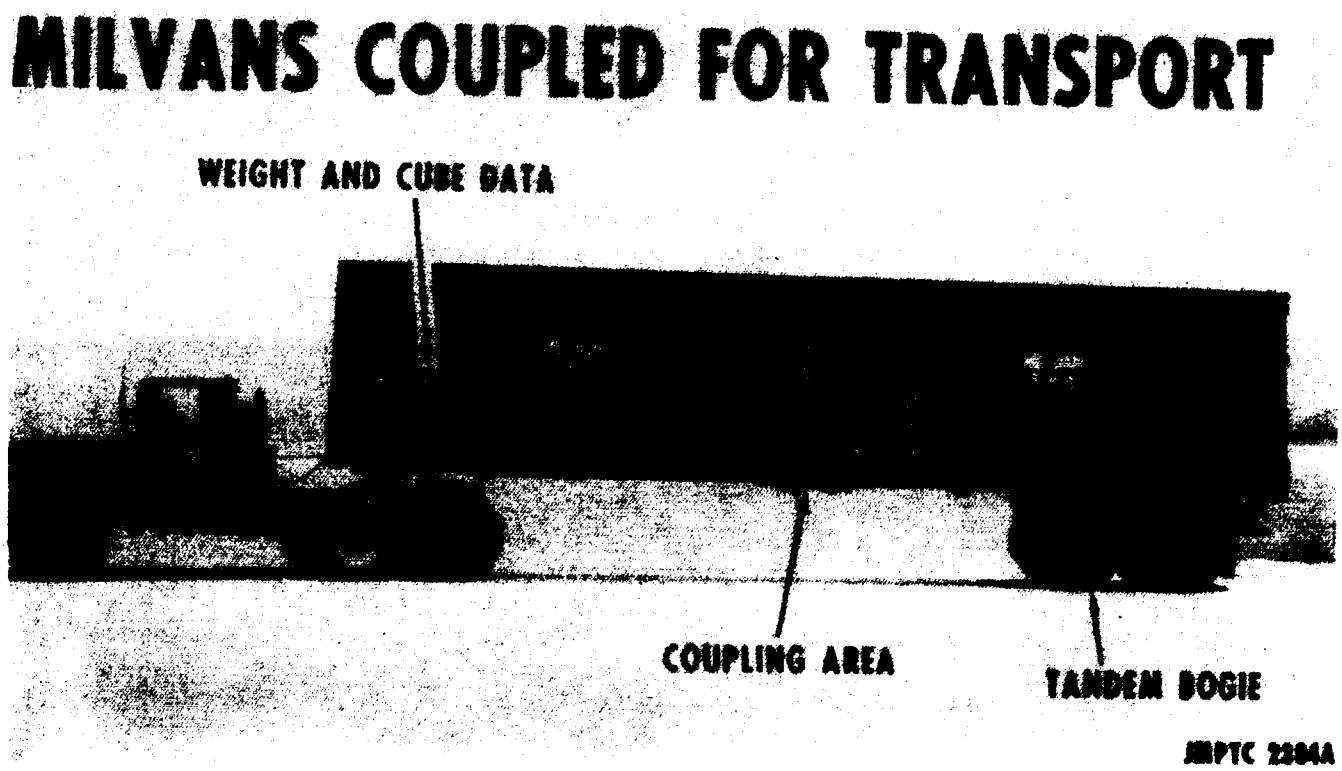

Figure 7-19. MILVAN cargo containers.

remove the bar, and cut off the surplus wire close to the twist with a bolt cutter.

(c) A padlock may be used in lieu of the wire when authorized. Care must be taken to insure that the consignee has the means to open the lock upon arrival.

(4) *Applying the seal to the door handle.*

(a) Make sure that the serial number on the seal corresponds with the number recorded on the shipping document.

(b) Thread a standard railway car seal through the slot in the door handle and the slot in the bracket which is located on the CONEX door.

(c) Thread one end of the seal into the locking device on the seal and snap into place.

g. Marking.

(1) *Location of markings.* Exterior marking plates are located on each side and on the front and rear of the CONEX. Address markings will appear only on these plates.

(2) *Obliterating old markings.* Obliterate old markings on the marking plates by repainting them.

(3) *Requirements for marking.* Markings on CONEXES must conform to MIL-STD-129, and to MILSTAMP/MILSTRIP requirements.

(4) *Applying the markings.* Apply the markings on the address plates in colors which contrast with the background, so that they can be read easily from a distance.

7-15. Use of MILVANs and SEAVANS

a. Description of MILVAN (MIL-C-52661) (fig 7-19). A MILVAN has inside dimensions of 231 inches in length, 92 inches in width, and 87 inches in height. The gross weight rating for each 20-foot container is 44,800 pounds. A MILVAN can be coupled to another MILVAN container to make a single unit 40 feet in length. A MILVAN has the capability of being moved by a semitrailer tractor when used in conjunction with a tandem bogie arrangement which serves as the rear wheels. When the double doors are properly closed, the MILVAN affords waterproof protection.

b. Description of SEAVAN (fig 7-20). SEAVANS vary from approximately 20 to 40 feet in length. The standard length utilized by the military is 40 feet. SEAVANS are 8 feet in height and 8 feet in width. They have a maximum gross weight capacity of 67,200 pounds. SEAVANS are compatible for movement by motor and rail and may be stored for shipment on specially containerized ships. They may be transported on a semitrailer

Figure 7-20. SEAVAN loaded for highway movement.

chassis and are lifted easily and loaded, minus the chassis, on board by modern materials-handling equipment. There are four general types and three specialized types of SEAVANS:

(1) *Dry cargo container.* The dry cargo container is weatherproof and is designed to protect the cargo from water. It is ideally suited for shipping items packed in domestic packs and any commodities susceptible to water damage. The dry cargo container is completely inclosed and must be loaded and unloaded by hand or forklift truck.

(2) *Dry cargo—canvas top container.* The canvas, or so-called "rag" top container, is similar to the dry cargo container, but has a removable canvas top. With the top removed, the cargo can be loaded and unloaded by crane as well as forklift. Canvas top containers are not 100 percent weatherproof; therefore, all items loaded in such containers must be in waterproof packs or otherwise not be susceptible to water damage.

(3) *Flatrack container.* The flatrack container resembles a flatbed truck with varying styles of side bracing and corner posts and comes in a variety of sizes. Generally, the flatrack has about two-thirds the cubic capacity of a dry cargo container, but with the same weight capacity. It is designed to carry high density and oddly shaped cargo that requires little protection against the elements, although some are equipped with fabric covers. Brackets on the sides of the bed facilitate efficient tiedown or banding of heavy items to the bed of the container. Removable sides facilitate the loading and unloading by crane or forklift truck.

(4) *Reefer (refrigerator) container.* Perishable cargo that must be refrigerated or frozen must be transported in a reefer. Most of the commercial reefers have standard refrigeration units that are fuel operated for road use and electrically operated for storage or ocean transit. The standard container can refrigerate or freeze from ambient temperature to -10 degree Fahrenheit.

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(5) *Insulated container.* This is a specialized container. It is used for cargo that should not be subjected to rapid temperature changes. It should be used when extreme changes in ambient temperatures are indicated.

(6) *Car-carrier.* This specialized container is designed to carry two or four privately-owned vehicles for ocean transportation. The container which carries four vehicles is 35 feet long and has double-deck frames. Due to its additional height, the four vehicle container has one and one-half times the cube capacity of a dry cargo container.

(7) *Tank container.* This also is a specialized container. It is a small tank, inclosed in a framework, that can be used for small lot shipments of bulk liquids.

c. Weight Distribution.

(1) Distribute the load evenly throughout the container with heavier items on the bottom.

(2) Cargo must be compatible with the size of the container. When the density of one commodity is not compatible with the container size, select an adequate commodity mix that will yield the best cube utilization. At least 80 percent of the cube should be used.

d. Weight Limitations. There are two overall transporter-weight limitations: First, the rated capacity of MILVANS and SEAVANS; and second, the road-weight limitation imposed by the States over which the container must travel by motor vehicle.

e. Shipment of Hazardous Materials.

(1) Hazardous materials must be compatible with the remainder of the load. Do not stuff food or medical supplies in the same container as insecticides, chemical products, radioactive materials, biological materials, poisons, or toxic materials.

(2) Do not ship noncompatible hazardous materials together.

(3) Pack, mark, label, and placard hazardous materials in strict accordance with Department of Transportation and US Coast Guard regulations.

(4) The US Coast Guard regulations prohibit certain explosives and other hazardous materials from being shipped in cargo containers. These include, but are not limited to, those mentioned in discussing the stuffing of CONEXES.

f. General Rules for Stuffing MILVANS and Seavans. The general rules discussed below concern the stuffing of general cargo into MILVANS and dry cargo type SEAVANS.

(1) Place heavy items on the bottom of the load, maintaining an even distribution of weight throughout the cargo container.

(2) When stuffing standard 43-inch high modular containers, double-tier them whenever possible. If double-tiering is not possible, top off the load with "fluff cargo" of low density. "Fluff cargo," which must be man-handled, should not exceed 200 pounds per item or pack.

(3) Leave several inches of head space between the top of the load and the top of the cargo container that the load can be removed easily with a forklift truck.

(4) Pack the load as tightly as practicable. Do not wedge the load or pack it so tightly that problems will occur during unstuffing operations.

(5) Always position palletized or skidded loads to rest on their pallets or skids. Face pallet access slots toward the doors to minimize forklift maneuvering during unstuffing operations.

(6) Never place a heavy crate or box so that it rests on top of, and inside the four corners of the box beneath it. Place dunnage over the lower level of containers when dense loads in the upper tier may cause damage to the containers below.

(7) Place boxes, crates, and cartons, which contain liquids that may leak, on the bottom of the load whenever practicable.

(8) Keep drums that contain petroleum products separated from general cargo. Stow drums with their bungs on top. Pack the drums tightly. When possible, palletize drums. When not palletized, place strips of dunnage between tiers of drums.

(9) Use lumber, burlap, fiberboard or paper, as applicable, to protect the cargo and to prevent it from shifting during transit. Use dunnage when it is available for filling spacing between large boxes or crates.

(10) A load checker should keep a running account of the weight of individual items being stuffed to ensure the correct total net weight. Enter the overall load weight and cube on the loading list or the Transportation Control Movement Document (TCMD).

(11) Brace cargo of average or high density to prevent it from falling out when the container doors are opened.

g. Closing and Sealing MILVANS and Seavans. Place the shipping documents in the space provided on the door. Make sure that both rear doors on MILVANS and SEAVANS are closed by sliding the closure bolts into the holes provided in the body of the cargo containers. Position the door handles over the latches in the doors and

attach a numbered railway car seal. MILVANS require that both door latches are provided with a seal.

(1) Make sure that the serial numbers on the seals correspond with the numbers on the shipping documents.

(2) Thread the seals through the latches on the doors and snap the seals into the seal locking devices.

(3) Use padlocks of approved design on cargo container containing classified material. Be sure that key control measures are provided.

h. Marking of MILVANS and SEAVANS. Shipment units and shipment units in consolidation will be address marked in accordance with Military Standard MIL-STD-129, Marking for Shipment and Storage. The address markings for MILVANS and SEAVANS shall be accomplished by attaching a waterproofed Military Shipping Tag (DD Form 1387-1) adjacent to the seal, if required, or at the rear of the van. Data for the tag will be in conformance with DOD 4500.32R, Military Standard Transportation and Movement Procedures (MILSTAMP) and MIL-STD-129.

APPENDIX

NATIONAL STOCK NUMBERS

1. General

The selection of the proper items of supply for use in military preservation, and packing operations is of vital importance. This selection must be made in accordance with requirements established on commodity and process specifications and other official publications. Items of supply are designated by name, type, class, style, grade, size, color, length, width, etc. The difference of an item in any of these respects from any other item, establishes it as a separate and distinct item of supply. These distinct items must be used as specified to properly perform preservation and packing processes and methods. To make proper selection possible, the Federal catalog system is designed to classify, describe and assign one, and only, one, National stock number to each item of supply. The listing of classifications, descriptions and National stock numbers for the hundreds of items used in preservation and packing, and appearing in the Federal supply catalog is beyond the scope of this manual. The purposes of this appendix is to emphasize the importance of stock numbers in the military supply system and to furnish general information concerning their structure and use.

2. Composition of the National Stock Number

The National stock number (NSN) is composed uniformly of 13 digits and is always written in a 4–2–3–4 format. The first four digits (8105) are the Federal Supply Classification Code (FSC) and the last nine digits (00–290–0345) are the National Item Identification Number (NIIN). The whole National stock number is never separated to run into a second line.

a. Federal Supply Classification. The Federal supply classification is used to classify items of supply identified in the Federal catalog system. It is designed to include all items known to be in the supply system of the Federal Government. Of the four digit code (8105) used to identify Federal supply classifications, the first two digits identify the broad *Group* of material. Group 81 covers containers, packaging, and packing supplies, and the last two digits identify a particular *Class* within the group. Class 05 covers bags and sacks. Other examples of Federal supply classifications are as follows:

FSC	Group	Class
	55	30
5530 ----	(Lumber, millwork, plywood, and veneer.)	(Plywood and veneer).
	81	(15)
8115 ----	(Containers, packaging and packing supplies.)	(Boxes, cartons and crates).

b. National Item Identification Number. The last nine digits of the National stock number comprise the National Item Identification Number. This number serves to differentiate each item of supply from all others within its *Class*. In the example above, the NIIN 00–290–0345 identifies a 9½ x 14½ paper cushioned shipping sack, conforming to sacks in the 05 *Class*. Each item of supply has one, and only one, National item identification number, and each National item identification number applies to one, and only one, item of supply. The National item identification numbers are assigned serially without regard to the name of the item, its description, or its classification. The National Codification Bureau code (NCB) is represented by the first two digits in the NIIN.

3. Breakdown of the National Stock Number

a. For clarification purposes the following is a breakdown of another National stock number related to a common packing material.

FSC NIIN
8 1 1 5- 00-753-4691
NCB Code

GROUP 81	CLASS 15	ITEM 00-753-4691
Packaging and Packing Supplies.).	(Boxes, Cartons and Crates.)	Fiberboard, Triple-Wall, PPP-B-640, length 58 inches, width 35-7/8 in., depth 28-1/2 in.).

b. The NSN is part of the NATO numbering system. The US will use 00 and 01 for the first 2 digits of the NIIN.

c. If the first 4 digits are followed by *00* the number is a former FSN. If the first 4 digits are followed by *01* the number indicated a new item.

4. Use of National Stock Numbers

Items of supply for use in preservation and packing operations are of wide range and appear under several classification codes. These codes cover cleaning materials, preservatives, barriers, tapes, adhesives, cushioning materials, various types of equipment, marking materials, fasteners, interior containers, exterior containers, and many other groups and classes. Oftentimes, there are several classifications covering general groups of items. National stock numbers are assigned to each specific item under each classification in accordance with item name and specific characteristics. When selecting items and materials which meet the requirements of preservation and packing specifications and directives, identification is accomplished by reference to titles and descriptions appearing in the Federal supply catalog. The following are representative examples:

National Stock No.	*Description*
8135-00-171-1559	*Barrier Material, Waterproofed, Flexible:* components and wt per 500 24- by 36-in. sheets, paper 30 lb. asphalt 50 lb, paper 30 lb; 200 yd roll, Fed PP-B-1055, class C-1; for interior wraps.
8135-00-558-0823	*Cushioning Material, Packaging:* cellulose wadding; water-resistant; low absorbency; 66 ft. long, 20 in. wide, 1 in. thick; Specification PPP-C-843, type II, class B.

5. Sources of National Stock Numbers

National stock numbers are listed in Federal supply catalogs published by the Defense Logistics Agency. Stores stock catalogs published by General Services Administration contain numbers and descriptions of items handled by this agency. Federal and military commodity specifications indicate Federal supply classification codes only.

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☆ U.S. GOVERNMENT PRINTING OFFICE : 1992 O - 311-803 (62074)

CHANGE
No. 3

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE; AND THE DEFENSE LOGISTICS AGENCY
Washington, DC, *June 1991*

PACKING OF MATERIEL—PACKING (VOLUME II)

DLAM, 4145.2, Vol II/TM 38-230-2/NAVSUP PUB 503, Vol II/AFP 71-16/MCO P4030.21C, 15 June 1977, is changed as follows:

1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the changed page.

Remove pages	*Insert pages*
i through viii	i through viii
xiii through xiv	xiii through xiv.1
1-1 and 1-2	1-1 and 1-2
1-7 and 1-8	1-7 and 1-8
1-29 and 1-30	1-29 and 1-30
1-41 and 1-42	1-41 and 1-42.1
1-59 and 1-60	1-59 and 1-60.1
2-1 thru 2-4	2-1 through 2-4.1
2-7 and 2-8	2-7 and 2-8
2-15 and 2-16	2-15 and 2-16.1
2-19 and 2-20	2-19.and 2-20
2-23 and 2-24	2-23 and 2-24
2-27 and 2-28	2-27 and 2-28
2-35	2-35
3-3 thru 3-6	3-3 through 3-6.1
3-17 thru 3-22	3-17 through 3-22
3-25 thru 3-26	3-25 through 3-26
3-29 thru 3-34	3-29 through 3-34.2
3-37 and 3-38	3-37 and 3-38.1
7-7 and 7-8	7-7 and 7-8

2. File this change sheet in front of the publication for reference purposes.

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CHANGE
NO. 2

DEPARTMENT OF THE ARMY, THE NAVY AND THE AIR FORCE: AND THE DEFENSE LOGISTICS AGENCY
WASHINGTON, D.C., *13 June 1986*

PACKAGING OF MATERIEL
PACKING
(VOLUME II)

DLAM 4145.2/TM 38-230/2NAVSUP PUB 503/AFP 71-16/MCO 4030.21C, 15 June 1977, is changed as follows:

1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the page. Added or revised illustrations are indicated by a vertical bar adjacent to the illustration number.

Remove pages	*Insert new pages*
i through xvi	i through xvi
1-1 and 1-2	1-1 and 1-2
1-13 through 1-22	1-13 through 1-22
1-27 through 1-30	1-27 through 1-30
1-35 and 1-36	1-35 and 1-36
1-39 through 1-42	1-39 through 1-42
1-47 and 1-48	1-47 and 1-48
1-51 through 1-64	1-51 through 1-64
2-11 through 2-16	2-11 through 2-16
2-19 through 2-24	2-19 through 2-24
2-35/(2-36 Blank)	2-35/(2-36 Blank)
3-5 through 3-18	3-5 through 3-18
3-21 through 3-30	3-21 through 3-30
3-43 and 3-44	3-43 and 3-44
5-1 through 5-4	5-1 through 5-4
5-11 through 5-14	5-11 through 5-14
6-5 through 6-8	6-5 through 6-8
6-17 and 6-18	6-17 and 6-18
6-21 through 6-26	6-21 through 6-26
6-81 through 6-88	6-81 through 6-88
6-91 and 6-92	6-91 and 6-92
7-3 through 7-24	7-3 through 7-24

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Marine Corps HK plus 7000176 (10)

Defense Logistics Agency: 3;62;J;A

CHANGE
No. 1

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE; AND THE DEFENSE LOGISTICS AGENCY
WASHINGTON, DC *15 October 1980*.

PACKAGING OF MATERIEL

PACKING
(VOLUME II)

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Remove pages—	*Insert pages—*
i through xiv	i through xiv
1–41 through 1–44	1–41 through 1–44
1–47 and 1–48	1–47 and 1–48
1–51 and 1–52	1–51 and 1–52
3–21 and 3–22	3–21 and 3–22
6–3 and 6–4	6–3 and 6–4
6–19 through 6–56	6–19 through 6–56

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