



Standard Specification for Heavy Duty Sheathed Wood Crates¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers requirements for two types and two classes of sheathed crates each of which may have two base styles. The crates are designed for net loads not exceeding 30 000 pounds lb [13 607 kg] and to withstand the most severe overseas shipping and storage conditions.

1.2 The crates described by this specification are intended to protect items from atmospheric elements during shipment and storage. They are designed to withstand the rough handling of logistic operations including stacking and outside storage for a prolonged period.

1.3 Class 1 and 2 crates may be used interchangeably as desired. However, the Class 2 crate should be used when weight is a prime consideration, as the lack of diagonals and thinner plywood sheathing results in a lighter crate.

1.4 Demountable crates, Type II, should be used whenever it is expected that the contained item will require reshipping to another destination.

1.5 Sill bases, Style B, are intended for items that project below their mounting points, such as disassembled vehicles.

1.6 If the use of other construction method or techniques is acceptable and permitted (see 5.10), the resulting packaging systems shall be of equal or better performance than would result from the use of these specified materials and procedures. The appropriate distribution cycle, specified in Practice D4169 can be used to develop comparative procedures and criteria.

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. See IEEE/ASTM SI 10 for conversion of units.

¹ This specification is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.12 on Shipping Containers, Crates, Pallets, Skids and Related Structures.

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1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

D996 Terminology of Packaging and Distribution Environments

D3953 Specification for Strapping, Flat Steel and Seals

D4169 Practice for Performance Testing of Shipping Containers and Systems

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials

D4675 Guide for Selection and Use of Flat Strapping Materials¹

D6199 Practice for Quality of Wood Members of Containers and Pallets

D6253 Practice for Treatment and/or Marking of Wood Packaging Materials

F1667 Specification for Driven Fasteners: Nails, Spikes, and Staples

IEEE/ASTM SI 10 Standard for Use of International System of Units (SI): The Modern Metric System

2.2 National Institute of Standards and Technology (NIST) Standards:

PS 1 Voluntary Product Standard, Structural Plywood³

PS 20 American Softwood Lumber Standard⁴

2.3 *Hardwood Plywood and Veneer Association Standard:*⁵
ANSI/HPVA HP-1-2004 American National Standard for Hardwood and Decorative Plywood

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from APA, The Engineered Wood Association, 7011 South 19th St., Tacoma, WA 98466–5399, <http://www.apawood.org>.

⁴ Available from American Lumber Standards Committee, Inc., (ALSC), P.O. Box 210, Germantown, MD 20875–0210, <http://www.alsc.org>.

⁵ Available from Hardwood Plywood and Veneer Association (HPVA), P.O. Box 2789, Reston, VA 22090–0789, <http://www.hpva.org>.

2.4 *National Hardwood Lumber Association (NHLA) Standard*.⁶

NHLA Rules for the Measurement and Inspection of Hardwood and Cypress

2.5 *ASME Standards*.⁷

ASME B18.2.1-2010 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

ASME B18.2.2-2010 Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASME B18.2.3.8M - 1981 Metric Hex Lag Screws

ASME B18.2.4.3M-1979 Metric Slotted Hex Nuts

ASME B18.5-2008 Round Head Bolts (Inch Series)

ASME B18.5.2.2M-1982 Metric Round head Square Neck Bolts

ASME B18.22M-1981 Metric Plain Washers

ASME B18.21.1-2009 Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

2.6 *International Standard*.⁸

ISPM 15 International Standards for Phytosanitary Measures Publication No. 15 (ISPM 15), Regulation of Wood Packaging Material in International Trade

3. Terminology

3.1 *Definitions*—General definitions for packaging and distribution environments are found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 The crate component parts discussed herein were selected on the basis of part function. Alternate names are sometimes used by industry.

3.2.2 *diagonals*—diagonals are frame members positioned between parallel frame members and placed at nearly 45° angles to them. Diagonals serve as braces and ensure rigidity in the crate.

3.2.3 *end frame members*—end frame members are similar to side frame members but perpendicular to the long dimension.

3.2.4 *filler strips*—filler strips are boards placed across the ends of thin, non-load-bearing floorboards, which serve to fill the space below the lower frame member of the crate sides.

3.2.5 *frame members*—frame members are those parts which form the fundamental crate structure upon which the strength and rigidity of a lumber-sheathed crate depends.

3.2.6 *hanger-metal*—hanger-metal is a metal nailed strap used to aid in support of the intermediate sill in sill-type bases.

3.2.7 *headers*—headers are either transverse members at each end of skid bases or longitudinal members at each end of top joists. Headers in bases serve to hold the base together as a unit, to transfer loads to outside skids, and to provide a

fastening member for end panels. Headers in top panels serve to position and support joists and to provide a fastening member for side panels.

3.2.8 *horizontal braces*—horizontal braces are members positioned between struts and parallel to the upper and lower frame members and serve to reduce the unsupported span of the sheathing.

3.2.9 *joists*—joists are members extending across the crate underneath the top, which serve to support and transfer vertical stacking loads to the side panels. Joists also serve to prevent crushing or buckling of crate tops when slings or grab hooks are used.

3.2.10 *lag screw strap*—lag screw strap is a metal reinforcing strap used on bolted crates sides and ends to reinforce and increase lag screw lateral resistance.

3.2.11 *load-bearing floorboards*—load-bearing floorboards are transverse base members which serve to distribute and transfer loads to the outside skids.

3.2.12 *rubbing strips*—rubbing strips are longitudinal members nailed to the skid bottom to provide for sling and forklift truck handling.

3.2.13 *sheathing*—sheathing is the plywood or boards nailed to the frame members and enclose the crate. Sheathing used on the top panels is called top sheathing; that used on the side or end panels is called side or end sheathing; that nailed to the top of skids is called flooring; and that nailed to the bottom of sills is called bottom sheathing.

3.2.14 *side frame members*—side frame members are the members of the crate top, without joists, which are parallel to the long dimension and serve as fastening members and to tie the crate construction together.

3.2.15 *sill bridging*—sill bridging are members of the same depth as the sills, which are inserted at right angles to the intermediate sills, and serve to prevent lateral sill turning or buckling.

3.2.16 *sills*—sills are the members, which with sill bridging form the frame work of sill-type bases. Sills carry and transfer loads to side panels and serve as fastening members. There are side, end, and intermediate sills.

3.2.17 *skids*—skids are longitudinal members attached to the crate bottom, which serve to support and transfer the load to the side panels.

3.2.18 *sleepers*—sleepers are members underneath the floor of skid-type bases to which the item is anchored (through the floor) so that the tie-down stress will be distributed.

3.2.19 *struts*—struts are vertical frame members, placed between the side and end panels' upper and lower frame members, and serve as columns for supporting vertical stacking loads. The end struts are sometimes referred to as corner posts.

3.2.20 *upper and lower frame members*—upper and lower frame members are those horizontal members at the top and bottom of the side and end panels which serve to tie the construction together.

⁶ Available from National Hardwood Lumber Association (NHLA), 6830 Raleigh LaGrange Rd., Memphis, TN 38134, <http://www.natllhardwood.org>.

⁷ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁸ Available from the International Plant Protection Convention, www.ippc.int.

3.2.21 *vertical joist supports*—vertical joist supports are vertical members attached to the crate sides inside face, which serve to support the joists and assist the struts in supporting vertical stacking loads.

4. Classification

4.1 Crates shall be of the following types, classes, and styles:

4.2 *Type*:

4.2.1 *Type I*—Nailed.

4.2.2 *Type II*—Bolted.

4.3 *Class*:

4.3.1 *Class 1*—Lumber sheathed.

4.3.2 *Class 2*—Plywood sheathed.

4.4 *Style*:

4.4.1 *Style A*—Skid base.

4.4.2 *Style B*—Sill base.

5. Ordering Information

5.1 Purchasers should select the preferred permitted options and include the following information in procurement documents:

5.2 Specification title, number, and date.

5.3 Crate type, class, and style (see Section 4).

5.4 Contents weight.

5.5 Crate dimensions specified in order of length by width by depth.

5.6 When inspection doors are required.

5.7 When top, sides, and ends shall be assembled with nails and the entire assembly bolted to the base.

5.8 Whether crates are to be shipped assembled or knocked down.

5.9 Whether other construction methods or techniques are acceptable and permitted (see 1.6).

5.10 Whether proof that other constructions methods or techniques are acceptable (see 1.6) is required.

5.11 If packaging is other than as specified.

5.12 When ISPM 15 compliance is required (see 12.1).

6. General Requirements

6.1 *Crate Loading*—When crates are furnished as filled containers, the extent of contents disassembly, the anchoring, blocking, and lifting attachments application shall be in accordance with this specification's Supplemental Requirements.

6.2 *Dimensions*:

6.2.1 *Inside Dimension*—Inside crate length or width is the distance between opposite struts inner surfaces. Inside height is the distance between skid base floorboards or sill bases' sill tops and the underside of top joists or framing members.

6.2.2 *Outside Dimensions*—Outside dimensions are the crate, or its contents, overall length, width, and height, whichever is greater. Actual dimensions, except in designing, are corrected whole inches [25 mm increments], any fraction less

than ½ in. [13 mm] being disregarded, and any fraction of ½ in. [13 mm] or greater being considered a full inch [25 mm increment].

6.2.3 *Cubic Displacement*—Crate cubic displacement is calculated from the outside dimensions in inches [millimetres] and is stated in cubic feet [cubic metres].

6.2.4 *Limitations*—The crate exterior dimensions shall not exceed the following limitations:

6.2.4.1 *Length*—30 ft [9144 mm].

6.2.4.2 *Width*—9 ft [2743 mm].

6.2.4.3 *Height*—10 ft [3048 mm].

6.2.5 *Interior Clearance*—A clearance of not less than 2 in. [50 mm] shall be allowed between the item and the closest side, end, or top crate member. Additional clearances may be provided for shock-mounted items. Protruding parts at the top may be allowed to extend between joists; joist spacing may be adjusted slightly to accommodate projections.

7. Materials and Manufacture

7.1 *Materials*—Materials shall be as specified herein. Materials not specified shall be selected by the contractor or crate builder and shall be subject to all provisions of this specification (see Section 11). Materials shall be free of defects, which adversely affect performance or serviceability of the finished product.

7.2 *Lumber*—Lumber components shall conform to Practice D6199, PS 20, or the NHLA Rules. All lumber sizes specified herein shall be nominal and shall be the minimum acceptable sizes for lumber components. Lumber components shall have a target thickness and width uniform in dimension and 50 % of components shall meet or exceed the target dimensions at the time of component manufacture.

7.3 *Plywood*—Plywood shall conform to PS 1 or ANSI/HPVA HP-1-2004. All panels shall be bonded with moisture resistant adhesive and be identified as either Exposure 1 or Exterior.

7.4 *Fasteners*—Fasteners are classified as driven nails, bolts, lag bolts, wood screws, and metal strapping.

7.4.1 *Nails*—Nails shall be in accordance with Specification F1667 and other industry standards. Nails are classified as plain-shank, helically threaded, annularly threaded, fluted, or twisted square wire.

7.4.2 *Staples*—Staples have either round-wire or approximately square-wire legs, referring to the cross-sectional shape of the wire. Staples should be made of low carbon steel wire and galvanized.

7.4.3 *Bolts, Lag Bolts, Nuts and Washers*—Bolts, lag bolts, nuts and washers shall conform to industry standards, including the following:

ASME B18.2.1-2010 (ASME B18.2.3.8M-1981),
ASME B18.5-2008 (ASME B18.5.2.2M-1982),
ASME B18.2.2-2010 (ASME B18.2.4.3M-1979), and
ASME B18.21.1-2009 (ASME B18.22M-1981).

Standard steel carriage bolts can be used in any of three styles: standard, slotted, or large head.

7.4.4 *Wood Screws*—Screws shall be inserted into the crate components to be assembled with a screwdriver or screw motion machine tool. Approximately two-thirds of the screw

length and seven times the shank diameter shall be the penetration length into the fastening member. Where pre-drilling is required, the maximum lead-hole diameter shall be the fastener-shank diameter, and the pilot-hole diameter shall not be larger than the thread-root diameter.

7.4.5 *Strapping*—Strapping shall conform to Specification D3953 and as specified herein (8.7.5.3). Finish shall be A, B, or C as applicable. Refer to Guide D4675 for additional guidelines.

7.5 *Protective Covering*—Felt or film.

8. Construction

8.1 *Nailing Procedure*—Sinkers, coolers, corkers, or common nails shall be used. Nail sizes specified for crate fabrication are based on Practice D6199 Group I and II Woods. When Group III or IV Woods are used, nail sizes may be one-penny size smaller than those specified. The nail patterns to be used for nailing two flat pieces of lumber shall conform to the details shown in Fig. 1 or as specified herein. Unless otherwise specified herein, the following requirements shall determine nail size, placement, and quantity.

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

8.1.2 All nails that are not to be clinched shall be cement-coated.

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

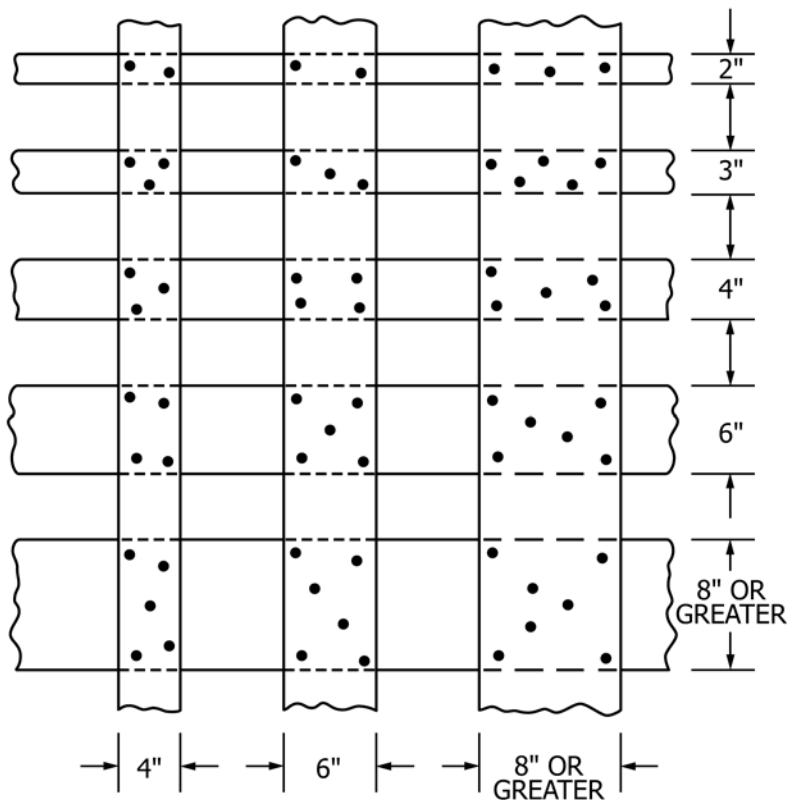
8.1.4 Nails for fastening plywood to framing shall be clinched at least 1/4 in. [6 mm]. Nail heads shall always be on the plywood side.

8.1.5 When the flat faces of lumber pieces are nailed together and the combined thickness is 3 in. [76 mm] or less (except for top joists and covering material), nails shall be long enough to pass through both thicknesses and shall be clinched not less than 1/4 in. [6 mm] or more than 3/8 in. [10 mm].

8.1.6 When the flat faces of lumber pieces are nailed together and the combined thickness is more than 3 in. [76 mm] 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 nail portion in the thicker piece shall not be less than 2 times the nail length in the thinner piece for ten-penny (3 in. [76 mm]) nails and smaller, and not less than 1 1/2 in. [38 mm] for twelve-penny (3 1/4 in. [82 mm]) nails and larger.

8.1.7 When diamond-point nails cause crate member splitting, the nails shall be slightly blunted. When blunting does not prevent the splitting, holes slightly smaller than the nail diameter shall be drilled for each nail.

8.1.8 Nails shall be driven so that neither the head nor the point projects above the wood surface. Occasional over-driving will be permitted, but nails shall not be over-driven more than one-eighth the thickness of the piece holding the head.



NOTE 1—All widths nominal. Use similar nailing patterns when boards cross at angles other than 90°.

FIG. 1 Nailing Schedule for Boards Crossing at Right Angles

8.1.9 Nails shall be positioned not less than the thickness of the piece from the end not less than one-half the thickness of the piece from the side edge of the lumber whenever possible. Nails driven into the lumber side edge shall be centered on the side edge.

8.1.10 Nails securing plywood sheathing to frame members shall be spaced as shown in Fig. 2. Machine driven nails having a definite head may be used for securing plywood sheathing providing they meet size requirements specified herein.

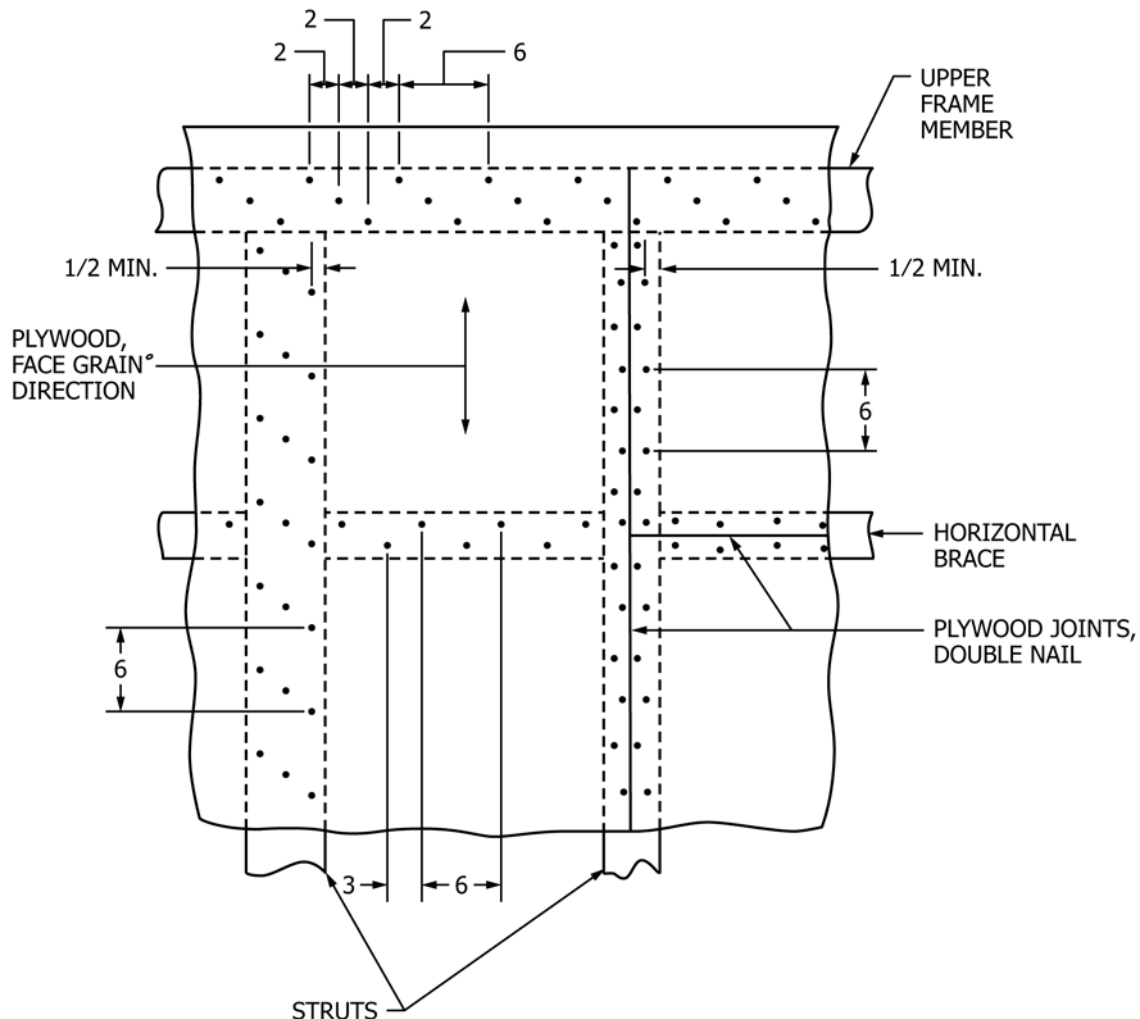
8.2 *Stapling*—Staples may be used to fasten sheathing to frame members. Staples shall not be used for base fabrication, fastening framing members to each other, or for crate assembly. Staples shall have crowns of not less than 3/8 in. [10 mm] wide and shall have a wire diameter of not less than 0.062 in. [16 gage, 1.59 mm]. Straight leg staples shall be long enough to provide a minimum 1/4-in. [6-mm] clinch; divergent point staples shall not be less than 1 in. [25 mm] long. Staple spacing shall be the same as for nails specified herein. Staples shall always be driven from the plywood side.

8.3 *Bolt Application*—Holes shall be pre-bored to receive carriage bolts and shall be no less than the 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 1. Lag bolts shall be placed by being turned in their holes the full bolt length and shall not be driven in with a hammer or by any similar means. If, for any reason, the thread in the wood is stripped when the lag bolts are placed, the lag bolt shall be removed and placed in a new hole near the old position. A flat washer shall be used under each lag bolt head and under each carriage bolt nut.

8.4 *Splices, Butt Joints and Lamination*—Splices and butt joints made in frame members and skids of long crates shall be as shown in Fig. 3. Lamination of wood is shown in Fig. 4.

8.5 *Inspection Doors*—When specified (see 5.6), one or more inspection or access doors shall be provided. Door size and location shall be specified by the purchaser and will be used for interim inspection or servicing of contents. Doors shall be built without cutting the frame members and shall be hinged at the top and fastened by lag screws at the sides and bottom as shown in Fig. 5. Cleats and stops shall be made of 1-in. [19-mm] material. Doors shall be made of the same type



NOTE 1—All dimensions in inches. Three rows of nails for all members over 4 in. wide. Two rows of nails for all members up to 4 in. wide.

FIG. 2 Fabrication Nailing Plywood Sheathing

TABLE 1 Lag Bolt Lead Hole Sizes

Lag Bolt Threaded Portion Diameter		Lead Hole Diameter, in. [mm]			
		Group I, II, & III Woods		Group IV Woods	
in.	[mm]	in.	[mm]	in.	[mm]
1/4	6	3/16	5	3/16	5
5/16	8	1/4	6	1/4	6
3/8	10	1/4	6	5/16	8
1/2	12	3/8	1	7/16	11
5/8	16	3/8	10	1/2	12
3/4	19	1/2	12	5/8	16

and thickness as material used for sheathing. Holes shall be provided through the door and an adjacent frame member for a seal wire and lead seal bearing the inspectors' stamp. When hinges with exposed screws are used, the hinge side of the door shall also be sealed.

8.6 Ventilation—All lumber and plywood sheathed crates shall be provided with ventilation holes or slots which shall be located at each end, or at ends and sides, or around the perimeter (Table 2). These ventilating holes or slots shall be located immediately below the top frame member, and be provided with a baffle as shown in Fig. 6 when slots are used in plywood sheathed crates, or when holes are in clusters in lumber sheathed crates. Single holes drilled without baffles shall be sloped at 45° to drain outward. No holes or slots shall be cut in any frame member.

8.7 Class 1 Crates—Class 1 crates may be either bolted or nailed. Bolted crates shall be designed so that the base, sides, ends, and top may be assembled to each other with lag bolts in order that the crate can be readily disassembled and, if desired, reassembled without major damage to the parts. Nailed crates are assembled with nails and straps, are not easily disassembled, and because of probable damage during disassembly, are not generally reused. When specified (see Section 5), a combination of top, side, and end panels may be fabricated and assembled to each other as specified for nailed crates, and the unit fastened to the base as specified for bolted crates.

8.7.1 Bases—Bases shall be designed to support the weight of the crated article only when the sides and ends are fastened in place (see Section 10).

8.7.1.1 Style A (Skid-Type)—Style A bases shall consist of longitudinal skids and rubbing strips, headers, load-bearing floorboards, and flooring as shown on Figs. 7 and 8. Details of construction shall be the same for bolted and nailed crates.

(1) *Skids*—Any species of wood except Group I shall be used for skids. Skids shall be spaced no farther apart than 48 in. [1219 mm], center to center, across the base width. Minimum size shall be as shown in Table 3. When either the length or net load exceeds the maximum shown, the next larger skid shall be used. When necessary, skids may be spliced or laminated according to the details shown in Fig. 3 or Fig. 4, but the use of 2 × 4 in. [38 × 89 mm] skids shall be limited to such lengths that no splicing would be required. Whenever possible, splices shall be made not more than one-third of the base length from the skid ends and the splice locations alternated in adjacent skids. To prevent splitting, all skids shall have a carriage bolt

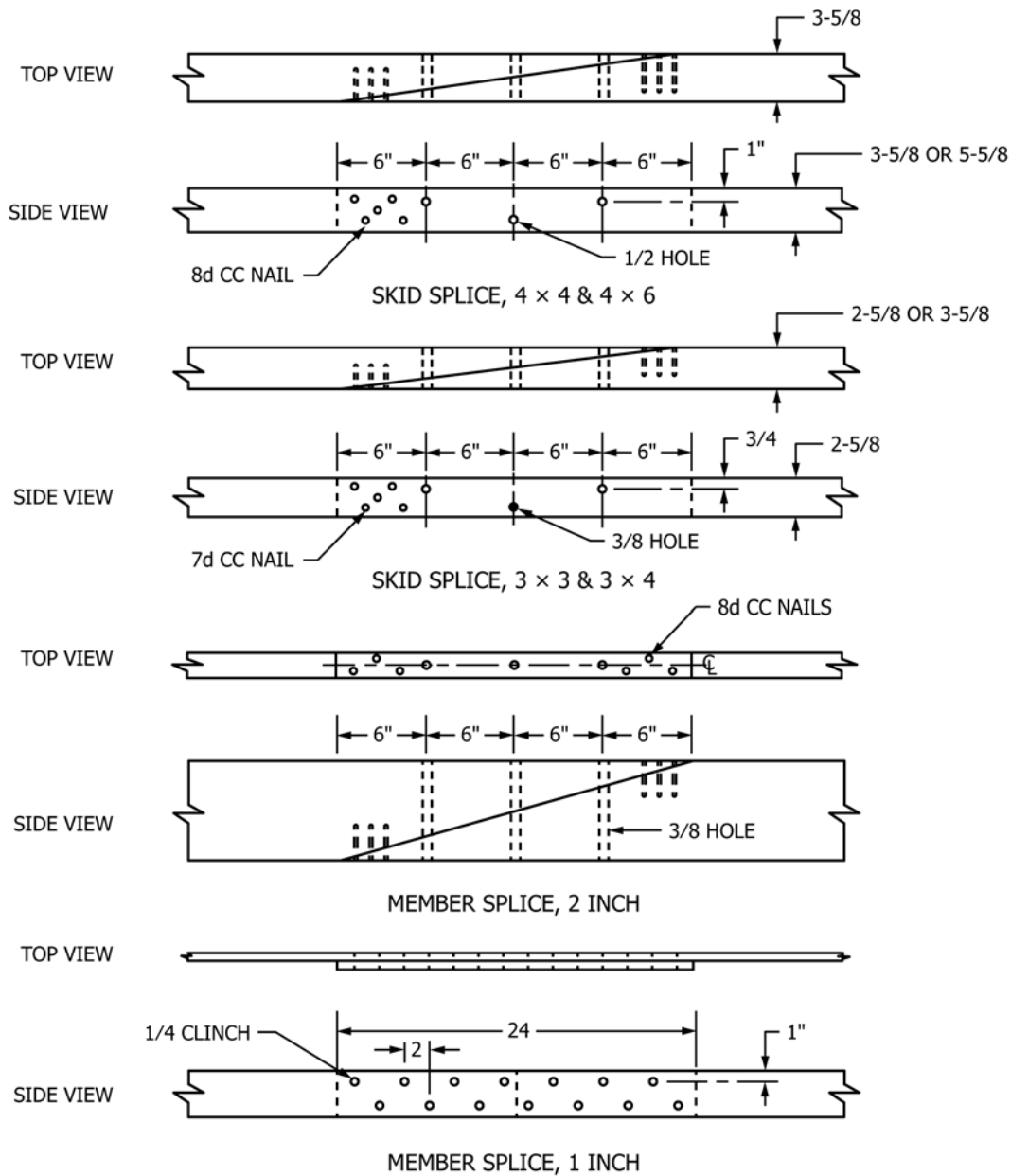
placed crosswise and 2 to 3 in. [51 to 76 mm] back from each skid end as shown in Fig. 7 and 24. Bolt sizes shall comply with Table 4.

(2) *Rubbing Strip for Skids*—Rubbing strips of 3-in. [64-mm] thick lumber, the same width as the skids, shall be attached to the skids with two staggered rows of nails spaced 12 in. [305 mm] apart in each row. The nails shall be driven through the rubbing strip into the skid. The nails shall be long enough to penetrate approximately 70 % (minimum) of the skid thickness and shall not protrude through the skid. The strips shall be beveled 45° full depth at sling and forklift openings. Openings in the rubbing strips for forklift-truck access shall be 12 in. [305 mm] in length, 28 in. [711 mm] center-to-center, and positioned to straddle the loaded crate center of balance. Sling openings not less than 4 in. [102 mm] in length, and preferably 8 in. [203 mm], shall be provided at the rubbing strip ends where permitted by the crate length and by the location of the forklift-truck access openings. No rubbing strips center pieces shall be less than 16 in. [406 mm] in length. On crates 5 ft [1524 mm] and less in length, the forklift openings shall be omitted; end sling openings shall not be less than 6 in. [152 mm] long and shall serve as both forklift and sling openings.

(3) *Headers*—Headers shall be placed at each end of the base and shall be bolted to each skid with one carriage bolt (Figs. 9 and 10). Header and bolts sizes shall be as shown in Table 4. Headers shall be a single piece and not built up to two or more pieces to meet the dimension requirements. Headers shall be placed atop the plywood when plywood flooring is used. Headers shall be placed a distance back from the skid ends skids equal to the end sheathing thickness. The header ends shall be notched for bases floored with lumber; header ends for plywood floored bases shall be set back from the outside edges of the outer skids (see Figs. 9 and 10). The notched and set back distances shall be equal to the thickness of the skids lower frame members.

(4) *Forklift Members*—The forklift members shall consist of the header and two equal size members, spaced 20 and 40 in. [508 and 1016 mm] (on center) from each skid end and bolted as shown in Fig. 7. Where the form of the item to be crated makes it impractical to use these members, or when crates are short or narrow, 2-in. [38-mm] thick lumber shall be used in the 48-in. [1219-mm] end areas as shown in Fig. 8. When 2-in. [38-mm] lumber is used in the forklift area and intermediate skids are required because of the base width, the 2-in. [38-mm] forklift members shall be bolted to the intermediate skids. Forklift members shall be bolted to the intermediate skids. Forklift members shall be notched or set back as specified for headers in 8.7.1.1(3). If loaded containers center of balance is other than the center of the base, the space for forklift entry shall be positioned so that the center of balance is centered in between forklift openings.

(5) *Load-bearing Floorboards*—Load-bearing floorboards shall be placed where the concentrated loads of the contents occur. The cross section shall be determined from Table 10. The forklift members and any 1 or 2-in. [19 or 38-mm] flooring may be considered as load bearing within limits of their assigned values. The load-bearing floor boards ends shall be



NOTE 1—Use carriage bolts. All dimensions in inches.

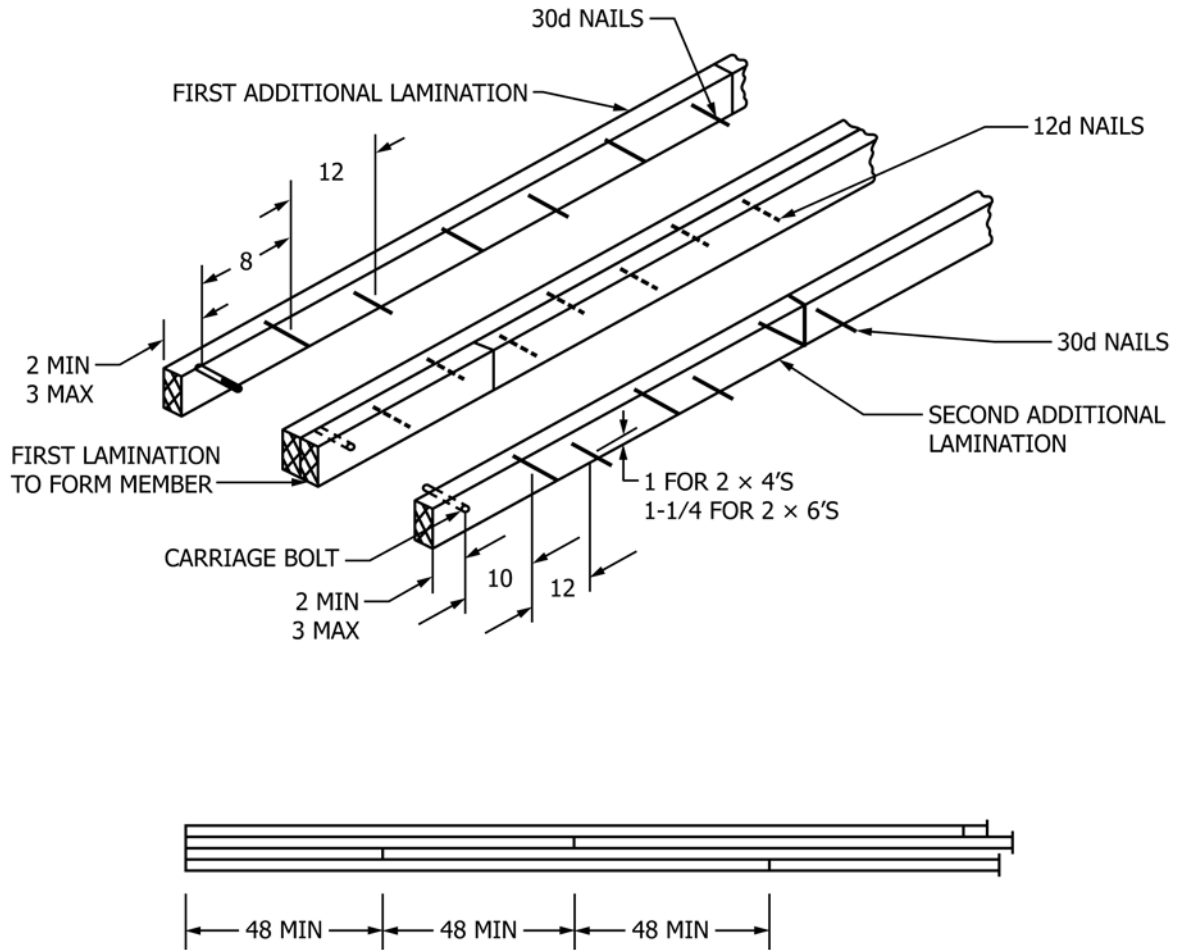
FIG. 3 Splicing of Members

notched or set back from the base edge in the same manner as described for headers as specified in 8.7.1.1(3) (see Figs. 7 and 8). Load-bearing floorboards 4 in. [89 mm] wide shall be bolted to each skid with one carriage bolt, and load-bearing floorboards over 4 in. [89 mm] wide shall be bolted to each skid with two carriage bolts, and the intermediate skid where one is required. Bolt diameters shall be the same as specified in 8.7.1.1(3) for corresponding skid sizes.

(6) *Lumber Flooring*—Lumber floorboards shall be neither less than 1 in. [19 mm] thick nor less than 4 in. [89 mm] wide, and shall be placed at right angles to the skids. Boards shall be spaced 1/4 in. [6 mm] apart for drainage and the leadboards flushed with the skids' outside face. When a large area of the base is floored with 2-in. [38-mm] thick lumber, the use of filler strips 2 in. [38 mm] wide shall be used along each side

over the thinner flooring to equal the thickness of the 2-in. [38-mm] flooring as shown in Fig. 8. The filler strips shall be nailed to the flooring with two staggered rows of nails spaced 10 in. [254 mm] apart. Nailing of floorboards to skids shall be as shown on Fig. 1 and as specified in 8.1.

(7) *Plywood Flooring*—Plywood 3/8 in. [10 mm] thick, may be used in place of 1-in. [19-mm] lumber flooring as shown in Figs. 7 and 8, but not as load-bearing floorboards. Plywood flooring shall be laid flush with the skids' outer edges and with the face grain perpendicular to the skid length. Headers and load-bearing floorboards shall be placed on top of the plywood and bolted to the skids after the plywood has been nailed in place. Plywood flooring shall be nailed to each skid with two staggered rows of nails, staggered and spaced 6 in. [152 mm] apart in each row. Spacing, 1/4 in. [6 mm], shall be allowed



STAGGERING JOINTS TOP VIEW

LAMINATION OF SKID OR SILL MEMBERS
(2 INCH THICK MATERIAL)

NOTE 1—All dimensions in inches.

FIG. 4 Laminating Method

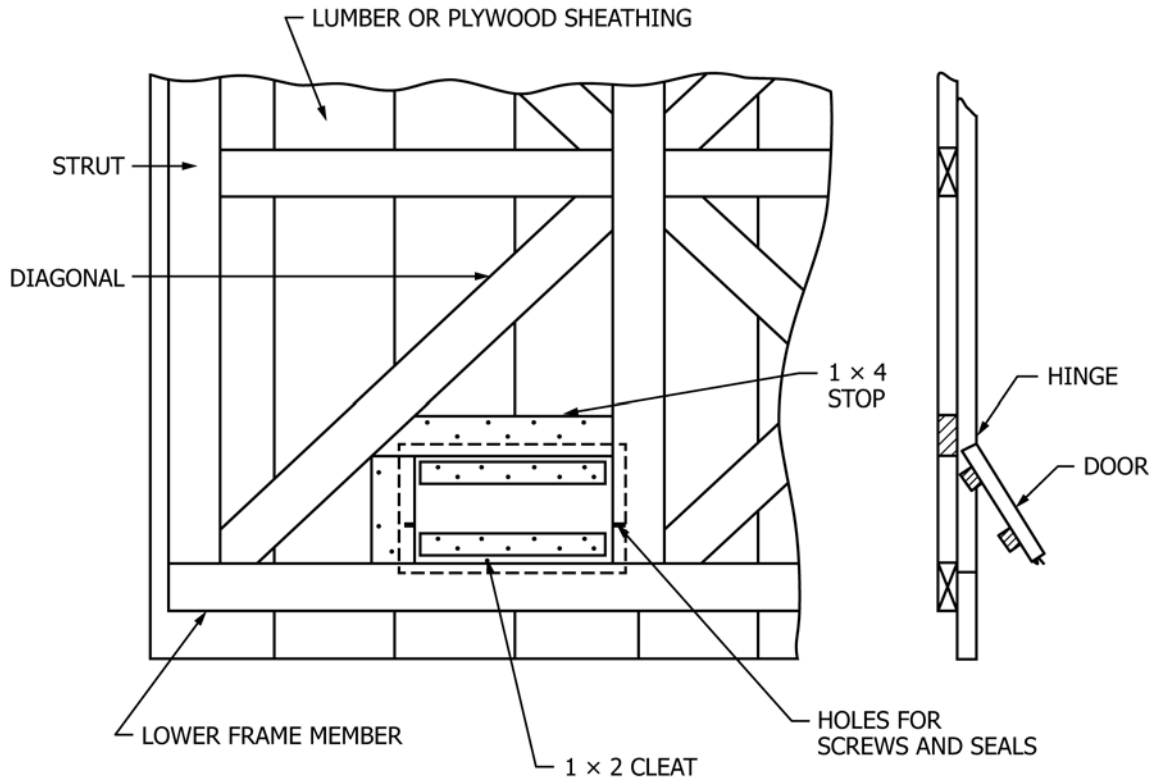
between plywood sheets for drainage. When $\frac{1}{3}$ to $\frac{1}{2}$ the area of the base is floored with 2-in. [38 mm] boards, the plywood flooring shall be used only between these areas. Filler strips shall be nailed over the plywood as shown in Fig. 8, with nailing as specified in 8.1.

(8) *Drainage*—A drainage hole, $\frac{1}{2}$ in. [13 mm] diameter, shall be drilled adjacent to each header or load-bearing member in each outer edge of each base plywood floored section (a “section” being a portion of the base in which water might be trapped) (Figs. 7 and 8). Care shall be taken to locate the holes so that the holes will not be covered when the contents are placed on the crate base.

8.7.1.2 *Style B (Sill-Type)*—Style B bases shall be constructed as shown in Fig. 9. The load contained on Style B bases shall always be transmitted to the side sills by means of intermediate sills or by the article itself.

(1) *Side and End Sills*—The side sill size shall be determined from Table 11. End sills shall be the same size as side sills. The side sills shall overlap the end sills as shown in Fig. 9. Sills shall be laminated as shown in Fig. 4, when necessary.

(2) *Intermediate Sills and Load-Bearing Headers*—Intermediate sills shall be applied crosswise of the base. The intermediate sill size shall be determined from Table 12. The weight used to determine the size of an intermediate sill shall



NOTE 1—All dimensions in inches.
FIG. 5 Inspection Door (Inside View)

TABLE 2 Ventilation Hole Requirements^A

Crate Volume ft ³ [m ³]	Lumber-Sheathed Crates End Ventilation ^B	Perimeter Ventilation ^C	Plywood-Sheathed Crates Area Required in Each End ^D in. ² [mm ²]
0–100 [0–2.8]	3	6	7 [4516]
100–150 [2.8–4.3]	4	8	10 [6451]
150–200 [4.3–5.7]	5	10	14 [9032]
200–400 [5.7–11.3]	9	18	27 [17 429]
400–600 [11.3–17]	14	27	40 [25 806]
600–800 [17–22.7]	18	36	52 [33 548]
800–1000 [22.7–28.3]	22	44	66 [42 581]
1000–1200 [28.3–34]	27	54	80 [51 613]
1200 and over [34 and over]	33	66	100 [64 516]

^A In large crates, where a large ventilating area is required, two or more slots or clusters of holes may be used in each panel.

^B Minimum number of ¾ in. [19 mm] diameter holes required in each end (place in cluster and use baffle).

^C As an alternative, total minimum number of ¾ in. [19 mm] diameter holes required around perimeter (space evenly and slope to drain out).

^D Use baffle and screen.

bearing headers shall be attached at their ends to intermediate sills and intermediate sills shall be attached at their ends to side sills by a combination of nailing and the use of metal strap hangers fabricated from 1¼ × 0.035 in. [32 × 0.89 mm] nail-on strapping as shown in Fig. 10.

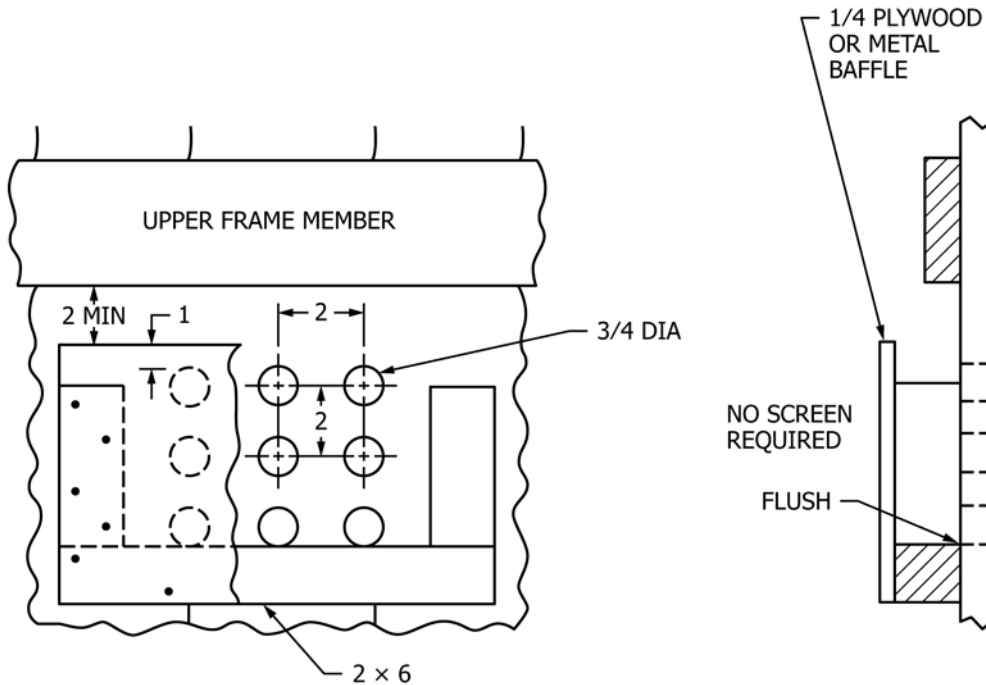
(3) *Bridging*—Intermediate sills shall be bridged at the ends with 1-in. [19-mm] lumber and at intervals along the span not exceeding 4 ft [1219 mm] with 2-in. [38-mm] lumber the same depth as the intermediate sills (see Fig. 9).

(4) *Bottom Sheathing*—Style B bases shall be sheathed on the bottom with lumber securely nailed to the sills bottom surface at right angles to the direction of the side sills. Boards shall be 4 to 10 in. [89 to 235 mm] wide and not less than 1-in. [19-mm] material for spans less than 30 in. [762 mm] between longitudinal members and not less than 2-in. [38-mm] material for spans of 30 in. [762 mm] or more. Bottom sheathing shall be flush with the outside face of all side and end sills and be spaced ¼ in. [6 mm] apart for drainage. Nailing pattern as shown in Fig. 1 shall be followed.

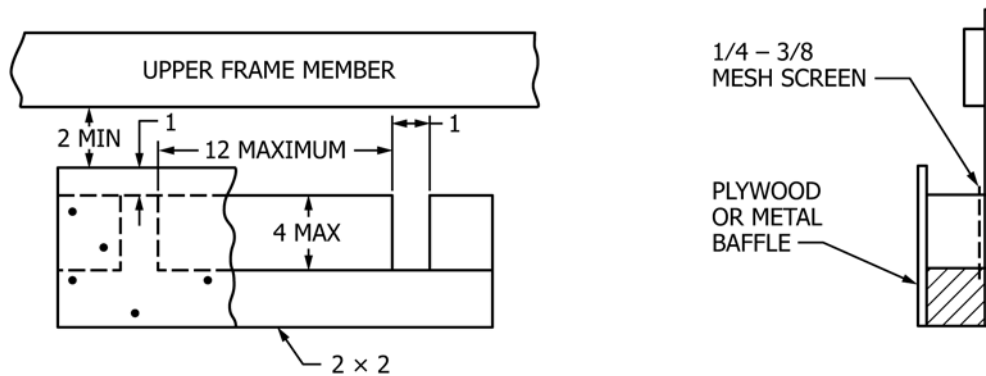
(5) *Rubbing Strips*—Style B bases shall have 3-in. [64-mm] thick rubbing strips, not less than 4 in. [89 mm] wide. The rubbing strips shall always be applied lengthwise of the base and positioned under each longitudinal member. When required, intermediate rubbing strips of the same sizes are located so that the clear distance between rubbing strips does not exceed 36 in. [914 mm]. Other requirements shall be as specified in 8.7.1.1(2).

8.7.2 *Tops*—Tops shall be double sheathed and shall be (a) narrow, widths through 54 in. [1372 mm]; (b) intermediate, widths over 54 through 60 in. [1372 through 1524 mm]; (c)

be that amount of the load actually supported by that sill. Load-bearing headers shall be the same size as intermediate sills. Load-bearing headers and intermediate sills will not be required when the side sills support the entire load. Load-



LUMBER SHEATHED CRATE



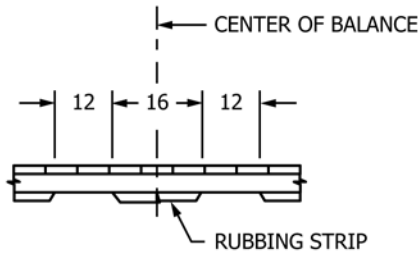
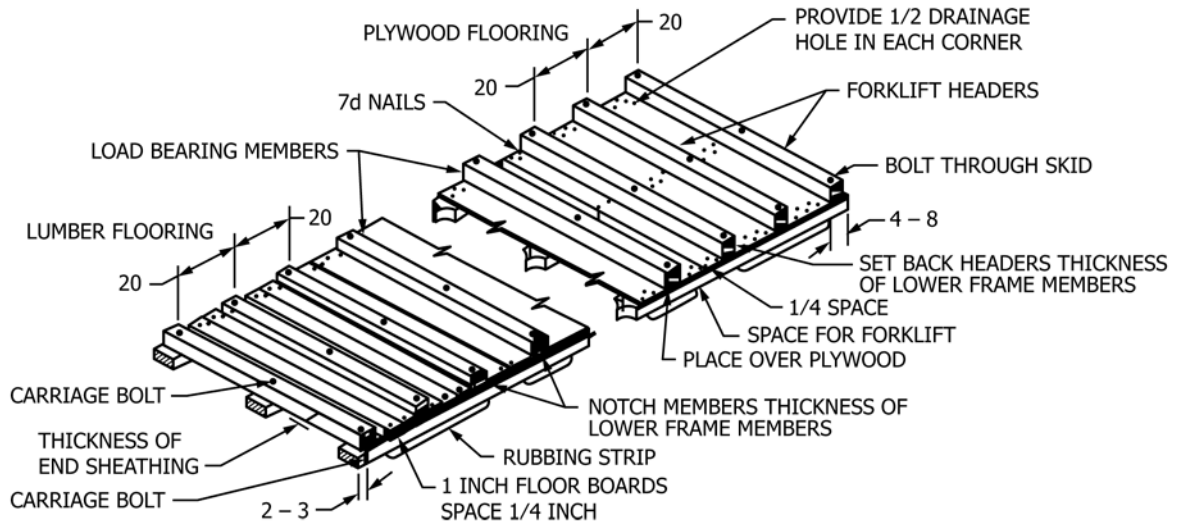
PLYWOOD SHEATHED CRATE

NOTE 1—All dimensions in inches.
FIG. 6 Crate Ventilation (Inside View)

wide, over 60 through 120 in. [1524 through 3048 mm] in width. Plywood sheathing 1/4 in. [6 mm] thick, shall be attached to the lumber framing with its face grain parallel with the top width and its edges flush with the framing outside edges. All plywood sheathing joints shall be made over joists or other frame members. Roofing felt, or polyethylene film not less than 4 mils thick, shall be applied over the plywood with a minimum 4-in. [102-mm] overlap at joints. A non-hardening caulk or mastic shall be applied in the overlap area. Top sheathing boards not less than 4 in. [89 mm] wide shall be placed over the plywood sheathing and waterproof barrier and shall extend beyond the top framing outer edges by an amount equal to the thickness of side and end panel sheathing less 1/8 in. [3 mm]. Headers joining the joists together shall be 1 in. [19 mm] thick by the joist depth for intermediate and wide tops For

tops not exceeding 96 in. [2438 mm] wide, 1/2-in. [13-mm] thick plywood single sheathing may be used in lieu of the double sheathed top. Plywood face grain shall be parallel with the top width. When joists do not coincide with plywood joints, a 1 x 4-in. [16 x 89-mm] lumber joint cover shall be used on the inside of the top. Prior to securing the plywood to the joists or joint covers, a non-hardening caulking shall be applied at three places at each joint—between the plywood panels at their butt joint, and between the plywood and joint cover or joist on either side of the butt joint. The caulk shall be applied as a continuous bead and may be either performed or applied with a gun.

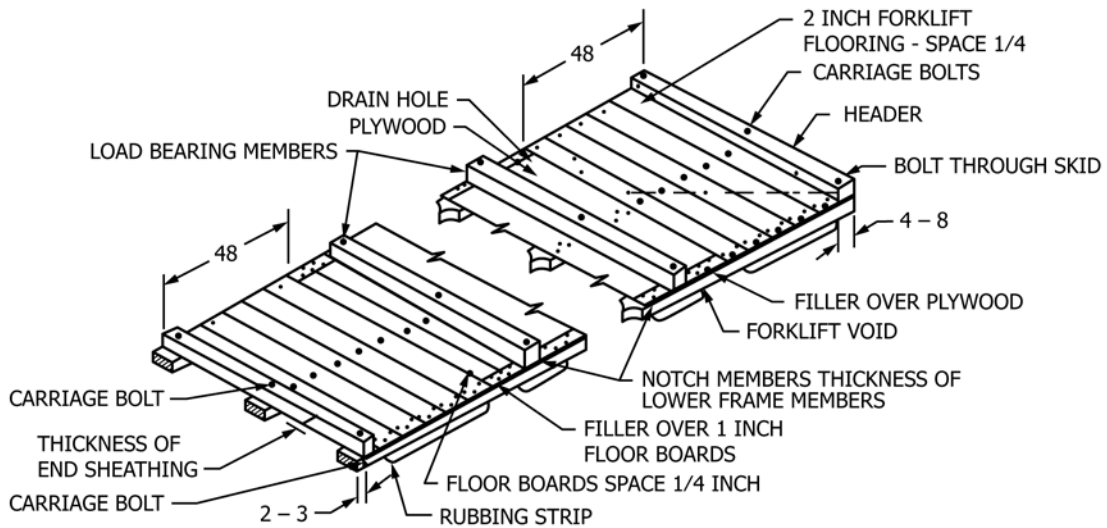
8.7.2.1 *Narrow Tops*—Narrow tops shall be framed on 2 x 4-in. [38 x 89-mm] members as shown in Fig. 11. Top sheathing board shall be applied parallel to the top width and



FORKLIFT AREA

NOTE 1—All dimensions in inches.

FIG. 7 Details of Skid-Type Base (With Forklift Headers)



LUMBER FLOORING

PLYWOOD FLOORING

NOTE 1—All dimensions in inches.

FIG. 8 Details of Skid-Type Base (With 2-in. Forklift Flooring)

TABLE 3 Allowable Minimum Skid Sizes

Maximum Net Load		Crate Maximum Length		Skids Nominal Size	
lb	kg	ft	mm	in.	mm
300	[136]	16	[4877]	2 × 4 (flat)	38 × 89 (flat) ^A
1000	[454]	12	[6858]	2 × 4 (flat)	38 × 89 (flat) ^A
2000	[907]	20	[6096]	3 × 3 or 3 × 4 (flat)	64 × 64 or 64 × 89 (flat) ^B
10000	[4535]	32	[9754]	4 × 4	89 × 89
30000	[13608]	20	[6096]	4 × 6 (on edge)	89 × 140 (on edge)

^A For nailed crates only.

^B For crates with 2-in. [38-mm] thick lower frame member or 2-in. [38-mm] end struts.

TABLE 4 Required Header Sizes and Carriage Bolt Sizes

Skid Size		Header Size		Bolt Diameter	
in.	[mm]	in.	[mm]	in.	[mm]
2 × 4	[38 × 89]	2 × 4 ^A	[38 × 89]	3/8	10
3 × 3	[64 × 64]	3 × 3	[64 × 64]	3/8	10
3 × 4	[64 × 89]				
4 × 4	[89 × 89]	4 × 4	[89 × 89]	1/2	12
4 × 6	[89 × 140]				

^A For nailed crates only in width to 48 in. [1219 mm]. For wider crates or bolted crates, use 3 × 3 in. [64 × 64 mm].

shall be single pieces. At plywood joints on the inside of the top, 2 × 3-in. [38 × 64-mm] pieces shall be used as shown in Fig. 11.

8.7.2.2 Intermediate Tops—Intermediate tops shall be framed on 2-in. [38-mm] joists placed flat and headers 1 in. [19 mm] by the thickness of the joists. The top sheathing boards shall be placed parallel to the top length (see Fig. 12). When the crate length is over 10 ft [3048 mm], end joints will be permitted in top sheathing boards. All joints shall be made over joists, two joints shall be adjacent to each other, and not more than one-third of the joints shall be made over any one joist.

8.7.2.3 Wide Tops—Wide tops shall be constructed similar to intermediate tops except that the wide tops shall be framed in joists and headers placed on edge as shown in Fig. 13.

8.7.2.4 Fabrication Nailing—Fabrication nailing of tops shall be as shown in Figs. 14 and 15. All plywood members shall be nailed on at least three edges.

8.7.2.5 Grab Hook Reinforcing Joists for Lifting Crates—When no joists are used, or when a joist does not coincide with the center of balance, a reinforcing joist shall be placed at the center of balance to distribute the load when the crate is lifted with a single set of grab hooks. Reinforcing joists shall conform to the requirements of Table 5.

8.7.2.6 Joint Lamination—When two members are to be nailed together for joists and are 1 and 2 in. [19 and 38 mm] thick, respectively, they shall be nailed with the nail heads in the thinner piece. When both members are 2 in. [38 mm] thick, appropriate nails shall be used. Nails shall be staggered in two rows at least 1 in. [25 mm] from the edges, and shall be 18 in. [457 mm] apart in the rows. When the gross loads exceed 22 000 lb [9979 kg] or where the width exceeds 96 in. [2438 mm] for any load over 10 000 lb [4536 kg], two 4 × 4-in. [89 × 89-mm] joists shall be used; one placed approximately 2 to

3 ft [610 to 914 mm] each way from the center of balance, for the use of two sets of grab hooks.

8.7.3 Sides:

8.7.3.1 Number and Type of Panels—Sides shall be constructed as shown in Figs. 16-18. In crates with Style B bases, the sides and ends sheathing shall reach below the lower horizontal frame member a distance equal to the sill depth plus floor thickness, less 1/8 in. [3 mm]. The type of side panels shall vary with the inside crate height as specified in Table 6. The number of panels for each full-length side shall be computed by dividing the inside crate length by the inside height, and using the nearest whole number.

8.7.3.2 Member Selection—The upper and lower frame members, struts, and diagonals sizes shall be determined from Tables 13-22 except as otherwise specified. Loads referred to in the tables are the net loads and the dimensions are the crates' inside measurements. The member sizes shall be based on Group II Woods. If the exact crate size is not given in the tables, member sizes for next greater length and width the crate, and the next smaller height shall be used.

(1) *Upper and Lower Frame Members*—Except where vertical joist supports are required, upper frame members for crates over 54 in. [1372 mm] wide shall always be 2 in. [38 mm] thick and a minimum of 2 × 4 in. [38 × 89 mm] in size. Upper or lower frame member splicing shall be done over or under a strut and shall be as shown in Fig. 3.

(2) *Vertical Struts*—Vertical struts shall be continuous from the lower to the upper frame member and the diagonal and horizontal braces shall be cut in between. The end struts shall be as shown in Table 7.

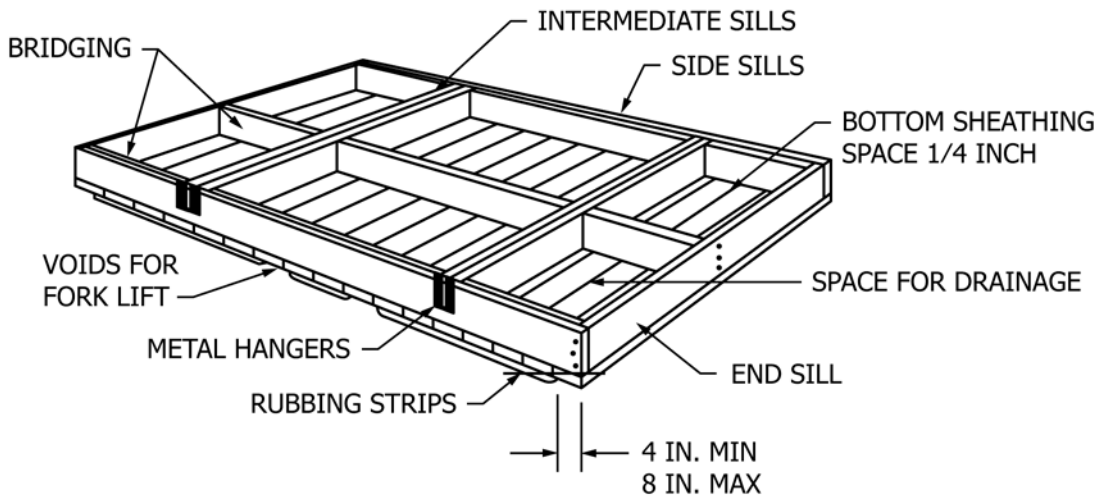
(3) *Horizontal Braces*—Horizontal braces for Types B and C panels (Figs. 17 and 18) shall be the same thickness as the struts and 4 in. [89 mm] wide.

(4) *Diagonals*—Diagonals' size shall be as specified in the member selection Tables 13-22 and shall be located as shown in Figs. 16-18. When frame members are 1 in. [19 mm] thick, gusset plates shall be cut from 1/4-in. [6-mm] plywood and shall be 12 in. [305 mm] minimum, in the shortest dimension. The corners shall coincide with the centerline of the diagonals as shown in Fig. 19.

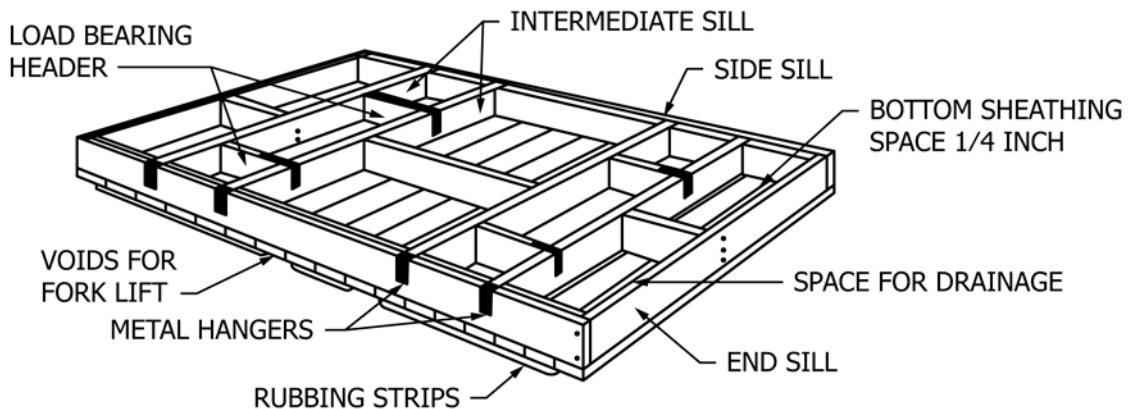
(5) *Joist Supports*—The upper frame members shall serve as supports for tops. When crates are 6 ft [1829 mm] wide and 12 ft [6858 mm] high or 8 ft [2438] wide and 10 ft [3048 mm] high (Tables 13-22) and when the struts are 1 in. [19 mm] thick, vertical joist supports shall be provided as shown in Fig. 19. These shall consist of 2 × 4-in. [38 × 89-mm] members placed on and nailed to the side frame members and extending under each interior joist to the floor.

8.7.3.3 Liners—A crate liner shall be applied between the sheathing and frame members of sides and ends of all lumber-sheathed crates. The liner shall be placed horizontally as unrolled, with a 4-in. [102-mm] minimum shingle lap applied for proper drainage and shall cover the entire framed area. Vertical joints, when required, shall have a minimum 4-in. [102-mm] lap and shall be located at a vertical member.

8.7.3.4 Sheathing—Sheathing for the crate side and end panels shall be applied vertically, shall extend to the skids bottoms on side panels and to the skids tops on the end panels



SILL BASE WITH DOUBLED SILLS



SILL BASE WITH LOAD-BEARING HEADERS

FIG. 9 Sill-Type Bases

of skid type base crates. Sheathing shall extend to the sills bottoms on sill-type base crates. Sheathing shall be either tongue-and-groove or square and shall be 1 in. [19 mm] thick. At least one side of all boards shall be dressed and the dressed side placed outward. No boards shall be less than 4 in. [89 mm] width. End boards shall be not less than 6 in. [140 mm] wide and preferably wider. No more than 10 % of the boards (not more than one out of 10 boards) shall be the minimum width, nor shall the narrow boards be adjacent to each other. Short boards, not less than 2 ft [610 mm] length, may be used under the following conditions (Fig. 20).

(1) Boards shall be cut at right angles.

(2) A short sheathing board center shall be at the approximate center of the width of a diagonal and shall have full coverage by the diagonal, or shall be joined on a horizontal member.

(3) At least every second board and all end boards shall be full length.

(4) Nailing shall be as shown in Fig. 20.

8.7.3.5 *Fabrication Nailing*—Nails securing sheathing to framing up to and including 2 in. [38 mm] thickness shall be driven through the sheathing and long enough to permit a 1/4-in. [6-mm] (minimum) clinch on the framing. For nailing sheathing to horizontal and diagonal frame members 4 to 6 in. [89 to

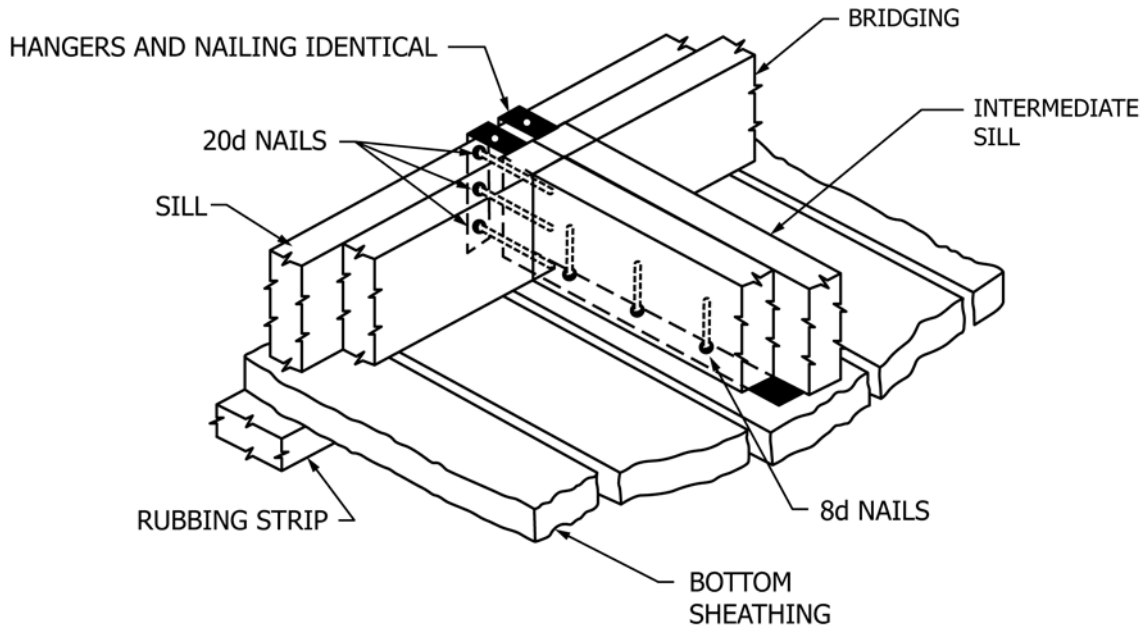
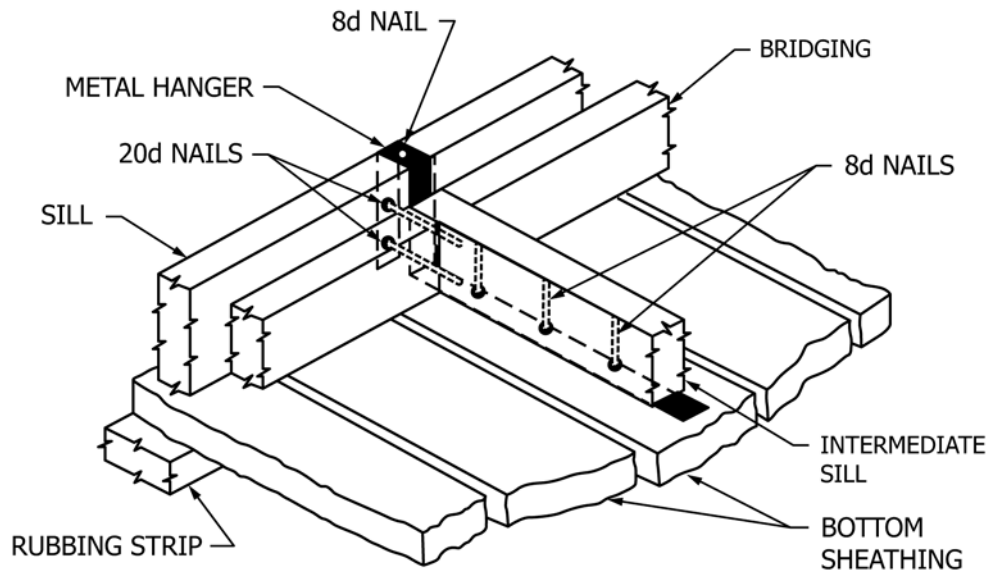


FIG. 10 Attaching Intermediate Sills to Side Sills

TABLE 5 Reinforcing Joist Requirements

Single Reinforcing Size		Gross Loads Not Exceeding		Joint Length Not Exceeding	
in.	[mm]	lb	[kg]	in.	[mm]
2 × 4	38 × 89	1000	[454]	72	1829
2 × 4	38 × 89	2000	[907]	60	1524
2 × 4	38 × 89	3000	[1361]	48	1219
2 × 4	38 × 89	5000	[2268]	36	914
4 × 4	89 × 89	10000	[4536]	96	2438
4 × 4	89 × 89	15000	[6804]	72	1829
4 × 4	89 × 89	22000	[9979]	60	1524

TABLE 6 Side Panel Types—Class 1 Crates

Crate Inside Height		Type of Panel	Reference Figure No.
in.	mm		
Over 24 to 60	Over 610 to 1524	A	13
Over 60 to 108	Over 1524 to 2743	B	14
Over 108 to 144	Over 2743 to 3658	C	15

140 mm] wide, three rows of nails shall be used. There shall be a minimum of three nails per crossing in sheathing boards 4 to 6 in. [89 to 140 mm] wide and four nails (minimum) in wider

TABLE 7 End Strut Requirements

Net Load		End Struts Nominal Sizes			
		Bolted Crate		Nailed Crate	
lb	[kg]	in.	[mm]	in.	[mm]
1000 or under over 1000	454 or under over 454	2 × 4 3 × 3	38 × 89 64 × 64	2 × 4 2 × 4	38 × 89 38 × 89
but under 5000 5000 and over	but under 2268 2268 and over	4 × 4	89 × 89	4 × 4	89 × 89

TABLE 8 Side Panel Types—Class 2 Crates

Inside Height of Crate		Panel Type	Fig.
in.	[mm]		
Over 24 to 60	Over 610 to 1524	A	29
Over 60 to 96	Over 1524 to 2438	B	30
Over 96 to 144	Over 2438 to 3658	C	31

boards (Fig. 20). For nailing sheathing to horizontal and diagonal frame members over 6 in. [140 mm] wide, four rows of nails shall be used. There shall be a minimum of four nails per crossing in sheathing boards 4 to 8 in. [89 to 191 mm] wide and five nails (minimum) in wider boards (Fig. 20). For nailing sheathing to struts 4 to 6 in. [89 to 140 mm] wide, two rows of nails shall be used. The nails shall be spaced approximately 8 in. [203 mm] apart in each row and staggered. For wider struts use three rows of nails. The nails shall be spaced approximately 12 in. [305 mm] apart and staggered (Fig. 20). Nail spacing at vertical butt joints shall be as shown in Fig. 20. Gusset plates shall be secured with seven-penny (2¼ in. [57 mm]) nails driven through and clinched on the sheathing as shown in Fig. 19. Vertical joist supports shall be secured with two ten-penny (3 in. [76 mm]) nails at each horizontal frame member crossing and one ten-penny nail at each diagonal crossing as shown in Fig. 19. Where vertical joists coincide with struts, there shall be two rows of nails on 30-in. [762-mm] centers.

8.7.3.6 Lag Screw Reinforcing Strap for Bolted Crates—Reinforcing strap shall be used on all demountable crates' side and end panels as shown in Fig. 16, Fig. 17, Fig. 18, and Fig. 21. Galvanized steel strap, punched or drilled, 1¼ × 0.035 in. [32 × 0.89 mm] for ¾-in. [10-mm] lag screws, and 2 × 0.050 in. [51 × 1.27 mm] for ½ and ⅝-in. [13 and 16-mm] lag screws, shall be nailed to the sheathing inner face between the bottom frame member lower edge and the sheathing bottom as shown in Fig. 21. The strap shall be located to coincide with the skid or header center and shall be nailed on maximum 2-in. [51-mm] centers to the sheathing with clout or similar nails. Nails shall be clinched at least ⅜ in. [10 mm].

8.7.4 Ends—End types and member size for ends in crates over 30 in. [762 mm] wide shall be determined in a manner similar to the sides, except that in all cases the upper and lower frame members thickness shall be the same as the struts specified in Tables 13-22. The member arrangement shall conform to the details shown in Fig. 22. For crates less than 30 in. [762 mm] wide, single diagonals only are required and all frame members shall be 1 × 4 in. [19 × 89 mm] in size as shown in Fig. 23.

8.7.5 Assembly (Class 1 Crates):

8.7.5.1 Bolted Crate:

(1) *General*—Type II (bolted) crates shall be assembled with lag bolts (see 8.3). Lead holes shall be used for lag bolts.

(2) *Fastening Sides to Base*—The sides shall be secured to the skids with lag bolts. Lag bolts ⅜ in. [10 mm] diameter by 3-in. [76-mm] long shall be used for 3 × 3-in. [64 × 64-mm] or 3 × 4-in. [64 × 89-mm] skids. Lag bolts ½ in. [13 mm] diameter by 4-in. [102-mm] long shall be used for 4 × 4-in. [89 × 89-mm] skids. Lag bolts ⅝ in. [16 mm] diameter by 4-in. [102-mm] long shall be used for 4 × 6-in. [140-mm] skids. The number of lag bolts shall be as specified in Table 23. One-half the number shall be used on each side and the spacing shall be uniform along the skid. Maximum spacing shall be 16 in. [406 mm] for ⅜ -in. [10-mm] lag bolts and 20 in. [508 mm] for ½-in. [13-mm] lag bolts. Lead holes shall conform to 8.3 in size and shall be drilled in line with, and through, the center of the metal reinforcing strap, as well as through the sheathing and into the skid. Assembly and placement details shall be as shown in Figs. 24 and 25.

(3) *Fastening Sides to Top*—Lag bolts, ⅜ in. [10 mm] diameter by 3½ in. [89 mm] long, shall be used to fasten the sides to the top. These lag bolts shall be placed so that there is one in the end of each joist, at the approximate center (Fig. 26). For tops without joists, lag bolts shall be placed at the approximate center of the top side frame member and spaced no greater than 24 in. [610 mm] apart.

(4) *Fastening Ends to Top, Sides, and Base*—Lag bolts for fastening ends to tops shall be ⅜ in. [10 mm] diameter by 2½ in. [64 mm] long. Lag bolts for fastening ends to sides shall be ⅜ in. [10 mm] diameter by 3½ in. [89 mm] long. Placement and other assembly details shall be as shown in Fig. 24 and Fig. 26. Lag bolts for fastening ends to base shall be the same size as specified in 8.7.5.1(2). Location and spacing shall be as shown in Figs. 24 and 25. Lead holes shall be centered on the reinforcing strap.

8.7.5.2 Nailed Crate:

(1) *General*—Type I crates shall be assembled with nails and metal straps. General rules for crate assembly shall be as shown in Table 24 and Figs. 27 and 28.

(2) *Fastening Sides and Ends to Base*—Sides and ends shall be nailed to the skids and headers (Fig. 27). Two rows of nails shall be used for 2 × 4-in. [38 × 89-mm], 3 × 3-in. [64 × 64-mm], 3 × 4-in. [64 × 89-mm], and 4 × 4-in. [89 × 89-mm] skids or headers and for Style B bases. The number of nails required for the crate perimeter shall be as shown in Table 25, and based on the gross load. Nail spacing shall be no greater than 6 in. [152 mm] in each row, and no less than two nails shall be used in each sheathing board.

(3) *Fastening Ends to Sides and Sides to Ends*—The end panels shall be nailed to the side panels with nails spaced 12 in. [305 mm] apart as shown in Table 24 and Fig. 27. The nails shall pass through the sheathing and the ends' edge struts into the edge of the sides' corner struts. Pre-drilling shall be used for these nails to prevent splitting and the bit for drilling shall be approximately 75 % of the nail shank diameter. The side panels' edge sheathing boards shall be nailed to the ends' edge struts with nails spaced 6 to 8 in. [152 to 203 mm] apart (Fig. 27).

TABLE 9 Tare Weight Estimating Factors

S Square Feet [Square Meters]	Weight of Crate, lb [kg]			
	1 × lumber sheathing and 2 × framing	1 × lumber sheathing and 1 × framing	¾ in. [9 mm] plywood sheathing and 2 × framing members	¾ in. [9 mm] plywood sheathing and 1 × framing members
Less than 20 [2]	A × 4.0	A × 3.6	A × 3.2	A × 2.9
20 [2] and over but less than 40 [4]	A × 5.0	A × 4.5	A × 4.0	A × 3.6
40 [4] and over but less than 70 [7]	A × 6.0	A × 5.4	A × 4.8	A × 4.3
70 [7] and over	A × 7.0	A × 6.3	A × 5.6	A × 5.0

**TABLE 10 Allowable Load in lb per inch of Floorboard Width
Groups I and II Woods
(MIL-C-104C)**

Distance between Skids (in.)	Thickness of Load-Bearing Floorboard (in.)					
	¾	1½	2½	3½	5½	7½
12	57	287	600	1170	2900	5000
18	38	191	400	780	1930	3350
24	29	143	300	590	1400	2500
30	23	115	240	470	1160	2000
36	19	95	200	390	960	1680
42	16	82	170	335	830	1440
48	14	71	150	290	720	1250
54	12	63	130	260	645	1120
60	11	57	120	234	580	1000
66	10	52	110	212	525	910
72	9	48	100	195	480	840
84	8	41	85	140	360	710
96	8	35	75	167	300	630
108	7	34	66	130	233	560
120	7	30	60	117	210	500

(4) *Fastening Top to Sides and Ends*—Tops shall be fastened to sides and ends with corner reinforcing straps and tensioned straps with anchor plates as shown in Fig. 28. Corner straps shall be of such length as to allow nailing into sides and ends framing.

8.7.5.3 *Strapping*—Strapping shall be used as shown in Fig. 28 on all bolted crates with net loads over 3000 lb [1360 kg] and for all nailed crates. Tensioned metal strapping and corner straps shall conform to Specification D3953, Type 1 or 3, Zinc-Coated finish, Grade 2, not less than ¾ × 0.028 in. [19 × 0.71 mm]. Corner strapping shall be pre-punched or drilled. In addition, on crates with Style B bases, corner-reinforcing straps shall be applied at the bottom corners as shown in Fig. 29. Nails shall be 1¼ to 1½-in. [32 to 38-mm]. Three nails (minimum) shall be used for each strap leg and strapping shall be located so that nailing is in a frame member.

8.8 *Class 2 Crates*—Class 2 crates shall be Type I or II as specified, and shall have the same use limitations as described for lumber-sheathed crates in 8.7.

8.8.1 *Bases*—The base construction shall conform to Class 1 crates as specified in 8.7.1. Construction details shall be as shown in Figs. 7-10.

8.8.2 *Tops*—Class 2 crates top construction is identical to that described for Class 1 tops in 8.7.2. Construction details shall be as shown in Figs. 11-15.

8.8.3 *Sides*:

8.8.3.1 *Panel Number and Type*—Panel types for various heights and corresponding illustrative figure numbers shall be as shown in Table 8.

(1) Type B panels include a horizontal brace and Type C panels have two horizontal braces. These shall be located so as to equally divide the space between upper and lower frame members. For all side panel types, struts shall be spaced 24 in. [610 mm] on centers except at one or both ends so that 48-in. [1219-mm] wide plywood can be utilized with a minimum of waste. Sides shall be constructed as shown in Figs. 30-32. In crates with Style B bases, the sides and ends sheathing shall reach below the horizontal frame member a distance equal to the sills' depth.

8.8.3.2 *Member Selection*—The upper and lower frame members and struts sizes shall be determined from Tables 13-22, except as otherwise specified. Loads referred to in the tables shall be the net loads and the dimensions shall be the crates inside measurements. The member sizes shall be based on Group II Woods. If the exact crate size is not given in the tables, member sizes for the next greater length and width crate, and the smaller height, shall be used.

(1) *Upper and Lower Frame Members*—The requirements for upper and lower frame members shall comply with those described for lumber-sheathed side panels in 8.7.3.2(1) and listed by size in Tables 13-22.

(2) *Vertical Struts*—The requirements for struts shall comply with those described for lumber-sheathed side panels in 8.7.3.2(2) and listed by sizes in Tables 13-22.

(3) *Diagonals*—No diagonals are required for Class 2 crates.

(4) *Joist Supports*—The joist supports shall comply with those described for Class 1 side panels in 8.7.3.2(5).

8.8.3.3 *Liners*—No liners are required for Class 2 crates.

8.8.3.4 *Sheathing*—Plywood sheathing shall be ¾ in. [10 mm] thick for net loads up to 10 000 lb [4536 kg], and ½ in. [13 mm] for net loads over 10 000 lb [4536 kg], and shall be applied so that the face grain is vertical. Face grain may be horizontal for crates 4 ft [1219 mm] or less in height. Vertical joints in plywood sheathing shall be made over a strut center. Horizontal joints in plywood sheathing shall not be permitted in Type A side panels, are not desirable but permitted in Type B panels, and shall be permitted in Type C panels. All horizontal joints shall be made over the center of a horizontal brace.

8.8.3.5 *Fabrication Nailing*—Nailing plywood sheathing to frame members of various widths shall be as shown in Fig. 2. For all fabrication, nails shall be driven through the plywood and clinched ¼ in. [6 mm] (minimum). Nailing vertical joist supports shall be as described in 8.7.3.5 except that nails shall

**TABLE 11 Nominal Size of Side Sills (in.)^A
(MIL-C-104C)**

Gross Weight of Crate (lb)	Length of Crate (ft)							
	4	8	12	16	20	24	28	32
to 2000	2×4	2×4	2×4	2×4	2×4	2×6	2×6	2×6
2001–4000	2×4	2×4	2×4	2×4	2×6	2×6	2×6	2×8
4001–6000	2×4	2×4	2×4	2×6	2×6	2×6	2×8	2×8
6001–8000	...	2×4	2×6	2×6	2×6	2×8	2×8	2×8
8001–10 000	...	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
12 001–14 000	...	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

^A The above sizes are for crates with a height of 3 ft or less. For heights of over 3 ft, increase 2×4 sizes to 2×6; increase 2×6 to 2×8; increase 2×8 to 2×10; and increase 2- 2×8 to 2- 2×10.

**TABLE 12 Allowable Load for Intermediate Sills
(in lb per inch of Sill Width)
(MIL-C-104C)**

Length of Sill (ft)	Sill Depth (in.) Groups I and II Woods						
	1½	2½	3½	5½	7½	9½	11½
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	620	1200

be used (see Fig. 19). Staples may be used to fasten plywood sheathing to framing members; application shall be in accordance with 8.2.

8.8.3.6 *Lag-screw Reinforcing Strap for Bolted Crates*—Reinforcing strap shall be used on side and end panels of all bolted crates as shown in Figs. 30-32. Construction details shall be as specified in 8.7.3.6 and as shown in Fig. 21.

8.8.4 *Ends*—Panel types and member sizes for ends shall be determined in a manner similar to the sides, except that in all cases, the upper and lower frame members thickness shall be the same as the struts specified in Tables 13-22. The member arrangement shall be as shown in Fig. 33. Fabrication shall be as shown in Fig. 2.

8.8.5 *Assembly (Class 2 Crates)*:

8.8.5.1 *Bolted-crate Assembly*—Plywood-sheathed bolted crate assembly shall comply with the details specified for Class 1 crates in 8.7.5.1 and as shown in Figs. 24-26.

8.8.5.2 *Nailed-crate Assembly*—Plywood-sheathed nailed crate assembly shall comply with the details specified for Class 1 crates in 8.7.5.2 and as shown in Figs. 27 and 28, except for nail size which shall be as specified in Table 24.

8.8.5.3 *Reinforcing Straps*—The reinforcing straps shall be as specified for Class 1 crates in 8.7.5.3 and as shown in Figs. 28 and 29.

8.9 *Tolerances*—A $\pm 1/8$ in. [± 3 mm] tolerance is allowable on the overall length and width of individual completed crate panels. Out-of-square deviation of individual panels shall be not more than $3/16$ in. [5 mm] ($3/8$ in. [10 mm] difference in diagonals).

8.10 *Workmanship*—Crate panels shall be clean and free of splinters and protruding fastener points. Crate panels shall be square and free of cracks, splits, or other damage which would prevent easy and correct assembly and adversely affect assembled crate performance.

9. Tests

9.1 *Moisture Content*—Moisture content shall be determined using Test Method D4442 moisture meter method. Six readings (minimum), at least one reading on a frame member of each crate panel, shall be taken. The average of the six readings shall meet the requirements of Practice D6199.

9.2 *Assembly Test*—A crate shall be completely assembled to insure a container which can be properly and easily assembled, which is square, and is the proper size.

10. Estimating Tare Weight Method

10.1 The approximate tare weight of either a lumber-sheathed or plywood-sheathed crate may be estimated as follows and as indicated in Table 9.

10.1.1 Estimate the length, width, and height of the crate to the nearest ½-ft [152-mm].

10.1.2 Compute the total area of sides, ends, top, and base = A.

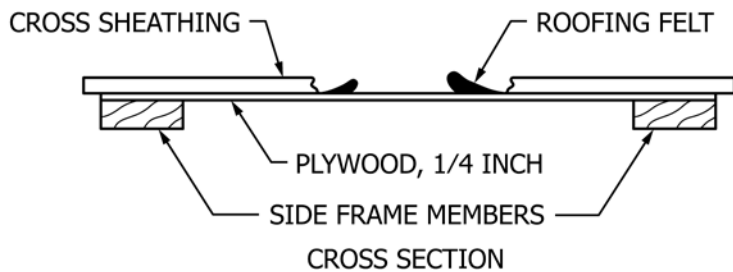
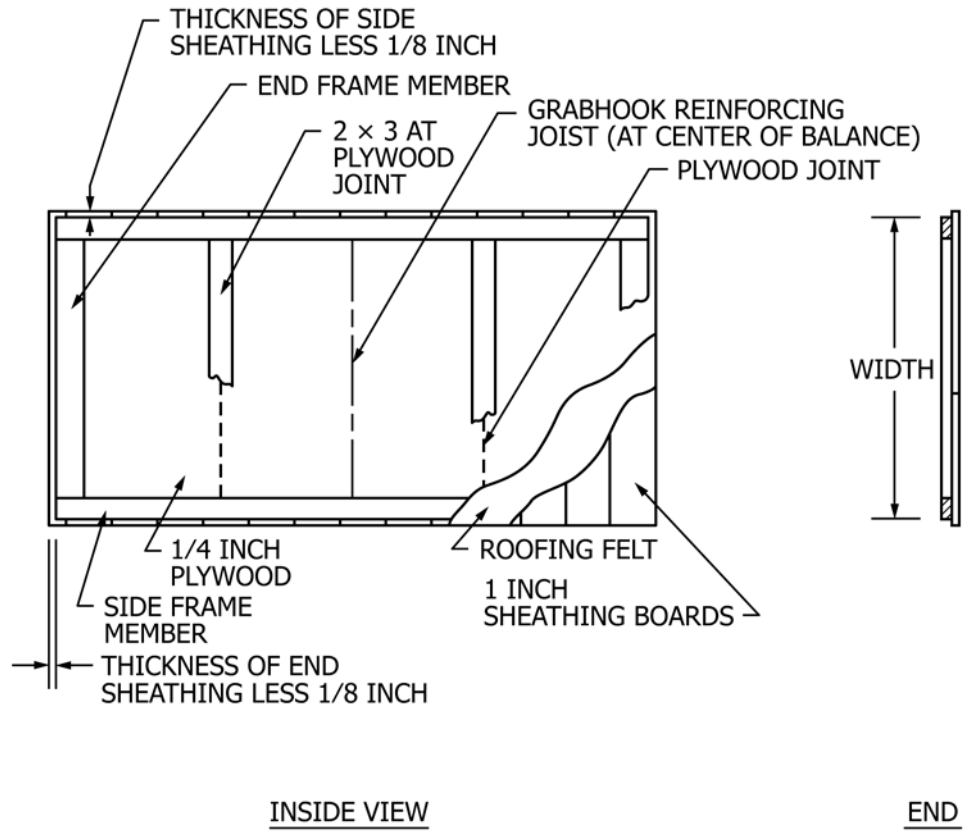
10.1.3 Multiply crate width by crate height = S.

11. Crate Design

11.1 The engineering design for crates includes consideration of normal handling stresses imposed on the loaded crate by forklift trucks, slings, or grab hooks as well as stresses on members and assembly fastenings encountered by drops. The tops have been designed for a superimposed load of 50 lb/ft² [244 kg/m²]. The sides have been designed for a top load, with dunnage, of 200 lb/ft² [977 kg/m²] for net loads of 10 000 lb [4536 kg], and 400 lb/ft² [1953 kg/m²] for loads over 10 000 lb [4536 kg]. The base skids have been considered as part of the lower frame member of the side in the engineering analysis. This analysis allows the use of smaller skids thereby saving cube and material, but prevents the handling of a loaded crate without the sides and ends in place.

12. Phytosanitation

12.1 Phytosanitary treatment and marking shall conform to Practice D6253 and ISPM 15.

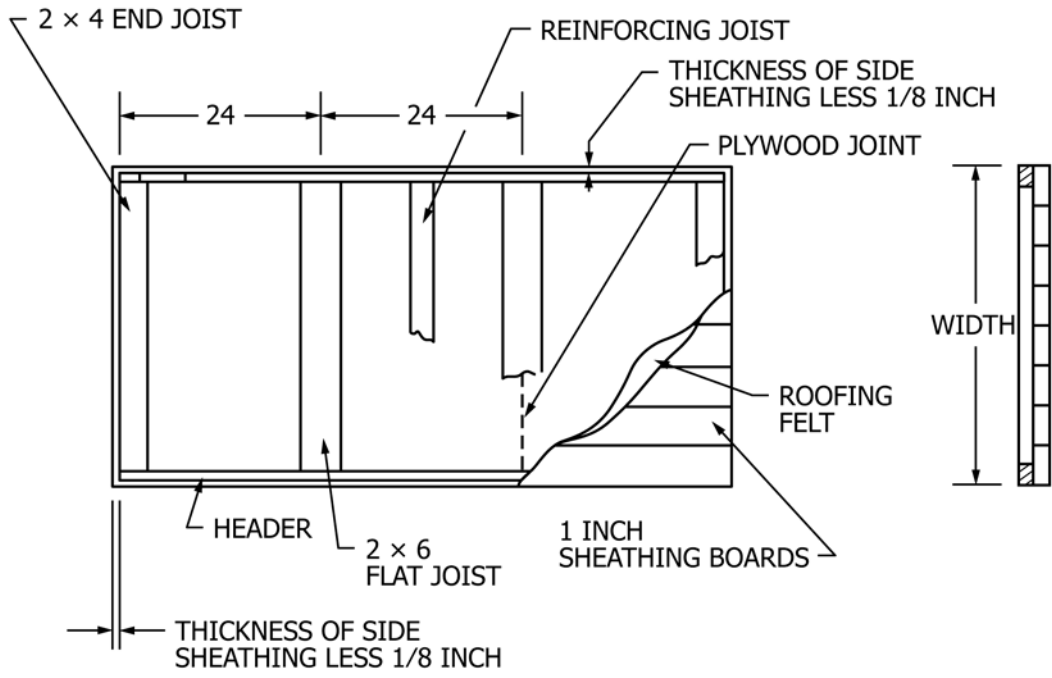


WIDTH - UP THROUGH 54 INCH
 JOISTS - NOT REQUIRED
 MEMBER SIZE - 2' x 4

FIG. 11 Narrow Tops (Widths Up to 54 in.)

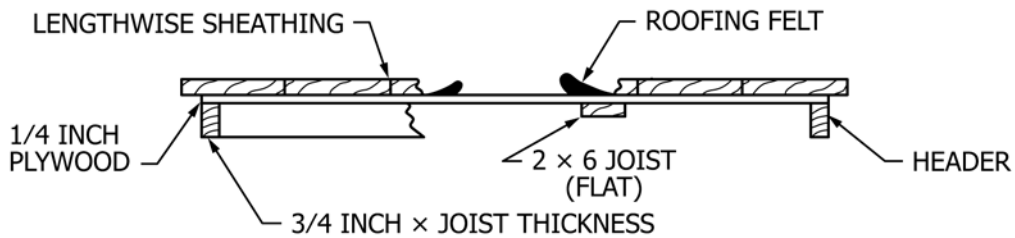
13. Keywords

13.1 crates; diagonals; lumber-sheathed; plywood-sheathed; sheathed; sheathing; sill-base; skid-base



INSIDE VIEW

END



CROSS SECTION

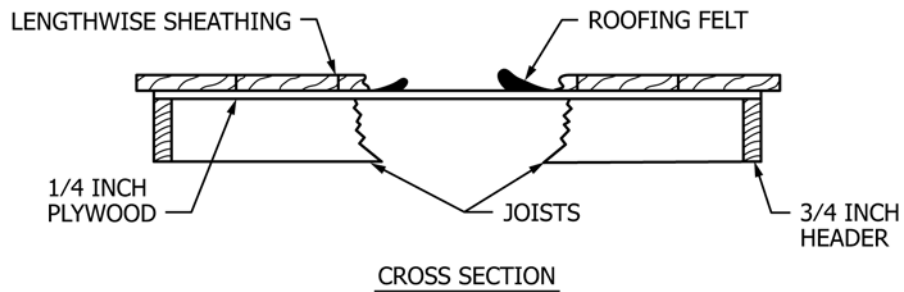
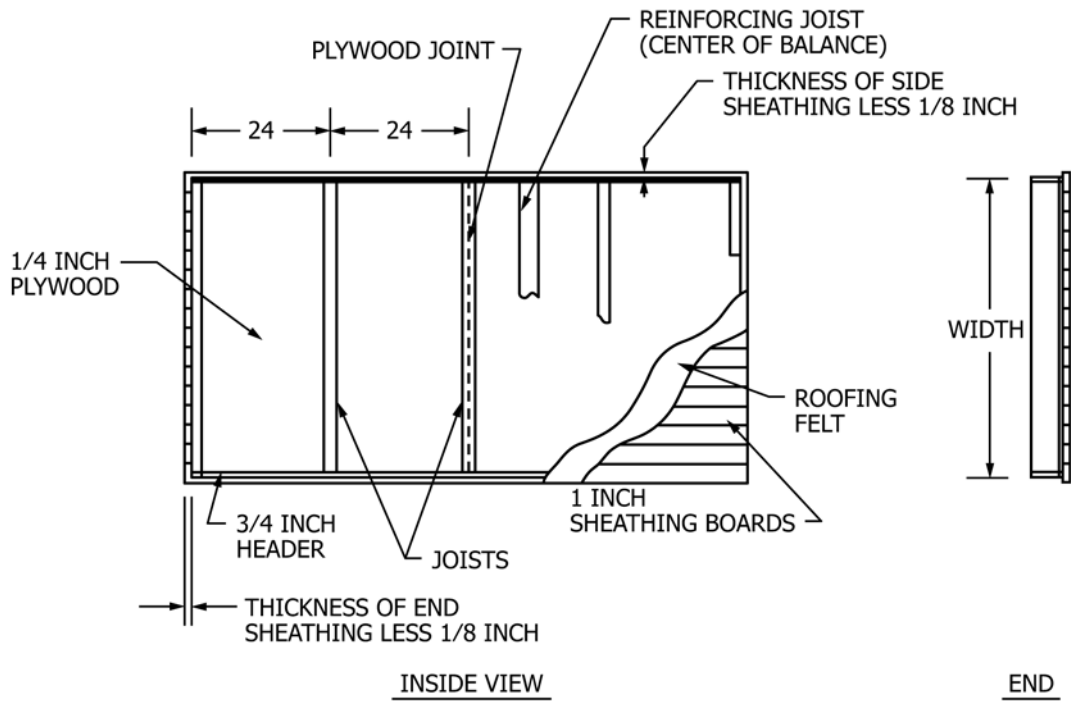
WIDTH - OVER 54 INCH THROUGH 60 INCH

JOISTS - 2 x 6 (FLAT), 24 INCHES O. C.

2 x 4 (FLAT) END JOIST

HEADER - 3/4 INCH x JOIST THICKNESS

FIG. 12 Intermediate Tops (Widths Over 54 in. through 60 in.)



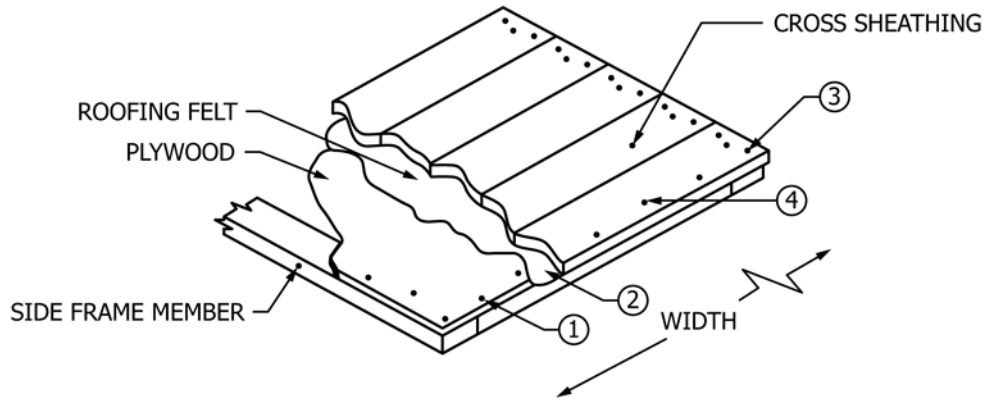
WIDTH - OVER 60 INCHES THROUGH 120 INCHES
JOISTS (SPACE 24 INCHES O. C.)

SPAN	SIZE
OVER 60 INCHES THRU 66 INCHES	2 x 4
OVER 66 INCHES THRU 78 INCHES	2 x 4 PLUS 1 x 4 OR 3 x 4 1/2
OVER 78 INCHES THRU 90 INCHES	2 - 2 x 4 OR 4 x 4 1/2
OVER 90 INCHES THRU 102 INCHES	2 x 6
OVER 102 INCHES THRU 120 INCHES	2 x 6 PLUS 1 x 6 OR 3 x 6 1/2

1/2 END JOIST TO BE SINGLE 2 INCH MEMBER AND SAME DEPTH AS JOISTS

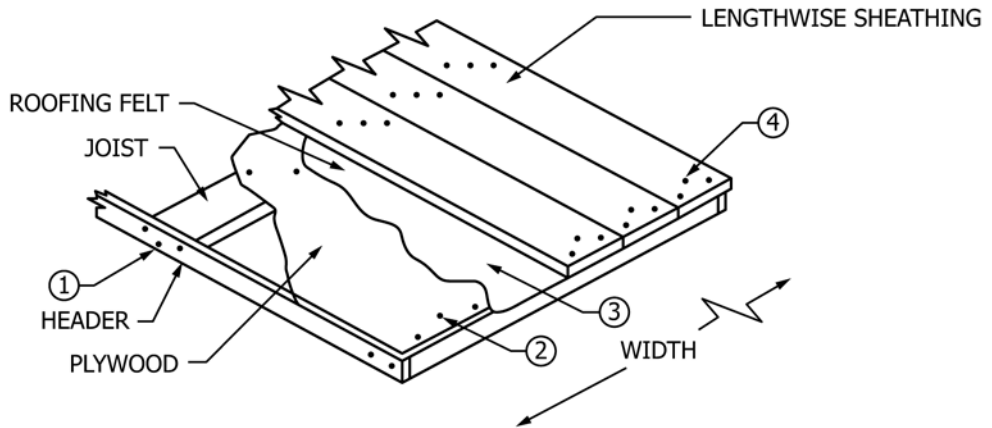
HEADERS - 3/4 INCH THICK AND SAME DEPTH AS JOISTS

FIG. 13 Wide Tops (Widths Over 60 in. through 120 in.)



NARROW TOPS

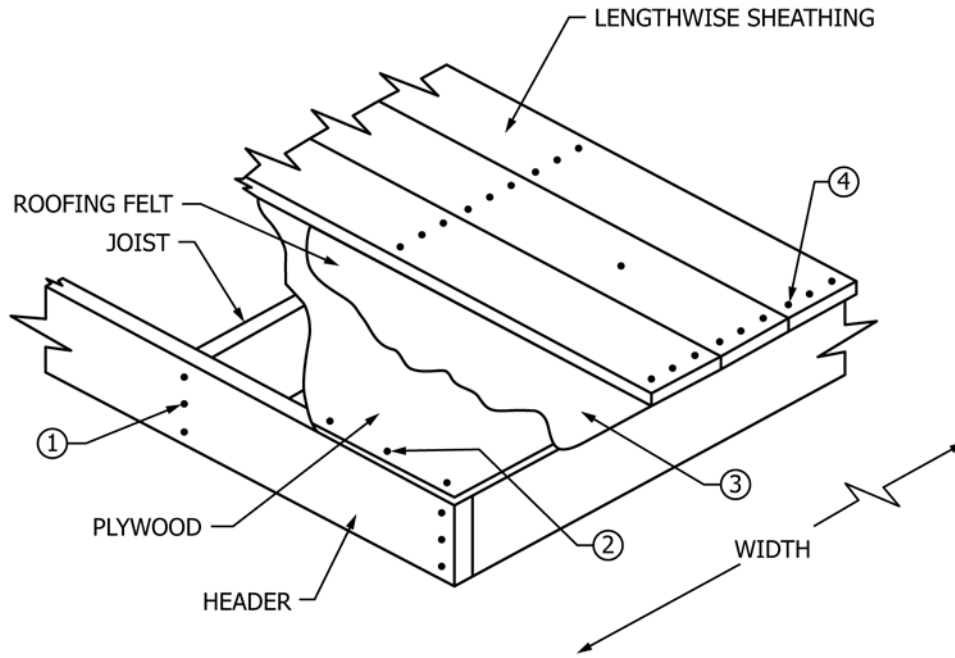
- ① PLYWOOD TO FRAME MEMBERS
NAILS - 5d CEMENT COATED
SPACING - 8 INCHES O. C.
- ② ROOFING FELT - 4 INCH LAP AT JOINT - USE MASTIC
- ③ SHEATHING THROUGH PLYWOOD INTO FRAMING MEMBER
NAILS - 8d CEMENT COATED
SPACING - 3 INCHES O C (MINIMUM 2 PER BOARD)
- ④ AS ③ BUT SPACE 8 INCHES O. C.



INTERMEDIATE TOPS

- ① HEADER TO FLAT JOIST - 12d CEMENT COATED NAIL, SPACE 2 INCHES O. C.
- ② PLYWOOD TO JOIST AND HEADER - 5d CEMENT COATED NAIL, SPACE 8 INCHES O. C.
- ③ ROOFING FELT - 4 INCH LAP AT JOINT - USE MASTIC
- ④ SHEATHING INTO JOIST - 8d CEMENT COATED NAIL, SPACE 3 INCHES O. C.

FIG. 14 Fabrication of Tops (Narrow and Intermediate)



WIDE TOPS

- ① HEADER TO JOIST - 12d cc NAIL
 2 x 4's - 2 NAILS
 2 x 6's - 3 NAILS
- ② PLYWOOD TO JOIST AND HEADER
 5d cc NAIL - SPACE 8 IN. ON CENTER
- ③ ROOFING FELT - 4 IN. LAP AT JOINT - USE MASTIC
- ④ SHEATHING INTO JOIST - 8d cc NAILS
 1 x 4, 1 x 6 - 2 NAILS PER JOIST
 1 x 8, 1 x 10 - 3 NAILS PER JOIST

FIG. 15 Fabrication of Tops (Wide Tops)

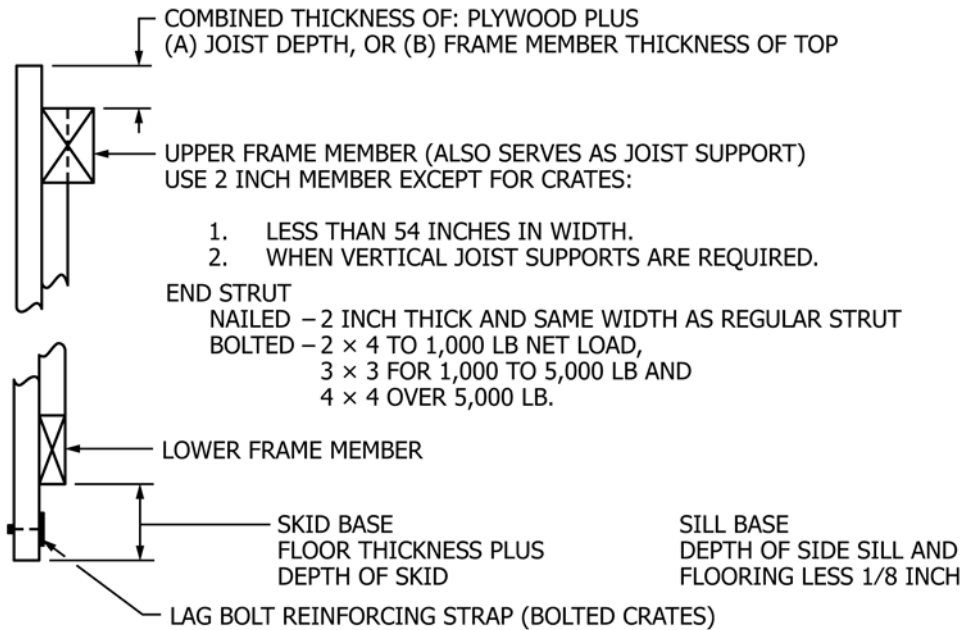
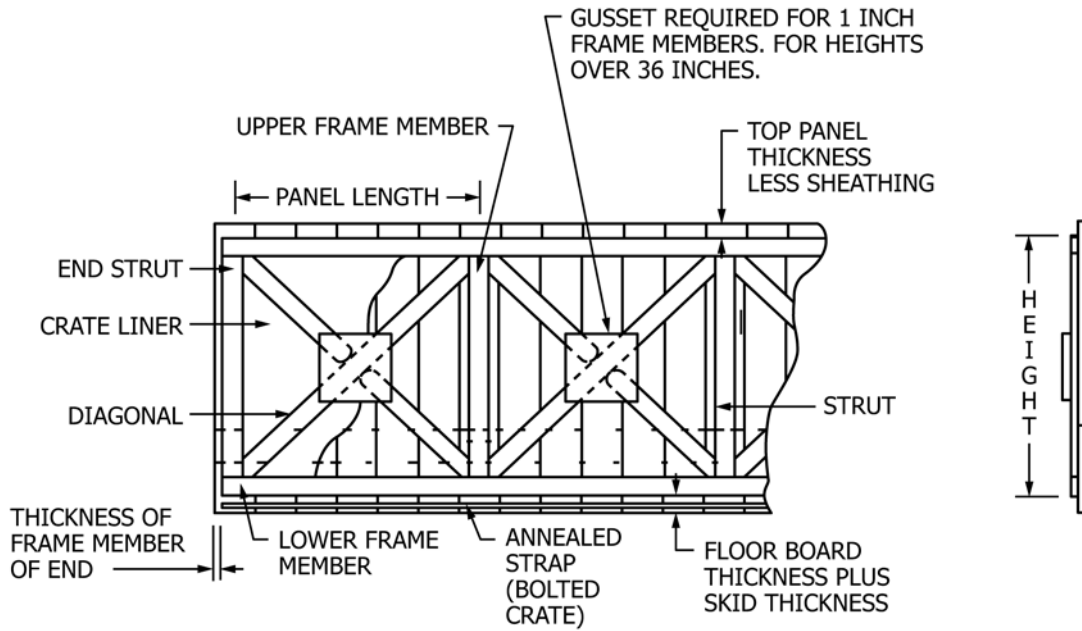


FIG. 16 Sides—Type A Panel (Lumber) (Heights Over 24 in. through 60 in.)

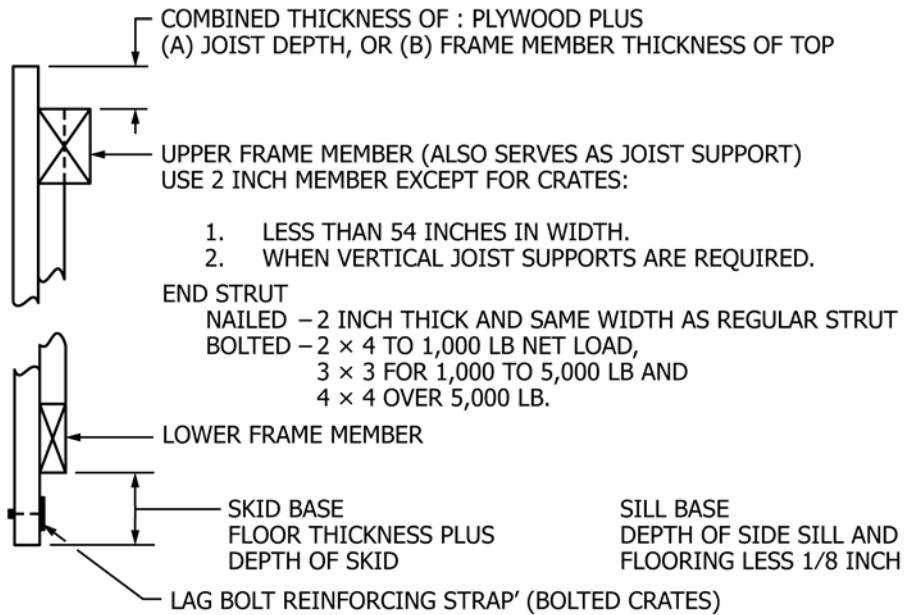
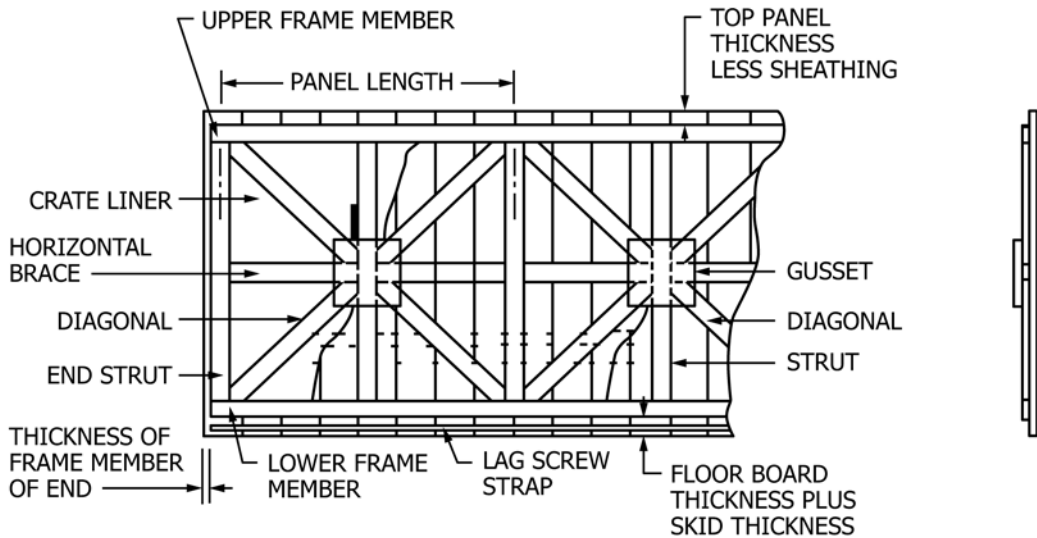


FIG. 17 Sides—Type B Panel (Lumber) (Heights Over 60 in. through 108 in.)

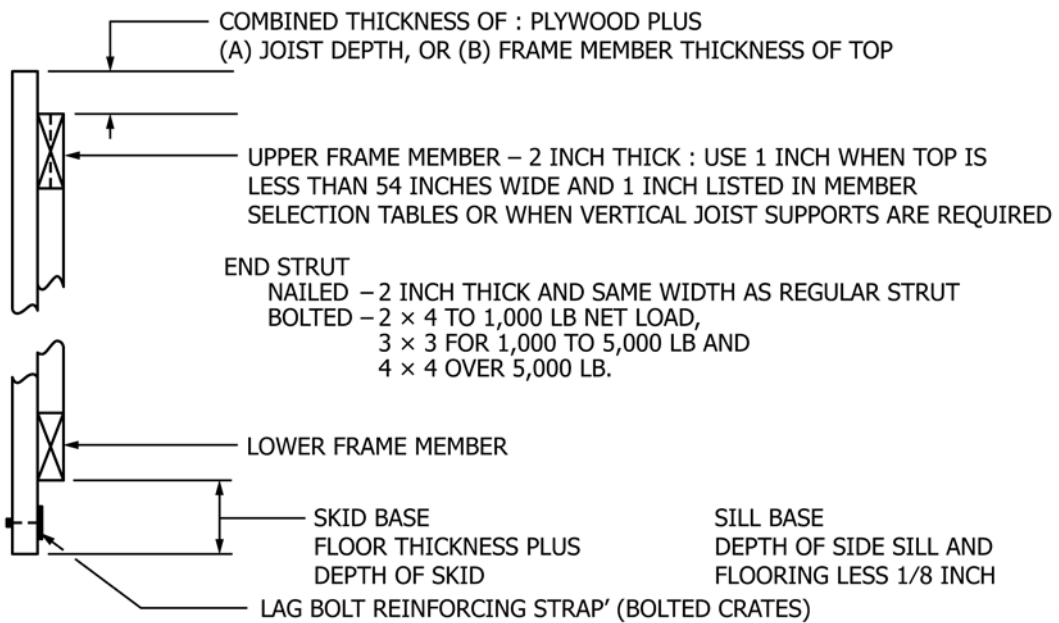
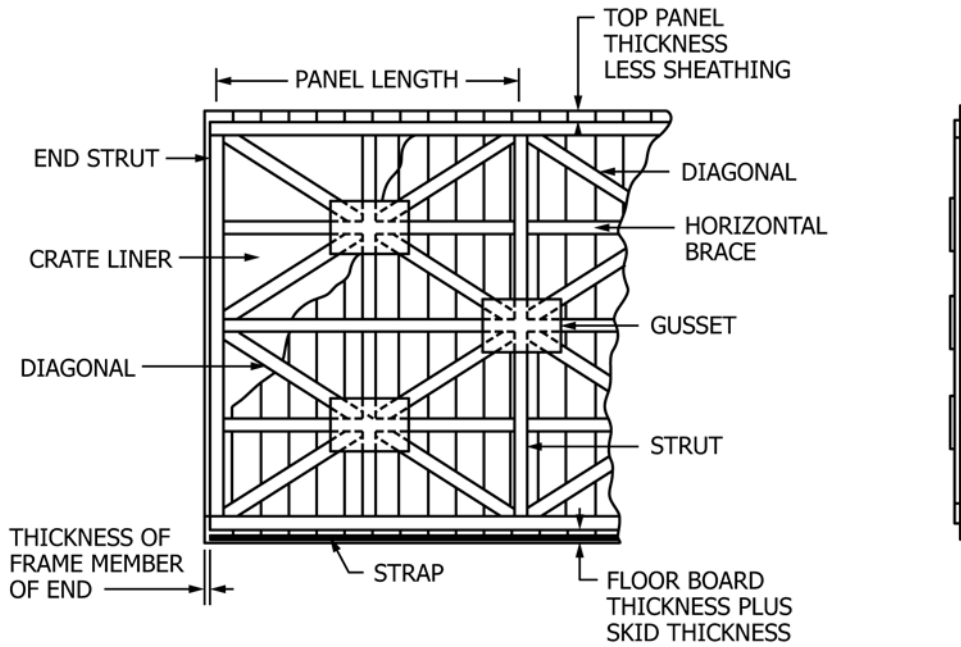


FIG. 18 Sides—Type C Panel (Lumber) (Heights Over 108 in. through 144 in.)



**TABLE 13 Panel Member Selection Table for 1000 lb Net Load^A
(MIL-C-104C)**

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width				6 ft width				8 ft width				10 ft width					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		
8	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal															1x6	1x6	2x4	2x4
10	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																1x6	1x6	2x4
12	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																	1x6	2x4
16	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal													1x6	1x6	1x6	1x6	2x4	2x4
20	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal															1x6	1x6	1x6	2x4
24	Upper frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	2x4
28	Upper frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	2x4
32	Upper frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	2x4

^A Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.



**TABLE 14 Panel Member Selection Table for 2000 lb Net Load^A
(MIL-C-104C)**

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width				6 ft width				8 ft width				10 ft width						
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	
6	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																			
8	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																1x6	2x4	2x4	2x4
10	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																			
12	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																			
16	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																			
20	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																			
24	Upper frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6
28	Upper frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6	1x6
32	Upper frame							1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal							1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4

^A Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.



**TABLE 15 Panel Member Selection Table for 4000 lb Net Load^A
(MIL-C-104C)**

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width				6 ft width				8 ft width				10 ft width					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		1x6
8	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame																		1x6
	Struts Diagonal																		1x6
10	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		1x6
12	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame																		1x6
	Struts Diagonal																		1x6
16	Upper frame	1x6						2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		1x6
20	Upper frame	1x6						2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame																		1x6
	Struts Diagonal																		1x6
24	Upper frame	1x6	1x6					1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		1x6
28	Upper frame	1x6	1x6					1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal																		1x6
32	Upper frame	1x6	1x6	2x4				1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame			2x4				1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			2x4															1x6

^A Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.



**TABLE 16 Panel Member Selection Table for 6000 lb Net Load^A
(MIL-C-104C)**

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width				6 ft width				8 ft width				10 ft width					
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12
6	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			1x6						1x6									
8	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			1x6						1x6	2x4	1x6							
10	Upper frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			2x4						2x4									
12	Upper frame	1x6						2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			2x4						2x4									
16	Upper frame	2x6						2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			2x4						2x4									
20	Upper frame	2x6	1x6					2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame							2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal			2x4						2x4									
24	Upper frame	1x6	1x6	1x6				1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame	1x6						1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal	1x6		2x4						1x6	2x4	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4
28	Upper frame	1x6	2x4	1x6	2x4			1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame	1x6						1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal	1x6		2x4						1x6	2x4	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4
32	Upper frame	2x6	2x6	1x6	2x4	2x4		2x6	2x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame	1x6						1x6	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts Diagonal	1x6		2x4						1x6	2x4	1x6	2x4	2x4	2x4	2x4	2x4	2x4	2x4

^A Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.

TABLE 17 Panel Member Selection Table for 8000 lb Net Load^A
(MIL-C-104C)

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width						6 ft width						8 ft width						10 ft width					
		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				2x4						2x4	2x4	2x4				2x4	2x4	2x4				2x4	2x4	2x4
	Lower frame				2x4						2x4	2x4	2x4				2x4	2x4	2x4				2x4	2x4	2x4
	Struts				2x4						2x4	2x4	2x4				2x4	2x4	2x4				2x4	2x4	2x4
	Diagonal			1x6	2x4		1x6				1x6	2x4	1x6				1x6	2x4	1x6				1x6	2x4	1x6
8	Upper frame	1x6			2x4		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame				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				2x4	2x4	1x6				1x6	2x4	1x6				1x6	2x4	1x6
10	Upper frame	1x6			2x4		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame				2x4		2x4				2x4	2x4	2x4				2x4	2x4	2x4				2x4	2x4	2x4
	Struts				2x4		2x4				2x4	2x4	2x4				2x4	2x4	2x4				2x4	2x4	2x4
	Diagonal			2x4	2x4		2x4				2x4	2x4	1x6				2x4	2x4	1x6				2x4	2x4	1x6
12	Upper frame	2x6			2x4		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame				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	1x6	1x6				2x4	2x4	1x6				2x4	2x4	1x6				2x4	2x4	1x6
16	Upper frame	2x6			2x4		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame				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	1x6	1x6				2x4	2x4	1x6				2x4	2x4	1x6				2x4	2x4	1x6
20	Upper frame	2x6	1x6		2x4		2x4	2x4	2x4	2x4	2x4	2x4	2x6	2x4	2x4	2x4	2x6	2x4	2x4	2x6	2x4	2x4	2x4	2x4	2x4
	Lower frame				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	1x6	1x6				2x4	2x4	1x6				2x4	2x4	1x6				2x4	2x4	1x6
24	Upper frame	2x6	2x6	1x6	2x4		2x4	1x6	1x6	1x6	2x4	2x4	1x6	2x6	2x4	2x4	1x6	2x6	2x4	1x6	2x6	2x4	2x4	2x4	2x4
	Lower frame	1x6			2x4		2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Struts	1x6			2x4		2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Diagonal	1x6		1x6	2x4	1x6	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
28	Upper frame	2x6	2x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x6	2x4	2x4	1x6	2x6	2x4	1x6	2x6	2x4	2x4	2x4	2x4
	Lower frame	1x6			2x4	2x4	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Struts	1x6			2x4	2x4	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Diagonal	1x6		2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
32	Upper frame	2x8	2x8	1x6	2x4		2x4	2x6	2x6	2x4	2x4	2x4	2x6	2x6	2x4	2x4	2x6	2x6	2x4	2x6	2x6	2x4	2x4	2x4	2x4
	Lower frame	1x8			2x4		2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Struts	1x8			2x4		2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4
	Diagonal	1x8		1x6	2x4	1x6	2x4	1x6	2x4	2x4	2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	2x4	1x6	2x4	2x4	2x4	2x4	2x4

^A Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.

TABLE 18 Panel Member Selection Table for 10 000 lb Net Load⁴
(MIL-C-104C)

NOTE 1—All blank spaces are 1x4s.

Length (ft)	Member	4 ft width						6 ft width						8 ft width						10 ft width					
		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			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
	Struts			2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
8	Upper frame	1x6		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
10	Upper frame	1x6		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
12	Upper frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
16	Upper frame	2x8	1x6	2x4	2x4	2x4	2x4	2x8	2x4	2x4	2x4	2x4	2x8	2x4	2x4	2x4	2x4	2x4	2x8	2x4	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
20	Upper frame	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x4	2x4	1x6	1x6	2x4	2x4	2x4	2x4	1x6	1x6	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
24	Upper frame	2x8	2x6	2x4	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
28	Upper frame	2x8	2x6	2x4	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x4	2x8	2x6	2x4	2x4	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4
32	Upper frame	2x8	2x8	2x6	2x6	2x4	2x4	2x8	2x8	2x6	2x6	2x4	2x10	2x10	2x6	2x6	2x4	2x4	2x10	2x10	2x6	2x6	2x4	2x4	
	Lower frame			2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	
	Struts			2x4	2x4	1x6	2x4	2x4	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4	1x6	2x4

⁴ Crates 12 ft high in 6-ft widths and crates 10 ft high in 8-ft widths require 2x4 vertical joist supports when struts are 1 in. thick; all other sizes use horizontal joist supports.



**TABLE 19 Panel Member Selection Table for 15 000 lb Net Load⁴
(MIL-C-104C)**

NOTE 1—All blank spaces are 2x4s.

Length (ft)	Member	4 ft width Height (ft)			6 ft width Height (ft)			8 ft width Height (ft)			10 ft width Height (ft)					
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
6	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
8	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
10	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
12	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
16	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
20	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
24	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
28	Upper frame															
	Lower frame															
	Struts Diagonal	2x10	2x6	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6
32	Upper frame															
	Lower frame															
	Struts Diagonal	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6

⁴ The above sizes are for uniform loads, but also apply to concentrated loads.

**TABLE 20 Panel Member Selection Table for 20 000 lb Net Load⁴
(MIL-C-104C)**

NOTE 1—All blank spaces are 2x4s.

Length (ft)	Member	4 ft width Height (ft)				6 ft width Height (ft)				8 ft width Height (ft)				10 ft width Height (ft)			
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	
6	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
8	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
10	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
12	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
16	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
20	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
24	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
28	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	
32	Upper frame																
	Lower frame																
	Struts Diagonal	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	2x6 2x6	

⁴ The above sizes are for uniform loads, but also apply to concentrated loads.

**TABLE 21 Panel Member Selection Table for 25 000 lb Net Load⁴
(MIL-C-104C)**

NOTE 1—All blank spaces are 2x4s.

Length (ft)	Member	4 ft width Height (ft)				6 ft width Height (ft)				8 ft width Height (ft)				10 ft width Height (ft)			
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12	
6	Upper frame	2x6	2x6				2x6	2x6				2x6	2x6				
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
8	Upper frame	2x6	2x6				2x6	2x6				2x6	2x6				
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
10	Upper frame	2x6	2x6				2x6	2x6				2x6	2x6				
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
12	Upper frame	2x6	2x6				2x6	2x6				2x6	2x6				
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
16	Upper frame	2x6	2x6				2x6	2x6				2x6	2x6				
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
20	Upper frame	2x10	2x6	2x6	2x6	2x6	2x10	2x6	2x6	2x6	2x10	2x6	2x6	2x6	2x6	2x6	
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
24	Upper frame	2x8	2x10	2x6	2x6	2x6	2x10	2x6	2x6	2x6	2x10	2x6	2x6	2x6	2x6	2x6	
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
28	Upper frame	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
	Lower frame			2x6	2x6	2x6			2x6	2x6				2x6	2x6	2x6	
	Struts Diagonal	2x6	2x8	2x8	2x8	2x8	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	2x6	
32	Upper frame	2x12	2x10	2x10	2x6	2x6	2x12	2x10	2x10	2x8	2x8	2x8	2x8	2x8	2x8	2x8	
	Lower frame	2x6					2x6							2x6			
	Struts Diagonal	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	2x8	

⁴ The above sizes are for uniform loads, but also apply to concentrated loads.

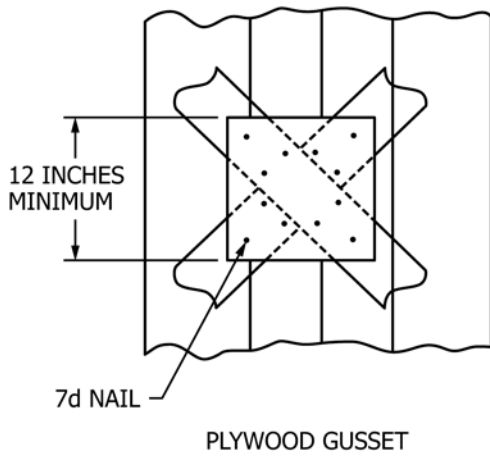


**TABLE 22 Panel Member Selection Table for 30 000 lb Net Load⁴
(MIL-C-104C)**

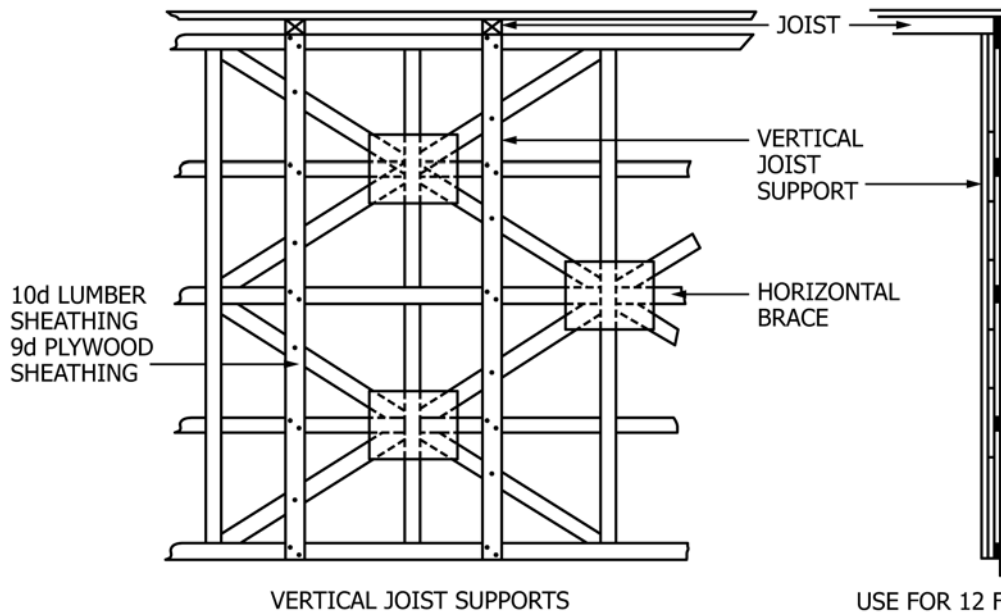
NOTE 1—All blank spaces are 2x4s.

Length (ft)	Member	4 ft width Height (ft)			6 ft width Height (ft)			8 ft width Height (ft)			10 ft width Height (ft)					
		4	6	8	10	12	4	6	8	10	12	4	6	8	10	12
6	Upper frame	2x6	2x6		2x6	2x8		2x6	2x6		2x6	2x6		2x6	2x6	
	Lower frame															
	Struts Diagonal	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8
8	Upper frame	2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6	
	Lower frame															
	Struts Diagonal	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
10	Upper frame	2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6	
	Lower frame															
	Struts Diagonal	2x6 2x6	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
12	Upper frame	2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6	
	Lower frame															
	Struts Diagonal	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
16	Upper frame	2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6		2x6	2x6	
	Lower frame															
	Struts Diagonal	2x10 2x8	2x10 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
20	Upper frame	2x10	2x8		2x10	2x8		2x10	2x8		2x10	2x8		2x10	2x8	
	Lower frame															
	Struts Diagonal	2x8 2x8	2x10 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
24	Upper frame	2x10	2x10		2x10	2x8		2x10	2x8		2x10	2x8		2x10	2x8	
	Lower frame															
	Struts Diagonal	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
28	Upper frame	2x12	2x10		2x12	2x10		2x12	2x10		2x12	2x10		2x12	2x10	
	Lower frame															
	Struts Diagonal	2x6 2x6	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8
32	Upper frame	2x12	2x10		2x12	2x10		2x12	2x10		2x12	2x10		2x12	2x10	
	Lower frame															
	Struts Diagonal	2x6 2x6	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8	2x8 2x8	2x8 2x8	2x10 2x10	2x8 2x8	2x8 2x8

⁴ The above sizes are for uniform loads, but also apply to concentrated loads.

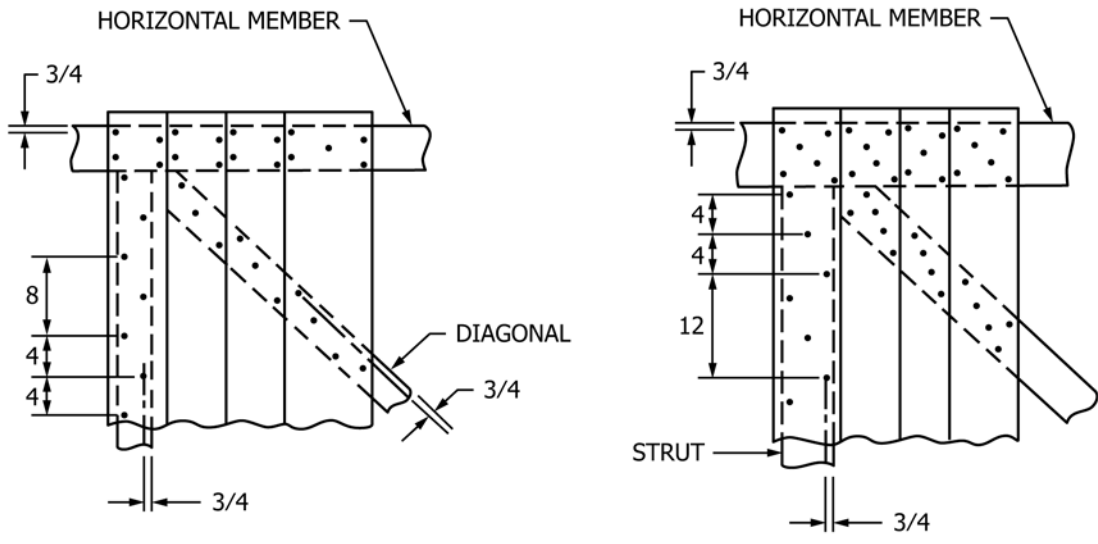


- 1 USE 1/4 INCH PLYWOOD SHORTEST DIMENSION 12 INCHES MINIMUM.
2. USE 3 NAILS (MIN.) PER MEMBER INTERSECTION - CLINCH ON SHEATHING SIDE.
- 3 CENTER CORNERS ON CENTERLINE OF DIAGONALS.
4. FOR CRATES WITH 1 INCH MEMBERS AND HEIGHTS OVER 36 INCHES.



USE FOR 12 FOOT CRATE HEIGHT IN 6 FOOT WIDTH AND FOR 10 FOOT HEIGHT IN 8 FOOT WIDTH WHEN STRUTS ARE SHOWN AS 1 INCH THICK IN MEMBER SELECTION TABLES IV TO IX

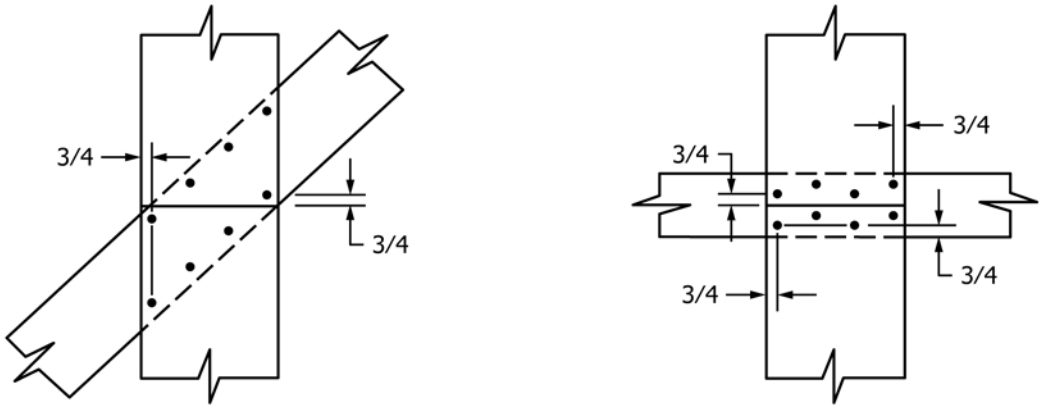
FIG. 19 Joist Supports and Gussets



FRAME MEMBER WIDTH

4 INCH AND 6 INCH WIDTHS

8 INCH AND WIDER



BUTT JOINTS OF SHEATHING

AT DIAGONAL

AT HORIZONTAL MEMBER

- 3 NAILS - 1 x 4 - 1 x 6
- 4 NAILS - 1 x 8 AND WIDER

- 3 NAILS - 1 x 4 - 1 x 6
- 4 NAILS - 1 x 8 AND WIDER

NOTE 1—All dimensions in inches. No adjacent boards shall be butt joined.

FIG. 20 Fabrication Nailing of Lumber Sheathing

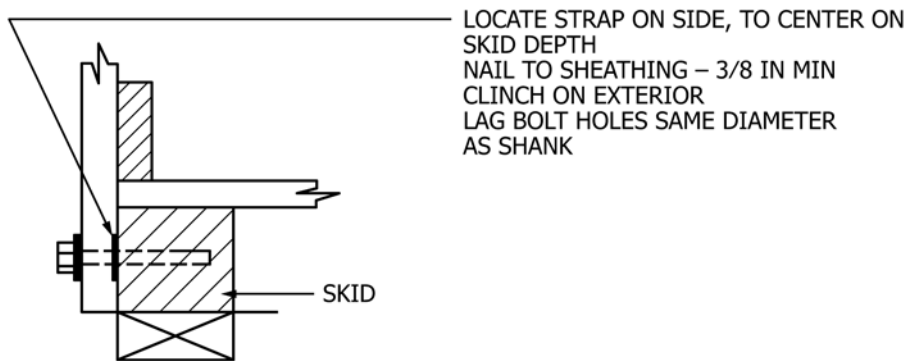
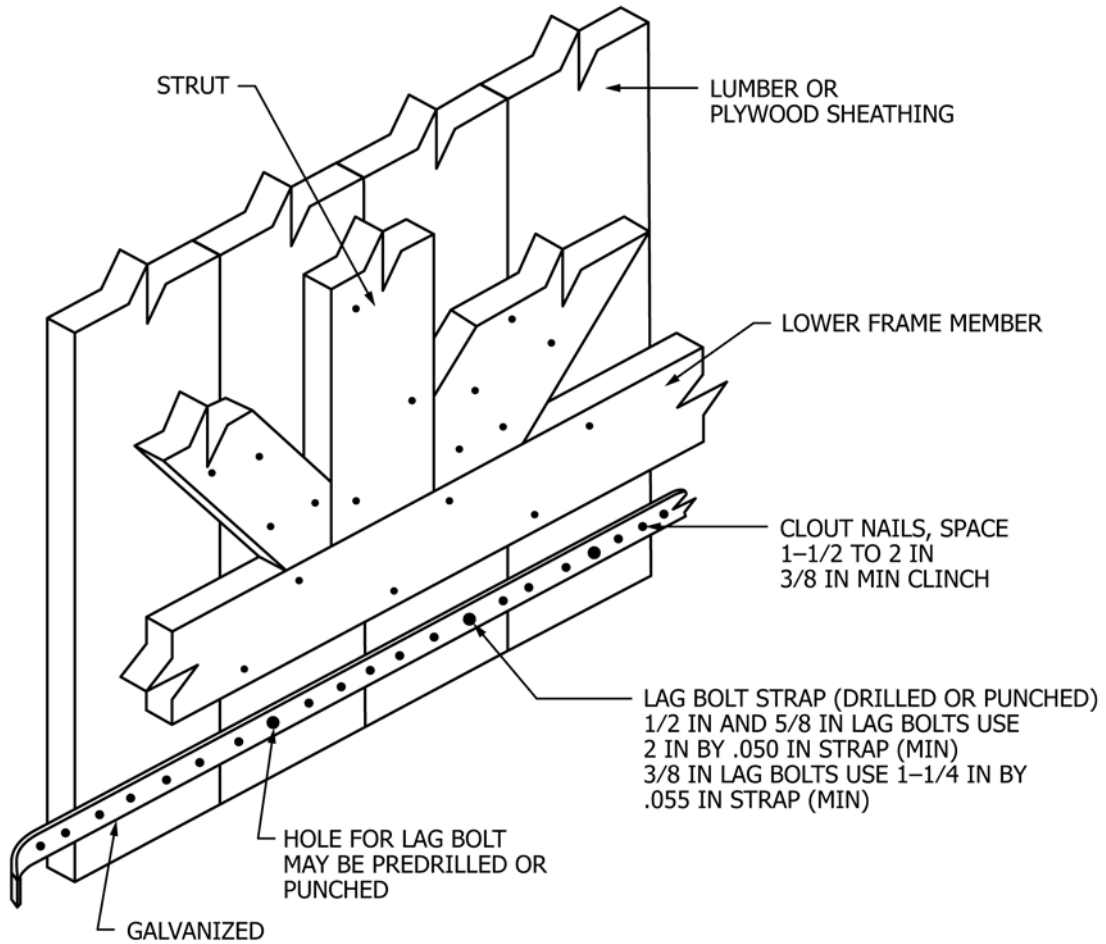


FIG. 21 Lag Bolt Reinforcing Strap for Bolted Crates

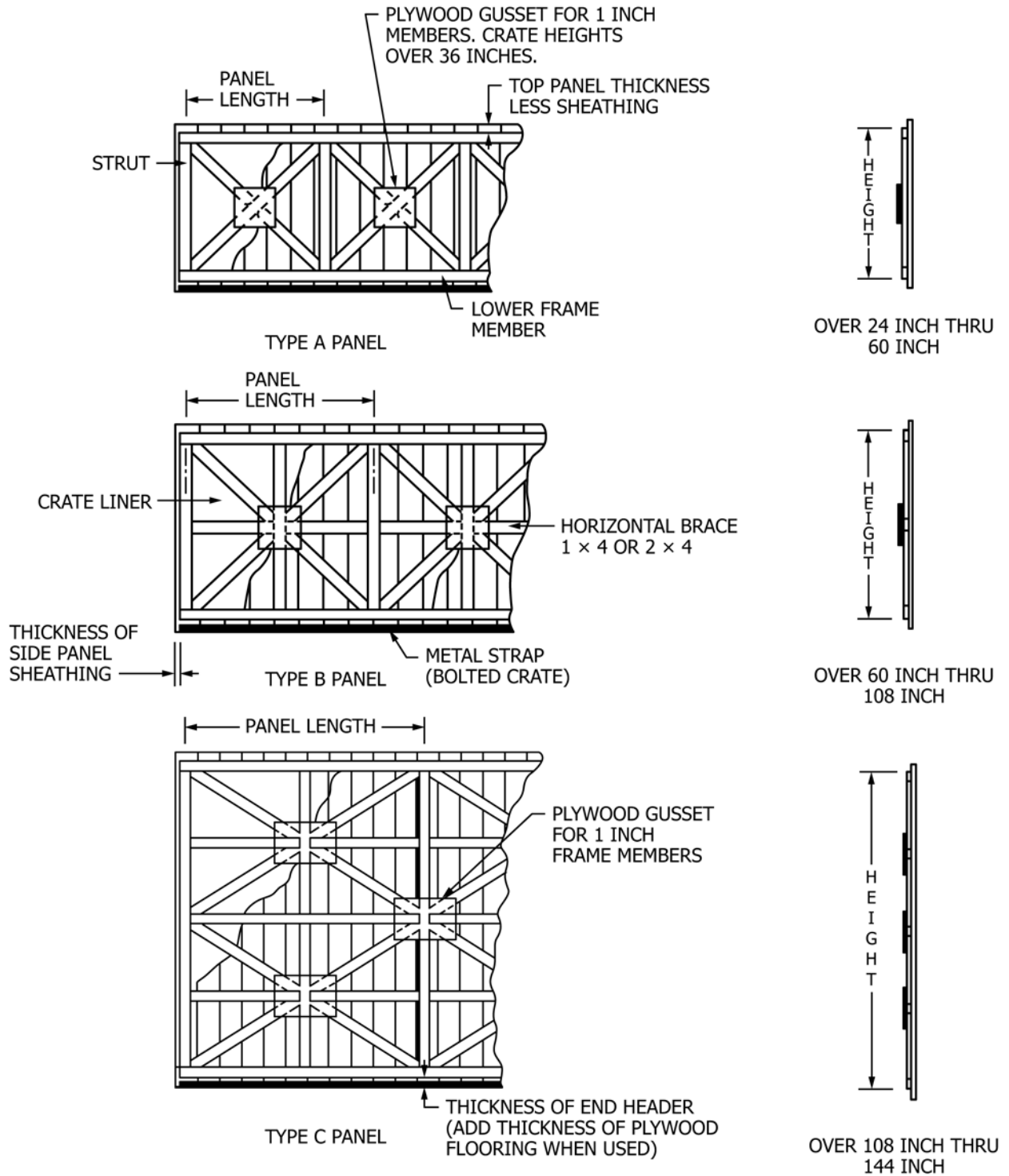


FIG. 22 End Panels Over 30 in. Wide Lumber Sheathed Crates

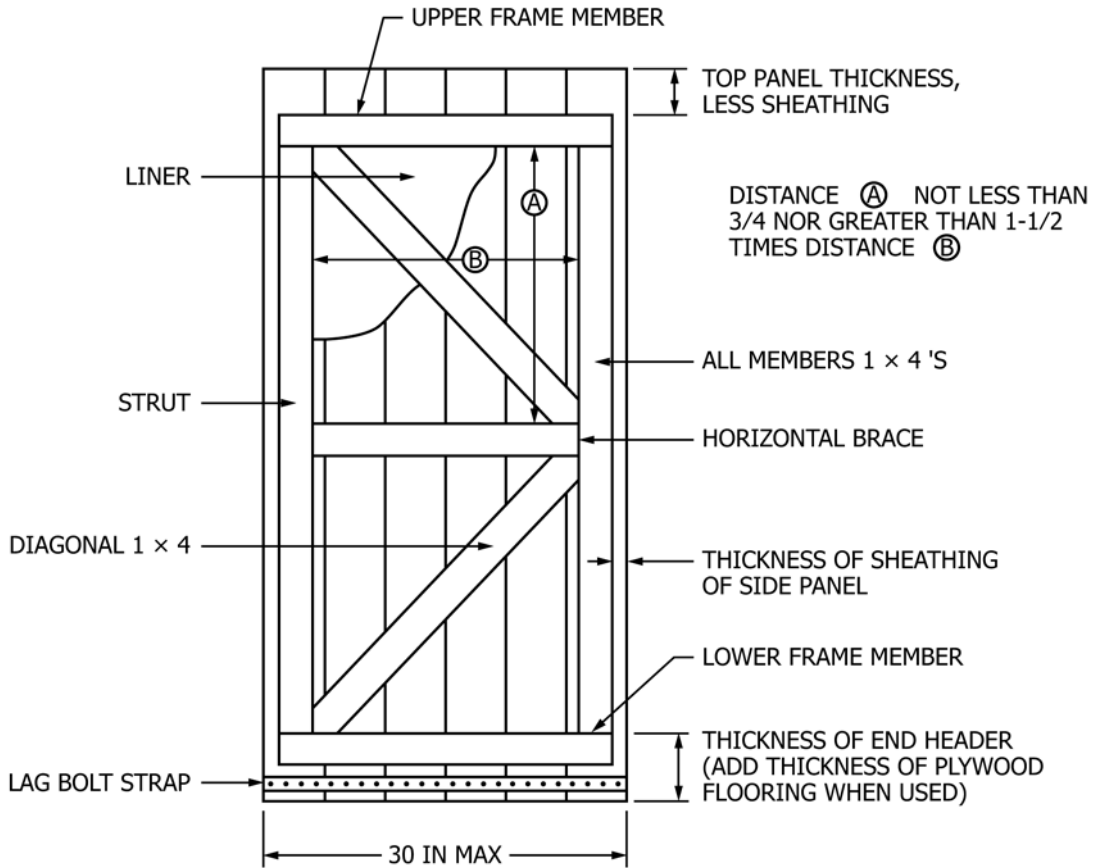


FIG. 23 Narrow End Panels (Lumber Sheathed Crates)

TABLE 23 Lag Bolts Required to Assemble Sides to Base of Bolted Crates Using Lag Bolt Reinforcing Strap (Skids to be Group II, III, or IV Woods)^A (MIL-C-104C)

Weight of Crate and Contents (lb)	Size of Lag Bolt		
	$\frac{3}{8} \times 3$ in. (3 x 3 or 3 x 4 in. skids)	$\frac{1}{2} \times 4$ in. (4 x 4 in. skids)	$\frac{5}{8} \times 4$ in. (4 x 6 in. skids)
2000	6	6	6
3000	10	6	6
4000	14	8	6
6000	20	12	8
8000	...	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

^A Use one-half the number on each side:

Maximum spacing:

$\frac{3}{8} \times 3$ — 16 in. on center

$\frac{1}{2} \times 4$ — 20 in. on center

$\frac{5}{8} \times 4$ — 20 in. on center

Minimum number: 3 per side, 2 per end

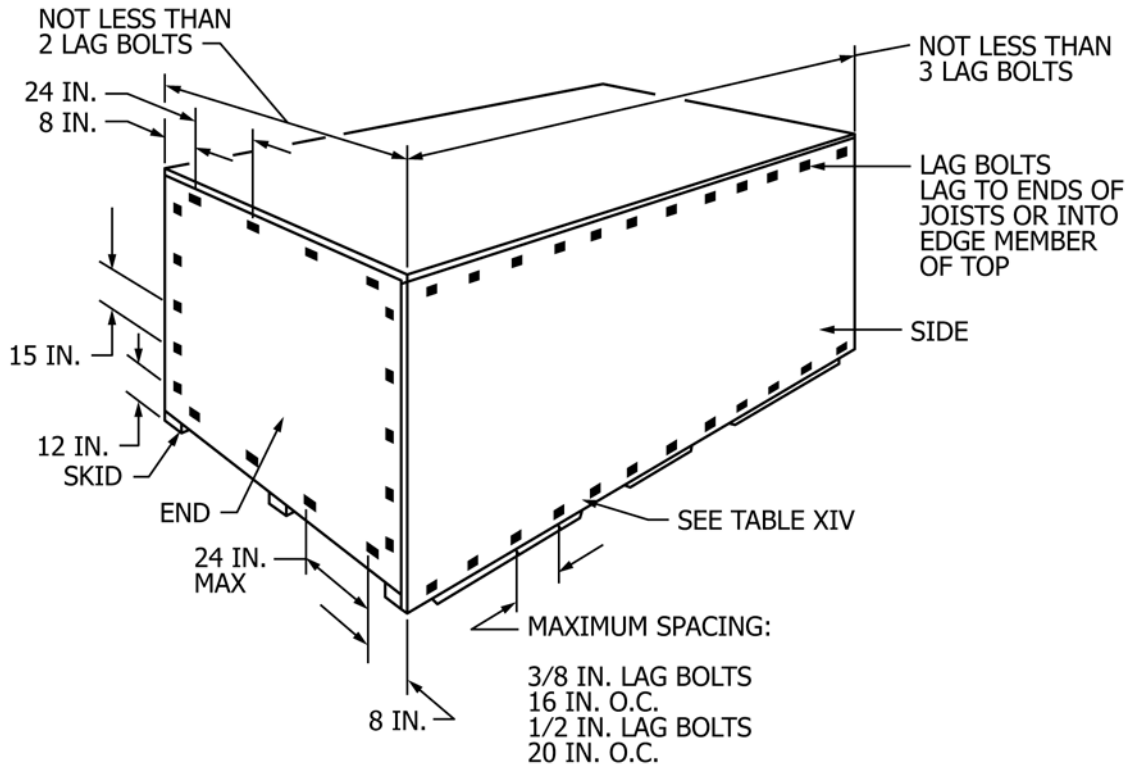
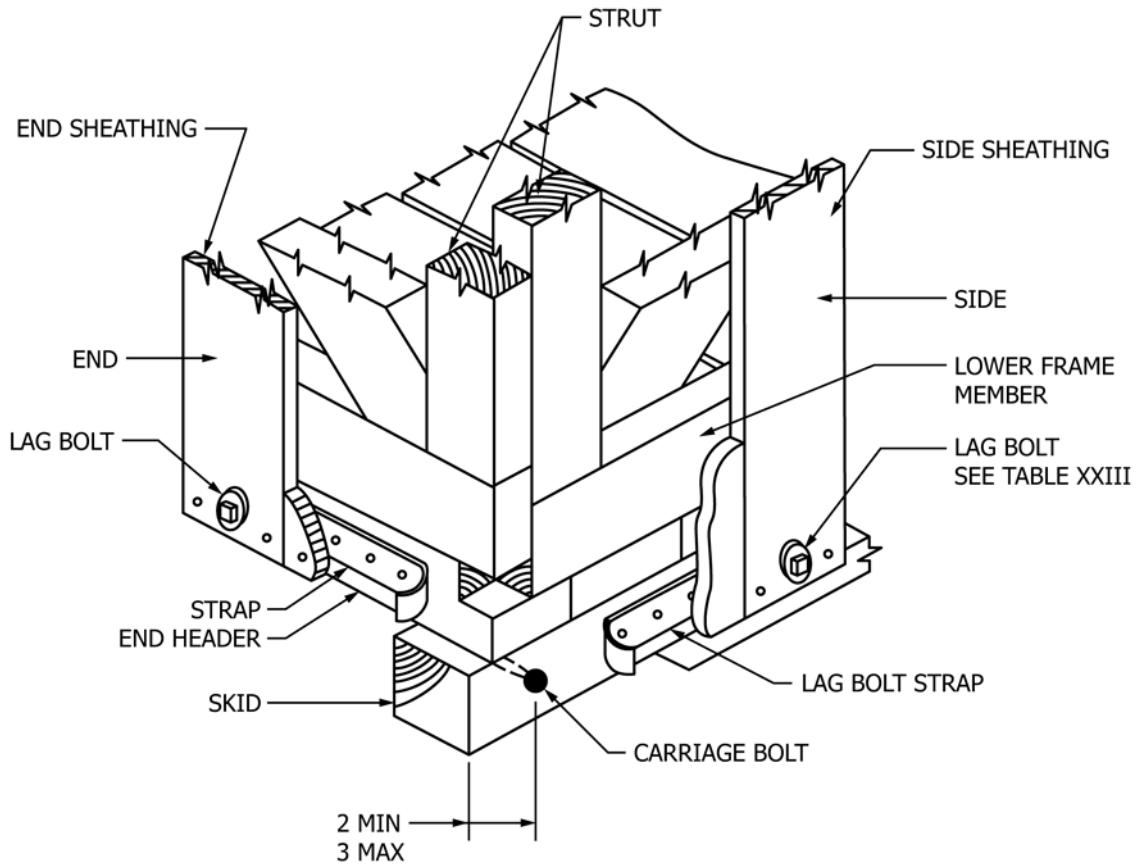


FIG. 24 Assembly of Bolted Crate (Lumber or Plywood Sheathed)



VIEW OF LOWER CORNER

NOTE 1—All dimensions in inches.

FIG. 25 Assembly of Bolted Crate

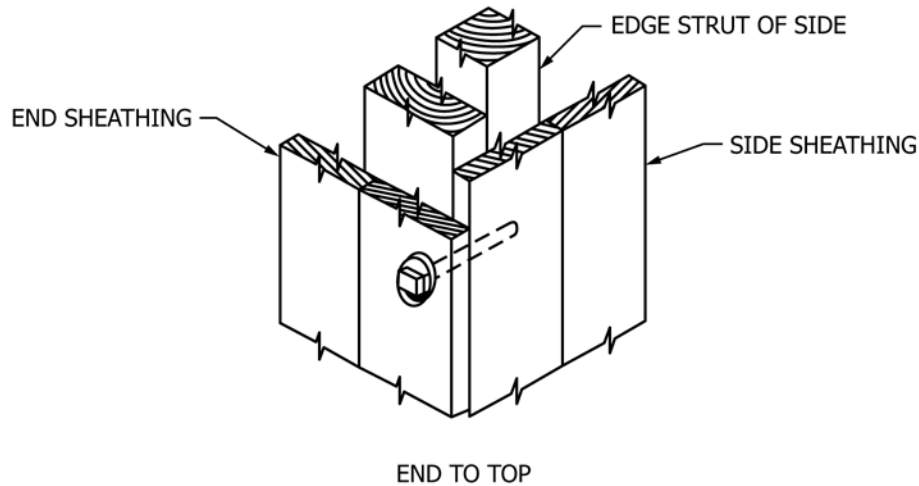
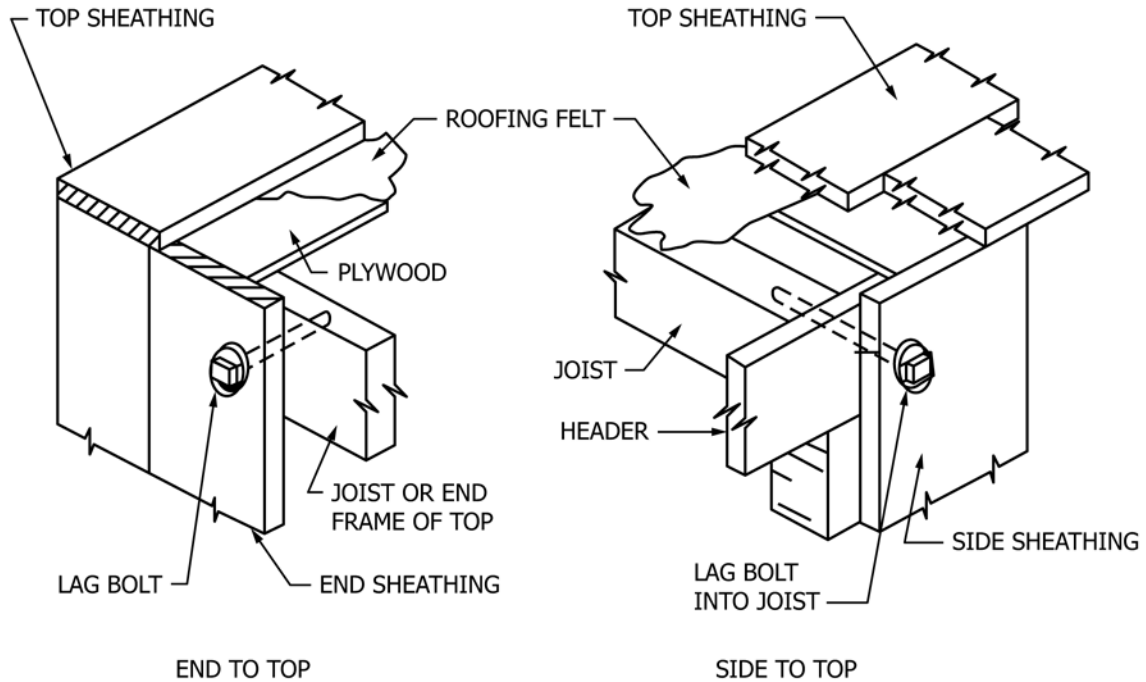


FIG. 26 Assembly of Bolted Crate

TABLE 24 Assembly Nailing of Nailed Crate (see Fig. 27)^A
(MIL-C-104C, Amendment 1)

Part	Fasten To Part	Lumber Sheathing	Nail Size and Spacing		Notes
			Lumber Sheathing	Plywood Sheathing	
Sheathing of side and end	Skid and end header (skid base)	Eight-penny (2½ in. [63 mm]) minimum size	Seven-penny (2¼ in. [57 mm]) minimum size		See nailing Table 25 for number required
	End and side sills (sill base)	3-in. maximum spacing 2 rows up to 4x4 skids 3 rows 4x6 skid (on edge) 3 rows for all sill bases	3-in. maximum spacing 2 rows up to 4x4 skids 3 rows for 4x6 skid (on edge) 3 rows for all sill bases		
	Corner strut of end	Twenty-penny (4 in. [102 mm]) predrill 12-in. spacing	Twelve-penny (3¼ in. [82 mm]) 12-in. spacing		
	Sheathing of side	Eight-penny minimum size 6 to 8-in. spacing	Seven-penny minimum size 6 to 8-in.		

^A For fastening top to sides and ends use strapping as specified in 3.3.5.5 (MIL-C-104C) and shown in Fig. 28.

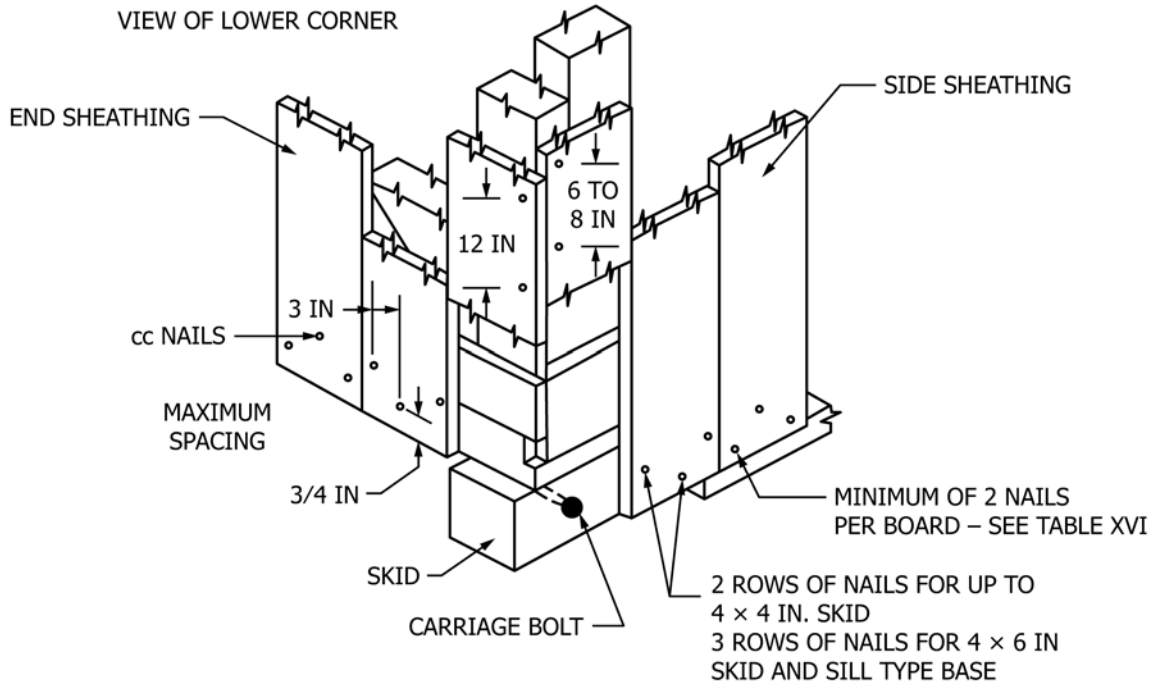
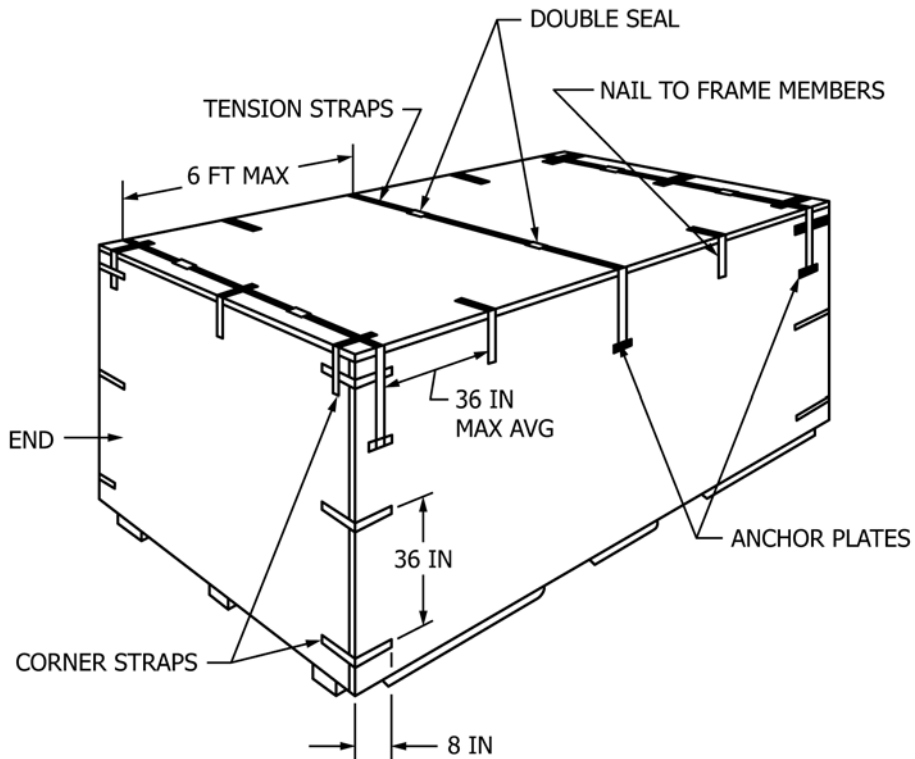


FIG. 27 Assembly of Nailed Crate (Lumber or Plywood Sheathed)



NOTE 1—Strapping required for all nailed crates. For bolted crates with net loads over 3000 lb, use corner straps only.

FIG. 28 Corner and Top Strapping (Lumber or Plywood Sheathed)

TABLE 25 Number of Nails per each 1000 lb gross Load (Nailing Sheathing to Base Around Perimeter of Nailed Crate)^A

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
	10d	15	16	12
	12d	15	16	12

^A Nails shall not be less than 2 per board (lumber sheathing) and shall neither be more than 3 in. apart nor less than 1½ in. apart.

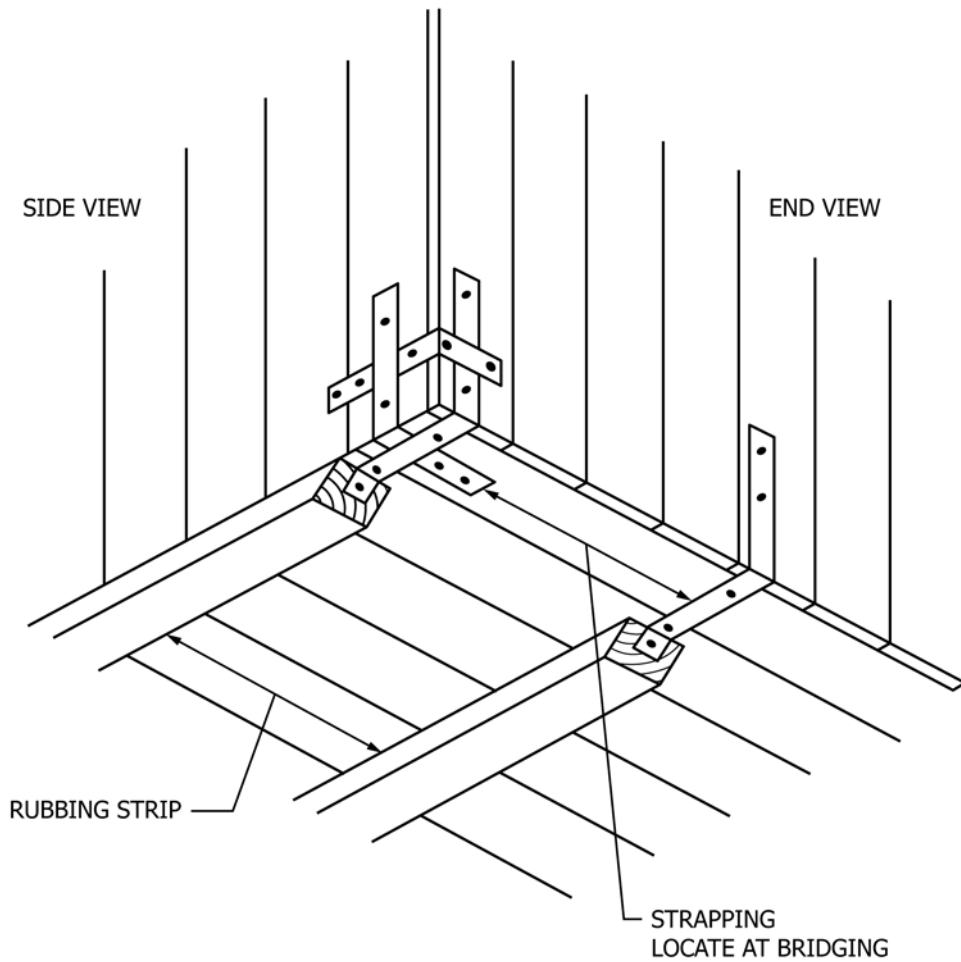


FIG. 29 Sill Base Strapping

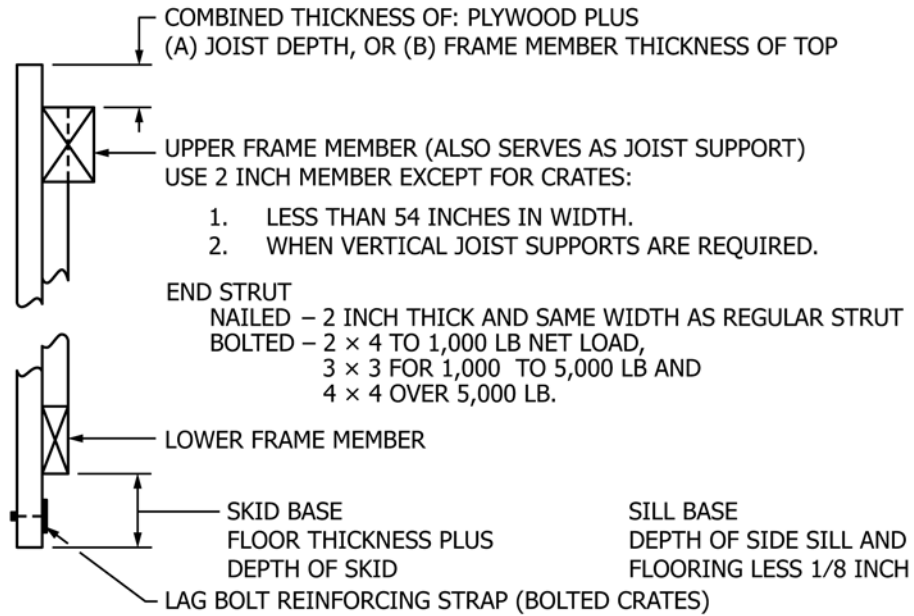
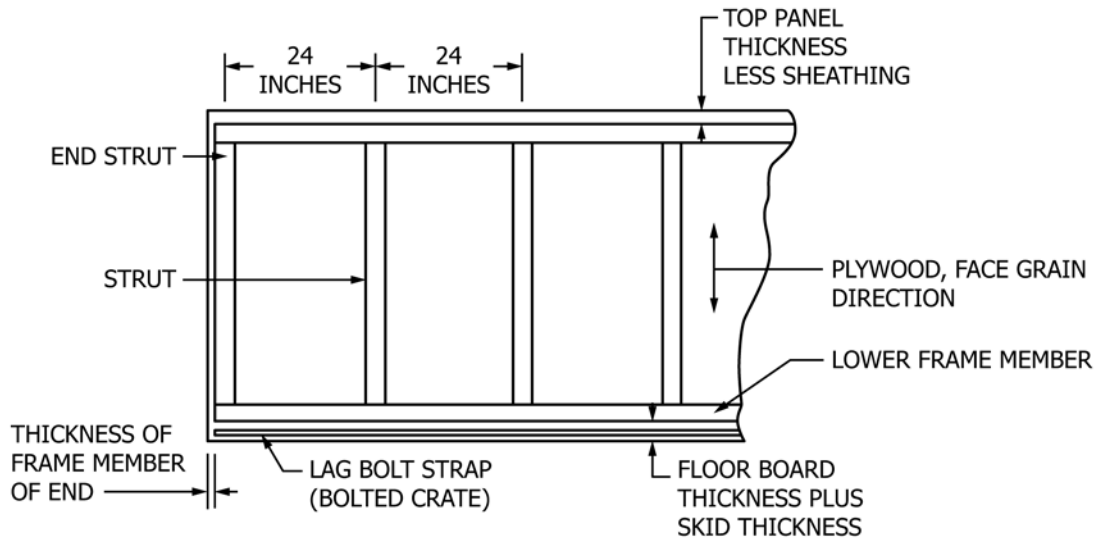


FIG. 30 Sides—Type A Panel (Plywood) (Heights Over 24 in. through 60 in.)

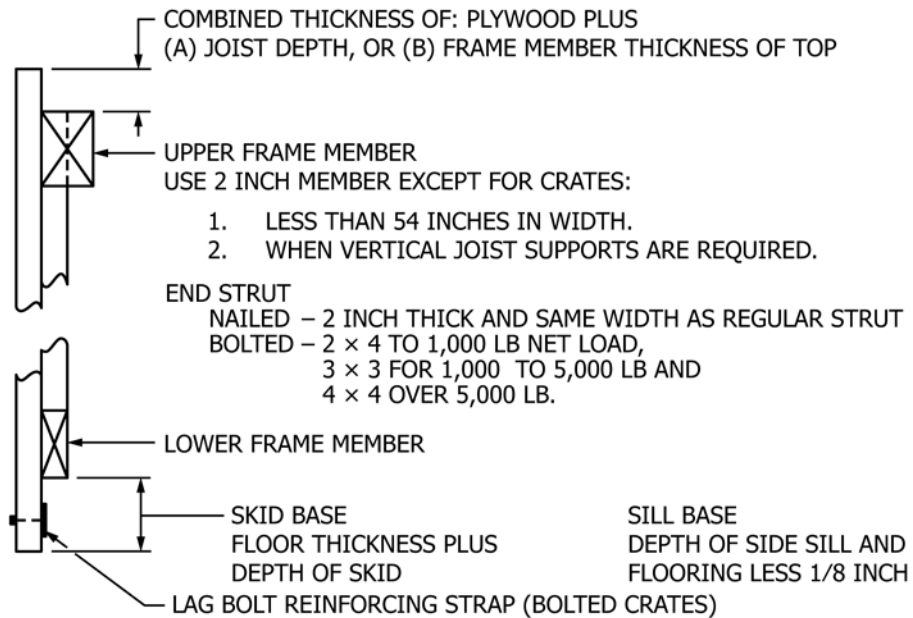
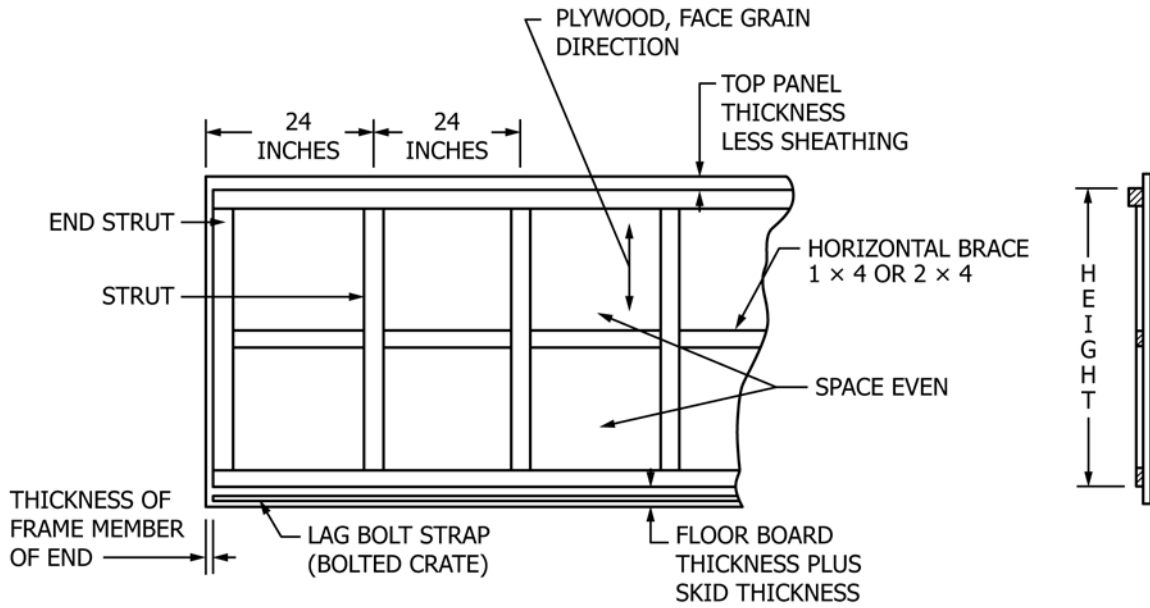


FIG. 31 Sides—Type B Panel (Plywood) (Heights Over 60 in. through 96 in.)

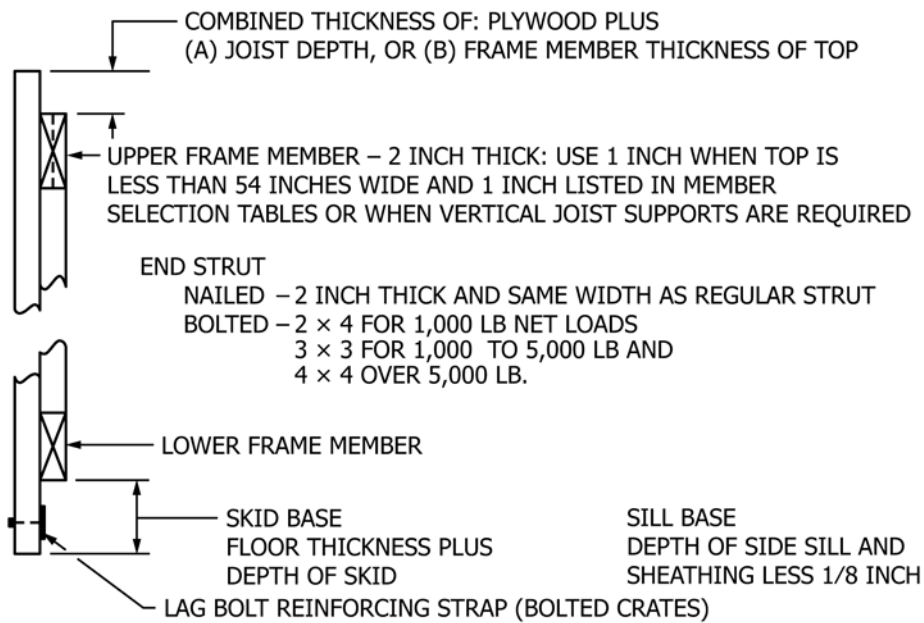
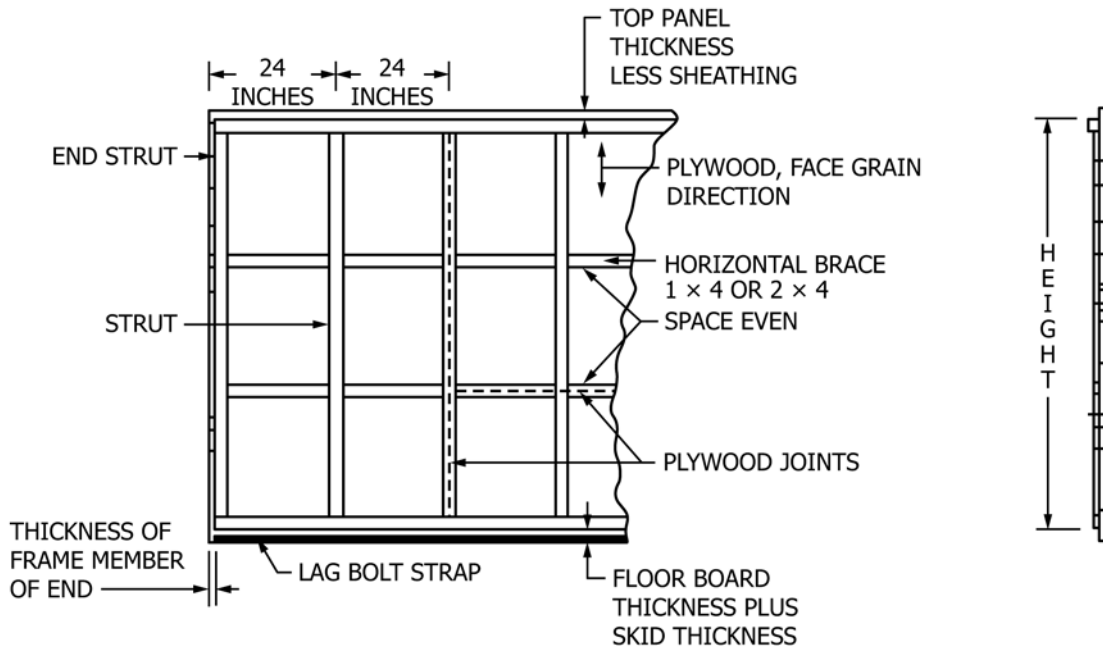
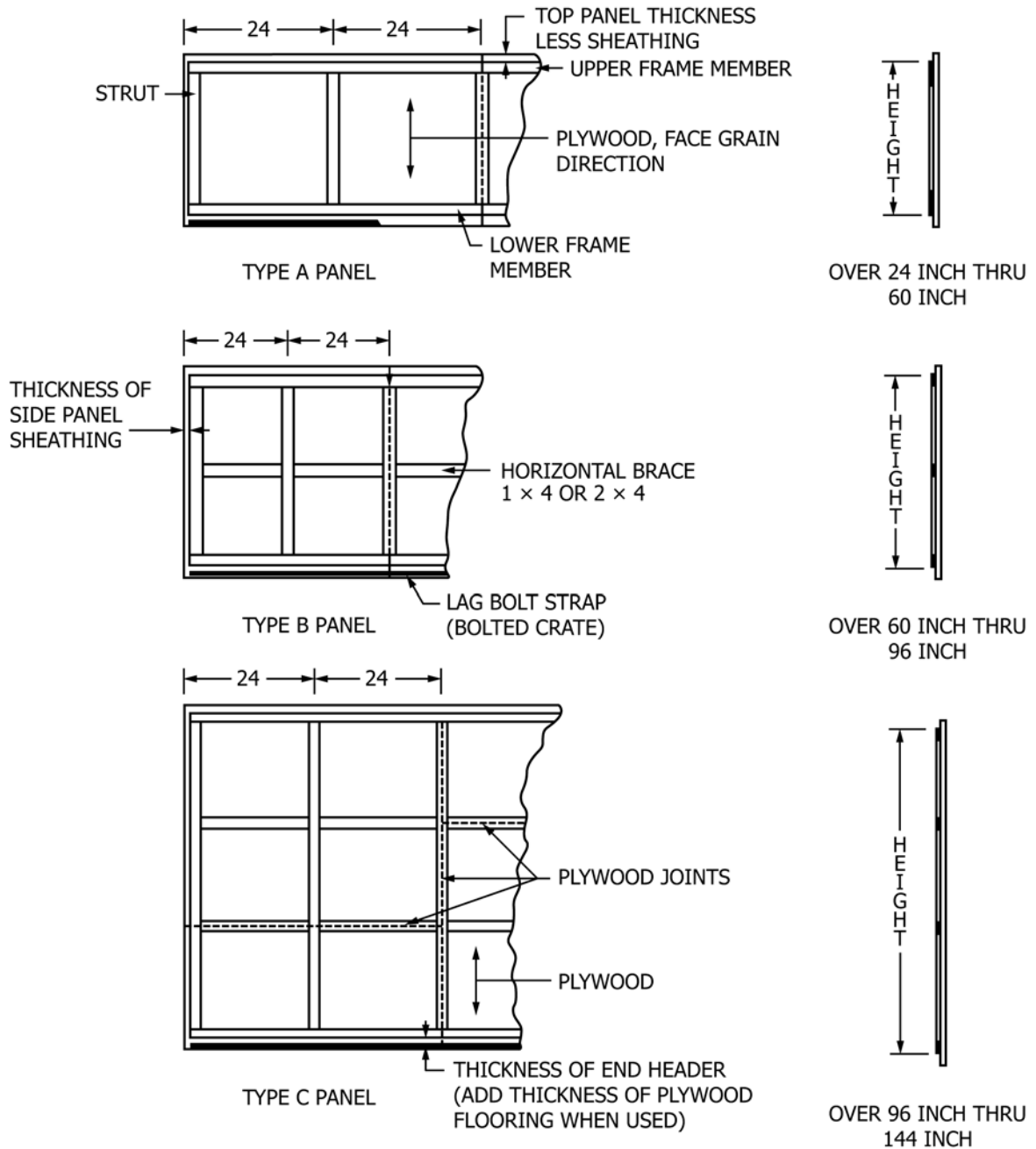


FIG. 32 Sides—Type C Panel (Plywood) (Heights Over 96 in. through 144 in.)



NOTE 1—All dimensions in inches.
FIG. 33 End Panels Plywood Sheathed Crates

SUPPLEMENTARY REQUIREMENTS

S1. Scope

S1.1 These Supplementary Requirements covers the disassembly of items, anchoring and blocking, lifting attachments, and center of balance.

S2. Requirements

S2.1 *Item Disassembly*—Crate design should be based on a careful study of the item(s) to be packed. Such a study should consider the shape, size, weight, strength and degree of fragility of the item(s), the availability of the mounting provisions and the disassembly permissible for shipment. All reasonable disassembly should be performed to effect a saving in crate volume. Unless otherwise specified by the procuring agency, the disassembly shall not be of such extent as to require special personnel or equipment or an unjustifiable amount of time for reassembling.

S2.2 Anchoring and Blocking:

S2.2.1 *General*—Attention shall be given to anchoring the contents within the crate in order that proper container design and construction will not be nullified during shipment and rough handling. Care shall be taken, by padding and cushioning where necessary, to prevent damage to the crate contents at points where blocks, braces, or straps come in contact with part of the crated item.

S2.2.2 *Bolting Down*—When there are holes in the item being crated which can be utilized for anchoring it to the crate base, the item shall be bolted through the skids or chamfered longitudinal sleepers. The skids or chamfered longitudinal sleepers, minimum size 2 × 4 in. [38 × 89 mm] by not less than 3 ft [914 mm] long, shall be added underneath the skid-type base floor so that the tie-down stress will be distributed. When bolting to sill bases, bolts shall not pass through the depth of the sill but through blocks, which shall be securely nailed or bolted to the sill.

S2.2.3 *Hold and Tie-Downs*—When bolt holes in the item being crated are not available, the item shall be anchored to the base by means of either lumber hold-downs, tie-down rods used in combination with hold-downs timbers, tensioned metal strapping, or soft iron straps securely attached to the skids, sills or other frame members. Consideration shall also be given to strapping parts of the item being crated to itself.

S2.2.4 *Strapping, Blocking, and Bracing*—In conjunction with, or in lieu of metal strapping, wood blocks and braces shall be used to prevent load movement within the crate. Sideways movement of top-heavy items shall be prevented either by strapping, blocking, or bracing. Wood blocks and braces shall be securely nailed to floorboards, sills, headers, or other frame members and not directly to sheathing. End grain nailing shall not be used to hold blocks in place.

S2.3 *Lifting Attachments*—Large, heavy crates are often severely damaged by ordinary handling with slings or grab hooks. The use of lifting attachments on crates can eliminate much of the damage. Such attachments are capable of carrying 12 000 lb [5443 kg] each with a factor of safety of about four. Smaller bars may be used for lighter crates but the safety factor of four should be maintained.

S2.4 *Center of Balance*—After crates are assembled and loaded, those over 10 ft [3048 mm] long shall be marked to indicate the center or balance. Marking shall consist of a 1-in. [25-mm] wide vertical stripe on each side extending from the lower panel edge upwards about 12 in. [305 mm]. The stripes may be either red or black and shall have “CENTER OF BALANCE” stenciled or printed in 1-in. [25-mm] high letters adjacent to or above them. The markings should be of waterproof materials and shall be applied to assure easy legibility.

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