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AN AMERICAN NATIONAL STANDARD

ASME MH1b-2000

ADDENDA

to

ASME MH1-1997
PALLETS, SLIP SHEETS, AND OTHER BASES FOR UNIT LOADS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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ASME MH1b-2000

Following approval of each Part by the ASME MH1 Committee and ASME, and after public review, the final part of ASME MH1b-2000 was approved by the American National Standards Institute on January 19, 2000. Revisions to Part 9 were approved by ANSI on June 7, 2000.

Addenda to the 1997 edition of ASME MH1 are issued in the form of replacement pages. Revisions, additions, and deletions are incorporated directly into the affected pages. It is advisable, however, that this page, the Addenda title and copyright pages, and all replaced pages be retained for reference.

SUMMARY OF CHANGES

This is the second Addenda to be published to ASME MH1-1997. A previous addenda was published in 1999.

Replace or insert the pages listed. Changes given below are identified on the pages by a margin note, **(b)**, placed next to the affected area. Previous Addenda changes are identified by **(a)**. The pages not listed are the reverse sides of the listed pages and contain no changes.

Page	*Location*	*Change*
iii, iv	Foreword	Revised
vii	Contents	Revised to reflect Addenda changes
ix	Preface	Updated
34.1–34.6	Part 3	Editorially revised
124, 124.1	Part 8	Editorially revised
147–173	Part 9	Editorially revised
175–189	Part 10	Added

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FOREWORD

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Hundreds of millions of wood pallets were manufactured in the United States of America during each of the past 30 years, considerably more than the 37 million pallets produced during 1953 when the ASME Standards Committee MH1 was established. It is estimated that approximately 20% of the total annual production of lumber in the United States was required for the assembly of these pallets. One pallet size of the approximately 100 sizes used, the 48 × 40 in. and 40 × 48 in. (1219 × 1016 mm and 1016 × 1219 mm) size, accounts for more than one-third of all the pallets produced; while ten additional sizes account for more than 1% of all pallets produced. Pallets made of metal, paper, and plastics are also manufactured in the United States. However, their production is limited and no production statistics are available.

The need for standardization of pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products, originated from the interconnecting nature of pallet usage. The great variety of pallet sizes and constructions restricted their movement through manufacturing and distributing channels. This variety was the result of each user treating pallet design as a private problem. More intense application of the unit-load method of assembling, stacking, storing, handling, and transporting of commodities in the United States and in international trade fostered extensive use of pallets both as captive and exchange pallets. The latter pallets, especially, required maximum standardization for any exchange to be successful.

Some industries and military services developed, by evolution, certain pallet standards to solve specific problems which are also existent with other users. Consequently, their sizes and constructions of pallets established a pattern of value to all users.

The American National Standards Institute (formerly the American Standards Association) project on pallet standardization was initiated in October 1953. A Material Handling Standards Committee, MH1 (initially B69), was organized to coordinate information and prepare standards under the scope of standardization of nomenclature, types, sizes, materials, and components of pallets, including sampling, inspection, and test procedures. The standards pertain to pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products. The standards were to accomplish the following:

(a) define terminology associated with pallets;

(b) apply to pallets irrespective of components used in their fabrication;

(c) provide a series of recommended pallet dimensions;

(d) describe procedures for pallet testing; and

(e) indicate procedures for designating pallet requirements.

During 1967, the MH1 Committee was reorganized. A Nominating Committee was established in compliance with the procedures of ANSI. The Nominating Committee selected officers for the MH1 Committee during 1968 and, in turn, became the nucleus for the new MH1 Executive Committee to guide the continuing revision activities and organize the task groups to be formed.

The name of the MH1 Committee was changed in 1979 to Standardization of Pallets, Slip Sheets, and Other Bases for Unit Loads by action of ANSI's Physical Distribution Standards Management Board in light of the establishment of the MH1 Subcommittee on

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Standardization of Slip Sheets in March 1979. The following scope of the Committee was established: standardization of nomenclature, types, sizes, materials, and components of pallets, slip sheets, and other unit load bases, including sampling, inspection, and test procedures.

The MH1 Committee, consisting of individual members and representatives of trade associations, engineering societies, and government agencies, organized a Technical Committee to perform its work. During July 1981, this Technical Committee was reorganized as an ASME Standards Committee operating under the ANSI accredited organization procedures.

The following MH1 Committee standards were issued:

MH1.1.2	Definitions and Terminology Covering Pallets and Related Structures
MH1.2.2M	Pallet Sizes
MH1.4.1M	Procedures for Testing Pallets
MH1.5M	Slip Sheets
MH1.6	Standard Procedures for Determination of Durability of Wooden Pallets and Related Structures
MH1.7M	Driven Fasteners for Assembly of Pallets and Related Structures
MH1.8M	Wood Pallets
MH1.9	Export Pallets

The MH1 Committee has published the above eight separate standards which are being consolidated into a single publication, MH1 Pallets, Slip Sheets, and Other Bases for Unit Loads. This 1997 Edition contains the consolidation of the revised MH1.1.2, MH1.4M (formerly MH1.4.1M), MH1.6, and MH1.7M standards. All of the documents contained in this Edition of the Standard were approved by ANSI as American National Standards on July 16, 1996.

The first addenda to this Edition added the remaining four standards to be consolidated into MH1. Part 2, the revised MH1.2.2, was approved by ANSI on August 6, 1998. Part 3, the revised MH1.8, was approved on August 6, 1998. Part 4, the revised MH1.9, was approved on January 30, 1998. Part 8, the revised MH1.5M, received approval on August 6, 1998. In addition, the military-specific Part 9, entitled "Wood Pallets for U.S. Government Use," was developed by the MH1 Committee in response to the Government's need to use voluntary standards. This final Part was approved by ANSI on February 4, 1999.

The second addenda to this Edition added Part 10 and revisions to Parts 3, 8, and 9. Part 10 was approved by ANSI on January 19, 2000. Revisions to Part 9 were approved by ANSI on June 7, 2000.

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PREFACE

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(This Preface is not part of ASME MH1-1997.)

ORGANIZATION OF THIS DOCUMENT

This Standard is arranged in Parts, and these Parts incorporate the requirements of previously published standards identified below:

ASME MH1-1997	Previous Designator	Title
Part 1	ASME MH1.1.2-1996 (Revision of ASME MH1.1.2-1989)	Definitions and Terminology Covering Pallets and Related Structures
Part 2	Revision of ASME MH1.2.2M-1989	Sizes of Wood Pallets
Part 3	Revision of ASME MH1.8M-1996	Wood Pallets
Part 4	Revision of ASME MH1.9-1993	Export Pallets
Part 5	ASME MH1.7M-1996 (Revision of ASME/ANSI MH1.7M-1988)	Driven Fasteners for Assembly of Pallets and Related Structures
Part 6	ASME MH1.6-1996 (Revision of ASME/ANSI MH1.6-1987)	Determination of Durability of Wood Pallets and Related Structures
Part 7	ASME MH1.4M-1996 (Revision of ASME MH1.4.1M-1989)	Testing Procedures for Pallets and Related Structures
Part 8	Revision of ASME MH1.5M-1993	Slip Sheets
Part 9	New	Wood Pallets for Military Use
Part 10	New	Performance Specification for Pallets to be Used in Automated Unit-Load Material Handling Equipment

CORRESPONDENCE

Suggestions for improvement of this Standard are welcome and should be sent to the following address: Secretary of the MH1 Committee, ASME, Three Park Avenue, New York, NY 10016-5990.

ADDENDA SERVICE

This Edition of ASME MH1-1997 includes an automatic addenda subscription service up to the publication of the next edition. The addenda subscription service will include the additional MH1 documents not already contained in the initial publication and approved revisions to the existing Parts.

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PART 3
WOOD PALLETS

Subpart I
Prescriptive Standard

(b) I-1 SCOPE

Part 3 of this Standard applies to all lumber-deck and panel-deck pallets, either new or repaired, as well as the lumber components, panels, and fasteners. Criteria contained in this Standard are applicable only at the completion of manufacture and repair.

This Standard is presented in three parts: Subpart I is the Prescriptive Standard, which concerns the manufacture of the pallet. This Subpart includes pallet and pallet-component descriptions, fastener descriptions, workmanship criteria, dimensional tolerances, markings, and moisture-content levels. Subpart II is the Performance Standard, which concerns the functionality of the pallet. This Subpart contains references to the testing of physical and computer models to assist manufacturers, distributors, and users to determine the performance level of a specified pallet. Use of the Performance Standard is required for new pallet constructions, along with conformance to Subpart I, the Prescriptive Standard. Subpart III covers the Quality Assurance Auditing Program.

This Part does not describe established special requirements for export pallets, Enhanced Wood® pallets, and phytosanitary pallets, and does not address the safety problems, if any, associated with the use of wood pallets. It is the responsibility of the user of this Part to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.

To assist the user of Part 3, other related standards are listed in Appendix A3-D.

In any dispute regarding dimensions of components or defects, the U.S. Customary Units are governing.

Wood pallets are manufactured or repaired for the sole purpose of storing and/or transporting material. Under no circumstances should any person stand, step, or lean upon them or otherwise use them for support, unless they are specifically designed for such usage. The pallet user has the obligation and responsibility to inspect for damage prior to each pallet use and to determine that the pallet design is appropriate for that particular unit load application.

I-2 PURPOSE

The purpose of Part 3 of this Standard is to establish nationally recognized minimum quality requirements for the principal types of wood pallets and to provide a basis for common understanding among manufacturers, repairers, distributors, and users of wood pallets.

I-3 CLASSIFICATIONS

I-3.1 Classes

(a) Class 1. Stringer pallet [see Fig. 1, sketch (a)].
(b) Class 2. Block pallet [see Fig. 1, sketch (b)].

I-3.2 Use Categories

Category 1, Multiple-Use (M): pallet designed for repeated uses for more than one unit load with an average minimum "life-to-first-repair" (LFR) of ten trips, or more, assuming an average of five handlings per trip and an average handling environment as defined in the Pallet Design System (PDS) (see Part 3, para. II-3.2); also known as a returnable pallet, reusable pallet, permanent pallet, general-purpose pallet, special-purpose pallet, special-service pallet, or through-transit pallet.

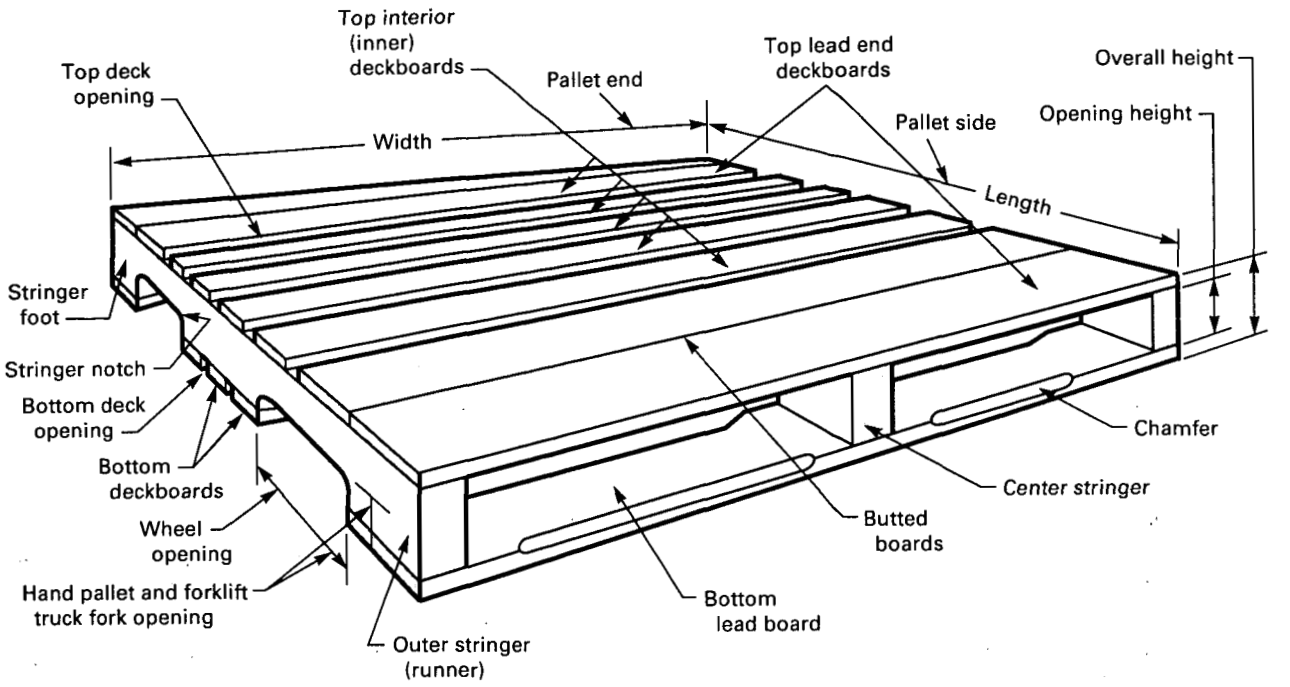
Category 2, Limited-Use (L): pallet designed for an average of up to nine trips, with an average of five handlings per trip and an average handling environment as defined in the Pallet Design System (PDS), before first repair, i.e., life-to-first-repair (LFR) (see Part 3, paras. I-4, I-9, and II-3.2); also known as a single-trip pallet, one-trip pallet, one-way pallet, expendable pallet, shipping pallet, or general-service pallet.

I-3.3 Types

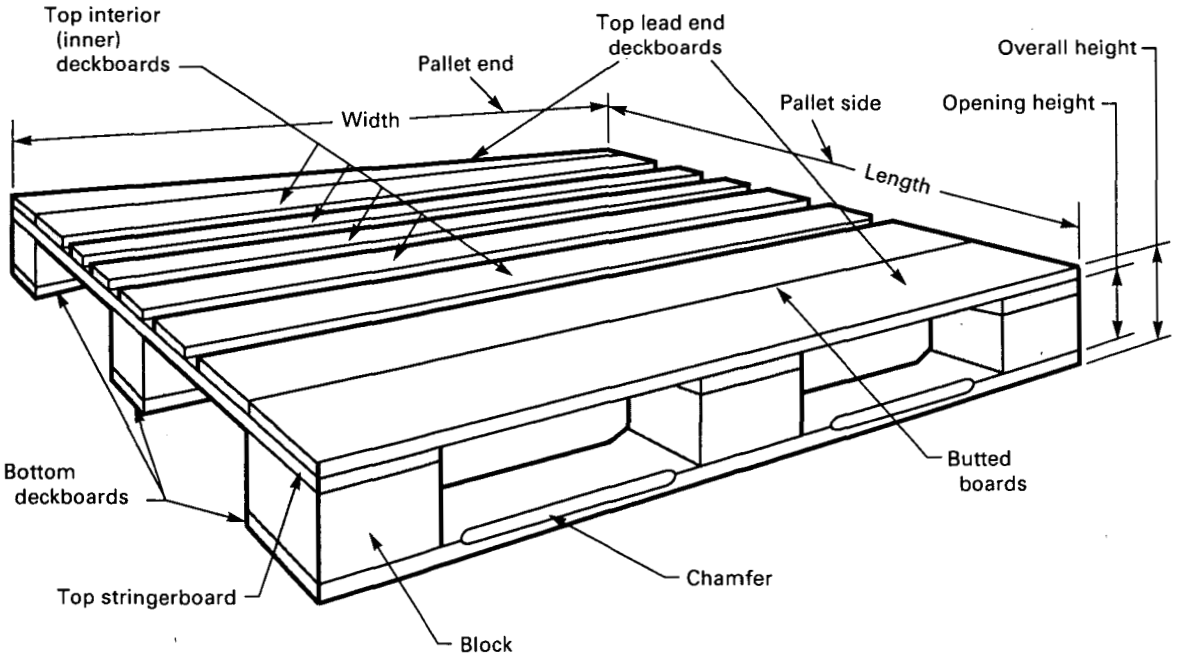
Type 1: two-way entry pallet with openings accepting handling equipment only in two pallet ends, i.e., unnotched stringer pallet.

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(a)



(b)

FIG. 1 SCHEMATIC DIAGRAMS OF TYPICAL STRINGER (U.S. GOVERNMENT CLASS 1, TYPE 2, STYLE 2) [SKETCH (a)] AND BLOCK (U.S. GOVERNMENT CLASS 2, TYPE 3, STYLE 2) [SKETCH (b)] CLASS PALLETS, WITH PRINCIPAL PARTS LABELED

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Type 2: partial four-way entry pallet with openings at both ends and sides with limited accessibility of the openings to common handling equipment, i.e., notched stringer pallet and block pallet with overlapping bottom stringerboards and bottom deckboards or panels.

Type 3: full four-way entry pallet with openings at both ends and sides with accessibility of all openings not limited to standard handling equipment, i.e., block pallets with perimeter boards, unidirectional, without bottom deckboards, or panel bottom decks with cutouts.

I-3.4 Styles

All decks with spaced or butted boards and/or butted end boards or panels.

Style 1 Single-deck (face), flush, nonreversible pallet.
Style 2 Double-deck (face), flush, nonreversible pallet.
Style 3 Double-deck (face), flush, reversible pallet.
Style 4 Single-deck (face), single-wing, nonreversible pallet.
Style 5 Double-deck (face), single-wing, nonreversible pallet.
Style 6 Double-deck (face), double-wing, nonreversible pallet.
Style 7 Double-deck (face), double-wing, reversible pallet.
Style 8[1] Single-deck (face), single-cantilever top and bottom stringerboards, flush, nonreversible pallet.
Style 9[1] Single-deck (face), single-cantilever, single-wing, nonreversible pallet.
Style 10[1] Double-deck (face), single-cantilever, flush, nonreversible pallet.
Style 11[1] Double-deck (face), single-cantilever, single-wing, nonreversible pallet.
Style 12[1] Double-deck (face), single-cantilever, double-wing, nonreversible pallet.
Style 13[1] Double-deck (face), double-cantilever, single-wing, nonreversible pallet.
Style 14[1] Double-deck (face), double-cantilever, double-wing, nonreversible pallet.
Style 15[1] Double-deck (face), double-cantilever, double-wing, reversible pallet.

I-3.5 Bottom-Deck Constructions

Bottom Deck 1: unidirectional bottom deckboards oriented in the direction of the pallet length or width only.

[1] Styles of block class pallets, in which stringerboard overhangs end blocks.

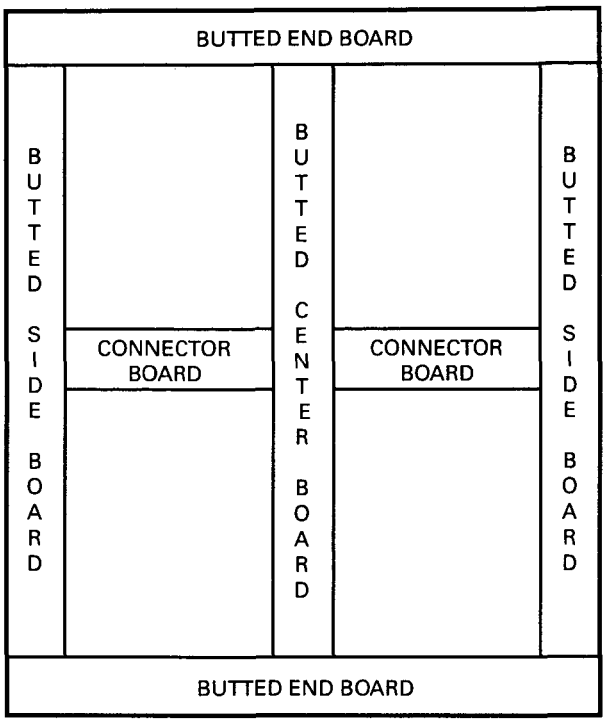


FIG. 2 COMPONENT NAMES FOR PERIMETER AND CRUCIFORM BOTTOM-DECK CONSTRUCTIONS, WITH BOTTOM-DECK COMPONENTS LOCATED IN ONE PLANE

Bottom Deck 2: overlapping bottom boards oriented in both directions of the length and width of the pallet containing both bottom deckboards and bottom stringerboards.

Bottom Deck 3: perimeter bottom deckboards oriented in both directions of the length and width of the pallet, containing butted side and end boards (see Part 3, Fig. 2).

Bottom Deck 4: cruciform bottom deckboards oriented in both directions of the length and width of the pallet, containing butted boards, end boards, and connector boards (see Part 3, Fig. 2) or panels with cutouts (see Part 3, Fig. 3).

I-3.6 Sizes and Designs

Each of the classified pallets is available in many sizes and designs. Therefore, size and design details need to be specified.

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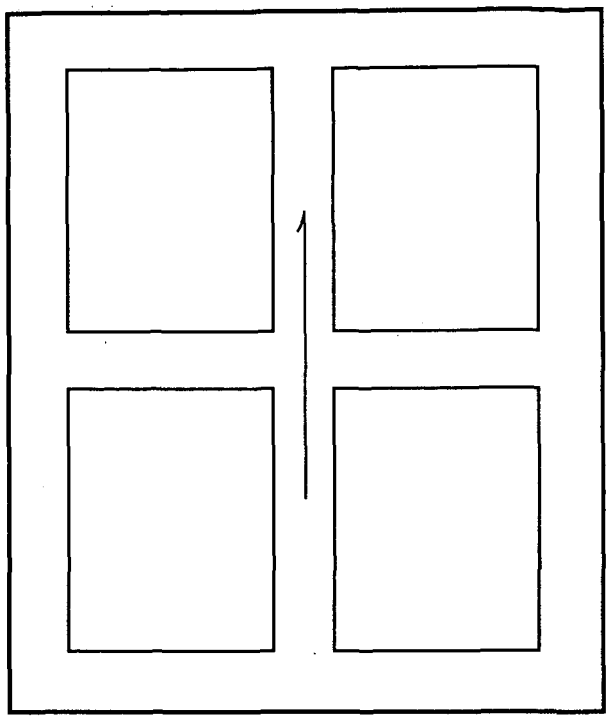


FIG. 3 PANEL BOTTOM DECK SHOWING CUTOUTS

I-4 DEFINITIONS AND TERMINOLOGY

Definitions and terminology that are included in Part 1 of this Standard apply to Part 3.

For definitions covering defects which affect the quality of pallet components, see Appendix A3-B.

Notch Area: a region around stringer notches with special defect limitations (see Part 3, Fig. 4).

Pallet Design System (PDS): for wood pallets, reliability-based computer-assisted design (CAD) procedure for determination of safe load-carrying capacity, performance, and economic life of wood and wood-based stringer and block pallets (see Part 3, para. II-3.2).

pallet length: dimension between the extreme pallet ends, parallel to and corresponding to the length of the stringers or top stringerboards; for panel deck block pallets, it is the top deck panel dimension parallel to the strong panel axis (face grain for plywood); refers to first dimension when describing pallet size.

pallet size: overall dimension of pallet, stated in terms of length, followed by width and height.

pallet width: pallet dimension between extreme pallet sides, parallel to and corresponding to the length of top deckboards; for panel deck block pallets, it is the top panel deck dimension perpendicular to the strong panel axis (face grain for plywood); refers to second dimension when describing pallet size.)

panel: a structural panel, either plywood or oriented strand board (OSB).

shiner: fastener shank or leg protruding from side of fastening member.

stringer: continuous, longitudinal, solid, built-up, or notched beam component of pallet, supporting and spacing deck components, often identified by its location as outer, side, edge, interior, or center stringer, bearer, runner (the preferential terms in some British Commonwealth countries).

stringerboard: continuous, solid, board member extending for full length of pallet, perpendicular to deckboard members and placed between deckboards and blocks, to serve as support of deckboards or deck.

stringerboard size: stated in terms of thickness, followed by width and length.

stringer size: stated in terms of width, followed by height and length.

I-5 MATERIALS

The materials used for pallet manufacture shall be in conformance with the requirements outlined in Subpart III, para. III-1.2.

I-5.1 Lumber Components

I-5.1.1 Species. The species of woods used in pallet manufacture are numerous. As an aid to the pallet designer, Appendix A3-A contains a classification of many commercially available woods listed according to similarities in mechanical properties, regional availability, and commercial use in pallets.[2] When specifying wood pallets, the wood species permissible in the structure can be indicated by the species class numbers given in Appendix A3-A.

[2] Details concerning the development of these wood-species classifications are found in McLeod, J.A., 1985, "Development of Flexural Values for Pallet Shock," M.S. Thesis, Department of Wood Science and Forest Products, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0503.

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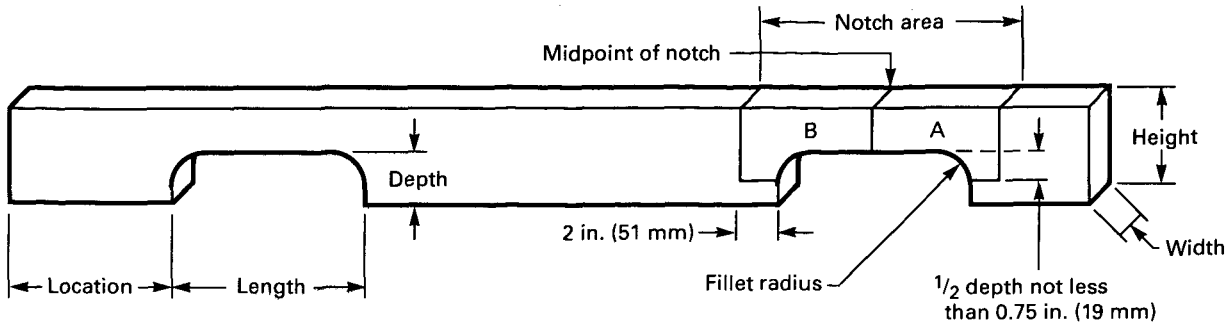


FIG. 4 SCHEMATIC DIAGRAM OF A PALLET STRINGER WITH NOTCH FEATURES INDICATED

I-5.1.2 Quality of Wood Pallet Components. Pallet components shall meet or exceed the minimum quality indicated by the growth-related defect limitations contained in Part 3, Table 1 and the manufactured defect limitations specified below. Descriptions and definitions of the defects in Part 3, Table 1 can be found in Appendix A3-B.

step: otherwise called saw (arbor) mismatch; not to exceed $1/32$ in. (0.75 mm) on exposed face of components.

bevel sawing: acceptable if no more damaging than allowable wane of allowable size tolerance for deckboards, stringerboards, stringers, and blocks.

manufactured (unintentional) hole: same as *unsound knot* (see Table 1 and para. I-6.1.2 of Part 3).

saw cuts: same as *unsound knot* (see Table 1 and para. I-6.1.2 of Part 3).

I-5.1.3 Moisture Content of Components. The moisture content of pallet components is not limited.

I-5.1.4 Preparation of Pallet Components

(b) **I-5.1.4.1 Component Dimensions.** Wood components shall have a target thickness and width uniform in dimension and 50% of components shall meet or exceed the target dimension at the time of component manufacture. Based on current Good Manufacturing Practices (GMP), the target thickness of deckboards and stringerboards may deviate $\pm 1/32$ in. (±0.75 mm). The target width and height of stringers and blocks may exceed the specified dimensions by a maximum of $1/8$ in. (3 mm) and $1/4$ in. (6 mm), respectively.

The following are acceptable manufacturing tolerances allowed on established target dimensions:

Deckboards and Stringerboards

Thickness: $\pm 1/16$ in. (±1.5 mm) maximum deviation [including target deviation of $\pm 1/32$ in. (±0.75 mm)]

Width: + narrower than 8 in. (205 mm), $-1/4$ in. (−6 mm) maximum deviation

Length: $+1/8$ in. (+3 mm), $-1/4$ in. (−6 mm) maximum deviation

Stringers and Blocks

Width: $\pm 1/16$ in. (±1.5 mm) maximum deviation

Height: $\pm 1/16$ in. (±1.5 mm) maximum deviation

Length: $+1/8$ in. (+3 mm), $-1/4$ in. (−6 mm) maximum deviation

Conformance to these manufacturing tolerances for components and pallets can be expressed using standard statistics reflecting variations equal to or less than those permitted in this Standard. Two standard deviations from target size shall be less than the tolerances specified.

I-5.1.4.2 Deckboard Chamfer. The deckboard chamfers, if specified, shall be located on both outside faces of bottom end boards and all interior edges of bottom boards adjoining wheel openings. The chamfers shall be at least 12 in. (305 mm) long and at an angle between 35 deg to 45 deg located $1/4$ in. (6 mm), $\pm 1/8$ in. (±3 mm) from the bottom of the board. Chamfers shall not extend into connections.

I-5.1.4.3 Stringer Notches. Notches in stringers, if required, shall be specified by location (distance from stringer end), depth, and length (see Part 3, Fig. 4). The recommended opening sizes to be provided by the notch and the bottom deck, if present, are 2 in.

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TABLE 1 MINIMUM PALLET COMPONENT QUALITY

Defect	Description	Defect Limitations	
		Multiple-Use (M) [Note (1)]	Limited-Use (L) [Notes (2) and (3)]
Sound knots [Note (4)]	Maximum portion of the cross-section affected	1/2	7/8
Frequency of knots	Number of maximum size knots per component	2 in 6 in. (153 mm) of length	1 in every 1/2 length of component
Unsound knots and holes [Note (5)]	Maximum portion of the cross-section affected [Note (6)]	1/4	2/3
Wane	Maximum portion of the actual deckboard or stringerboard width by thickness (full length) [Notes (6) and (9)]	1/4 × 2/3 (exposed) [Note (8)] 1/3 × 2/3 (non-exposed) [Note (8)]	3/8 × full thickness (exposed) [Notes (7) and (8)] 1/2 × full thickness (non-exposed) [Notes (7) and (8)]
	Maximum portion of the actual stringer and block width and height (full length) [Notes (6) and (9)]	1/3 × 1/2 [Note (8)]	5/8 × 2/3 [Note (8)]
Decay	Maximum portion of the cross-section affected [Note (10)]	1/4	1/4
Splits/shakes [Note (11)]	Maximum portion of deckboards, stringerboards, stringers, and blocks length (L) or width (W)	Deckboards 1/3 L Stringerboards 1/3 L Stringers [Note (12)] Horizontal—less than 2 in. (51 mm) or 2 × W Vertical—same Block 1/2 L	Full length Less than full length Less than 4 in. or 2 × W 1/2 L 1/2 L
Slope-of-grain	Maximum deviation along deckboard, stringerboard, or stringer length	1 in. (25 mm) in 4 in. (102 mm) of length	1 in. (25 mm) in 4 in. (102 mm) of length

NOTES:

(1) This minimum quality description corresponds to all PDS Grades except 4, 7, 13, and 15 (see Part 3, para. II-3.2).

(2) This minimum quality description corresponds to all PDS Grades (see Part 3, para. II-3.2).

(3) This quality is limited to use for deckboards and stringerboards 5/8 in. (17 mm) thick, or greater, and stringers or blocks 1 1/4 in. (38 mm) wide, or greater. Limited-Use (L) pallets with deckboards and stringerboards less than 5/8 in. (17 mm) thick or stringers or blocks less than 1 1/4 in. (38 mm) in width shall meet or exceed the Multiple-Use (M) quality level.

(4) Sound knots are limited in any portion of the notch area "B" (see Part 3, Fig. 4) to 1/3 of the net cross-section above the notch, and in any portion of notch area "A" to 1/2 the net cross section above the notch.

(5) Unsound knots (decay within knot) or holes are limited to 1/4 of the net cross-section above the notch in areas "A" and "B" (see Part 3, Fig. 4).

(6) Provided the average width of the wood is not less than 1/4 of the actual width of the component.

(7) Full thickness of wane on non-exposed surfaces is permitted in no more than 2 pieces per pallet.

(8) Fasteners driven through maximum wane or decay shall be compensated (Part 3, para. I-6.1.3).

(9) In the notch area the wane shall be limited to 1/3 of the stringer width and 1/3 of the height above the notch. No wane shall be permitted in or below the notch fillets within the notch area (see Part 3, Fig. 4).

(10) No decay (outside of unsound knot) is allowed over or within 2 in. (51 mm) of the ends of the stringer notches.

(11) See definition of splits in Appendix A3-B.

(12) Not allowed in the notch area (see Part 3, Fig. 4).

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platens: two or more component assemblies with open space between them, comprising a load plate.

side shift load plate: a load plate which moves independently of the pusher rack, with or without its unit load, in a lateral direction to the longitudinal axis of the lift truck.

slotted load plate: a load plate consisting of two or more platens in the same horizontal plane, spaced apart to allow a void between the platens. This load plate allows insertion of the platens into pallet openings and handling of compatible pallet sizes.

pusher rack: a vertical mechanical assembly of the push pull, moveable forward and backward, providing the means and force to discharge or retrieve a slip sheet unit load. The rack can be extended beyond the tip of the load plate or fully retracted.

faceplate: term for *pusher rack.*

multi-stop pusher rack: a pusher rack with one or more retracting stop positions, between fully extended and retracted positions, to accommodate different lengths of slip sheet unit loads.

4.3 Slip Sheet Dispenser

slip sheet dispenser: a powered mechanical device, holding multiple slip sheets, which automatically discharges one sheet at a time to form the base to accommodate a unit load of goods or products. The dispenser is normally used in conjunction with an automatic or semi-automatic product unitizer.

4.4 Slip Sheet Caliper

slip sheet caliper: the measured thickness of slip sheet material. Caliper is frequently expressed as a decimal.

4.5 Slip Sheet Tensile Strength

slip sheet tensile strength: the resistance to tearing of a slip sheet subject to an applied pulling force.

5 MATERIALS

5.1 Typical Materials

Typical materials used for the manufacture of slip sheets are those described below.

5.1.1 Corrugated Fiberboard. Corrugated fiberboard is a board with paperboard facings bonded to a fluted or corrugated medium providing adequate tensile strength. The board is often referred to in terms of flute size and board test or basis weight and tensile strength. For slip sheet applications, corrugated fiberboard shall be specified using tensile strength (see Part 8, para. 7). To obtain adequate performance where high moisture conditions exist, the flutes and paperboard facings, impregnated or coated with a water-repellent material, shall be bonded to each other using a weather-resistant (see ASTM D 4727-1996) adhesive. If additional strength is required, nylon string can be incorporated into the slip sheet during its manufacture, with the nylon string oriented in the pulling direction of the slip sheet.

5.1.2 Solid Fiberboard. Solid fiberboard is defined as plies of paperboard laminated together to provide adequate tensile strength for slip sheet requirements. Caliper is expressed in points, where 1 point = 0.025 mm (0.001 in.). To obtain adequate performance where high moisture conditions exist, the plies of the slip sheet, impregnated or coated with a water-repellent material, shall be bonded to each other using a moisture-resistant adhesive.

5.1.3 Plastics. Plastics are any kind or combination of polymerized materials in sheet form, including but not limited to polyethylene or polypropylene, that provides adequate tensile strength and other requirements of the slip sheet. Caliper is expressed in mils, where 1 mil = 0.025 mm (0.001 in.).

5.2 Other Materials

Such materials as a woven fabric with a laminated tab or paper overlayed veneer, for example, can be used provided tensile strength and caliper requirements are met. Sheet metal shall not be used for slip sheets.

6 DIMENSIONS

6.1 Base Size

The load surface size of a slip sheet, which excludes tab(s), shall approximate the plan view (footprint) dimensions of the unit loads. The longer of the two dimensions shall be the length and the shorter of the two dimensions, excluding tab(s), shall be the width. The length shall at least equal the unit load length dimension and may exceed the load length by a maximum of 50 mm (2 in.). The width shall not be more than 50 mm (2 in.) smaller than the load width nor more than 25 mm (1 in.) greater than the load width.

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6.2 Unit Load Size

Reference is made to ISO 6780, ISO 3676, and Part 2 of ASME MH1 for guidance in selecting the appropriate load surface dimensions.

6.3 Tab Width

The width of the tabs shall be a minimum of 75 mm (3 in.) and a maximum of 105 mm ($4^1/_8$ in. or 4.125 in.). A shorter width makes the sheet difficult for the operator to see and grab.

6.4 Overall Size

The combination of the base and tab dimensions determines the full slip sheet size.

6.5 Tolerances

The overall size of the slip sheet shall be within ±7 mm ($\pm^9/_{32}$ in. or 0.2503 in.) of the dimensions specified by the user.

6.6 Slip Sheet Thickness

The minimum caliper of the three common materials used for slip sheets shall be as follows.

6.6.1 Corrugated Fiberboard. 3.0 mm (0.118 in.); more for double-wall and triple-wall corrugated fiberboard

6.6.2 Solid Fiberboard. 1.0 mm (0.039 in.)

6.6.3 Plastics. 1.0 mm (0.039 in.)

7 PERFORMANCE REQUIREMENTS

7.1 Tensile Strength

Tensile strength is the maximum pulling strength developed prior to failure of the slip sheet. For a particular unit load, the slip sheet shall possess sufficient tensile strength to avoid rupture when the tab is properly pulled by the gripper jaw and the unit load is in place.

7.1.1 Tensile Strength Guidelines. Tensile strength cannot be considered a performance determinant by itself. Other factors such as scoring, stiffness, moisture, and sheet construction interrelate and affect slip sheet performance. In general, higher tensile strengths are required for heavier unit loads or loads subjected to repeated handling by push pull equipment.

TABLE 1 RANGE OF TENSILE STRENGTH VALUES

	Grain Direction of Paperboard	
Type of Paperboard	Machine	Cross
Corrugated fiberboard	40–65 kN/m (230–370 lbf/in.)	25–40 kN/m (140–230 lbf/in.)
Solid fiberboard	45–95 kN/m (260–540 lbf/in.)	20–40 kN/m (115–230 lbf/in.)

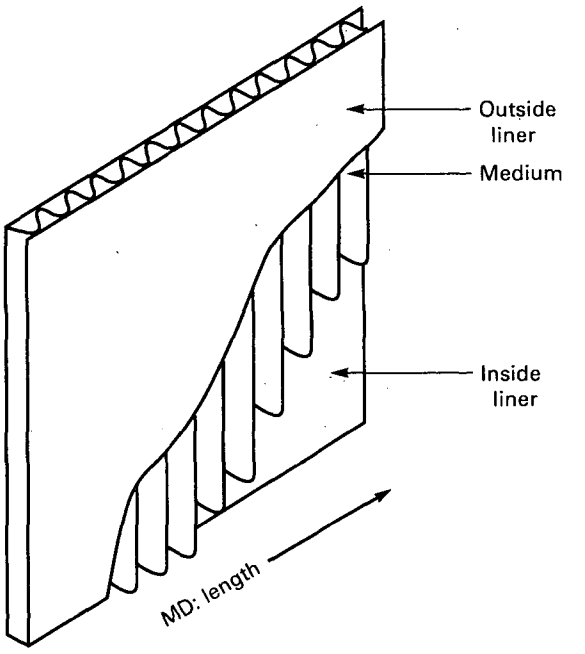


FIG. 9 CORRUGATED MACHINE DIRECTION (MD)

7.1.2 Tensile Strength Values. Depending on the type of paperboard used, the tensile strength values shall range as shown in Part 8, Table 1, when tested according to the constant rate of elongation method (see TAPPI T 494 and ISO 1924).

7.1.3 Estimating Tensile Strength Requirements for Corrugated Fiberboard Slipsheets. (b) Depending upon the type of unit-load and handling equipment, it is possible to estimate a minimum tensile strength requirement for the machine and cross directions. This estimate is also useful in determining which pull tab should be aligned to the stronger machine direction (Fig. 9).

A minimum tensile strength requirement (T, lbf/in.) for a given slip sheet direction may be estimated from:

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$$T = (W \times \mu \times SF) / L$$

where

L = pull tab length in inches
μ = Coefficient of friction, typically 0.6
SF = safety factor, typically 6.0
W = unit load weight in pounds

This is an estimating procedure. Verification by the testing of prototypes is recommended.

7.2 Stiffness

Adequate stiffness of the slip sheet is required for handling certain products such as bagged goods or irregularly shaped materials to avoid deformation of the tab, which can prevent proper clamping by the gripper jaw. Additional stiffness is normally obtained by increasing the thickness of the slip sheet.

7.3 Markings

No markings are set forth as requirements. Individual manufacturers of slip sheets or the user may designate appropriate markings for their own purposes.

8 TESTING

8.1 Maximum Tensile Strength of Solid Fiberboard

Maximum tensile strength of solid fiberboard is obtained by pulling in the machine direction of the fibers.

8.2 Maximum Tensile Strength of Corrugated Fiberboard

Maximum tensile strength of corrugated fiberboard is obtained by pulling in the machine direction of the paper faces, that is, at a right angle to the direction of the flutes.

8.3 Tensile Strength at Right Angle to the Slip Sheet Score Line

Tensile strength at right angle to the slip sheet score line is obtained after bending the tab along the score line 90 deg in either the up or down direction. The test sample of the material shall include the score line.

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Part 9
Wood Pallets for Military Use

(a)
(b)

[Commercial and Government Entity (CAGE) Code for ASME: 05047]

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PART 9
WOOD PALLETS FOR MILITARY USE

(b)

(b) 1 SCOPE

Part 9 (which identifies ASME MH1-1997, Part 9, Wood Pallets for Military Use) applies to light- and heavy-duty, limited- and multiple-use wood pallets used by the Department of Defense and DOD contractors. Federal agencies and commercial entities may find this Part useful but are not required in any way to use the pallets described herein. These pallets are commonly used by DOD activities for handling, storage, and transportation of general supplies and ammunition in worldwide logistics.

This Part replaces Military Specification MIL-P-15011, Pallets, Material Handling, Wood Post Construction, 4-Way Entry, and Federal Specification NN-P-71, Pallets, Material Handling, Wood Stringer Construction, 2-Way and 4-Way Partial, for public use. Part 9 was developed to cover the basic requirements for pallets previously procured by both specifications. Part 1, Definitions and Terminology Covering Pallets and Related Structures, shall apply to Part 9.

(b) 2 PURPOSE

The purpose of Part 9 is to provide the relevant physical details for construction of military pallets. It provides the minimum standards for construction of lumber-deck stringer and block pallets. This Part defines the size, class, type, style, species class, minimum nails required, preservation, marking, and quality of the assembled pallets.

(b) 3 SIZES

Most of the pallets described in this Part are 40 in. by 48 in. platform size; other platform sizes are used in limited quantities. Part 9, Table 1, Military Pallet Sizes, lists the commonly used sizes.

TABLE 1 MILITARY PALLET SIZES (b)

Size	Length x Width, in.
1	32 x 40
2	40 x 48
3	48 x 48
4	48 x 60
5	44 x 44
6	35 x 45.5
7	42 x 53
8	48 x 40

4 CONSTRUCTION DETAILS

4.1 Wood Components

Wood components for pallet manufacture are to be per Part 3, para. I-5.1, Lumber Components and Table 1, Minimum Pallet Component Quality, except that no decay or bark is allowed due to the anticipated overseas destinations for military shipments.

4.2 Pallet Construction

Part 9, Tables 2 and 3 cover the size and number of deckboards and stringers/blocks required in constructing pallets. The basic pallet class, type, style, wood quality, and other essential pallet design features are explained in Part 3, para. I-3. Part 9, Table 4 lists the pallets commonly used.

5 PRESERVATION (REQUIRED FOR CERTAIN PALLETS LISTED IN TABLE 4)

5.1 Wood Pallet Preservation

When specified in Table 4, the assembled pallets (or unassembled pallet components) shall be preserved and preservative marking applied to one side-center block of the pallet (see Part 9, Figs. 4, 6, or 8). Moisture content of the wood shall not exceed 19% prior to treatment. The wood shall not be cut after treatment.

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(b)

TABLE 2 STRINGER AND BLOCK SIZES

(See ASME MH1-1997, Part 3, Para. I-3 for explanations of Class, Type, Style of Pallets and Part 9, Table 1 for Pallet Size)

				Stringers and Blocks		
Class	Type	Style	Pallet Size	No.	Size, in. [See Note (5)]	Reference
1	1	2	1	3	1.5 × 3.5 × 32	See Notes (1), (2), and (4)
1	1	2	2	3	1.5 × 3.5 × 40	
1	1	2	2	4	1.5 × 3.5 × 40	
1	2	2	2	3	1.5 × 3.5 × 40	See Fig. 1
1	1	2	3	3	1.5 × 3.5 × 48	
1	2	6	3	3	1.5 × 3.5 × 48	
1	1	2	4	5	1.5 × 3.5 × 48	See Note (3)
1	1	2	5	3	1.5 × 3.5 × 44	See Fig. 2
1	1	6	2	3	1.5 × 3.5 × 40	
1	1	6	3	3	1.5 × 3.5 × 48	
1	2	6	1	3	1.5 × 3.5 × 32	
1	2	2	1	3	1.5 × 3.5 × 32	
1	2	6	2	4	1.5 × 3.5 × 40	See Fig. 3
1	2	6	2	3	1.5 × 3.5 × 40	
1	2	2	2	3	1.5 × 3.5 × 40	
2	3	6	2	3	7.25 × 3.63 × 2.75	Center Blocks
...	...	...	2	6	5.50 × 3.63 × 2.75	Side Blocks
2	3	6	6	3	7.25 × 3.63 × 2.75	Center Blocks
...	...	...	6	6	5.50 × 3.63 × 2.75	Side Blocks
2	3	6	7	3	7.25 × 3.63 × 2.75	Center Blocks
...	...	...	7	6	5.50 × 3.63 × 2.75	Side Blocks
1	2	2	8	3	1.50 × 3.50 × 48	

NOTES:

(1) Strapping slots shall be provided in the upper surface of all stringers for all wing (Class 1) pallets (except recycled or reclaimed wood pallets) as shown in Part 9, Figs. 3, 10, 11, and 12. Strapping slots for Class 2 (block) pallets are shown in Part 9, Figs. 4 through 9 and Fig. 17.

(2) See para. I-5.1.4.3 of Part 3, for size of stringer (fork entry) notches on the bottom of stringers. Notch openings shall begin 6 inches from the end of the stringer, except for the Size 1 pallet. Notch openings for the Size 1 pallet will begin 5 inches from the end of the stringer and will be $8\frac{1}{2}$ in. in length.

(3) Stringers shall be equally spaced, unless otherwise noted on drawing(s).

(4) For all untreated pallets, unless otherwise specified, moisture content of all pallet components shall be as listed in the Moisture Content column of Table 4 of Part 9 at the time of shipment. For treated pallets, the moisture content shall not exceed 19% prior to preservative applications.

(5) Deckboards and stringers/blocks of any one pallet shall be uniform in thickness and width. Note that Part 9, Table 2 does not apply to recycled-wood pallets (Part No. MH1/9-144048R as listed in Part 9, Table 4).

5.2 Preservative Materials

Pallet components (or assembled pallets) shall be completely immersed for a minimum of one minute in one of the following listed wood preservative solutions:

(a) copper-8-quinolinolate reduced (diluted) with water down to a solution of 1.8% copper (as a metal) by volume in water. (This compound is also known as oxine copper.)

(b) zinc naphthenate reduced (diluted) with water down to a solution of 3% zinc (as a metal) by volume in water.

(c) copper naphthenate reduced (diluted) with water down to a solution of 2% copper (as a metal) by volume in water.

5.3 Requirements

All interior and exterior surfaces of the assembled pallet are to be completely immersed in the preservative

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TABLE 3 ACTUAL DECKBOARD SIZES, in. (b)

Class	Type	Pallet Size	Top and Bottom Lead End Deckboards (Min. Width) [Notes (1) and (2)]	Deckboard Thickness (min.) [Note (3)]	Deckboards Over Strapping Slots (Min. Width)	Top and Bottom *Interior* Deckboards (Random Width)	*Side* Stringerboard Size	*Center* Stringerboard Size	Deckboard *Spacing* (max.) [Note (6)]
1	1	1	5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	2	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	3	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	4	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	5	3.5	0.75	N/A	See Fig. 2	N/A	N/A	See Fig. 2
1	2	1	5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	2	2	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	2	3	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
2	3	2	5.5	0.75	See Fig. 5	3.5 to 7.5	0.75 × 7.25	0.75 × 3.50	1.5
2	3	6	See Fig. 7	0.75	See Fig. 7	5.5	0.75 × 7.25	0.75 × 3.50	1.5
2	3	7	5.5	0.75	See Fig. 9	3.5 to 7.5	0.75 × 7.25	0.75 × 3.50	1.5
1	2	8	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5

NOTES:

(1) Except for pallet size 4, the upper edges of all bottom deckboards shall be chamfered in accordance with Part 3, para. I-5.1.4, Preparation of Pallet Components. Upper edges of bottom deckboards shall not be chamfered for Part Nos. MH1/9-02SW4048 and MH1/9-14SW4048.

(2) Top and bottom lead deckboards shall be of the same thickness and width except for Size 1 pallets. Bottom lead deckboards, of Size 1 pallets, shall be 5 in. in width. See Part 9, Fig. 10.

(3) Deckboard thickness tolerances shall be +0.125, -0 in. (or +1/8, -0 in.) for the thickness dimensions listed in Table 3, unless otherwise specified in Part 9 figures (drawings). Deckboard thickness is intended to be the "as received (by the Military) thickness."

(4) Unless otherwise specified, *moisture content of all pallets components shall be as listed in the Moisture Content column in* Part 9, Table 4.

(5) See Figs. 1 through 16 of Part 9 for size and location of bottom interior deckboards.

(6) Deckboards shall be equally spaced, unless otherwise noted on drawings(s). Deckboard length shall correspond to the width of the size pallet being fabricated, e.g., a 40 x 48 in. pallet requires 48 in. deckboards.

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TABLE 4 MILITARY PALLETS, BY PART NUMBER (b)

ASME Part No. [See Note (1)]	Class	Type	Style	Size	No. of Stringers	Species Class (Per Part 3) [See Note (3) for equivalents]	Moisture Content of Wood (%, Maximum) [See Note (4)]	Nails Req'd (Note No.)	Preserv. Req'd (Note No.)	Load Rating, lb [Note (2)]
MH1/9-01SW3240	1	2	6	1	3	1, 3, 4, 21	30	(5)	No	1,500
MH1/9-02SW4048	1	2	6	2	3	1, 3, 11, 12, 29	30	(5)	No	1,500
MH1/9-03SW4048	1	2	6	2	4	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-04SF4048	1	1	2	2	3	3, 11, 12	30	(5)	No	3,000
MH1/9-05SW4048	1	2	6	2	3	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-06SW4048	1	2	6	2	4	11, 12, 13	25	(5)	No	3,000
MH1/9-07SW4848	1	1	6	3	3	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-08SF4860	1	1	2	4	5	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-09SF4444	1	1	2	5	3	11, 12, 13	25	(5)	No	3,000
MH1/9-10BW4048	2	3	6	2	0, Note (1)	1, 3, 4, 21	19	(7)	No	4,000
MH1/9-11BW4048P	2	3	6	2	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-12BW3545P	2	3	6	6	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-13BW4253P	2	3	6	7	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-14SW4048R	1	2	6	2	3, Note (9)	1, 3, 11, 12, 29	30 (stringers)	(5), (9)	No	1,500
MH1/9-15SF4840	1	2	2	8	3	1, 3, 4, 21	25	(5)	No	2,500

NOTES:

(1) Part No. Codes: B = block; S = stringer; F = flush; W = wing;
P = preservative used; R = reclaimed- or recycled-wood content

(2) *Load Rating: The loaded pallet weight is limited to a maximum number of pounds as shown in the Load Rating column of Part 9, Table 4.*

(3) Preferred wood species are listed by Species Class. Equivalent wood species, in terms of strength and stiffness, are also allowed except for block pallets used for ammunition loads (Part Nos. MH1/9-11BW4048P, MH1/9-12BW3545P, and MH1/9-13BW4253P).

(4) For all untreated pallets, unless otherwise specified, moisture content of all pallet components, at the time of shipment to the Military, shall be as listed in the Moisture Content column in Part 9, Table 4. For treated pallets (Part Nos. MH1/9-11BW4048P, MH1/9-12BW3545P, and MH1/9-13BW4253P), the moisture content shall not exceed 19% (19% maximum) prior to preservative application (immersion).

(5) Minimum nail requirements (for all stringer pallets) are listed in Part 3, Appendix A3-A, Table A1 for Category M (new, multiple-use) pallets. They are $11\frac{1}{2}$ gauge, 0.112 in. wire diameter, helically threaded nails.

(6) Denotes block pallets which require 9 blocks per pallet.

(7) Hardened nails, fabricated of suitable steel wire, are required for block pallets that are primarily used for ammunition loads. Nails shall be staggered and evenly spaced throughout the joint area per Part 9, Fig. 17. The hardened nails are specified in ASTM F 1667, Table 25, and are designated as Type 1, Style 18 pallet nails:

ASTM F 1667 (Dash No.)	Length (in.)	Diameter (in.)
NL PL-01D	1.500	0.120
NL PL-04D	2.250	0.120
NL PL-10D	3.250	0.135

(8) Preservative treatment of finished, nailed pallets or pallet components (for ammunition pallets) is required for the part numbers listed. See para. 5, Preservation, of Part 9 for requirements and process.

(9) Pallet (Part No. MH1/9-14SW4048R) is constructed of reclaimed- or recycled-wood deckboards, nails, and new stringers (moisture content—30% max.). Interior top- and bottom-deckboards may be of two-piece construction (i.e., two 24 in. deckboards, butted at center stringer). Outside stringers may be fabricated of 1.25- by 3.5- by 40-in. length hardwood or 1.50- by 3.5- by 40-in. length hardwood or softwood. The center stringer is fabricated of 2.25- by 3.5- by 40-in. length wood (Species Class 1, 3, or 11) or 1.50- by 3.5- by 40-in. length wood (Species Class 1, 3, 11, 12, or 29). Chamfers on top of bottom deckboards and strap slots on top of stringers are not required. On all reclaimed-/recycled-wood components, cut-off nails shall be flush with, or below, the surface of the wood. Presence of sharp end(s) of cut-off nails is cause for rejection of the pallet.

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solution. Care shall be exercised to assure complete coverage of all surfaces of the pallets or pallet components. After immersion, pallets shall be air dried for 24 hr (min.) in a well-ventilated area allowing free air circulation around all surfaces of the wood. Accelerated drying in an oven or kiln is permitted, provided that oven or kiln temperatures do not exceed 160°F. The preservative on the pallets shall be thoroughly dried to the touch prior to shipment to the customer.

5.4 Concentration Level

The concentration of the applicable preservatives shall be checked in accordance with the manufacturer's recommendations prior to utilization of the dipping tank and every 8 hr of use thereafter.

5.5 Preservative Treatment Markings

Each pallet shall be marked near the center of the outside stringer, or side-center block, in 1-in. high (min.) letters. The letters "PA" shall be marked on all pallets immersed in copper-8-quinolinolate preservative; the letters "PB" shall be marked on all pallets subjected to zinc naphthenate preservative; and the letters "PC" shall be marked on all pallets immersed in the copper naphthenate preservative.

6 MARKING

(b) 6.1 Marking

All Class 1 (stringer) pallets shall be permanently marked (stenciled or branded) with the prime contractor's Commercial and Government Entity (CAGE) code and the month and year of the contract under which the pallet is procured. All Class 2 (block) pallets shall be permanently marked (stenciled or branded) with the prime contractor's CAGE code, or the manufacturer's marking, and (if a preservative is applied) the preservative identification marking. All marking shall be on the outside of either the stringer or center block and be easily visible. Characters shall be a minimum of 0.75 in. in height.

7 QUALITY ASSURANCE PROVISIONS

7.1 Wood Quality

Materials shall comply with the minimum requirements of multiple use (M) grade in Part 3, para. 1-5, Materials and para. 1-6, Manufacture, and the specific requirements of this Part. Wood shall be free of decay that can be visually detected or detected by normal brashness when picked with a sharp instrument.

7.1.1 Wood shall be free from insects, beetles, powder-post beetles, and any other infestation, which may result in subsequent pallet deterioration, at time of delivery to the Military. **(b)**

7.1.2 Wood components shall be bark-free for all pallets in this Part to insure that the pallet is free from the "oak wilt fungus." Bark shall not appear on any timber (lumber) member of the assembled pallet. **(b)**

7.1.3 Splits (and cracks), for all Class 2 block pallets, that are not longer than the width of the wood member (deckboards and stringerboards) are permitted for ASME Part numbers MH1/9-10BW4048, MH1/9-11BW4048P, MH1/9-12BW3545P, and MH1/9-13BW4253P. Splits (and cracks) for Class 1 (stringer pallets) shall be per this Part 9, para. 7, Quality Assurance Provisions and Part 3, para. I-5, Materials, and para. I-6, Manufacture. **(b)**

7.2 Moisture Content

Unless specified in the contract or order, moisture content of all pallet components or assembled pallets shall be as listed in the Moisture Content of Wood column of Part 9, Table 4 (including pertinent notes) at the time of pallet shipment to the U.S. Military. Note that for two high-demand pallets (Part Nos. MH1/9-02SW4048 and MH1/9-05SW4048) (see Moisture Content column on Table 4), the moisture content shall not exceed 30% at time of pallet shipment.

7.3 Cut-off Nails

On all reclaimed-/recycled-wood components, cut-off nails shall be flush with, or below, the surface of the wood at time of delivery to the Military. Presence of sharp end(s) of cut-off nails is cause for rejection of the pallet.

7.4 Contractor Certification

The contractor shall certify and maintain substantiating evidence that: the product (pallet) meets the requirements of Tables 1, 2, 3, and 4 and all pertinent sections

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Stringer Pallet Construction Details
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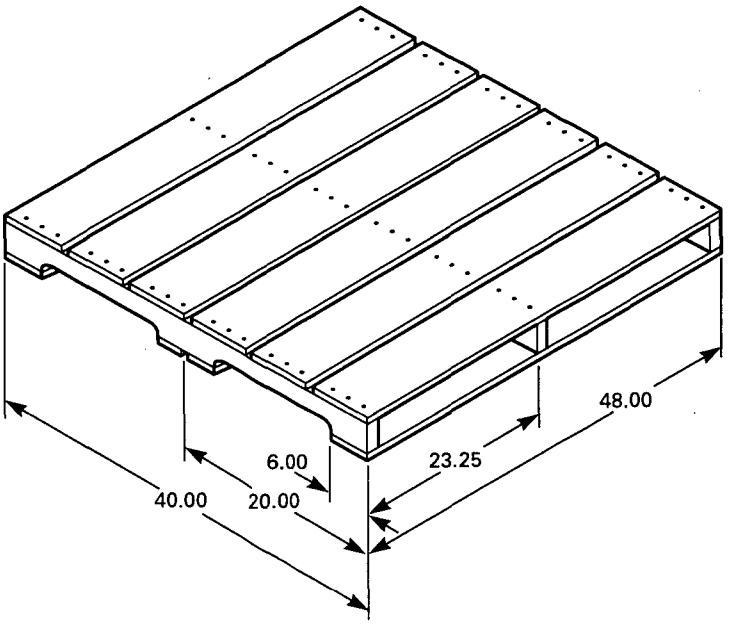


FIG. 1 ISOMETRIC VIEW, PARTIAL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET FOR WAREHOUSE USE (b)

[Shown is a Class 1, Type 2, Style 2, Size 2 (40 × 48 in.), 3-stringer pallet. Two interior bottom deckboards are required of random width (3.50 to 5.00 in.), with a maximum deckboard spacing of 1.5 in. allowed between the two bottom deckboards. All dimensions are in inches.]

of Part 9; the finished pallet conforms to the Military drawings, specifications, workmanship standards; and, the finished pallets meet standard industry quality assurance practices. Pallets with known defects shall not be submitted for Military acceptance. Military procurement reserves the right to perform or witness any of the inspections it deems necessary to insure supplies and services conform to prescribed requirements.

7.5 Precedence (b)

In the event of a conflict between the figure (drawing) of a pallet and the four tables in Part 9, the figure (drawing) shall have precedence over the tables of component specifications or tolerances. This precedence applies to components, construction details, materials, dimensions, and tolerances.

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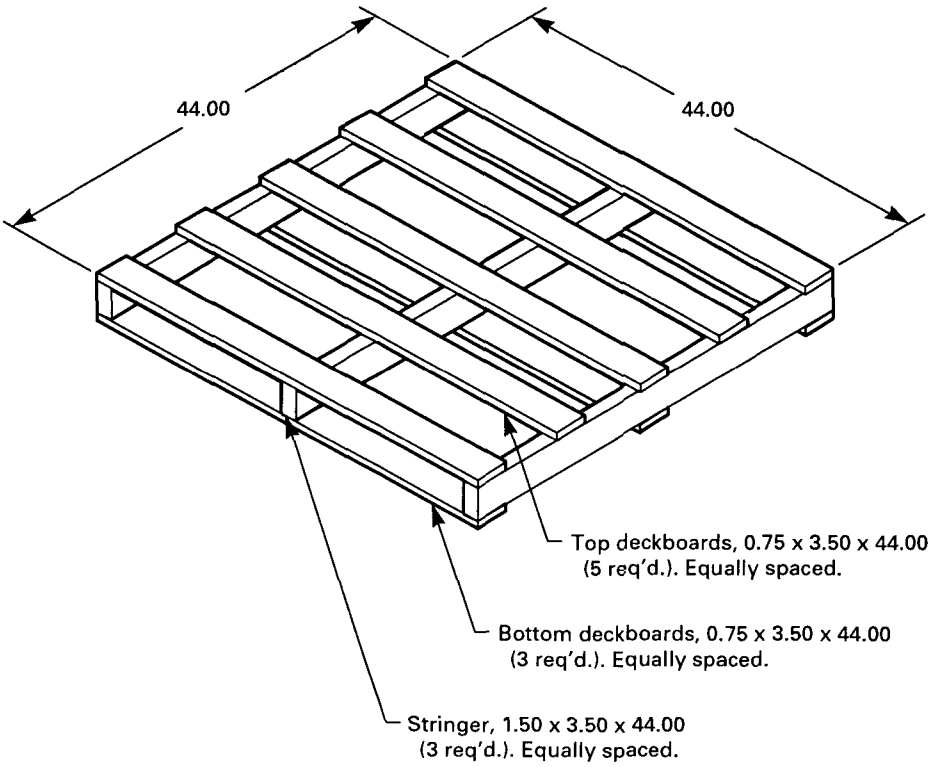
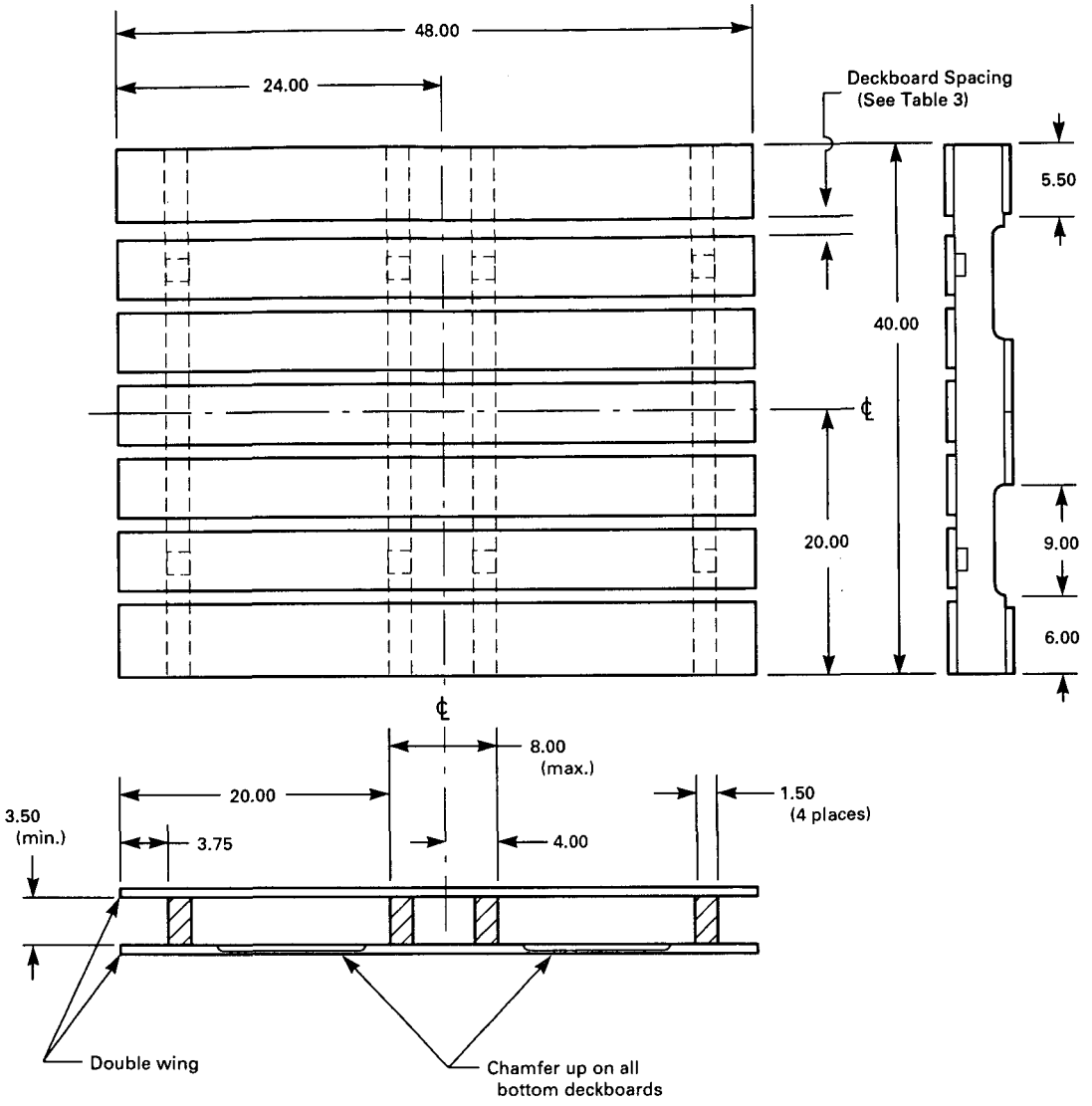


FIG. 2 ISOMETRIC VIEW, 2-WAY ENTRY, SIZE 5, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET

[Shown is a Class 1, Type 1, Style 2, Size 5 (44 x 44 in.), 3-stringer pallet. All dimensions are in inches.]

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Stringer Pallet Construction Details
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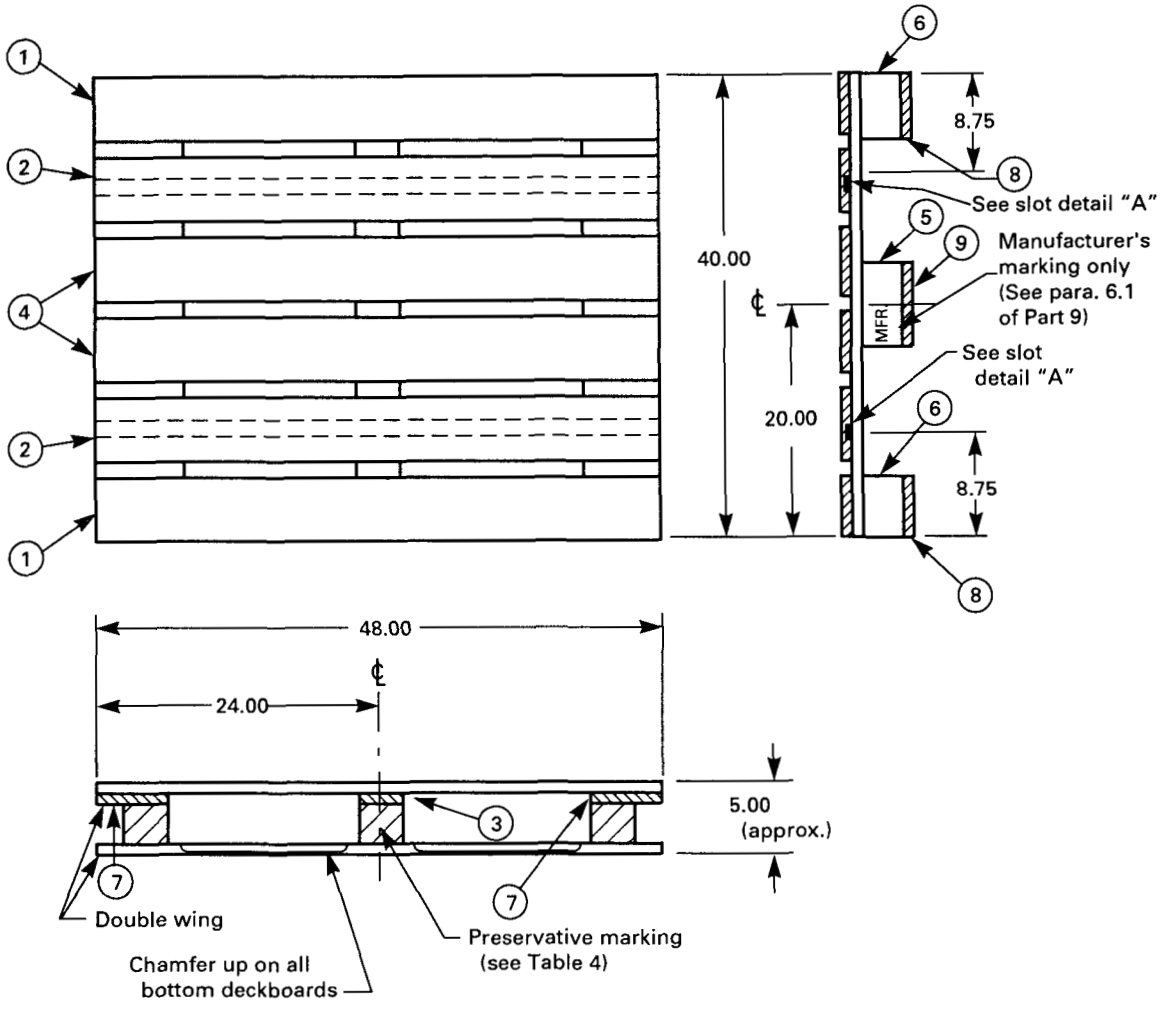
GENERAL NOTE: Supplier may choose one of two interior bottom deckboard options.
(a) One interior bottom deckboard is required, of 5.5 in. (min.) width, centered on 10.00 in. interior stringer foot.
(b) Two interior bottom deckboards are required, of random width (3.50 to 5.00 in.), with a maximum deckboard spacing of 1.5 in. allowed between the two bottom interior deckboards.

(b) **FIG. 3 TOP AND SIDE VIEW, PARTIAL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING PALLET**

[Shown is a Class 1, Type 2, Style 6, Size 2 (40 × 48 in.), 4-stringer pallet. Strapping slots shall be included, as shown in Fig. 3. All dimensions are in inches.]

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Block Pallet Construction Details
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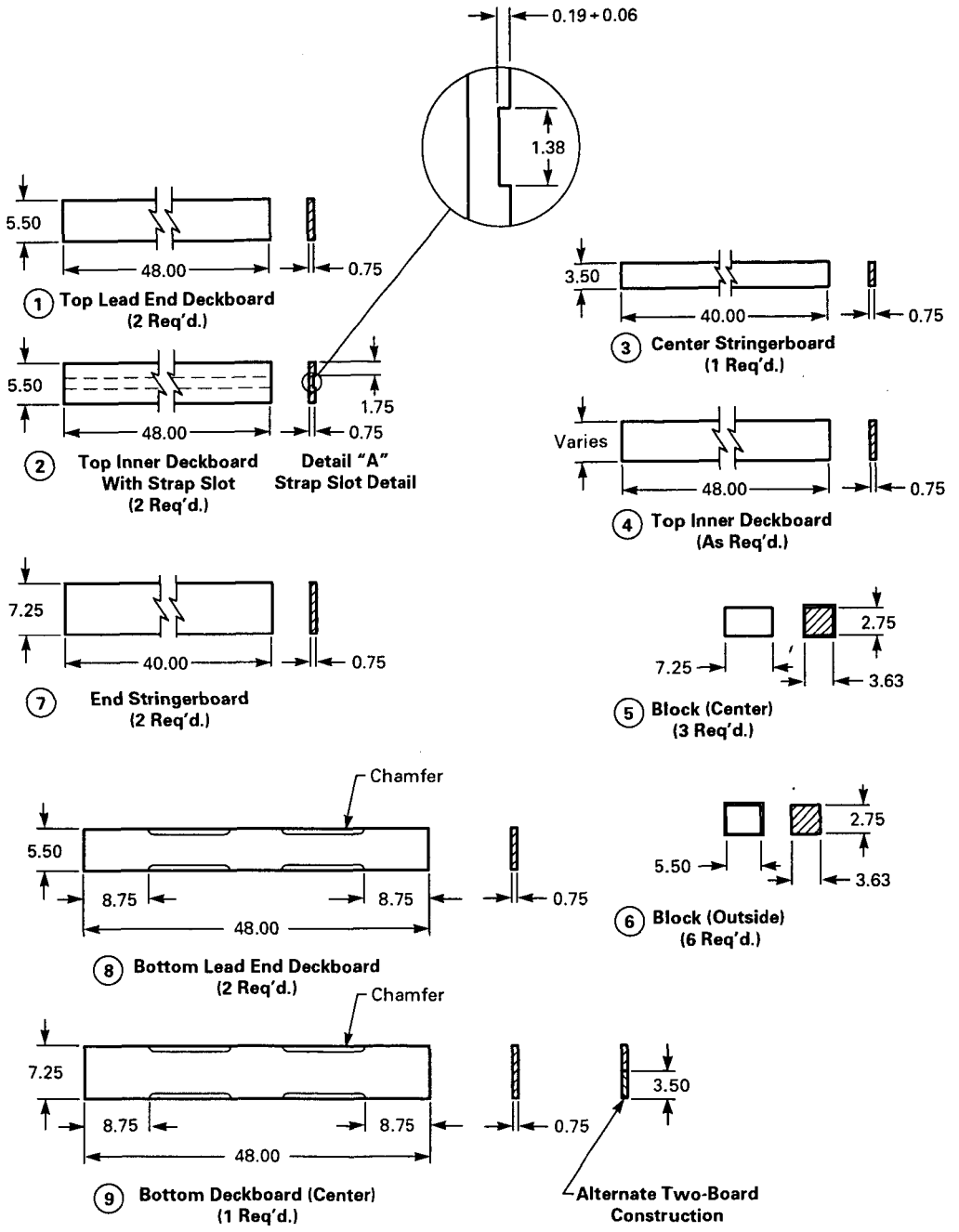
GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

FIG. 4 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET **(b)**

[Shown is a Class 2, Type 3, Style 6, Size 2 (40 × 48 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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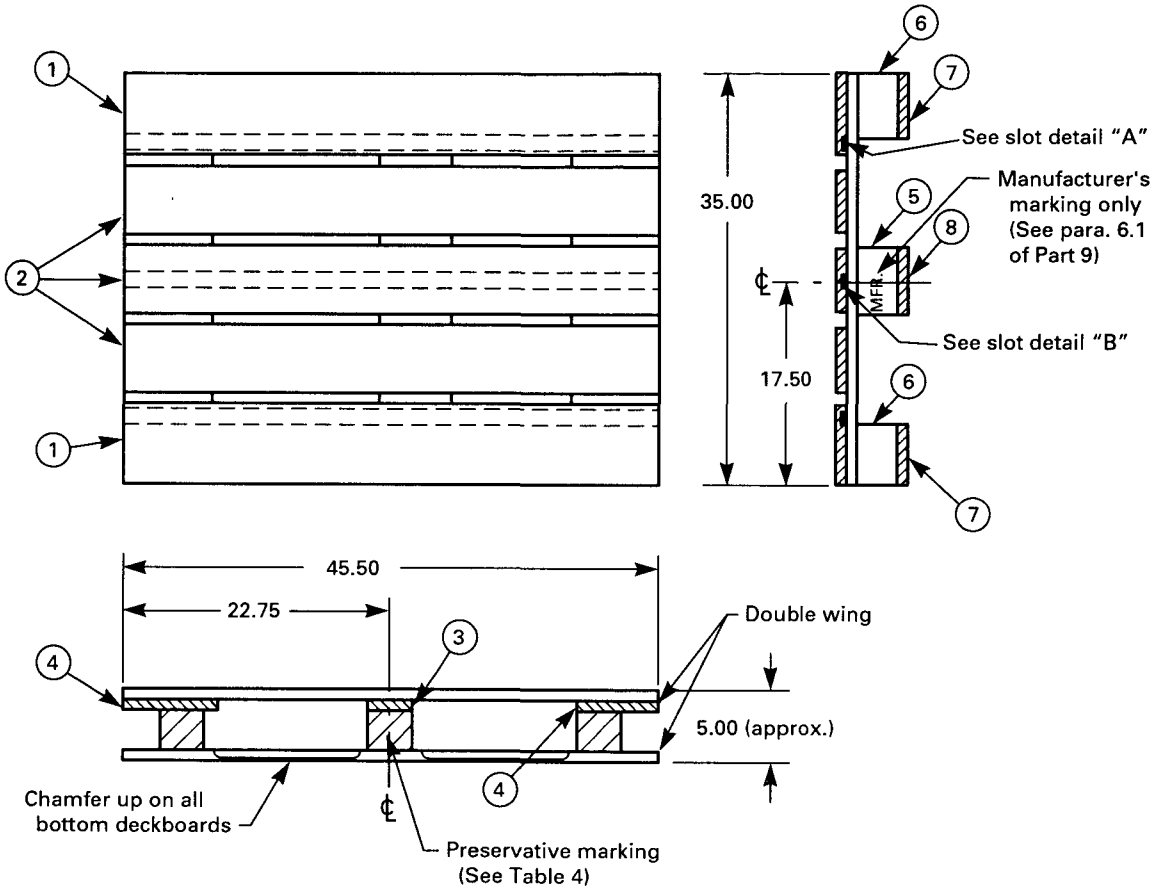
(b) FIG. 5 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 2 (40 × 48 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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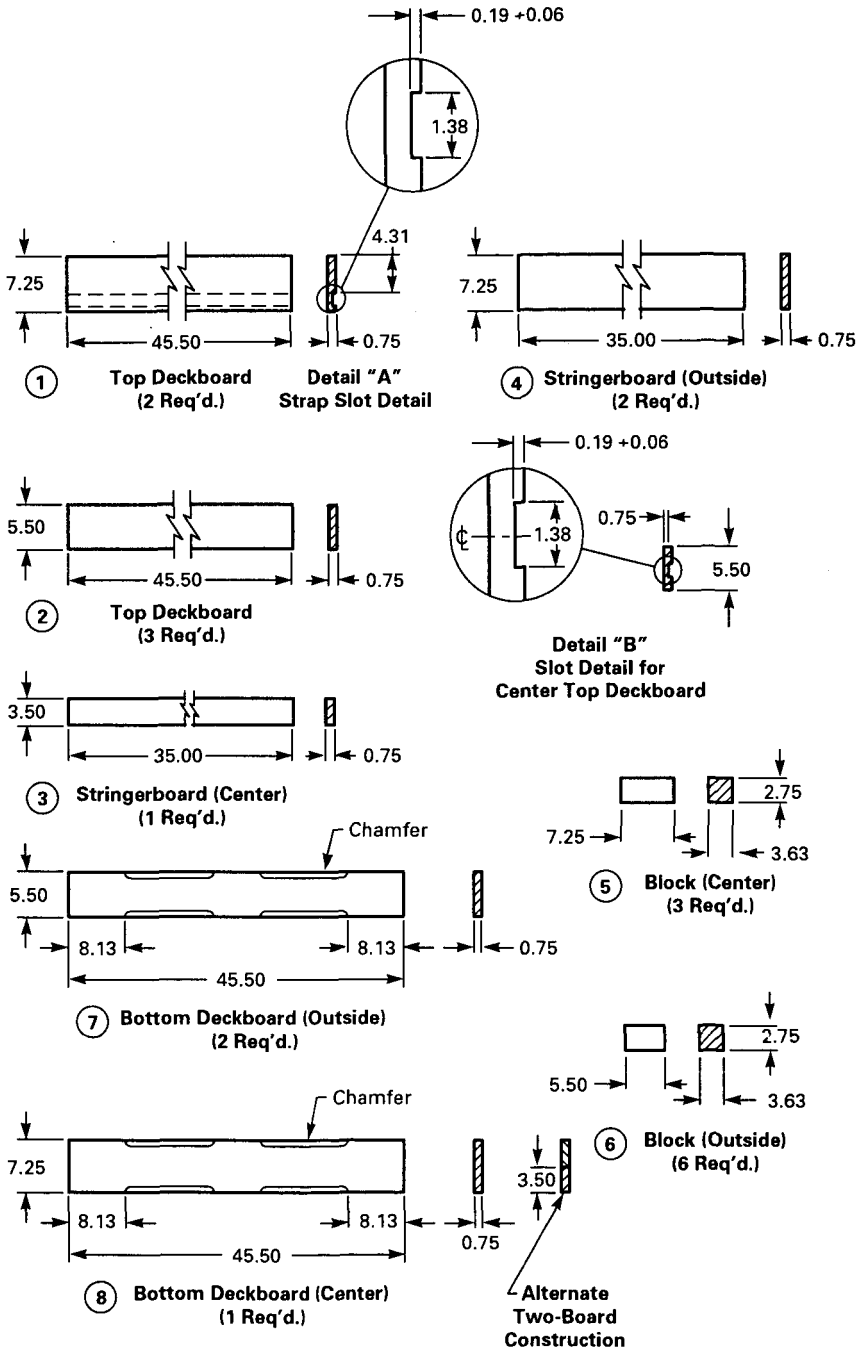
GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

FIG. 6 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 6, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET **(b)**

[Shown is a Class 2, Type 3, Style 6, Size 6 (35 × 45.5 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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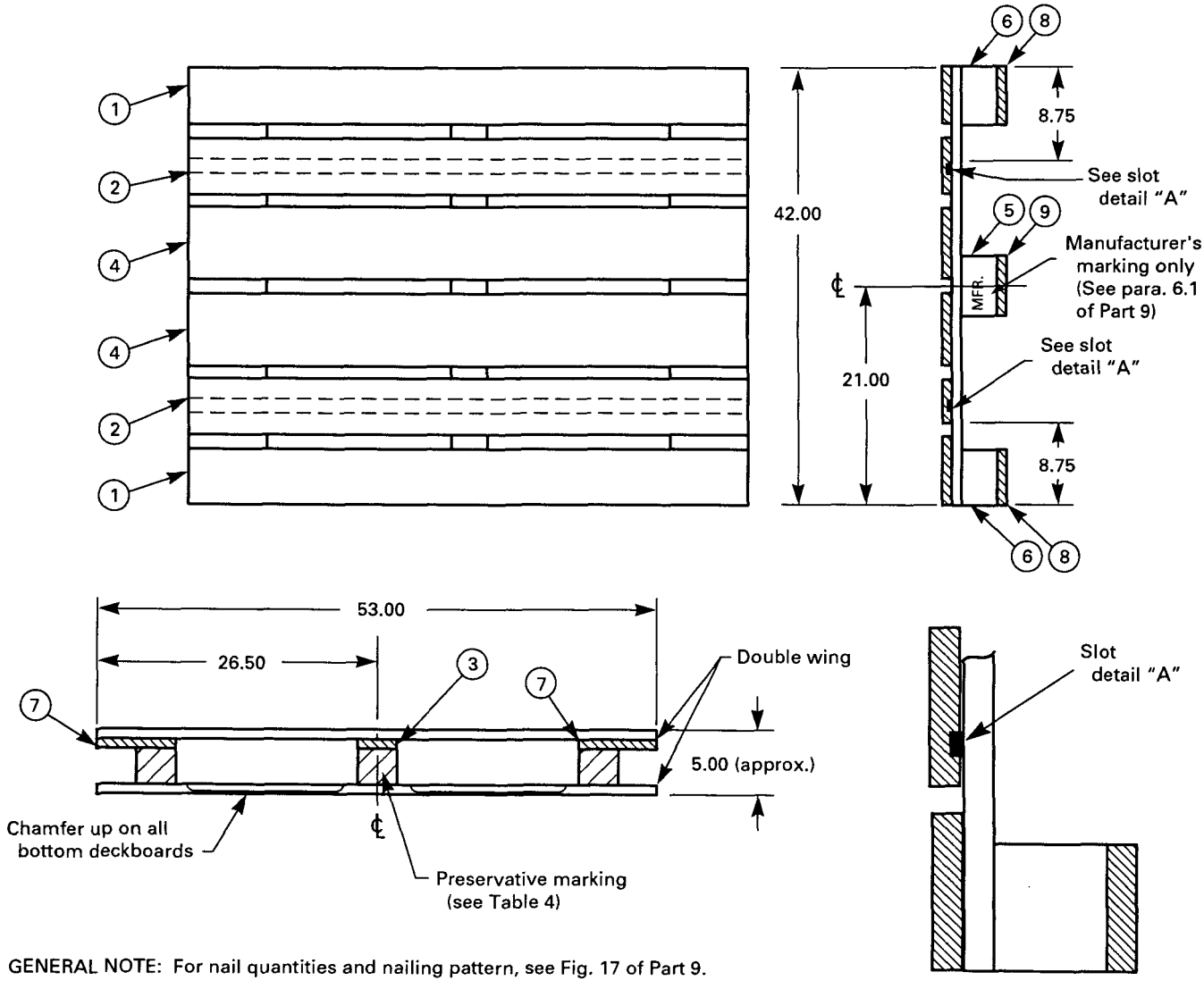
(b) FIG. 7 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 6, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 6 (35 × 45.5 in.), block pallet. All dimensions are in inches.]

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GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

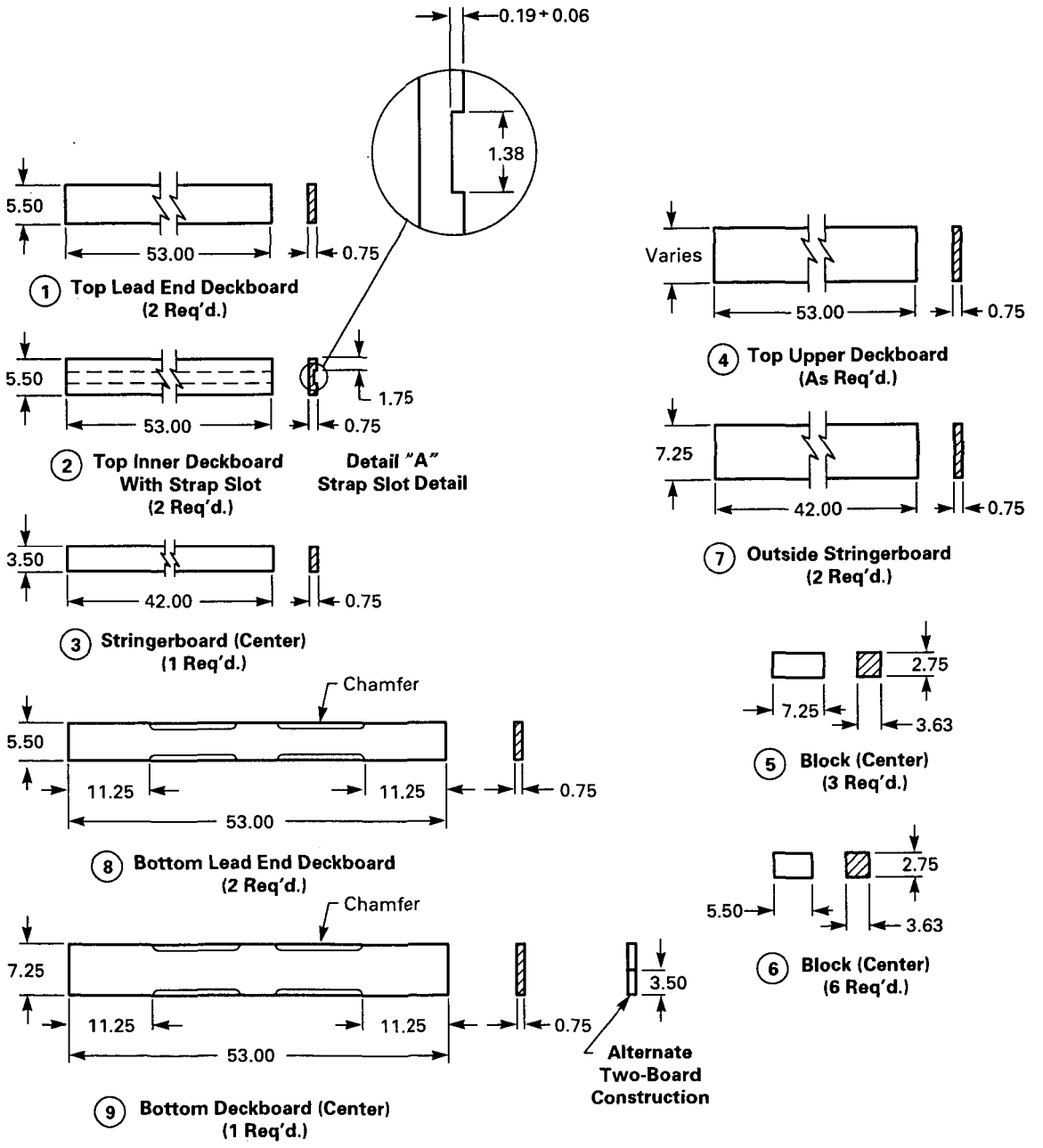
FIG. 8 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 7, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET **(b)**

[Shown is a Class 2, Type 3, Style 6, Size 7 (42 × 53 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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(b) FIG. 9 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 7, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 7 (42 × 53 in.), block pallet. All dimensions are in inches.]

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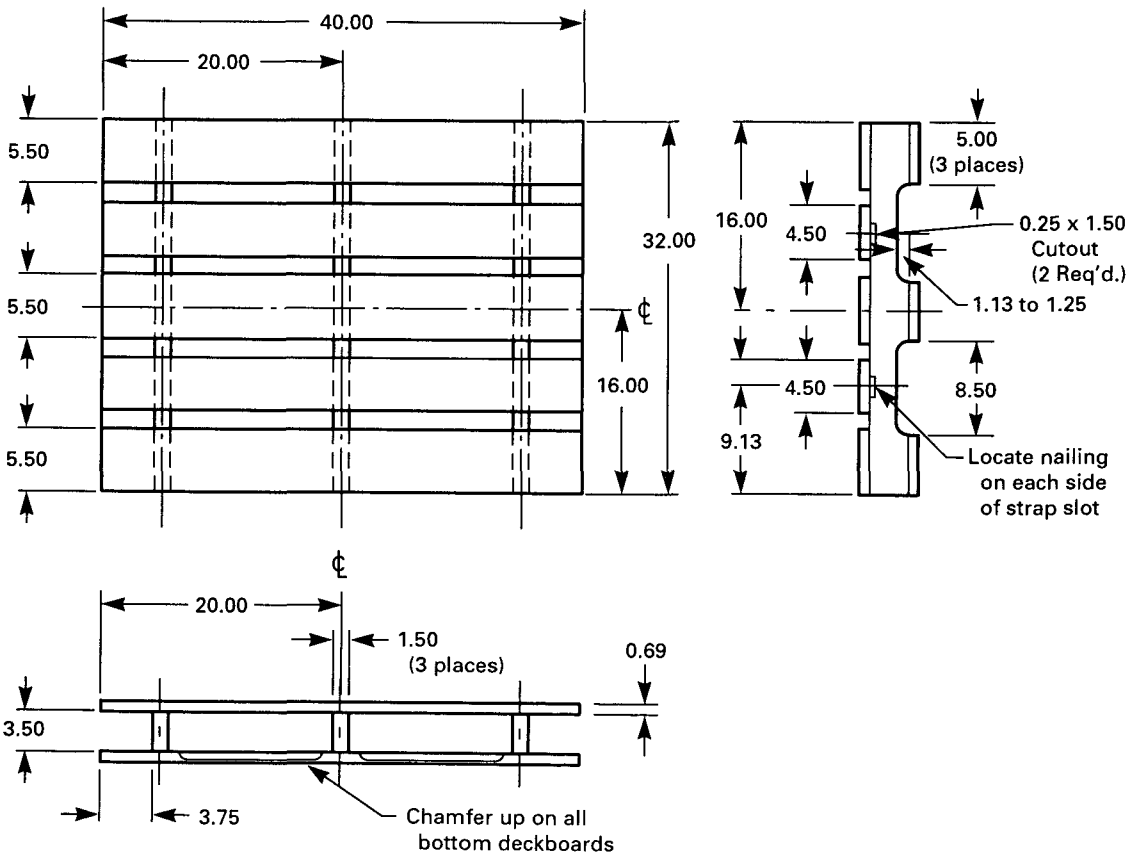
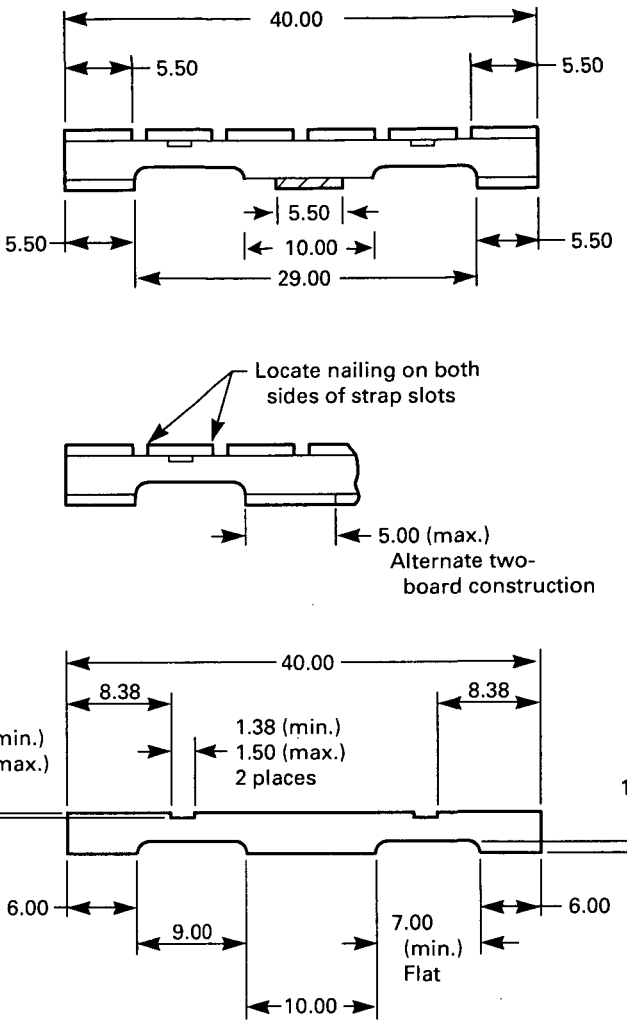


FIG. 10 TOP, END, AND SIDE VIEW OF PARTIAL 4-WAY ENTRY, SIZE 1, DOUBLE-WING PALLET
[Shown is a Class 1, Type 2, Style 6, Size 1 (32 × 40 in.), 3-stringer pallet. All dimensions are shown in inches.]

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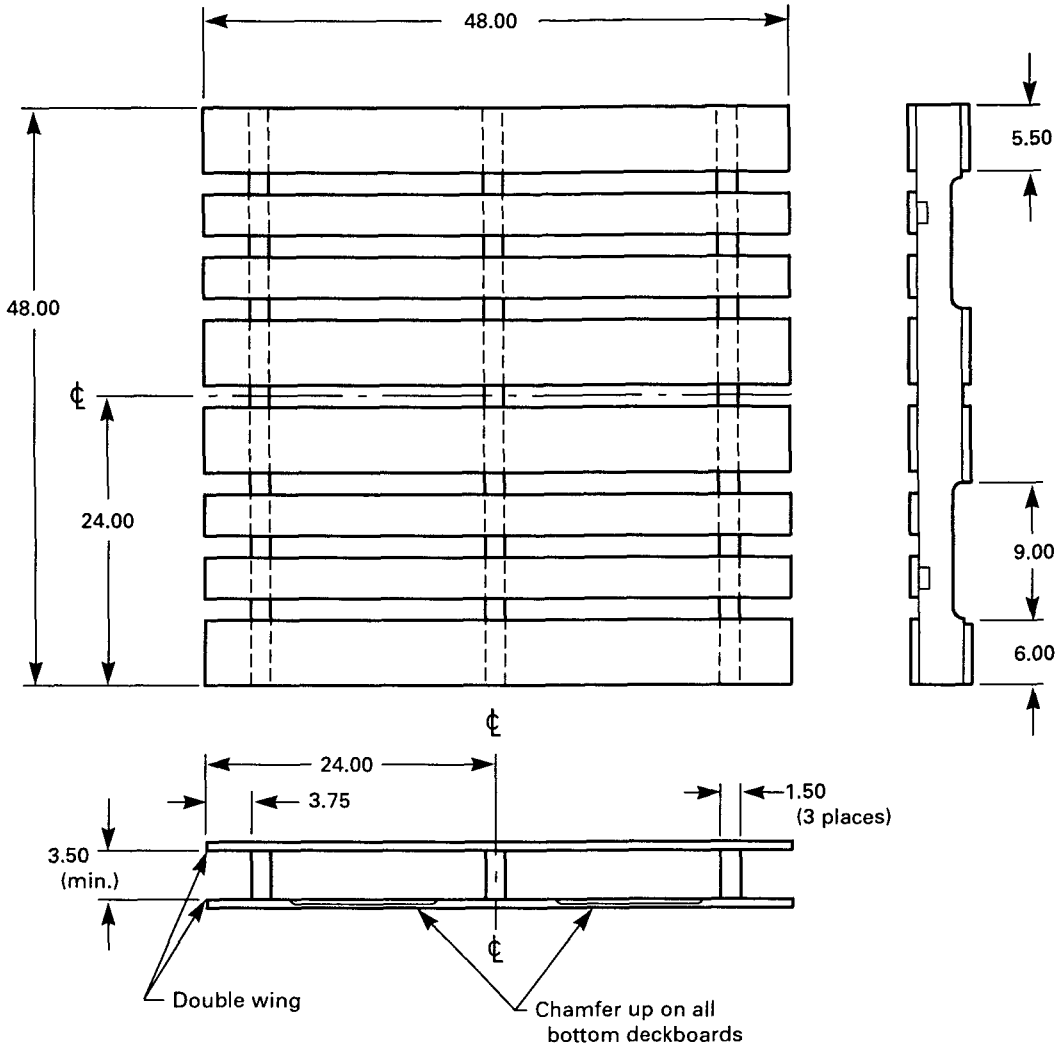


GENERAL NOTE: Supplier may choose one of two bottom-interior deckboard options.
(a) One bottom-interior deckboard is required, of 5.5 in. (min.) width, centered on 10.00 in. interior stringer foot.
(b) Two bottom-interior deckboards are required, of random width (3.50 to 5.00 in.), with a maximum deckboard spacing of 1.5 in. allowed between the two bottom-interior deckboards.
All dimensions are in inches.

(b) FIG. 11 SIDE VIEWS, PARTIAL 4-WAY ENTRY, FLUSH OR DOUBLE-WING, STRINGER PALLET
[Detail shows a stringer for a Size 2 (40 × 48 in.) pallet and the location and size of the strapping slots.]

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Stringer Pallet Construction Details
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GENERAL NOTE: Two or three bottom-interior deckboards may be used and supplier may choose one of the two bottom-interior deckboard options.

(a) Two bottom-interior deckboards are required, of 5.50 in. (min.) width, centered on the 18.00 in. interior stringer foot, with a maximum spacing of 1.50 in. between deckboards.

(b) Three bottom-interior deckboards are required, of random width [3.50 (min.) to 5.50 in.], with a maximum deckboard spacing of 1.50 in. allowed between the three bottom-interior deckboards.

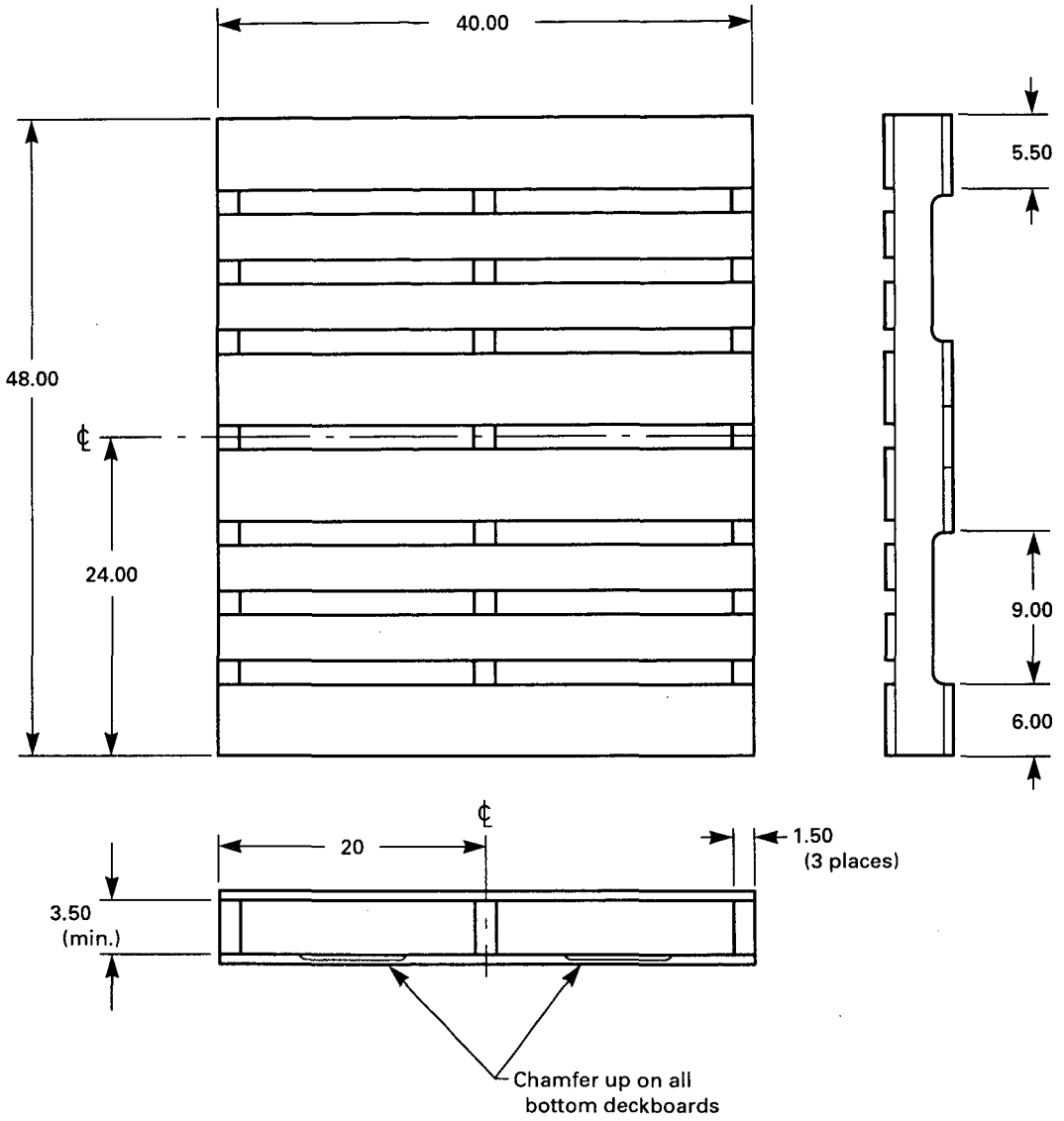
Strapping slots on top surface of stringer to be located 8.38 in. from each end of stringer, as shown in Fig. 11. All dimensions are in inches.

FIG. 12 TOP, END, AND SIDE VIEWS, PARTIAL 4-WAY ENTRY, SIZE 3, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE STRINGER PALLET **(b)**

[Detail shows a Class 1, Type 2, Style 6, Size 3 (48 × 48 in.), 3-stringer pallet. Two or three bottom-interior deckboards may be used. Strapping slots shall be included, as shown in this figure.]

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Stringer Pallet Construction Details
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GENERAL NOTE: Two or three bottom-interior deckboards may be used and supplier may choose one of the following bottom-interior deckboard options.

(a) Two bottom-interior deckboards are required, of 5.50 in. (min.) width, centered on the 18.00 in. interior stringer foot, with a maximum spacing of 1.50 in. between deckboards.

(b) Three bottom-interior deckboards are required, of random width [3.50 (min.) to 5.50 in.], with a maximum deckboard spacing of 1.5 in. allowed between the three bottom-interior deckboards.

All dimensions are in inches.

(b) **FIG. 13 TOP, END, AND SIDE VIEWS, PARTIAL 4-WAY ENTRY, SIZE 8, DOUBLE DECK, FLUSH, NONREVERSIBLE STRINGER PALLET**

[Detail shows a Class 1, Type 2, Style 2, Size 8 (48 × 40 in.), 3-stringer pallet. Two or three bottom-interior deckboards may be used. All dimensions are in inches.]

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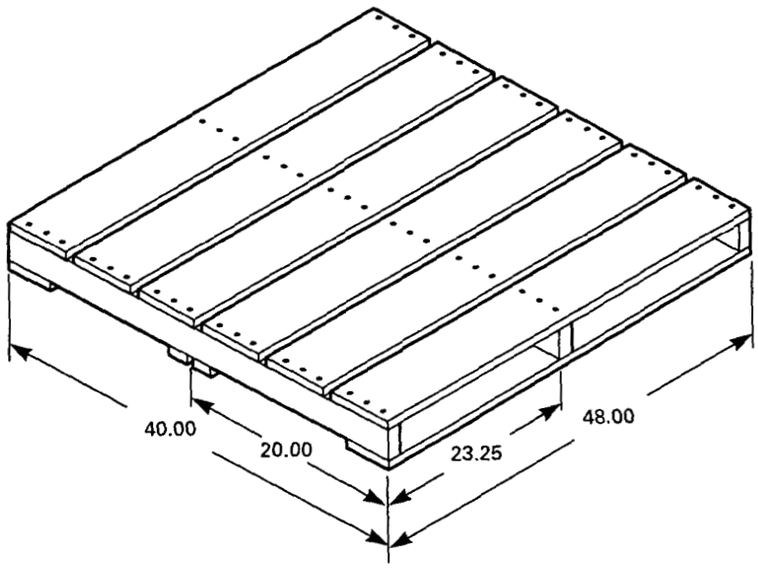
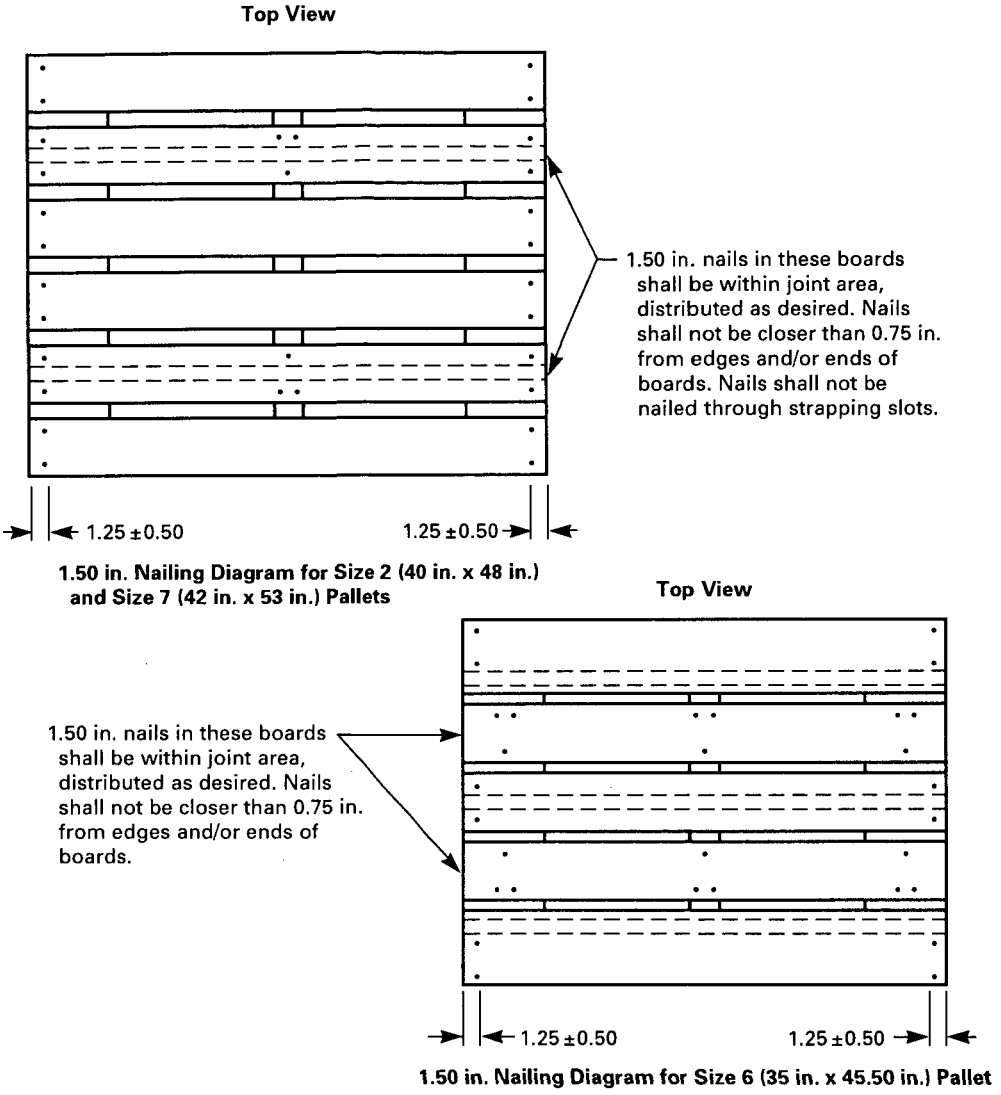


FIG. 16 ISOMETRIC VIEW, SIZE 2, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET
[Shown is a Class 1, Type 1, Style 2, Size 2 (40 × 48 in.), 3-stringer pallet. Bottom intermediate deckboards may be either two 3.5 in. wide deckboards or one 7.25 in. wide deckboard. All dimensions are in inches.]

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Block Pallet Nailing Diagrams
(Reference Figs. 4 – 9 of Part 9.)



GENERAL NOTE:
Top deckboards shall be fastened to stringerboards with 1.50 in. nails. For quantities and locations, please see diagrams above. Top deckboards and stringerboards shall be nailed to blocks with 3.25 in. nails. These nails are not shown in the diagrams above, only 1.50 in. nails are shown. Three nails shall be used for the 5.50 in. blocks and four nails shall be used for the 7.25 in. blocks with the nails to be evenly distributed throughout the joint area. No nails shall be nailed through the strapping slots. Bottom deckboards shall be nailed to blocks with 2.25 in. nails or alternatively 3.25 in. nails may be used. Three nails shall be used for the 5.50 in. block and four nails shall be used for the 7.25 in. blocks with the nails to be evenly distributed throughout the joint area. All nails shall be no closer than 0.75 in. from edges and/or ends of boards.

(b) **FIG. 17 NAILING DIAGRAMS AND NAIL SIZES FOR SIZES 2, 6, AND 7, NONREVERSIBLE BLOCK PALLETS**
(All dimensions are in inches.)

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NONMANDATORY APPENDIX A9-B
REFERENCED DOCUMENTS

(b)

(This Appendix is not part of Part 9 of ASME MH1-1997, and is included for information purposes only.)

The following documents were reviewed during the preparation of this Part:

ASME MH1-1997, Pallets, Slip Sheets, and Other Bases for Unit Loads

Publisher: American Society of Mechanical Engineers (ASME International), Three Park Avenue, New York, NY 10016-5990

ASTM D 1185-94, Standard Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping

ASTM F 1667, Standard Specification for Driven Fasteners: Nails, Spikes, and Staples

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428

ISO 6780-1988/1994, General Purpose Flat Pallets for Through Transit of Goods—Test Methods—Principal Dimensions and Tolerances

ISO 8611-1991, General Purpose Flat Pallets for Through Transit of Goods—Test Methods—Amendment 1: Wing Pallets

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1121, Genvève 20, Switzerland/Suisse

MIL-P-15011J, Pallets, Material Handling, Wood, Post Construction, 4-Way Entry, September 16, 1985 (out of print)

NN P-71C, Pallet, Material Handling, Wood, Stringer Construction, 2-Way and 4-Way (Partial), September 10, 1973 (out of print)

Publisher: Superintendent of Documents, United States Government Printing Office, Washington, DC 20402

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Part 10 (b)
Performance Specification for Pallets To Be Used in Automated Unit-Load Material Handling Equipment

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Mandatory Appendix

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Nonmandatory Appendices

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PART 10 (b)
PERFORMANCE SPECIFICATION FOR PALLETS TO BE USED IN AUTOMATED UNIT-LOAD MATERIAL HANDLING EQUIPMENT

1 SCOPE

Part 10 of this Standard is applicable to any new, used, or reconditioned pallets designed and fabricated from any materials including wood, plastic, metal, or paper, that are intended for use in automatic unit-load material handling systems. These automatic material handling systems include such equipment as automatic storage and retrieval warehouse racks, automatic palletizers, unit-load stretch wrapping, strapping, and shrink-wrapping machines, automatic guided vehicles, flow racks, and chain and roller conveyors.

The use of automatic unit-load material handling devices is growing in the U.S., Europe, and Asia. The requirements of pallets used in these systems are different from the requirements of pallets used in more manual systems based on "rider-on-board" forked equipment.

Automatic systems are more sensitive to variations in pallet quality and to deflections and deformations which will occur in pallets during use.(1) When both automatic and manual systems are used together, pallets should meet the requirements of the most sensitive component, which is typically an automatic device. For a pallet to perform satisfactorily in automatic material handling systems, it should meet the test criteria for flatness, size and shape uniformity, and stiffness required in this Standard.

2 PURPOSE

Part 10 contains pallet performance and quality criteria that will aid pallet producers and their customers design, manufacture, and select pallets which will function efficiently in automatic unit load material handling systems. The sensitivity of automatic unit-load material handling systems to variation in pallet quality differs from system to system. Pallets meeting the quality and performance characteristics in this standard may not function efficiently in all such systems.(1)

3 DEFINITIONS AND TERMINOLOGY

The terminology used in Part 10 is in accordance with Part 1. The following specific definitions are not included in Part 1.

automatic guided vehicle (AGV): automated floor traveling material handling systems used to move materials throughout facilities.

automatic palletizer: a machine which automatically places packaged product onto a pallet deck. They are generally of three designs: vacuum head, row stripping, or robotic.

automatic storage and retrieval systems (ASRS): fully (riderless) or semi- (rider-on-board) automatic systems that store and retrieve material typically consisting of racks, pickup and delivery stations, and storage and retrieval.

chain conveyors: multiple powered chains, typically 0.50 to 1 in. (13 to 25 mm) wide, generally 2 through 5 "strands," in channels acting on the bottom deck of unit loads to transport and transfer between conveyors.

flow rack: a storage rack in the form of a conveyor, either powered or driven by the force of gravity.

push-back storage racks: generally 2 to 5 unit-loads-deep warehouse racking systems using shuttles moved typically by the force of gravity for storing palletized product.

roller conveyors: horizontal conveyers with powered or nonpowered rollers, typically 2 to 5 in. (51 to 127 mm) in diameter and spaced 3 to 6 in. (76 to 152 mm) apart (on center). Rolls are typically longer than the dimensions of the unit loads being transported.

shuttle carts: generally cable driven, wheeled carts with top decks that may be elevated to transport unit loads within "deep-bay" warehouse racking and sortation systems.

skate-wheel conveyors: narrow rollers typically 1 in. (25 mm) or less in width, of varying diameters, forming 2 or 3 "strands" of rollers which support unitized loads.

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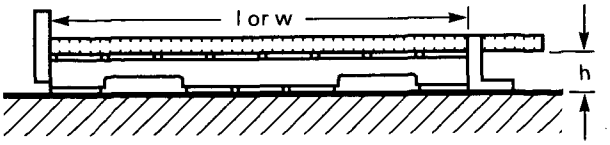


FIG. 1 MEASUREMENT OF PALLET LENGTH (L), WIDTH (W), AND HEIGHT (H), WITH A "T" SQUARE AND CARPENTER SQUARE

4 PERFORMANCE SPECIFICATIONS FOR PALLETS TO BE USED IN AUTOMATIC UNIT-LOAD MATERIAL HANDLING SYSTEMS

For convenience, the criteria in subsections 4.1 through 4.7 are summarized in Appendix A. Unless otherwise specified, measurement shall be made to the nearest 0.02 in. (0.5 mm). Sampling procedures are not specified because they will depend on (1) the level of conformance required by the pallet user; (2) the variability of the pallets; and (3) the volume of pallets used. Once these factors are known, standard statistical procedures are available for determining sample size and sampling frequency.

4.1 Maximum Allowable Pallet Size and Shape Variations

Narrow gaps or clearances between structural members, moving components of automatic unit-load material handling equipment, and pallets, require pallets to be consistent in size and shape. Appendix B contains diagrams showing typical design clearances between pallets and components of automatic handling equipment.(1)

4.1.1 Test Criteria. Variations in pallet size and shape should not exceed the following:

- pallet length and width +0.13/-0.25 in. of target pallet size
- pallet height +0.13/-0.38 in. of target pallet height
- squareness 0.50 in. (13 mm) maximum difference in pallet diagonals

4.1.2 Method of Measurement

pallet length (l): Place the pallet on a flat surface. Lay an appropriate length T-square across pallet length. Place carpenter square at opposite pallet end and read length as intersection of carpenter and T-squares (see Fig. 1). Note that this includes characteristics such as a bottom endboard overhang. It may be necessary to measure at more than one location. The maximum length is recorded. Temperature may affect the dimensions of plastic or metal pallets.

Therefore, dimensional measurements of plastic or metal should be at a temperature agreeable to the specifier of the pallet (22 ±2°C is recommended). During use, expansion and contraction of plastic or metal pallets will be 0.1% per 10° temperature change.

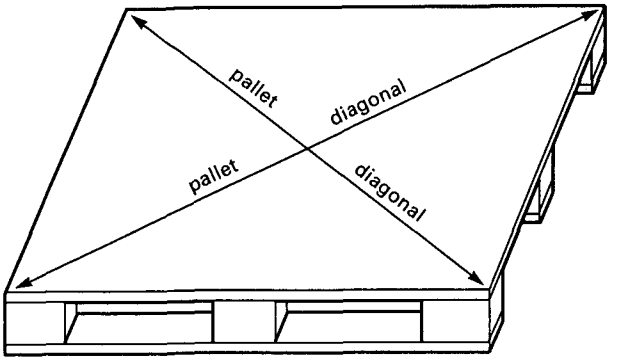


FIG. 2 MEASURING THE DIAGONALS OF PALLET TOP AND BOTTOM

pallet width (w): The measurement is similar to pallet length, except measured across the pallet width. The maximum pallet width is recorded.

pallet height (h): the pallet is placed on a flat surface. Place straight edge across the pallet top deck. The height is the distance from straight edge to flat surface. Maximum height is recorded. Note that solid timber pallets are typically manufactured green (moisture content greater than 30%) and dry to 10-15% moisture content during use. Timber pallets may shrink up at 4% in pallet height [0.25 in. (6 mm) of a 5 to 7 in. (127 to 178 mm) pallet height]. If less height variation with timber pallets is required, it is suggested that pallets be manufactured 4% over height and then dried before use. Plywood and predried timber pallets will not experience significant shrinkage or dimensional changes.

pallet squareness: Measure the opposite pallet diagonals of the top deck, including overhanging components, as shown in Fig. 2. This is usually measured with a tape or straight edge. Repeat this measurement on the bottom deck.

4.2 Pallet Deck Flatness

Nonflat pallet decks interfere with the efficient operation of some palletizing equipment and may affect the efficient movement of palletized loads on different types of conveyors.

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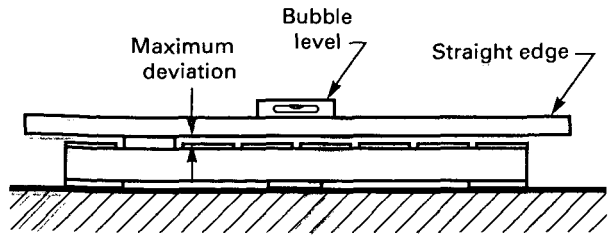


FIG. 3 SCHEMATIC DIAGRAM SHOWING THE MEASURING OF PALLET DECK FLATNESS

4.2.1 Test Criteria. Flatness of the pallet deck supporting no load shall be within 0.25 in. (6 mm) of the target level.

4.2.2 Method of Measurement. The pallet is placed on a level, flat surface. A straight edge with a bubble level is laid across pallet diagonals. Only pallet components designed to physically contact the load are applicable. Intentional protrusions, such as lips or deformations on pallet decks which do not interfere with handling efficiency, may be ignored. Measure the maximum deviation between the straight edge and these applicable components, as shown in Fig. 3. Turn the pallet over, and repeat the procedure on the bottom deck of double deck pallets, measuring only those components designed for physical contact with a floor or conveyor surfaces.

4.3 Slipping Resistance of Pallet Decks

The slip resistance of pallet decks affects the efficient movement of unit loads on conveyors, in push-back racks, and on forked equipment. Slip resistance of pallet decks also affects the stability of loads placed on the pallet, as well as the stability of stacks of empty pallets being moved. The slip resistance of three surfaces of pallets are important. These are the top and bottom surfaces of the top deck, and the bottom surface of the bottom deck. The measure of slip resistance is the static coefficient of friction (COF).

When conditions of pallet use will alter the static coefficient of friction, such as cold temperatures or water, the pallet deck surfaces should be tested in the condition that represents the least resistance to slipping. Green wood pallets or plastic pallets that would be used in freezers should be tested under the frozen conditions of use.

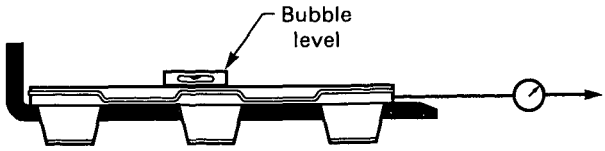


FIG. 4 SCHEMATIC DIAGRAM OF THE SLIP RESISTANCE TESTS OF PALLET DECKS

4.3.1 Test Criteria. The minimum allowable static coefficient of friction shall be 0.15.

4.3.2 Method of Measurement. The Coefficient of Friction (COF) is the ratio of normal force (in this test the empty pallet weight) to horizontal force required to move the pallet from a position of rest. To test COF under the top deck, place bottom surface of the top deck of an empty pallet on two fork tines longer than the pallet length. Typical tines measure 4 inches in width. Attach a scale to a pallet edge and gradually apply a horizontal force to the pallet until first pallet movement is observed. This is shown schematically in Fig. 4. Record the force required to move the pallet. Repeat the procedure on all sides and ends of the pallet designed for fork tine entry. Repeat this procedure for the top surface of the bottom deck and the bottom surface of the bottom deck by placing the pallet on a flat steel sheet larger than the pallet. Calculate the static coefficient of surface friction using Eq. (1) for each surface.

$$\text{COF} = N/H \tag{1}$$

where

N = normal force
H = horizontal force

4.4 Pallet Component Placement Variation

This specification is primarily intended for pallets assembled with glues or mechanical fasteners, and is not necessarily applicable to molded plastic pallets. Large components of pallets should be accurately placed during manufacture. If the location of pallet components is altered during use, they should be replaced or repositioned. Many automatic handling systems have optical systems which automatically position or stage palletized loads based on identifying the location of a pallet component. Therefore, if components are not accurately placed,the pallet will not be correctly positioned. Also, misplaced components may compromise the design clearances between handling equipment and the pallet (see Appendix B).

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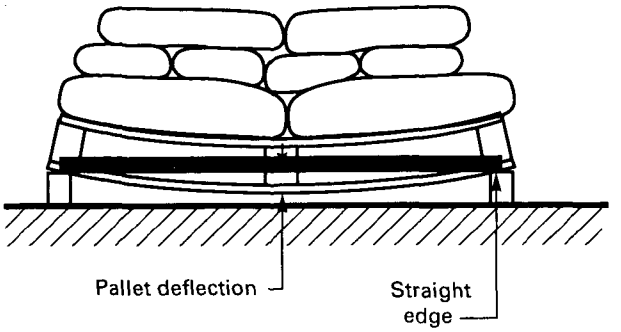


FIG. 5 MEASURING PALLET DEFLECTION

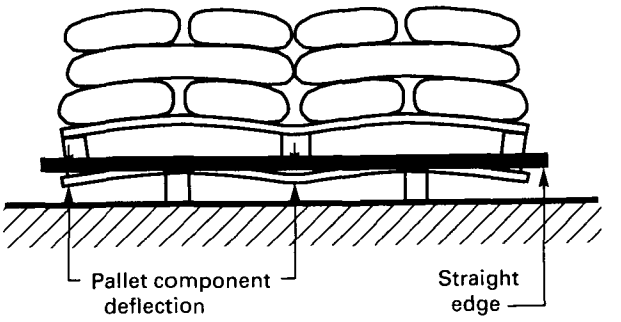


FIG. 6 SCHEMATIC DIAGRAM SHOWING PALLET COMPONENT DEFLECTION WHEN SUPPORTED IN AUTOMATIC HANDLING EQUIPMENT

4.4.1 Test Criteria. Components, therefore, shall be within 0.25 in. (6 mm) of the target location.

4.4.2 Method of Measurement. Component location shall be measured in the following manner:

deckboards: deckboard placement is measured as the distance from the end of each stringer, stringerboard, or post. Record the placement that gives the maximum deviation from the specified location.

stringers, stringerboards, and blocks: placement is measured as the distance from the pallet side or end. Record the placement that gives the maximum deviation from the specified location.

4.5 Pallet Deflection Under Load

Deflection of a pallet under load depends on the stiffness of the pallet, the spans between the supports of the handling equipment, the mass upon the pallet, and the distribution pattern of the load placed on the pallet. Excessive deformation will compromise design clearance between the bottom of the pallet and the supporting system of automated handling equipment. This reduces unit load handling efficiency and may prevent operation of the system. These deflections are shown schematically in Fig. 5.

4.5.1 Test Criteria. Maximum design deflections of pallets under load should not exceed 0.50 in. (13 mm). To allow for variations in stiffness, this deflection limit should include a minimal allowable clearance between the loaded pallet and the handling device of 0.50 in. (13 mm).

4.5.2 Measurement Method. The actual load to be placed on the pallet during use should be used for the test. However, a reasonable facsimile of both the load and automatic equipment can be used if either or both are not available. Maximum deflection of the pallet under load can be measured by placing a straight edge across the rack, chain, or other supports, and measuring the location of the bottom pallet deck relative to the supports. When this deformation varies across the bottom deck, it is the maximum deflection that is used. Automatic equipment designed for pallets conforming to this Standard should be designed to allow at least 0.50 in. (13 mm) clearance between the bottom of the pallet under load and the frame supports of conveyors and racks or the top surface of the shuttle cart. When conditions during use, such as temperature and humidity are known to affect unit load stiffness, the test should be conducted under those conditions, which would result in the greatest deflection.

4.6 Maximum Allowable Deflection of Pallet Components Under Load

During some movements, one or more components of a pallet may be subjected to stresses that result in deflections of part of the pallet rather than the entire pallet. An example of this is the deflection of the pallet bottom deck when moving on skate wheel type or chain conveyors such as shown in Fig. 6.

4.6.1 Test Criteria. Deflection of pallet components shall be limited to 0.25 inches, and clearances between the pallet and the equipment must be 0.50 in. (13 mm) as in para. 4.5.1. When effects are cumulative, i.e., component and pallet deflection as in subsection 4.4, the cumulative total deformation is limited to 0.50 in. (13 mm).

4.6.2 Method of Measurement. To measure maximum deflection of pallet components under load, place the design-use, actual load the pallet will support on the pallet and support the pallet on a facsimile of

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the actual automatic device that will support the pallet for a typical duration that may occur during use. Place straight edge across pallet deck. Measure maximum pallet component deflection below this straight edge. Repeat the measurement of all applicable components on top and bottom decks. When conditions such as temperature or humidity will affect stiffness, the test should be conducted under the condition of use that results in the greatest deformation.

4.7 Other Pallet Bottom Deck Design Criteria

The bottom deck of a pallet will interface with many automatic handling devices. When the direction of movement on roller conveyors is perpendicular to the bottom deck component orientation, the width of bottom deck components shall exceed the center-to-center spacing of the rollers. Pallets with mesh or ribbed bottom deck components may experience difficulty in conveyance on skate wheel conveyors. Interactions between the mesh or rib spacing, bottom deck stiffness, unit load weight, and skate wheel configuration determine the ability to convey. One solution is to incorporate solid regions at least 3 in. (76 mm) in width in all bottom deck components. Pallets with low bottom deck compression strength (typically plastic post designs) may experience difficulty during conveyance on rollers. If deflections occur, comparison tests using design loads and facsimilies of the skate wheels can be used to determine whether problems may occur.

4.8 Pallet Maintenance Criteria

The condition of pallets will change during use. Deterioration in a pallet may lead to the loss of pallet functionality in automated handling systems. Wood pallets should be maintained in accordance with the guidelines in Part 3.(2) Additionally, the following characteristics of used pallets are necessary for efficient utilization:

- No broken or loose components
- No exposed fasteners
- No loose stretch wrap, packaging, etc., that may interfere with equipment
- No companion stringers, half stringers, or plug stringer repairs
- Metal repair plates are allowed if covered with dark, non-reflective paint

The condition of the automatic unit load handling equipment will also change during use. For example, design clearances between equipment and pallets may also change. It is, therefore, necessary to maintain the handling equipment as well as the pallets for efficient operation.

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MANDATORY APPENDIX A10-A
PERFORMANCE SPECIFICATIONS FOR PALLETS TO BE USED IN AUTOMATED UNIT-LOAD MATERIAL HANDLING EQUIPMENT

(b)

TABLE 1 PERFORMANCE SPECIFICATIONS FOR PALLETS TO BE USED IN AUTOMATED UNIT-LOAD MATERIAL HANDLING EQUIPMENT [Notes (1), (2)]

Pallet size and shape variation	
length	+0.13 / -0.25 in. (+3.3 / -6 mm)
width	+0.13 / -0.25 in. (+3.3 / -6 mm)
height	+0.13 / -0.38 in. (+3.3 / -9.5 mm)
squareness	diagonals shall be within 0.50 in. (25 mm)
Flatness of decks (supporting no load)	Within 0.25 in. (6 mm) of target level [Note (3)]
Minimum static coefficient of surface friction: Top and bottom surface of top deck and bottom surface of bottom deck	0.15
Component placement variation	Within 0.25 in. (6 mm) of target location
Maximum deflection of the pallet under load	0.50 in. (13 mm)
Minimum clearance between pallet under load and handling equipment	0.50 in. (6 mm)
Maximum deflection of pallet components under load	0.25 in. (6 mm)

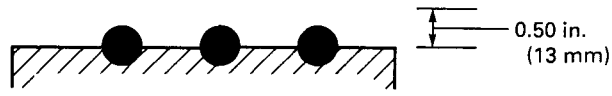
NOTES:
(1) No standard pallet design is implied by these recommendations. Pallet design shall be specified by the system designer.
(2) In addition, the following requirements must also be met:
- no broken or loose components
- no exposed fasteners
- no loose stretch wrap, packaging, etc. that may interfere with equipment
- no companion stringers, half stringers, or plug stringer repairs
- metal repair plates are allowed if covered with dark, nonreflective paint
- bottom deck components should span the center-to-center distance between rollers and skate wheels
- pallets with mesh or ribbed bottom deck components may experience difficulty in conveyance on skate wheel conveyors. Interactions between the mesh or rib spacing, bottom deck stiffness, unit load weight, and skate wheel configuration determine the ability to convey. One solution is to incorporate solid regions at least 3 in. (76 mm) width in all bottom deck components.
- pallets with low bottom-deck compression strength (typically plastic post designs) may experience difficulty in conveyance on rollers.

(3) Intentional protrusions exceeding these limits may be acceptable by mutual consent by both buyer and seller.

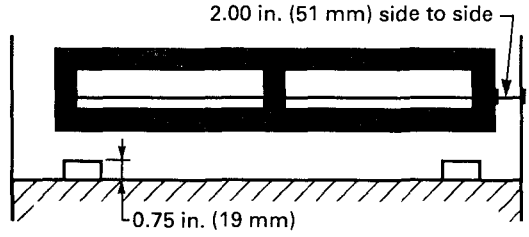
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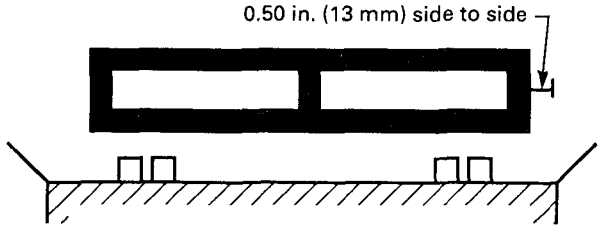
NONMANDATORY APPENDIX A10-B (b)
TYPICAL CLEARANCES BETWEEN COMPONENTS AND BETWEEN PALLETS AND COMPONENTS OF AUTOMATED UNIT LOAD HANDLING EQUIPMENT



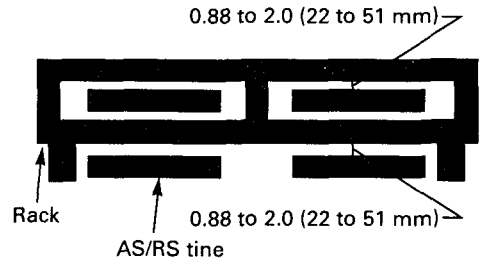
Roller conveyor/frame clearance



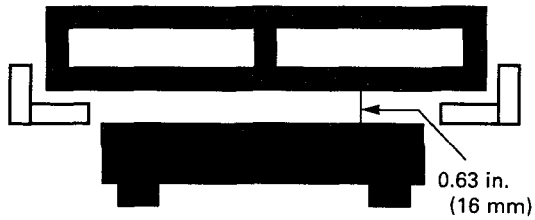
Chain conveyor/frame clearance



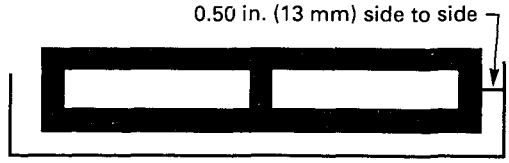
Dynamic rack with skate wheel conveyors



AS/RS clearance



Shuttle cart clearances



AGV docking station

TYPICAL CLEARANCES BETWEEN COMPONENTS AND BETWEEN PALLETS AND COMPONENTS OF AUTOMATIC UNIT LOAD HANDLING EQUIPMENT

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NONMANDATORY APPENDIX A10-C
REFERENCES

(b)

(1) Development Of Performance Specification For Pallets Used In Automated Unit-Load Material Handling Equipment. White, M.S. and J.W. Clarke. 1997.

Publisher: Center For Unit-Load Design. Virginia Tech, Blacksburg, VA 24061-0503

(2) ASME MH1-1997 Pallet, Slip Sheets, and Other Bases for Unit Loads

Publisher: American Society of Mechanical Engineers. Three Park Avenue, New York, NY 10016-5990.

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ASME MH1a-1999

ADDENDA

to

ASME MH1-1997
PALLETS, SLIP SHEETS, AND OTHER BASES FOR UNIT LOADS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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ASME MH1a-1999

Following approval of each Part by the ASME MH1 Committee and ASME, and after public review, the final four parts of ASME MH1a-1998 were approved by the American National Standards Institute on the following dates: August 6, 1998 (Part 2), August 6, 1998 (Part 3), January 30, 1998 (Part 4), August 6, 1998 (Part 8), and February 4, 1999 (Part 9).

Addenda to the 1997 edition of ASME MH1 are issued in the form of replacement pages. Revisions, additions, and deletions are incorporated directly into the affected pages. It is advisable, however, that this page, the Addenda title and copyright pages, and all replaced pages be retained for reference.

SUMMARY OF CHANGES

This is the first Addenda to be published to ASME MH1-1997.

Replace or insert the pages listed. Changes given below are identified on the pages by a margin note, **(a)**, placed next to the affected area. The pages that appear in this Addenda that are not listed are the reverse sides of the listed pages and contain no changes.

Page	*Location*	*Change*
iv	Foreword	Revised
v	Committee Roster	Updated
vi	Note	Added
vii	Contents	Revised to reflect Addenda changes
ix	Preface	Updated
5	3 (Referenced Standards)	ASME address updated
31–32.10	Part 2	Added
33–34.42	Part 3	Added
35–36.16	Part 4	Added
95, 96	8.1	Editorially revised
	8.2	Editorially revised
	8.3	Editorially revised
107	B1	Editorially revised
	B2	Editorially revised
119–148	Part 8	Added
149–178	Part 9	Added

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FOREWORD (a)

(This Foreword is not part of ASME MH1-1997.)

Hundreds of millions of wood pallets were manufactured in the United States of America during each of the past 30 years, considerably more than the 37 million pallets produced during 1953 when the ASME Standards Committee MH1 was established. It is estimated that approximately 20% of the total annual production of lumber in the United States was required for the assembly of these pallets. One pallet size of the approximately 100 sizes used, the 48 × 40 in. and 40 × 48 in. (1219 × 1016 mm and 1016 × 1219 mm) size, accounts for more than one-third of all the pallets produced; while ten additional sizes account for more than 1% of all pallets produced. Pallets made of metal and plastics are also manufactured in the United States. However, their production is limited and no production statistics are available.

The need for standardization of pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products, originated from the interconnecting nature of pallet usage. The great variety of pallet sizes and constructions restricted their movement through manufacturing and distributing channels. This variety was the result of each user treating pallet design as a private problem. More intense application of the unit-load method of assembling, stacking, storing, handling, and transporting of commodities in the United States and in international trade fostered extensive use of pallets both as captive and exchange pallets. The latter pallets, especially, required maximum standardization for any exchange to be successful.

Some industries and military services developed, by evolution, certain pallet standards to solve specific problems which are also existent with other users. Consequently, their sizes and constructions of pallets established a pattern of value to all users.

The American National Standards Institute (formerly the American Standards Association) project on pallet standardization was initiated in October 1953. A Material Handling Standards Committee, MH1 (initially B69), was organized to coordinate information and prepare standards under the scope of standardization of nomenclature, types, sizes, materials, and components of pallets, including sampling, inspection, and test procedures. The standards pertain to pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products. The standards were to accomplish the following:

(a) define terminology associated with pallets;
(b) apply to pallets irrespective of components used in their fabrication;
(c) provide a series of recommended pallet dimensions;
(d) describe procedures for pallet testing; and
(e) indicate procedures for designating pallet requirements.

During 1967, the MH1 Committee was reorganized. A Nominating Committee was established in compliance with the procedures of ANSI. The Nominating Committee selected officers for the MH1 Committee during 1968 and, in turn, became the nucleus for the new MH1 Executive Committee to guide the continuing revision activities and organize the task groups to be formed.

The name of the MH1 Committee was changed in 1979 to Standardization of Pallets, Slip Sheets, and Other Bases for Unit Loads by action of ANSI's Physical Distribution

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Standards Management Board in light of the establishment of the MH1 Subcommittee on Standardization of Slip Sheets in March 1979. The following scope of the Committee was established: standardization of nomenclature, types, sizes, materials, and components of pallets, slip sheets, and other unit load bases, including sampling, inspection, and test procedures.

The MH1 Committee, consisting of individual members and representatives of trade associations, engineering societies, and government agencies, organized a Technical Committee to perform its work. During July 1981, this Technical Committee was reorganized as an ASME Standards Committee operating under the ANSI accredited organization procedures.

The following MH1 Committee standards were issued:

MH1.1.2	Definitions and Terminology Covering Pallets and Related Structures
MH1.2.2M	Pallet Sizes
MH1.4.1M	Procedures for Testing Pallets
MH1.5M	Slip Sheets
MH1.6	Standard Procedures for Determination of Durability of Wooden Pallets and Related Structures
MH1.7M	Driven Fasteners for Assembly of Pallets and Related Structures
MH1.8M	Wood Pallets
MH1.9	Export Pallets

The MH1 Committee has published the above eight separate standards which are being consolidated into a single publication, MH1 Pallets, Slip Sheets, and Other Bases for Unit Loads. This 1997 Edition contains the consolidation of the revised MH1.1.2, MH1.4M (formerly MH1.4.1M), MH1.6, and MH1.7M standards. All of the documents contained in this Edition of the Standard were approved by ANSI as American National Standards on July 16, 1996.

The first addenda to this Edition added the remaining four standards to be consolidated into MH1. Part 2, the revised MH1.2.2, was approved by ANSI on August 6, 1998. Part 3, the revised MH1.8, was approved on August 6, 1998. Part 4, the revised MH1.9, was approved on January 30, 1998. Part 8, the revised MH1.5M, received approval on August 6, 1998. In addition, the military-specific Part 9, entitled "Wood Pallets for U.S. Government Use," was developed by the MH1 Committee in response to the Government's need to use voluntary standards. This final Part was approved by ANSI on February 4, 1999.

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ASME STANDARDS COMMITTEE MH1
Standardization of Pallets, Slip Sheets, and Other Bases for Units Loads

(a)

(The following is the roster of the Committee at the time of approval of this Standard.)

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PREFACE (a)

(This Preface is not part of ASME MH1-1997.)

ORGANIZATION OF THIS DOCUMENT

This Standard is arranged in Parts, and these Parts incorporate the requirements of previously published standards identified below:

ASME MH1-1997	Previous Designator	Title
Part 1	ASME MH1.1.2-1996 (Revision of ASME MH1.1.2-1989)	Definitions and Terminology Covering Pallets and Related Structures
Part 2	Revision of ASME MH1.2.2M-1989	Sizes of Wood Pallets
Part 3	Revision of ASME MH1.8M-1996	Wood Pallets
Part 4	Revision of ASME MH1.9-1993	Export Pallets
Part 5	ASME MH1.7M-1996 (Revision of ASME/ANSI MH1.7M-1988)	Driven Fasteners for Assembly of Pallets and Related Structures
Part 6	ASME MH1.6-1996 (Revision of ASME/ANSI MH1.6-1987)	Determination of Durability of Wood Pallets and Related Structures
Part 7	ASME MH1.4M-1996 (Revision of ASME MH1.4.1M-1989)	Testing Procedures for Pallets and Related Structures
Part 8	Revision of ASME MH1.5M-1993	Slip Sheets
Part 9	New	Wood Pallets for U.S. Government Use

CORRESPONDENCE

Suggestions for improvement of this Standard are welcome and should be sent to the following address: Secretary of the MH1 Committee, ASME, Three Park Avenue, New York, NY 10016-5990.

ADDENDA SERVICE

This Edition of ASME MH1-1997 includes an automatic addenda subscription service up to the publication of the next edition. The addenda subscription service will include the additional MH1 documents not already contained in the initial publication and approved revisions to the existing Parts.

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PART 1
DEFINITIONS AND TERMINOLOGY COVERING PALLETS AND RELATED STRUCTURES

1 SCOPE

Part 1 provides definitions and terminology associated with the construction and use of pallets and related structures, such as skids and pallet containers.

2 PURPOSE

The purpose of Part 1 is to provide generally accepted definitions and terminology that serve as the basis for common understanding when describing pallets and related structures and their use.

(a) 3 REFERENCED STANDARDS

The following standards were reviewed during the preparation of Part 1:

ASME MH1.1.2-1989, Definitions and Terminology Covering Pallets and Related Structures
ASME MH1.4.1-1989, Procedures for Testing Pallets
ASME/ANSI MH1.6-1987, Standard Procedures for Determination of Durability of Wooden Pallets and Related Structures
ASME/ANSI MH1.7M-1988, Driven Fasteners for Assembly of Pallets and Related Structures
ASME MH1.8M-1996, Wood Pallets
ASME MH1.9-1993, Export Pallets

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990

ASTM D 1185-1994, Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping
ASTM F 680-1980 (1993), Test Methods for Nails
ASTM F 1575-1995, Test Method for Determining Bending Yield Moment of Nails
ASTM F 1667-1995, Specifications for Driven Fasteners: Nails, Spikes, and Staples
ASTM E 380-1993, International System of Nails, The Modern Metric System

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, Conshohocken, PA 19428-2959

ISO 445-1996, Pallets for Materials Handling — Vocabulary
ISO 6780-1988 (1994), General-Purpose Flat Pallets for Through Transit of Goods — Principal Dimensions and Tolerances
ISO 8611-1995, General-Purpose Flat Pallets for Through Transit of Goods — Test Methods. Performance Requirements, Design Rating, and Maximum Working Load. Determination of Joint Strength
ISO/DIS 12777-1-1994, Methods of Test for Pallet Joints With Mechanical Fasteners — Pallet Nails, Other Dowel-Type Fasteners, and Staples — Determination of Bending Resistance, Testing for Shank Withdrawal and Head Pull-Through Resistance

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1211, Genèva 20, Switzerland/Suisse

NWPCA-1994, Uniform Voluntary Standard for Wood Pallets

Publisher: National Wooden Pallet and Container Association (NWPCA), 1800 North Kent Street, Arlington, VA 22209-2104

Fiber Box Handbook-1987

Publisher: Fiber Box Association, 8725 Higgins Road, Chicago, IL 60631

4 DEFINITIONS AND TERMINOLOGY

accuracy: degree of agreement between specified value and that actually obtained.

adhesive: material capable of adhering one surface to another, such as plies of solid fiberboard, facings of corrugating medium in combined corrugated board, overlapping sides of container, and flaps in closing container as well as unit load to pallet deckboards or deck.

all-way entry pallet: see *pallet, all-way entry.*

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aluminum pallet: see *pallet, aluminum.*

analysis: determination of level of performance.

annularly threaded nail or *annular nail:* see *nail, annularly threaded* or *nail, annular.*

assembled pallet: see *pallet, assembled.*

assembly: process of connecting components to form an integral structure.

banding notch: see *strap slot.*

base: structural assembly designed to support unit load.

base pallet: see *pallet, base.*

basis weight, containerboard: see *containerboard, basis weight.*

bearer: see *stringer*; bearer (the preferential term in some British Commonwealth countries).

bearing surface: interface between pallet elements and components, such as deckboard and stringer or stringerboard or cross stringer of corrugated pallet. Also, interface between pallet top deck and unit load supported by pallet, such as complete top deck for uniformly distributed unit load or partial top deck for concentrated unit load. Also, interface between pallet bottom deck and pallet-supporting area. Also, interface between bottom deck of stacked pallet and palletized unit load supporting stacked pallet.

bevel: see *chamfer.*

bevel, sawn: missing edge along wood component, resulting from sawing or planing.

beveled deckboard: see *deckboard, chamfered.*

bias: systematic error in test results; contributing to difference between population mean of test results.

bin: multi-sided superstructure to be mounted on pallet base, with or without cover; also known as box or container.

bin pallet: see *pallet, bin.*

biodegradable: material property resulting in deterioration due to such environmental factors as exposure to moisture, oxygen, and bacterial action.

block: rectangular, square, multisided, or cylindrical deck or deck-mat spacer between top and bottom decks or beneath top deck of single-deck pallets, often identified by its location within pallet as corner block, end block, edge block, inner block, center or middle block; post.

block dimensions: length measured in direction of pallet length; width measured in direction of pallet width; height measured in direction of pallet height; not related to grain direction of block.

block pallet: see *pallet, block.*

block size: stated in terms of width followed by height and length.

blow molding: see *molding, blow.*

board: wood member sawn and dressed on its four sides, less than 50 mm (2 in.) in nominal thickness.

board, corrugated: see *corrugated board.*

board, water-resistant: sized board, treated with water-repellant material, to have a degree of resistance to damage or deterioration by water.

bolt: fastener with coarse thread along shank at end opposite square or hexagonal head, provided with washers and nut; to be inserted in oversize predrilled hole.

bolted pallet: see *pallet, bolted.*

bottom deck: assembly of elements comprising lower face of pallet; bearing surface of pallet; with construction being unidirectional, overlap (two-directional), and of perimeter or cruciform design (see *pallet classification*).

bottom deckboard: see *deckboard, bottom.*

box: see *bin*; also, container with solid or closely fitted sides, ends, bottoms, and top made of wood, metal, plastic, fiberboard, paperboard, or foamed or cellular plastic, completely and securely enclosing box contents.

box pallet: see *pallet, bin.*

bracket: angle-shaped support or connection fastened to components to be tied together.

bursting strength: material strength, in $lbf/in.^2$, as measured with Cady or Mullen tester.

butted deckboard: see *deckboard, butted.*

CAD: computer-assisted design.

CAD pallet software: tool to design pallet for specified use conditions.

cage pallet: see *pallet, cage.*

caliper: sheet thickness, in thousandths of inch, with 0.001 in. often called "point."

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Part 2
Sizes of Wood Pallets

(a)

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PART 2
SIZES OF WOOD PALLETS

1 SCOPE

Part 2 of this Standard provides a series of the most common sizes of wood pallets recommended as bases for assembling, storing, stacking, handling, and transporting goods as unit loads.

2 PURPOSE

The main objective of Part 2 of this Standard is the attainment of a minimum number of sizes of wood pallets, which provide the maximum efficiency, economy, interchangeability, and flexibility when used in the U.S.A. and worldwide.

3 SIZES

(a) The definitions of pallet sizes shall be in accordance with Part 1 of this Standard, Definitions and Terminology Covering Pallets and Related Structures.

(b) Tolerances of $\pm^1/_4$ in. (6 mm) are permissible on the overall dimensions.

(c) The most commonly used sizes of wood pallets, among the more or less than 100 sizes currently used in the U.S.A., are listed in Part 2, Table 1, with their dimensions given in inches and arranged according to the reported frequencies of use.

(d) Criteria for the establishment of the most common sizes are given in Appendix A2-A.

(e) Metric equivalents and recommended international pallet sizes are listed in Appendix A2-B, to assist users of this Standard in the selection of pallet sizes.

(f) To reduce potential misunderstandings, nominal pallet sizes, in millimeters, as given in Appendix A2-B for the most common pallet sizes listed in Part 2, Table 1, should not be used in pallet specifications.

(g) Comparisons of the utilization percentages of the floor area of selected common carriers are given in Appendix A2-C for current pallet sizes listed in this Standard. These percentages are valid for pallets with no load overhang.

TABLE 1 WOOD PALLET SIZES MOST COMMONLY USED IN THE U.S.A.

Sizes, in.	1996 Production, %
48 x 40	30.0
42 x 42	5.7
48 x 42	4.7
40 x 48	4.0
48 x 48	3.7
44 x 44	3.5
40 x 40	3.1
36 x 36	3.0
36 x 48	1.7

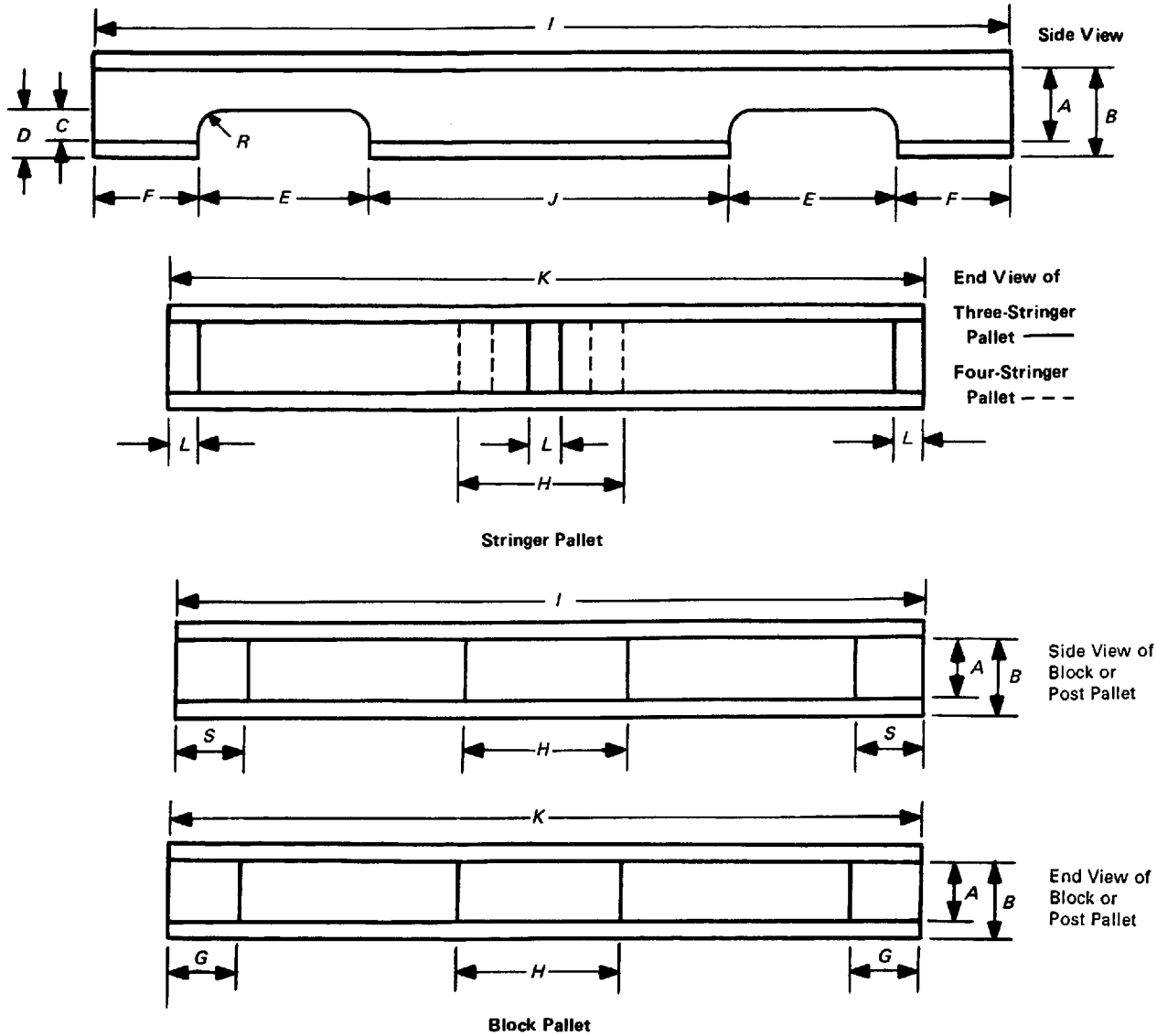
GENERAL NOTE:
The 95% confidence limits are ±3.4 % around the mean data.

4 DIMENSIONS

Dimensions common to 48 x 40 in. (1219 x 1016 mm) wood pallets produced in the U.S.A. during 1996 are given in Part 2, Fig. 1.

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A = $3\frac{1}{2}$ in. (89 mm) min. to $3\frac{3}{4}$ in. (96 mm) max.
B = $4\frac{3}{16}$ in. (106 mm) min.
C = $1\frac{1}{4}$ in. (32 mm) min. to $1\frac{1}{2}$ in. (38 mm) max.
D = $1\frac{7}{8}$ in. (48 mm) min.
E = 9 ($\pm\frac{1}{4}$) in. [229 (±6) mm]
F = 6 ($\pm\frac{1}{4}$) in. [152 (±6) mm]
G = 5 in. (127 mm) max.
H = 6 in. (152 mm) max.
I = 48 ($\pm\frac{1}{4}$) in. [1219 (±6) mm] for 48 X 40 in. pallet
J = 18 ($\pm\frac{1}{4}$) in. [457 (±6) mm] for 48 X 40 in. pallet
K = 40 ($\pm\frac{1}{4}$) in. [1016 (±6) mm] for 48 X 40 in. pallet
L = $1\frac{1}{4}$ in. (32 mm) to $1\frac{1}{2}$ in. (38 mm)
R = $\frac{3}{4}$ ($\pm\frac{1}{16}$) in. [19 (±2) mm] to $1\frac{1}{2}$ ($\pm\frac{1}{16}$) in. [38 (±2) mm]
S = 4 ($\pm\frac{1}{4}$) in. [101.6 (±6) mm] to 8 ($\pm\frac{1}{4}$) in. [203.2 (±6) mm]

FIG. 1 DIMENSIONS COMMON TO 48 x 40 in. (1219 x 1016 mm) WOOD PALLETS PRODUCED IN THE U.S.A.

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NONMANDATORY APPENDIX A2-A
CRITERIA

(This Appendix is not part of Part 2 of ASME MH1-1997, and is included for information purposes only.)

A1 USE

Pallets are used to assemble, store, stock, handle, and transport a wide variety of shapes, sizes, and kinds of goods and materials as unit loads in various facilities with different types of equipment and in all types of transport carriers.

A2 BENEFITS

Pallets, properly selected and applied in distribution systems, may result in benefits which improve service from grower/producer to consumer/user, reduce costs, improve inventory control, and decrease damage and loss.

A3 STANDARD SIZES

Standards for the most common pallet sizes should, consistent with the above-mentioned uses, result in attaining a minimum number of pallet sizes in common use. Standard sizes must be adequate and comprehensive for current overall conditions, and be adaptable to changing methods and equipment. Provisions must be made for the efficient use not only of a single size but also of combinations of sizes.

A4 NONCAPTIVE PALLETS

Noncaptive pallets should be of common standardized sizes.

A5 ADAPTABILITY

Pallet sizes should be adaptable to the widths and lengths of warehouse stacks, rail, highway, and ocean carriers, and combinations of these carriers.

A6 EFFECTS OF DENSITY

Utilization of available volume or cube of storage facilities and carriers becomes economically significant when low-density materials and products are shipped. For instance, if the density of materials and products and the pallets shipped on land carriers is 20 lb/ft^3 (320 kg/m^3) or less, the size of the pallet selected and the height of the load may be an economic consideration to freight forwarders, shippers, and consumers. If the density is 40 lb/ft^3 (640 kg/m^3) or higher, the pallet unit loads will usually be stowed one high. In the latter case, filling of the entire carrier cube becomes of lesser importance.

A7 DETERMINATION OF APPROPRIATE PALLET SIZE(S)

The total storage, handling, and distribution cycle should determine the size(s) of the most common pallet(s) to be used. Transportation is only a part of the total flow cycle of materials and goods. The influence of the nine most common pallet sizes on the utilization of the floor area of commonly used carriers is shown in Appendix A2-C for the case when the unit load does not overhang beyond the pallet sides and ends.

A8 MOST COMMON WOOD PALLET SIZES

The nine most common wood pallet sizes in use during 1996 cover dimensions from 36 to 48 in. (914 to 1219 mm). These dimensions should accommodate many requirements commonly encountered.

A9 SELECTION CRITERIA

The selection of the nine most common wood pallet sizes is based on the most common sizes fabricated in the U.S.A. during 1996, as shown in Part 2, Table 1.

A10 EVALUATION OF 1996 PRODUCTION SURVEY

The 1996 pallet production quantities for given pallet sizes are based on the 1997 survey by the National Wooden Pallet and Container Association (NWPCA) of its membership. A total of 155 usable responses

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were received and evaluated by the U.S. Forest Service's Northeastern Forest Experiment Station in Princeton, WV. The 155 respondents represent an estimated 10% of the total production of new wood pallets during 1996. Responses for individual sizes are weighted by the total amount of wood pallets produced by each manufacturer to arrive at the average for each sample.

A11 COMPARISON OF 1985 AND 1996 PRODUCTION SURVEYS

The 1985 production listed in Appendix A2-A, Table A1 is not fully comparable with the 1996 data shown in Part 2, Table 1, since the two surveys were based on slightly different questionnaires and the data was evaluated using different statistical procedures. However, the overall ranking of the sizes of new wood pallets produced can be considered representative of the production.

A12 DEPARTMENT OF FORESTRY OF SOUTHERN ILLINOIS SURVEYS

The Department of Forestry of Southern Illinois University (SIU) undertook surveys of U.S. pallet manufacturing during 1980, 1985, and 1990. During the 1990 survey, 3222 U.S. pallet manufacturers were contacted, resulting in 865 usable returns. The observed ranking of pallet sizes produced during those years is shown in Table A2 of Appendix A2-A. Consistently, in the NWPCA and USI surveys, the 48 x 40 in. and 40 x 48 in. pallet sizes were found to be the most frequently produced. They accounted for more than one-third of all wood pallets produced.

Table A1 Wood Pallet Sizes Most Commonly Used in U.S. During 1985, %

48 x 40 and 40 x 48	36.4
48 x 42 and 42 x 48	5.8
36 x 48 and 48 x 36	3.8
48 x 48	2.7
42 x 42	2.7
40 x 40	2.4
30 x 30	2.1
35 x 47	1.7
46 x 46	1.3
36 x 36	1.2
48 x 78	1.2
44 x 44	0.9

Table A2 Ranking of U.S. Production of New Wood Pallets by Size During 1980, 1985, and 1990 (According to Surveys by Southern Illinois University, Carbondale, IL 62901-4411)

Size	1990	1985	1980
48 x 40	1	1	1
42 x 42	2	2	4
40 x 48	3	3	3
48 x 42	4	4	7
48 x 48	5	5	2
36 x 36	6	6	5
40 x 40	7	7	8
42 x 48	8	8	10
36 x 48	9	9	6
44 x 44	10	10	9

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NONMANDATORY APPENDIX A2-B
COMPARABLE METRIC DIMENSIONS OF MOST COMMONLY USED PALLET SIZES

(This Appendix is not part of Part 2 of ASME MH1-1997, and is included for information purposes only.)

When pallets are to be used in international trade, consideration should be given to the specific sizes recommended in the International Organization for Standardization (ISO) Standard 6780 (December 1988), General Purpose Flat Pallets for Through Transit of Goods—Principal Dimensions and Tolerances, as amended during 1994. The four pallet sizes included in this ISO Standard are listed below:

1200 x 1000 mm (European Industrial—UK and Continental Europe)

1200 x 800 mm (European Pallet Pool—Continental Europe)

1140 x 1140 mm (Australia and Pacific Area)

1219 x 1016 mm and 1016 x 1219 mm (48 x 40 in. and 40 x 48 in.) (North America)

NOTE: Pallets of sizes deviating from the above four sizes, but within the dimensional deviations from the unit loads defined in ISO 3676, will not be rejected on the basis of the International Standard sizes, e.g., 1100 X 1100 mm, the Japanese Standard pallet size. Furthermore, pallets with special 89 mm vertical entry will not be rejected on the basis of this International Standard.

TABLE B1 COMPARABLE METRIC DIMENSIONS OF MOST COMMONLY USED PALLET DIMENSIONS

Inches	Nearest Whole Millimeters	Nominal Millimeter Size
48	1219	1200
42	1067	1050
40	1016	1000
36	914	900
45	1143	1150
44	1118	1100
42	1067	1050

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NONMANDATORY APPENDIX A2-C
UTILIZATION OF FLOOR AREA OF COMMON CARRIERS, WITH NO LOAD OVERHANG ON PALLET

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Table C1 follows on next page.

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TABLE C1 UTILIZATION BY COMMON PALLET SIZES OF FLOOR AREA OF COMMON CARRIERS, WITH NO LOAD OVERHANG ON PALLET

Pallet Size, in. (mm)	40 x 8 ft Truck Trailer and Freight Container Approx. Inside Dimension 92 x 474 in.	48 x 8½ ft Truck Trailer and Freight Container Approx. Inside Dimension 96 x 570 in.	28 x 8½ ft Twin Trailer and Freight Container Approx. Inside Dimension 96 x 330 in.	40½ and 50½ x 9½ ft Railroad Boxcar and Freight Container Approx. Inside Dimension	
				110 x 486 in.	110 x 606 in.
48 x 48 (1219 x 1219)	47.5%	92.6%	87.4%	86.2%	83.9%
Number of Pallets on Floor	9	22	12	20	24
48 x 42 (1219 x 1069)	87.8%	95.8%	89.1%	86.7%	84.7%
Number of Pallets on Floor	19	22	14	23	28
40 x 48 (1219 x 1016)	92.5%	98.2%	97.0%	86.2%	86.5%
Number of Pallets on Floor	21	28	16	24	30
36 x 48 (1219 x 914)	87.2%	94.7%	98.2%	97.0%	93.3%
Number of Pallets on Floor	22	30	18	30	36
44 x 44 (1118 x 1118)	88.8%	84.9%	85.6%	79.7%	75.5%
Number of Pallets on Floor	20	24	14	22	26
42 x 42 (1067 x 1067)	89.0%	83.8%	78.0%	72.6%	74.1%
Number of Pallets on Floor	22	26	14	22	28
40 x 40 (1016 x 1016)	80.7%	81.9%	80.8%	71.8%	72.0%
Number of Pallets on Floor	22	28	16	24	30
36 x 36 (914 x 914)	77.3%	71.1%	73.6%	94.6%	93.3%
Number of Pallets on Floor	26	30	18	30	48

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NONMANDATORY APPENDIX A2-D
REFERENCED DOCUMENTS

(This Appendix is not part of Part 2 of ASME MH1-1997, and is included for information purposes only.)

The following documents were reviewed during the preparation of Part 2:

MH1.2.2M-1989, Pallet Sizes

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, New York 10016-5990

ISO 6780-1988/1994, General Purpose Flat Pallets for Through Transit of Goods—Principal Dimensions and Tolerances

ISO 3676-1983, Packaging — Unit Load Design — Dimensions

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1211, Genèva 20, Switzerland/Suisse

McCurdy, D. R., and J. E. Phelps, 1992. Trends in the U.S. Pallet Industry 1980, 1985 and 1990 (Forest Products Journal 42(1)2 25-27)

Publisher: Forest Products Society, 2801 Marshall Court, Madison, Wisconsin 53705-2295

West, Cynthia D., 1997. Analysis of NWPCA 1997 Wooden Pallet Size Survey

Publisher: USDA Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia 24740

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Part 3
Wood Pallets

(a)

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PART 3
WOOD PALLETS

Subpart I
Prescriptive Standard

I-1 SCOPE

Part 3 of this Standard applies to all lumber-deck and panel-deck pallets, either new or repaired, as well as the lumber components, panels, and fasteners. Criteria contained in this Standard are applicable only at the completion of manufacture and repair.

This Standard is presented in three parts: Subpart I is the Prescriptive Standard, which concerns the manufacture of the pallet. This Subpart includes pallet and pallet-component descriptions, fastener descriptions, workmanship criteria, dimensional tolerances, markings, and moisture-content levels. Subpart II is the Performance Standard, which concerns the functionality of the pallet. This Subpart contains references to the testing of physical and computer models to assist manufacturers, distributors, and users to determine the performance level of a specified pallet. Use of the Performance Standard is required for new pallet constructions, along with conformance to Subpart I, the Prescriptive Standard. Subpart III covers the Quality Assurance Auditing Program.

This Part does not describe established special requirements for export pallets, Enhanced Wood® pallets, and phytosanitary pallets, and does not address the safety problems, if any, associated with the use of wood pallets. It is the responsibility of the user of this Part to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.

To assist the user of Part 3, other related standards are listed in Appendix A3-D.

In any dispute regarding dimensions of components or defects, the U.S. Customary Units are governing.

I-2 PURPOSE

The purpose of Part 3 of this Standard is to establish nationally recognized minimum quality requirements for the principal types of wood pallets and to provide a basis for common understanding among manufacturers, repairers, distributors, and users of wood pallets.

I-3 CLASSIFICATIONS

I-3.1 Classes

(a) Class 1. Stringer pallet [see Fig. 1, sketch (a)].
(b) Class 2. Block pallet [see Fig. 1, sketch (b)].

I-3.2 Use Categories

Category 1, Multiple-Use (M): pallet designed for repeated uses for more than one unit load with an average minimum "life-to-first-repair" (LFR) of ten trips, or more, assuming an average of five handlings per trip and an average handling environment as defined in the Pallet Design System (PDS) (see Part 3, para. II-3.2); also known as a returnable pallet, reusable pallet, permanent pallet, general-purpose pallet, special-purpose pallet, special-service pallet, or through-transit pallet.

Category 2, Limited-Use (L): pallet designed for an average of up to nine trips, with an average of five handlings per trip and an average handling environment as defined in the Pallet Design System (PDS), before first repair, i.e., life-to-first-repair (LFR) (see Part 3, paras. I-4, I-9, and II-3.2); also known as a single-trip pallet, one-trip pallet, one-way pallet, expendable pallet, shipping pallet, or general-service pallet.

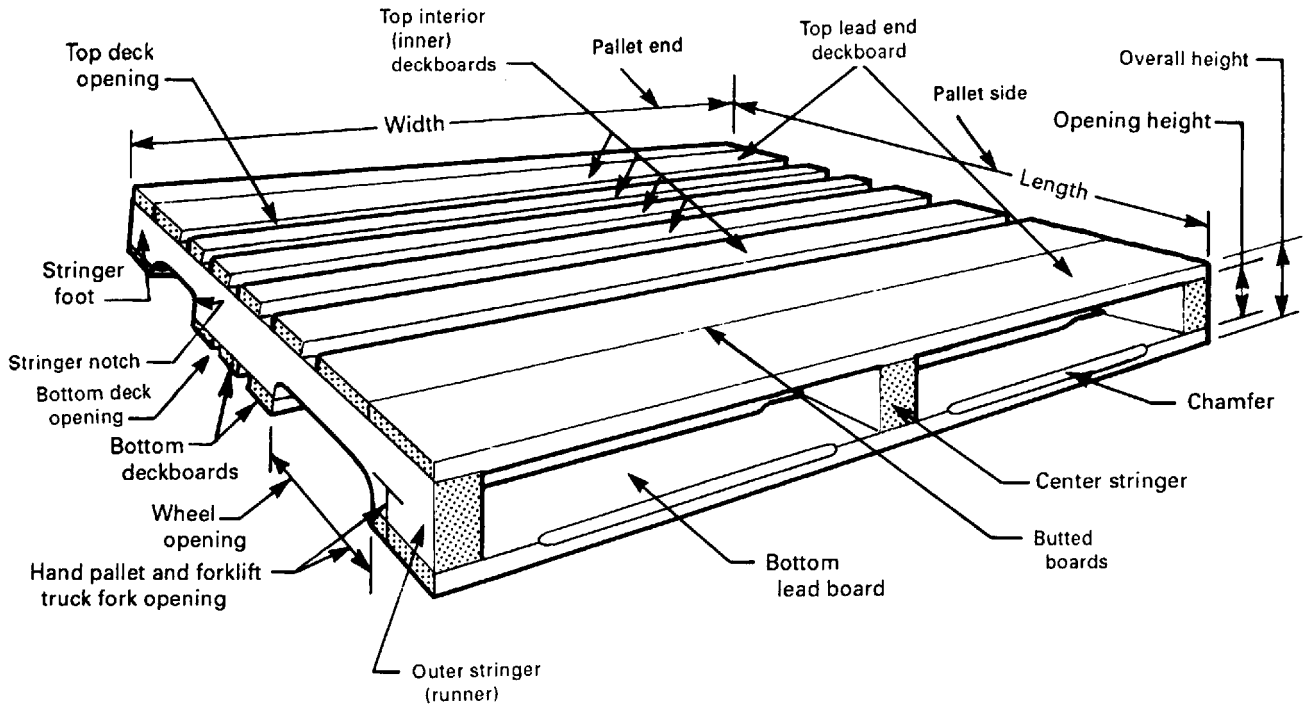
I-3.3 Types

Type 1: two-way entry pallet with openings accepting handling equipment only in two pallet ends, i.e., unnotched stringer pallet.

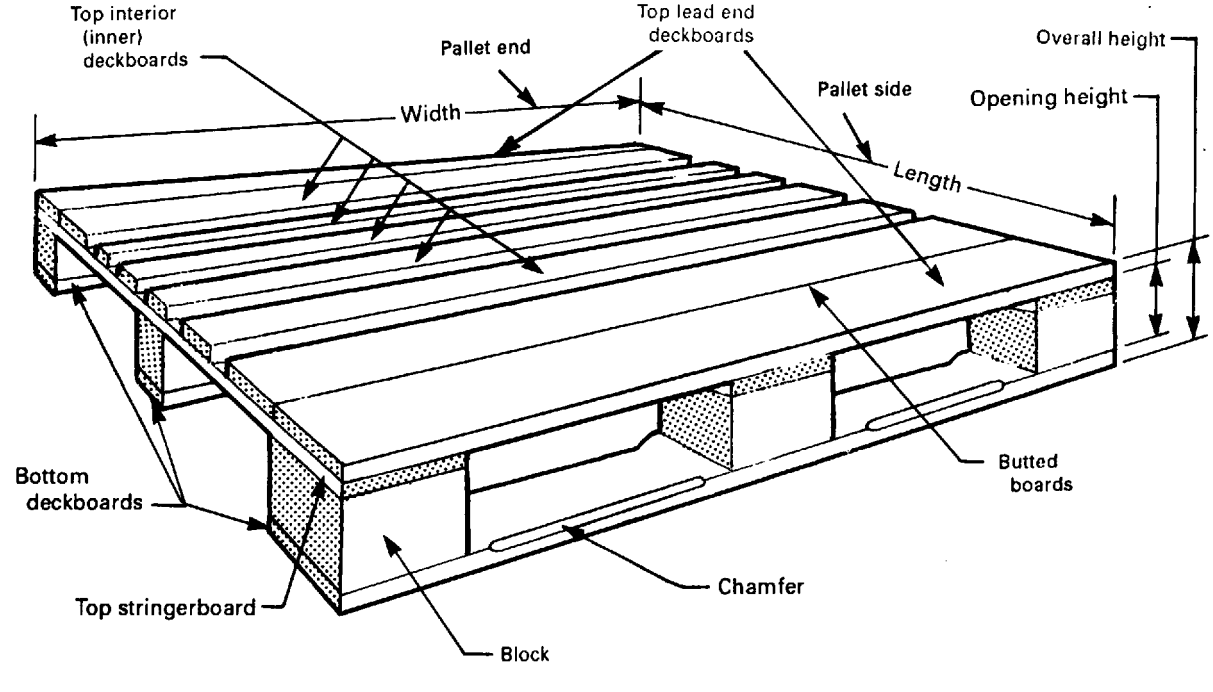
Type 2: partial four-way entry pallet with openings at both ends and sides with limited accessibility of the openings to common handling equipment, i.e., notched

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(a)



(b)

FIG. 1 SCHEMATIC DIAGRAMS OF TYPICAL STRINGER (U.S. GOVERNMENT CLASS 1, TYPE 2, STYLE 2) [SKETCH (a)] AND BLOCK (U.S. GOVERNMENT CLASS 2, TYPE 3, STYLE 2) [SKETCH (b)] CLASS PALLETS, WITH PRINCIPAL PARTS LABELED

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stringer pallet and block pallet with overlapping bottom stringerboards and bottom deckboards or panels.

Type 3: full four-way entry pallet with openings at both ends and sides with accessibility of all openings not limited to standard handling equipment, i.e., block pallets with perimeter boards, unidirectional, without bottom deckboards, or panel bottom decks with cutouts.

I-3.4 Styles

All decks with spaced or butted boards and/or butted end boards or panels.

Style 1	Single-deck (face), flush, nonreversible pallet.
Style 2	Double-deck (face), flush, nonreversible pallet.
Style 3	Double-deck (face), flush, reversible pallet.
Style 4	Single-deck (face), single-wing, nonreversible pallet.
Style 5	Double-deck (face), single-wing, nonreversible pallet.
Style 6	Double-deck (face), double-wing, nonreversible pallet.
Style 7	Double-deck (face), double-wing, reversible pallet.
Style 8[1]	Single-deck (face), single-cantilever top and bottom stringerboards, flush, nonreversible pallet.
Style 9[1]	Single-deck (face), single-cantilever, single-wing, nonreversible pallet.
Style 10[1]	Double-deck (face), single-cantilever, flush, nonreversible pallet.
Style 11[1]	Double-deck (face), single-cantilever, single-wing, nonreversible pallet.
Style 12[1]	Double-deck (face), single-cantilever, double-wing, nonreversible pallet.
Style 13[1]	Double-deck (face), double-cantilever, single-wing, nonreversible pallet.
Style 14[1]	Double-deck (face), double-cantilever, double-wing, nonreversible pallet.
Style 15[1]	Double-deck (face), double-cantilever, double-wing, reversible pallet.

I-3.5 Bottom-Deck Constructions

Bottom Deck 1: unidirectional bottom deckboards oriented in the direction of the pallet length or width only.

[1] Styles of block class pallets, in which stringerboard overhang end blocks.

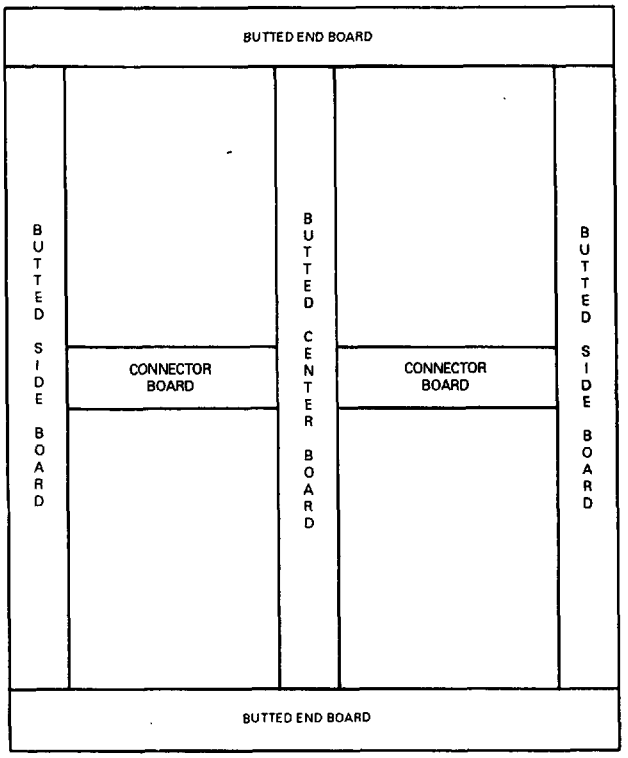


FIG. 2 COMPONENT NAMES FOR PERIMETER AND CRUCIFORM BOTTOM-DECK CONSTRUCTIONS, WITH BOTTOM-DECK COMPONENTS LOCATED IN ONE PLANE

Bottom Deck 2: overlapping bottom boards oriented in both directions of the length and width of the pallet containing both bottom deckboards and bottom stringerboards.

Bottom Deck 3: perimeter bottom deckboards oriented in both directions of the length and width of the pallet, containing butted side and end boards (see Part 3, Fig. 2).

Bottom Deck 4: cruciform bottom deckboards oriented in both directions of the length and width of the pallet, containing butted boards, end boards, and connector boards (see Part 3, Fig. 2) or panels with cutouts (see Part 3, Fig. 3).

I-3.6 Sizes and Designs

Each of the classified pallets is available in many sizes and designs. Therefore, size and design details need to be specified.

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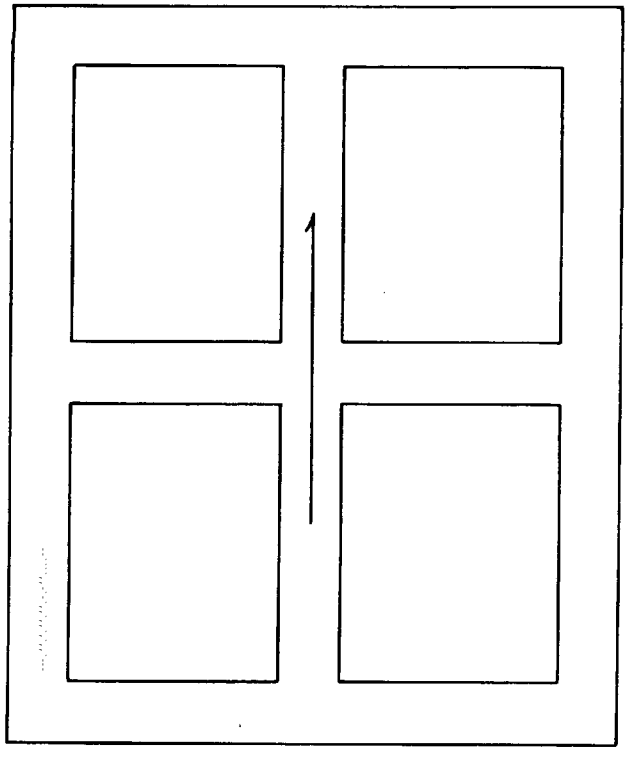


FIG. 3 PANEL BOTTOM DECK SHOWING CUTOUTS

I-4 DEFINITIONS AND TERMINOLOGY

Definitions and terminology that are included in Part 1 of this Standard apply to Part 3.

For definitions covering defects which affect the quality of pallet components, see Appendix A3-B.

Notch Area: a region around stringer notches with special defect limitations (see Part 3, Fig. 4.

Pallet Design System (PDS): for wood pallets, reliability-based computer-assisted design (CAD) procedure for determination of safe load-carrying capacity, performance, and economic life of wood and wood-based stringer and block pallets (see Part 3, para. II-3.2).

pallet length: dimension between the extreme pallet ends, parallel to and corresponding to the length of the stringers or top stringerboards; for panel deck block pallets, it is the top deck panel dimension parallel to the strong panel axis (face grain for plywood); refers to first dimension when describing pallet size.

pallet size: overall dimension of pallet, stated in terms of length, followed by width and height.

pallet width: pallet dimension between extreme pallet sides, parallel to and corresponding to the length of top deckboards; for panel deck block pallets, it is the top panel deck dimension perpendicular to the strong panel axis (face grain for plywood); refers to second dimension when describing pallet size.)

panel: a structural panel, either plywood or oriented strand board (OSB).

shiner: fastener shank or leg protruding from side of fastening member.

stringer: continuous, longitudinal, solid, built-up, or notched beam component of pallet, supporting and spacing deck components, often identified by its location as outer, side, edge, interior, or center stringer, bearer, runner (the preferential terms in some British Commonwealth countries).

stringerboard: continuous, solid, board member extending for full length of pallet, perpendicular to deckboard members and placed between deckboards and blocks, to serve as support of deckboards or deck.

stringerboard size: stated in terms of thickness, followed by width and length.

stringer size: stated in terms of width, followed by height and length.

I-5 MATERIALS

The materials used for pallet manufacture shall be in conformance with the requirements outlined in Subpart III, para. III-1.2.

I-5.1 Lumber Components

I-5.1.1 Species. The species of woods used in pallet manufacture are numerous. As an aid to the pallet designer, Appendix A3-A contains a classification of many commercially available woods listed according to similarities in mechanical properties, regional availability, and commercial use in pallets.[2] When specifying wood pallets, the wood species permissible in the structure can be indicated by the species class numbers given in Appendix A3-A.

[2] Details concerning the development of these wood-species classifications are found in McLeod, J.A., 1985, "Development of Flexural Values for Pallet Shock," M.S. Thesis, Department of Wood Science and Forest Products, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0503.

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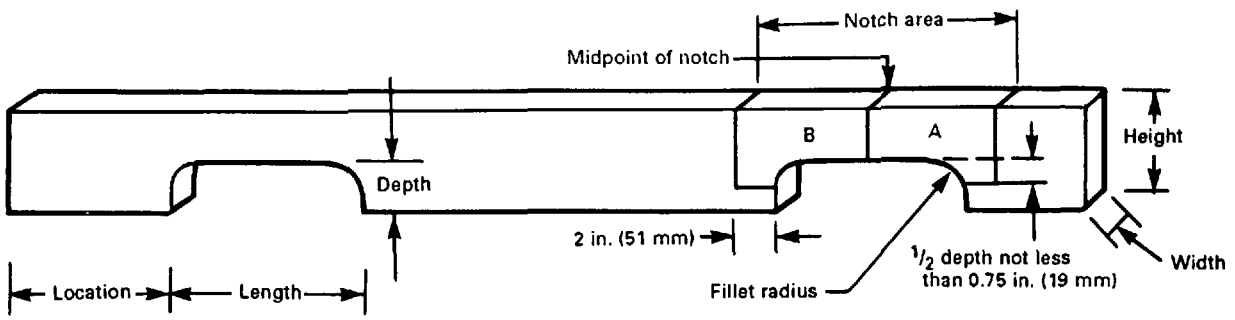


FIG. 4 SCHEMATIC DIAGRAM OF A PALLET STRINGER WITH NOTCH FEATURES INDICATED

I-5.1.2 Quality of Wood Pallet Components. Pallet components shall meet or exceed the minimum quality indicated by the growth-related defect limitations contained in Part 3, Table 1 and the manufactured defect limitations specified below. Descriptions and definitions of the defects in Part 3, Table 1 can be found in Appendix A3-B.

step: otherwise called saw (arbor) mismatch; not to exceed $\frac{1}{32}$ in. (0.75 mm) on exposed face of components.

bevel sawing: acceptable if no more damaging than allowable wane of allowable size tolerance for deckboards, stringerboards, stringers, and blocks.

manufactured (unintentional) hole: same as *unsound knot* (see Table 1 and para. I-6.1.2 of Part 3).

saw cuts: same as *unsound knot* (see Table 1 and para. I-6.1.2 of Part 3).

I-5.1.3 Moisture Content of Components. The moisture content of pallet components is not limited.

I-5.1.4 Preparation of Pallet Components

I-5.1.4.1 Component Dimensions. Wood components shall have a target thickness and width uniform in dimension and 50% of components shall meet or exceed the target dimension at the time of component manufacture. Based on current Good Manufacturing Practices (GMP), the target thickness of deckboards and stringerboards may deviate $\pm\frac{1}{32}$ in. (±0.75 mm). The target width and height of stringers and blocks may exceed the specified dimensions by a maximum of $\frac{1}{8}$ in. (3 mm) and $\frac{1}{4}$ in. (6 mm), respectively.

The following are acceptable manufacturing tolerances allowed on established target dimensions:

Deckboards and Stringerboards

Thickness: $\pm\frac{1}{16}$ in. (±1.5 mm) maximum deviation [including target deviation of $\pm\frac{1}{32}$ in. (±0.75 mm)]

Width: + narrower than Bin (205 mm), $-\frac{1}{4}$ in. (−6 mm) maximum deviation

Length: $+\frac{1}{8}$ in. (+3 mm), $-\frac{1}{4}$ in. (−6 mm) maximum deviation

Stringers and Blocks

Width: $\pm\frac{1}{16}$ in. (±1.5 mm) maximum deviation

Height: $\pm\frac{1}{16}$ in. (±1.5 mm) maximum deviation

Length: $+\frac{1}{8}$ in. (+3 mm), $-\frac{1}{4}$ in. (−6 mm) maximum deviation

Conformance to these manufacturing tolerances for components and pallets can be expressed using standard statistics reflecting variations equal to or less than those permitted in this Standard. Two standard deviations from target size shall be less than the tolerances specified.

I-5.1.4.2 Deckboard Chamfer. The deckboard chamfers, if specified, shall be located on both outside faces of bottom end boards and all interior edges of bottom boards adjoining wheel openings. The chamfers shall be at least 12 in. (305 mm) long and at an angle between 35 deg to 45 deg located $\frac{1}{4}$ in. (6 mm), $\pm\frac{1}{8}$ in. (±3 mm) from the bottom of the board. Chamfers shall not extend into connections.

I-5.1.4.3 Stringer Notches. Notches in stringers, if required, shall be specified by location (distance from stringer end), depth, and length (see Part 3, Fig. 4). The recommended opening sizes to be provided by the notch and the bottom deck, if present, are 2 in.

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TABLE 1 MINIMUM PALLET COMPONENT QUALITY

Defect	Description	Defect Limitations	
		Multiple-Use (M) [Note (1)]	Limited-Use (L) [Notes (2) and (3)]
Sound knots [Note (4)]	Maximum portion of the cross-section affected	1/2	7/8
Frequency of knots	Number of maximum size knots per component	2 in 6 in. (153 mm) of length	1 in every 1/2 length of component
Unsound knots and holes [Note (5)]	Maximum portion of the cross-section affected [Note (6)]	1/4	2/3
Wane	Maximum portion of the actual deckboard or stringerboard width by thickness (full length) [Notes (6) and (9)]	1/4 × 2/3 (exposed) [Note (8)] 1/3 × 2/3 (non-exposed) [Note (8)]	3/8 × full thickness (exposed) [Notes (7) and (8)] 1/2 × full thickness (non-exposed) [Notes (7) and (8)]
	Maximum portion of the actual stringer and block width and height (full length) [Notes (6) and (9)]	1/3 × 1/2 [Note (8)]	5/8 × 2/3 [Note (8)]
Decay	Maximum portion of the cross-section affected [Note (10)]	1/4	1/4
Splits/shakes [Note (11)]	Maximum portion of deckboards, stringerboards, stringers, and blocks length (L) or width (W)	Deckboards 1/3 L Stringerboards 1/3 L Stringers [Note (12)] Horizontal—less than 2 in. (51 mm) or 2 × W Vertical—same Block 1/2 L	Full length Less than full length Less than 4 in. or 2 × W 1/2 L 1/2 L
Slope-of-grain	Maximum deviation along deckboard, stringerboard, or stringer length	1 in. (25 mm) in 4 in. (102 mm) of length	1 in. (25 mm) in 4 in. (102 mm) of length

NOTES:

(1) This minimum quality description corresponds to all PDS Grades except 4, 7, 13, and 15 (see Part 3, para. II-3.2).

(2) This minimum quality description corresponds to all PDS Grades (see Part 3, para. II-3.2).

(3) This quality is limited to use for deckboards and stringerboards 5/8 in. (17 mm) thick, or greater, and stringers or blocks 1 1/4 in. (38 mm) wide, or greater. Limited-Use (L) pallets with deckboards and stringerboards less than 5/8 in. (17 mm) thick or stringers or blocks less than 1 1/4 in. (38 mm) in width shall meet or exceed the Multiple-Use (M) quality level.

(4) Sound knots are limited in any portion of the notch area "B" (see Part 3, Fig. 4) to 1/3 of the net cross-section above the notch, and in any portion of notch area "A" to 1/2 the net cross section above the notch.

(5) Unsound knots (decay within knot) or holes are limited to 1/4 of the net cross-section above the notch in areas "A" and "B" (see Part 3, Fig. 4).

(6) Provided the average width of the wood is not less than 1/4 of the actual width of the component.

(7) Full thickness of wane on non-exposed surfaces is permitted in no more than 2 pieces per pallet.

(8) Fasteners driven through maximum wane or decay shall be compensated (Part 3, para. I-6.1.3).

(9) In the notch area the wane shall be limited to 1/3 of the stringer width and 1/3 of the height above the notch. No wane shall be permitted in or below the notch fillets within the notch area (see Part 3, Fig. 4).

(10) No decay (outside of unsound knot) is allowed over or within 2 in. (51 mm) of the ends of the stringer notches.

(11) See definition of splits in Appendix A3-B.

(12) Not allowed in the notch area (see Part 3, Fig. 4).

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(50 mm) to the top of the notch and 9 in. (230 mm) in length with a minimum flat surface of 7 in. (180 mm) recommended for the notch top. Notches shall have rounded or filleted corners with a radius not less than $\frac{1}{2}$ in. (13 mm), nor greater than $1\frac{1}{2}$ in. (18 mm). Square notches are not acceptable. Manufacturing tolerances shall be $\pm\frac{1}{8}$ in. (±3 mm) of actual specified dimensions, except for the notch location which shall be within $\pm\frac{3}{8}$ in. (±9.5 mm) of target.

I-5.2 Wood Panel (Plywood or OSB) Components

I-5.2.1 Quality of Panel Components. Panels shall conform to the latest edition of one of the following standards:

(1) U.S. Product Standard PSI-83 for Construction and Industrial Plywood, 1983 American Plywood Association, Tacoma, Washington.

(2) Voluntary Product Standard PS2-92 Performance Standard for Wood Based Structural Use Panels, American Plywood Association, Tacoma, Washington.

(3) Performance Standards and Policies for Structural Use, Panels APA PRP-108, 1994 American Plywood Association, Tacoma, Washington.

(4) Performance Standard and Policies for Structural Use, Panels PRP-133 PFS/TECO, Madison, Wisconsin.

Each panel deck piece shall be identified with the appropriate trademark of a recognized grading agency (see Appendix A3-D). If this is not practical, the firm supplying the panels shall furnish certification that the original panels were trademarked.

All panels used for pallet components shall be bonded with exterior (fully water-resistant) adhesive.

Panels that exceed the delamination limits of standards listed in this section as a result of their manufacturing process are not permitted to be used for new or repaired pallets.

5.2.2 Grade of Panel Components. Unless specified otherwise by the purchaser, panels for panel decks shall be either Rated Sheathing, Exposure 1, or Rated Sturd-I-Floor, or similar product, Exposure 1. Exterior is an acceptable alternative to Exposure 1. Panels of any grade are used to fabricate laminated pallet blocks.

I-5.2.3 Preparation of Panel Components

I-5.2.3.1 Panel Component Dimensions. Panel decks for block-class pallets shall consist of a single piece. Panel decks for stringer-class pallets shall be oriented with the plywood face grain (strong panel axis) perpendicular to the stringers, and may consist of more than one piece, provided the minimum width (perpendicular to plywood face grain or strong panel axis) of any piece is 24 in. (610 mm) or greater, and the panel joints are perpendicular to the stringers.

Wood panel components shall have a target thickness and width uniform in dimension, and 50% of the components shall meet or exceed the target dimension at the time of component manufacture. Based on current Good Manufacturing Practices (GMP), the target thickness tolerance of panel decks and plywood strip bottom deckboards may deviate $\pm\frac{1}{32}$ in. (±75 mm).

Blocks are laminated from panel components. The target width, length, and height of finished panel component blocks may exceed the specified dimensions by a maximum of $\frac{1}{8}$ in. (3 mm). Sides shall not deviate from being square to the block top or bottom by more than $\frac{1}{8}$ in. (3 mm), and any deviation from square shall not be in addition to the target width and length.

The face grain of plywood strip bottom deckboards shall run in the direction of the deckboard length. OSB strips are not permitted to be used as bottom deckboards.

The following are acceptable manufacturing tolerances allowed on established target dimensions:

Panel Decks and Plywood Strip Bottom Deckboards

Plywood strip bottom deckboards and panel areas around cutouts shall be not less than 6 in. (150 mm) wide. The following tolerances are applicable:

Thicknesses:	$\pm\frac{1}{32}$ in. (±0.75 mm) maximum deviation
Length and Width:	$\pm\frac{1}{8}$ in. (±3 mm)

Laminated Blocks (including individual laminations)

The following tolerances are applicable:

Width:	$\pm\frac{1}{8}$ in. (±3 mm) maximum deviation
Height:	$\pm\frac{1}{16}$ in. (±1.5 mm) maximum deviation
Length:	$\pm\frac{1}{8}$ in. (3 mm) maximum deviation

Conformance to these manufacturing tolerances in components and pallets can be expressed using standard statistics reflecting variations equal to or less than those permitted in this Standard. Two standard deviations from target size shall be less than the tolerances specified.

I-5.2.3.2 Panel-Decks and Plywood-Strip Bottom-Deckboard Chamfer. The deckboard chamfers, if specified, shall be located on both outside faces of bottom end boards and all interior and exterior edges of panel bottom decks along wheel openings. The

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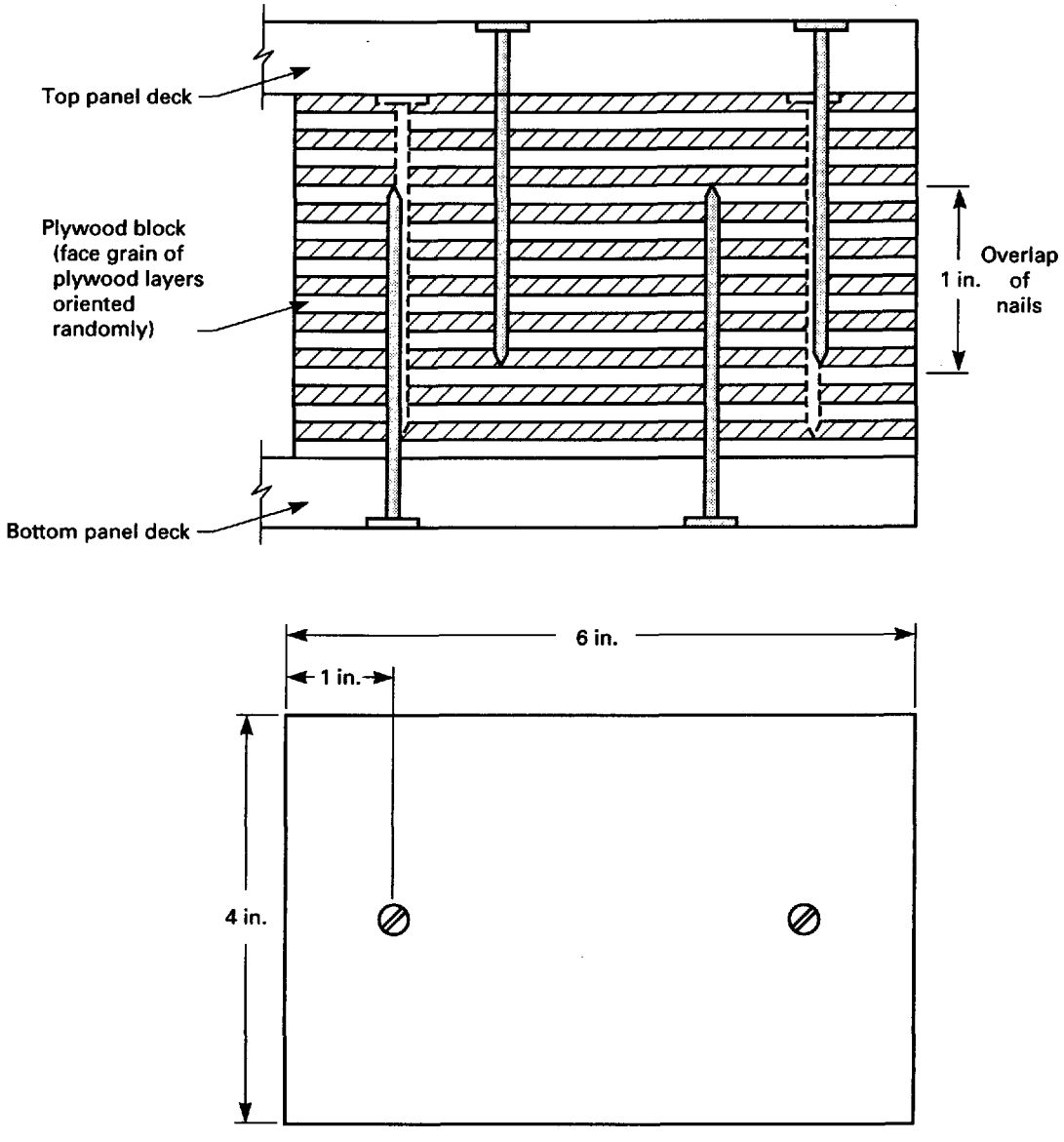


FIG. 5 SCHEMATIC DIAGRAMS SHOWING THE LAMINATION OF PLYWOOD PALLET BLOCKS AND THEIR FASTENINGS

chamfers shall extend the full width of the openings, and shall be at an angle of 35 to 45 deg located $^1/_4$ in. (6 mm), $\pm^1/_8$ in. (±3 mm) from bottom of deck or board.

I-5.2.3.3 Laminated Pallet Blocks (Part 3, Fig. 5). Pallet blocks are laminated from solid wood or panel components using either fasteners or adhesives. In the latter, a water-resistant adhesive shall be used and applied according to manufacturers' recommendations.

I-5.3 Fasteners

Fasteners are classified as driven nails and staples, bolts, wood screws, and lag bolts. The properties of the fasteners used dramatically affect pallet performance.

I-5.3.1 Driven Fasteners. Driven fasteners include nails and two-legged staples. As used in pallets, nails are classified as plain-shank, helically threaded, annularly threaded, fluted round wire, or twisted square wire.

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TABLE 2 PHYSICAL AND MECHANICAL CHARACTERISTICS OF DRIVEN FASTENERS USED IN PALLETS [Note (1)]

Nails [Note (2)]				Staples	
Plain Shank	Helically Threaded	Annularly Threaded	Fluted/Square Wire	Round Wire	Squared Wire
Length	Length	Length	Length	Length	Length
Wire diameter	Wire diameter	Wire diameter	Wire diameter	Wire diameter	Wire width / wire thickness
Head diameter	Head diameter	Head diameter	Head diameter	Crown length Crown width	Crown length Crown width
...	Thread length	Thread length	...	...	...
...	Thread-crest diameter	Thread-crest diameter	Flute-crest diameter	...	...
...	Number of helixes	Number of rings	Number of helixes	...	...
...	Number of flutes	...	Number of flutes	...	...
MIBANT angle [Notes (3) and (4)]	MIBANT angle	MIBANT angle	MIBANT angle	MIBANT angle	MIBANT angle

NOTES:
(1) ASTM F 680-92, Standard Test Methods for Nails, Volume F 16.06. American Society For Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
(2) Nail heads shall be flat or slightly countersunk in shape. Nails shall have no point or a blunt point, not to exceed $^5/_{32}$ in. (4 mm) in length. For chisel-point nails, the point width shall not exceed the wire diameter.
(3) When the MIBANT test is performed, not more than 8% of the fasteners shall show partial or complete shank failure.
(4) MIBANT angles are measured according to procedures contained in ASTM F 680-93, Standard Test Methods for Nails, Volume F16.06. Publisher: American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2989.

Staples have either round-wire or approximately square wire legs, referring to the cross-sectional shape of the wire. All driven fasteners shall be specified using either of three methods:

(a) direct measurement of the physical and mechanical characteristics indicated in Table 2 and Fig. 6 of Part 3;

(b) the Fastener Shear and Fastener Withdrawal Indexes (FSI and FWI); and

(c) the Fastener Code (see Part 5).

The fastener length shall be sufficient to provide a minimum penetration of $1^1/_4$ in. (32 mm) into the stringer or block for all deckboard thicknesses over $^1/_2$ in. (13 mm) and a minimum penetration of 1 in. (25 mm) for deckboard thicknesses of $^1/_2$ in. (13 mm) or less. Mat fasteners shall be of such a length that they penetrate the stringerboard sufficiently to allow point clinching. Manufacturing tolerances shall conform to those specified in Part 5. The minimum acceptable quality of driven fasteners is specified in Part 3, Table 3. To assist the pallet designer, physical descriptions of fasteners meeting the performance criteria in Part 3, Table 3 are contained in Appendix A3-C, Tables C1, C2, and C3.

I-5.3.2 Bolts. For bolted constructions, standard steel carriage bolts are used in any one of three styles—standard, slotted, or large head. Unless otherwise specified, these bolts shall be furnished in the course-thread series, Class 2, free fit.[3] When ordinary standard commercial carriage bolts are employed, a washer under the head of the bolt shall be used if specified. If bolts with fin construction under the head are specified, instead of carriage bolts, washers under the head shall be deleted. Washers shall be located under the bolt nut.

The sizes of the holes drilled through deckboards and stringerboards into stringers or blocks shall be $^1/_{32}$ in. (0.75 mm) larger in diameter than the bolt diameter for bolts less than $^1/_2$ in. (13 mm) in diameter. For $^1/_2$ in. (13 mm) or larger diameter bolts, the hole shall be $^1/_{16}$ in. (1.5 mm) larger.

When two or more bolts are connecting green members, the oversizing of holes shall be twice that specified above.

The head- and nut-bearing surfaces shall be washer faced with a flat or lock washer as specified. If "Tee-

[3] Soled, J. 1957, Fastener Handbook, Reinhold Publishing Corporation, New York, NY, pp. 430.

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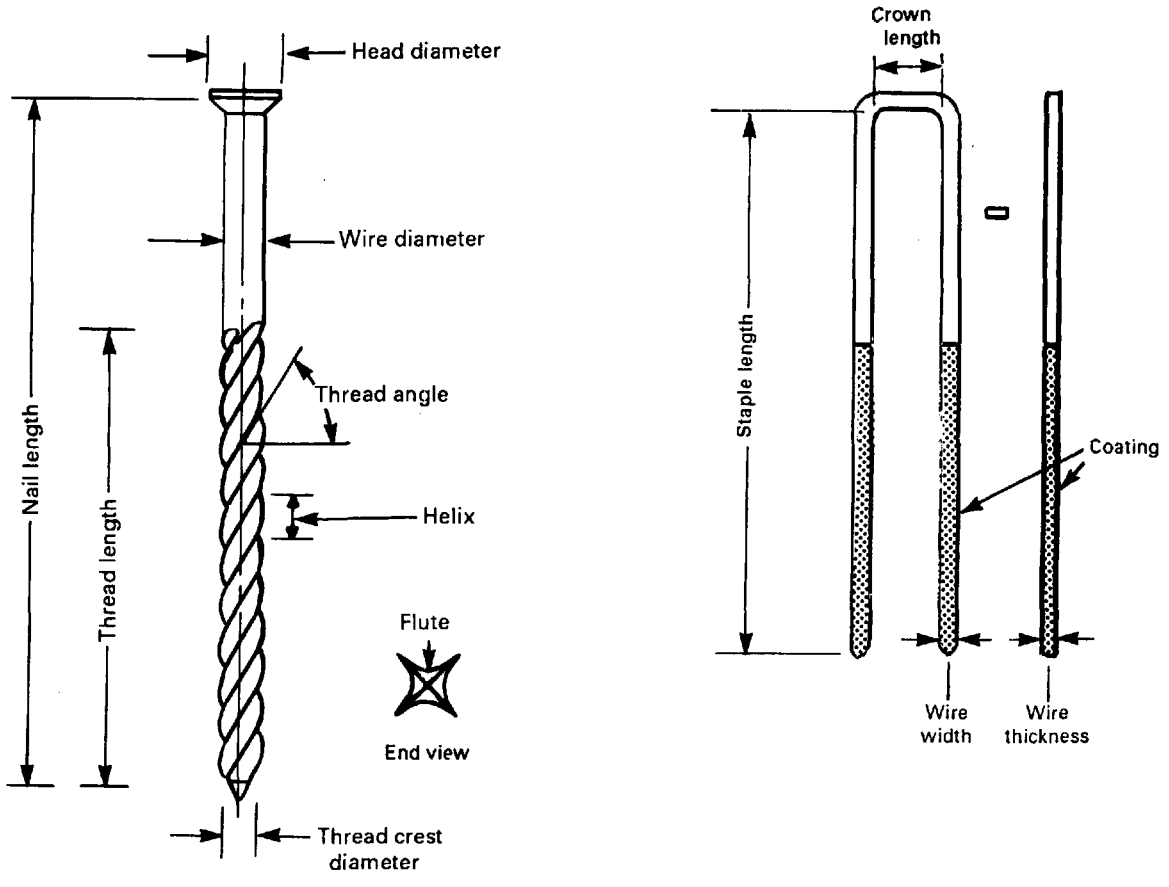


FIG. 6 SCHEMATIC DIAGRAM OF DRIVEN FASTENERS USED IN PALLETS, INDICATING THE MEASUREMENTS OF THE PHYSICAL CHARACTERISTICS INCLUDED IN TABLE 2

Nuts," or equivalent, are specified, washers below the head shall be deleted.

The correct bolt sizes, or their equivalent, for the various pallet loads are as follows:

Load per Pallet	Size of Bolt
0 to 2500 lbf (0-11.1 kN)	1/4 in. (6 mm)
2501 to 4000 lbf (11.2-17.8 kN)	5/16 in. (8 mm)
Over 4000 lbf (17.8 kN)	3/8 in. (9.5 mm)

I-5.3.3 Wood Screws and Lag Bolts. Screws and lag bolts, provided with cut or rolled, single or double threads along two-thirds of their shank length, shall be inserted into the pallet components to be assembled with a screwdriver or screw-motion machine tool. Over-driving and over-tightening of the connection shall be avoided. 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. Where lag bolts are used, washers under the head of the bolts shall be used.

I-6 MANUFACTURE

The pallet manufacturing practices shall be in conformance to the requirements specified in Subpart III, para. III-1.

I-6.1 Location of Defects

For definitions, see Appendix A3-B.

I-6.1.1 Sound Knots. Fasteners may be driven through sound knots.

I-6.1.2 Unsound Knots and Holes. Fasteners shall be compensated when associated with unsound knots or holes. Unsound knots or holes shall not be permitted in the outer edge of end boards, or on the exposed ends of stringers or blocks.

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TABLE 3 MINIMUM QUALITY OF DRIVEN FASTENERS [Note (1)]

	Minimum Depth of Penetration in Fastening Member	Minimum Fastener Withdrawal Index (FWI)		Minimum Fastener Shear Index (FSI)		Minimum Ratio of Nail Head/Shank Diameter		Minimum Staple Crown Length
		Multiple Use (M)	Limited Use (L)	Multiple Use (M)	Limited Use (L)	Multiple Use (M)	Limited Use (L)	
Block or stringer fasteners	1.25 in. (32 mm) [Notes (2) and (3)]	65	50	55	40	2.25	2.00	0.375 in. (9.5 mm) [Note (4)]
Clinched mat fasteners [Note (5)]	Completely through the fastened and fastening members and clinched	25	20	25	20	2.00	2.00	0.375 in. (9.5 mm) [Note (4)]

NOTES:

(1) Driven fasteners or their equivalent per connection as determined by comparison of the Fastener Withdrawal Resistance (FWR), Fastener Shear Resistance (FSR), and Fastener Head or Crown Pull-Through Resistance (HPR) multiplied by the minimum number of fasteners per connection in Part 3, para. I-6.2.4.1.

(2) For fasteners with deformed shanks, the entire portion of the shank in the block or stringer shall be threaded.

(3) For Limited-Use (L) pallets with ½ in. (12 mm) thick, or thinner, deckboards, the minimum penetration depth shall be 1 in. (25 mm).

(4) Acceptable in both Multiple-Use (M) and Limited-Use (L) pallets.

(5) When non-clinched mat fasteners are used, the Minimum Fastener Withdrawal Index (FWI) shall be 60 and the minimum depth of penetration into the fastening member shall be 0.625 in. (16 mm).

I-6.1.3 Wane and Decay of Wood. Wane and decay of wood are permitted on any component, provided they are not located on the outer edge of endboards, on the exposed sides of stringers or blocks.

Use of decayed wood is discouraged. Decay of wood is not permitted in the notch area (see Part 3, Fig. 4).

Wane is permissible on the surface or edge of other components, but in no case shall fasteners be driven into or through either defect. Not more than one-third (33%) of the components in a pallet may contain wane. Any fastener associated with maximum wane shall be compensated.

I-6.1.4 Splits and Shakes. Splits and shakes running the full thickness of a component (not applicable to nail splits) shall be straddled with fasteners in the top and bottom end deckboards and butted side bottom deckboards.

I-6.1.5 Panel Components. Knots, knotholes, splits in individual veneers, and other voids may not significantly affect the strength and stiffness of plywood panels having a minimum dimension of 24 in. (600 mm). For widths less than 24 in. (600 mm), the plywood face shall not have knots, plugs, or open defects (knotholes and splits) that aggregate more than one-fourth the width of either face ply at any cross-section of the piece.

I-6.2 Assembly

I-6.2.1 Wood-Component Placement. The placement of wood components shall be as follows.

(a) All leading deckboards shall be within ±¼ in. (±6 mm) of their specified location.

(b) Other wood components shall be within ±½ in. (±13 mm) of their specified location, except that bottom boards shall not extend into the stringer notch.

(c) Unless otherwise specified, lead deckboards and ends of deckboards shall be flush with the stringer. All allowable deviations under Part 3, para. I-6.2.1 are subject to the overall pallet-size criteria in Part 3, para. I-6.2.2.

Maximum placement deviation shall be limited to one-third of the components in any pallet. All similar components shall be placed parallel unless otherwise specified.

I-6.2.2 Pallet-Size Deviation. The pallet size shall be limited to +¼ in. (+6 mm) and −½ in. (−13 mm) of the target dimension, as measured at specific points along the pallet length and width. The pallets must be

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TABLE 4 MINIMUM NUMBER OF DRIVEN FASTENERS

Deckboard Width	Minimum Number of Fasteners per Connection of Limited-Use (L) or Multiple-Use (M) Pallets [Note (1)]
Up to 5¼ in. (133 mm)	2
5¼ up to 7 in. (133 to 178 mm)	3
7 to 8 in. (178 to 203 mm)	4
Corner Block	3 [Note (2)]
Interior Block	2

NOTES:

(1) No less than one nail or staple per 8 sq in. (512 mm^2) of block fastening surface.

(2) Corner blocks with less than 16 sq in. (1032 mm^2) of block fastening surface shall be connected with at least two (2) fasteners.

flat on their top and bottom surfaces to within ¼ in. (6 mm) maximum deviation from the corner-to-corner straight line.

I-6.2.3 Squareness. Square or rectangular pallets shall be limited to 1.5% or 1 in. (25 mm) difference in the measured length of the two principal top-deck diagonals of square part of pallet, whichever is greater.

I-6.2.4 Fastenings (Mechanical Fasteners)

I-6.2.4.1 Fastening Schedules

(a) Nails and Staples. The minimum number of driven fasteners per pallet-component is specified in Part 3, Table 4.

(b) Bolts, Wood Screws, and Lag Bolts. If nails or staples are not used for pallet assembly, the end deckboards shall have at least two bolts, wood screws, or lag bolts, per corner connection and at least one at all other connections. If a combination of different fasteners is used, they shall be selected in such a way that they ensure effective simultaneous overlapping. It is recommended that bolts shall be retightened at the time the connected components reach equilibrium moisture content (EMC) during the use of the pallet.

If nails or staples are not used for block assembly, panel-deck block pallets shall have at least one bolt per block. The bolt shall be centered in a round block. Bolted blocks that are not round shall have at least one additional pallet assembly fastener per block to prevent block rotation.

I-6.2.4.2 Fastener Placement. Fasteners shall be placed in such a way as to minimize splitting of the connected components. Bolts shall be located near the center of bolted round blocks. Staple crowns shall not be parallel to the grain of the deck components. A combination of the various fastener types in a single connection shall not be permitted if they do not interact effectively; that is, simultaneously contribute to the stiffness and strength, or both, of the connection. For example, bolts in oversize holes and driven fasteners represent a poor combination and cannot be expected to work in unison. They shall not be placed in the same connection or different connections of an assembly.

I-6.2.4.3 Clinching Points of Driven Fasteners. Clinched fasteners shall be at least ¼ in. (6 mm) longer than the sum of the thicknesses of the components being fastened and driven in such a manner as to prevent buckling of the fastener under the head or crown.

I-6.2.4.4 Fastener-Caused Splits. Open splits with visible fastener shanks or legs shall be limited. No more than one open split with a visible fastener shank or leg per connection shall be permitted and not more than one-third of the components per pallet shall contain open splits with visible fastener shanks or legs at the completion of manufacture.

I-6.2.4.5 Protruding Fasteners. Nail heads, staple crowns, bolt heads, nuts, and screw heads shall be flush with or below deck surfaces. Countersinking fastener heads and protruding fastener points shall not significantly affect pallet performance. No protruding fastener points (shiners) shall be permitted on the exposed face of outside stringers or blocks or in lead deckboard areas. Two protruding fasteners on unexposed surfaces are permitted so long as they do not significantly affect pallet performance. Protruding fastener points are not permitted when using non-clinched fasteners to attach deckboards to stringerboards in block class pallets. Fasteners not driven into stringers and blocks shall be compensated.

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I-6.2.5 Fastening With Chemical Adhesives and Glues. Adhesives and glues shall only be used in conjunction with mechanical fasteners conforming to Part 3, para. I-5.3.

I-6.2.6 Laminated Block Fastening Schedule. Laminated blocks shall be assembled with a minimum of two fasteners driven through either face conforming to the quality requirements of Part 3, Table 3. They shall be equal in length to the block height [$-\frac{1}{2}$ in. (13 mm) if countersunk $\frac{1}{4}$ in. (6.5 mm)] (see Part 3, Fig. 5).

I-7 PALLET REPAIR

I-7.1 Purpose and Scope

This section defines the general classifications for pallet repairs. Detailed repair requirements are described. Pallets needing repair are of two distinct requirement groups; therefore, each group receives different repair treatments.

Properly repairing and recycling wood pallets yields increased efficiencies and results in long-range cost reductions to pallet users. The purpose of this section is to simplify the many variables inherent to pallet repair by establishing useful definitions and to give assurance of consistent quality of repair to the user.

NOTE: No specific level of pallet performance is assured when meeting the requirements of this section about repair.

Proper use of this section requires compliance with the requirements that specify the markings of repaired pallets.

I-7.1.1 Multiple-Use (Category M) Pallets, M-R Repair. This category covers special-service pallets whose original manufacturing specification are known, and the repair is required to maintain a similar performance quality. The original pallet met durability requirements for multiple use and was classified and originally marked as a Multiple-Use Longer-Life Pallet.

I-7.1.2 Limited-Use (Category L) Pallets, R Repair. This category (the most common category) covers pallets with their original specification unclear or those pallets failing to meet Multiple-Use criteria. These general-service (Category L, Limited-Use) pallets shall have their specification established by visual inspection before repair can commence.

I-7.2 Sizes and Types of Pallets

This section is applicable to all lumber-deck and panel deck, stringer, and block pallets as described in Part 3, para. I-3.

I-7.3 Repair Classifications

I-7.3.1 Repair of Multiple-Use (M) Pallets, M-R Repair. Repair of special-service pallets, with known original manufacturing specifications, made to Category M as new pallets, are defined as M-R repairs and are detailed in Part 3, para. I-7.5.

I-7.3.2 Repair of Limited-Use (L) Pallets, R Repair. The R repair designation is intended for pallets which meet the requirements of this Standard, are not repaired to M-R repair standards, fulfill the requirements of the pallet repair section, and cover repairs to all other pallets.

R-1 Component replacement with similar elements is allowed.

The following types of repair concern stringer pallets only:

R-1P Component replacement and appropriate proper stringer metal plating are allowed (see Part 3, para. I-7.7).

R-2 Single full- or half-companion stringer and metal plating are allowed.

R-3 Multiple half stringer companions and metal plating are allowed.

The types of R repairs are fully defined in Part 3, para. I-7.6.

I-7.4 Markings for Repaired Pallets

Approved marking devices include stencils, brands, and ink jet printers.

(a) The marking shall include the following information:

(1) type of repair;

(2) repairer's identification number (i.e., 123);

(3) date of repair (if applicable);

(4) pallet identification number (optional).

(b) A unique pallet identification number may be required (see Part 3, para. III-1.3). Indicating the date of repair is optional. Space permitting, the mark shall be a minimum of 2 in. (50 mm) high, with letters 1 in. (25 mm) high.

(c) The designation M-R shall be used for pallets repaired according to para. I-7.5. The designations R-

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1, R-1P, R-2, and R-3 shall be used for pallets repaired according to para. I-7.6.

(d) After the first pallet repair, the repair mark, indicating the type of repair made, shall be placed adjacent to the original pallet mark (which shall not be obliterated). For subsequent repairs, previous repair marks shall be obliterated by spray painting over the previous mark with white paint, and applying a new mark stenciled on the pallet in black. If required, the new mark shall show MH1 Part 3 (and M or L), the type of repair, the repairer's identification number, and the date of repair.

(e) The pallet shall be re-marked and the previous marks obliterated if any one or more of the following conditions exist:

(1) the pallet is repaired to a different repair type;

(2) the mark becomes illegible;

(3) the pallet is repaired by a different repairer or manufacturer from that who applied the previous marking.

I-7.5 M-R Type Repair for Multiple-Use (M) Pallets With Known Original Manufacturing Specifications

These pallets were special-service Multiple-Use (M) pallets and originally marked as M pallets.

I-7.5.1 Repair of Multiple-Use (M) Pallets, M-R Repair. M-R repair shall use only *new* material. Any component may be replaced.

I-7.5.2 Component Species, Quality, and Size Accuracy for M-R Level Pallet Repairs. All materials and fasteners are as defined for specific pallets under Part 3, paras. I-5 and I-6. Any nonconforming components shall be removed and replaced.

(a) Lumber. Components shall meet or exceed the grade and species group (see definitions in Part 1) for M type repairs. For both M-category new pallets, and the M-R type repairs, the lumber-quality levels shall be equal or exceed the M requirements in Part 3, paras. I-5 and I-6. Any nonconforming components shall be removed and replaced.

(b) Panels. Components shall meet or exceed the grades shown in Part 3, para. I-5.2.2 for M type repairs. For both M category new pallets, and the M-R type repairs, the panel quality levels shall equal or exceed the "M" requirements in Part 3, paras. I-5 and I-6. Any nonconformant components shall be removed and replaced.

(c) Fasteners. The fasteners used for all M-R repair shall meet the minimum requirements for Multiple-Use pallets as described in Part 3, para. I-5.3. Examples of fasteners and corresponding schedules, meeting the minimum performance requirements in para. I-5.3.1 and Table 3 of Part 3, are given in Appendix A3-C, Tables C1 to C3.

I-7.5.3 Allowable Damage, M-R Repair. Each pallet component has allowable levels of damage that may remain unrepaired. However, not more than 20% of components shall have damage at the maximum limit allowed.

All broken or cracked components (see Part 3, Fig. 7) and those with unacceptable damage shall be removed and replaced. All the exposed fasteners shall be clipped, removed, or driven-in to provide a flush surface. Any component with damage defined as unacceptable for this type of repair shall be repaired or removed and replaced.

All dimensions quoted below refer to 48 × 40 in. (1219 × 1016 mm) pallets. For pallets of different sizes, the given dimensions shall be proportioned relative to the relevant length. The allowable damage limits apply to all species.

(a) Any existing undamaged or damaged component, which does not meet the specification grade or species standard, shall be replaced.

(b) Any existing component that does not meet the specification size standard shall be replaced.

(c) All missing components shall be replaced.

I-7.5.3.1 Splits (See Part 3, Fig. 8). Multiple splits in any one component are not allowed. Allowed splits are permitted in any part of a component. The maximum split dimensions allowed in components are listed as follows.

(a) Top and bottom deckboards: 1/3 the length and 1/8 in. (3 mm) wide, full thickness.

(b) Stringers

(1) Horizontal splits shall be less than 4 in. (102 mm) or 2 × width in length and 1/8 in. (3 mm) wide.

(2) Vertical splits are defined as splits if the separation is deeper than 1/2 of the height. In that case, the length is limited to less than 4 in. (102 mm). If the vertical separation is less than 1/2 of the height, the length is unlimited (see definitions in Appendix A3-B).

(c) Stringerboards: 1/3 of the length and 1/8 in. (3 mm) wide, full thickness.

(d) Blocks: a split is defined when the separation is deeper than 1/2 of the dimension. In that case, the split

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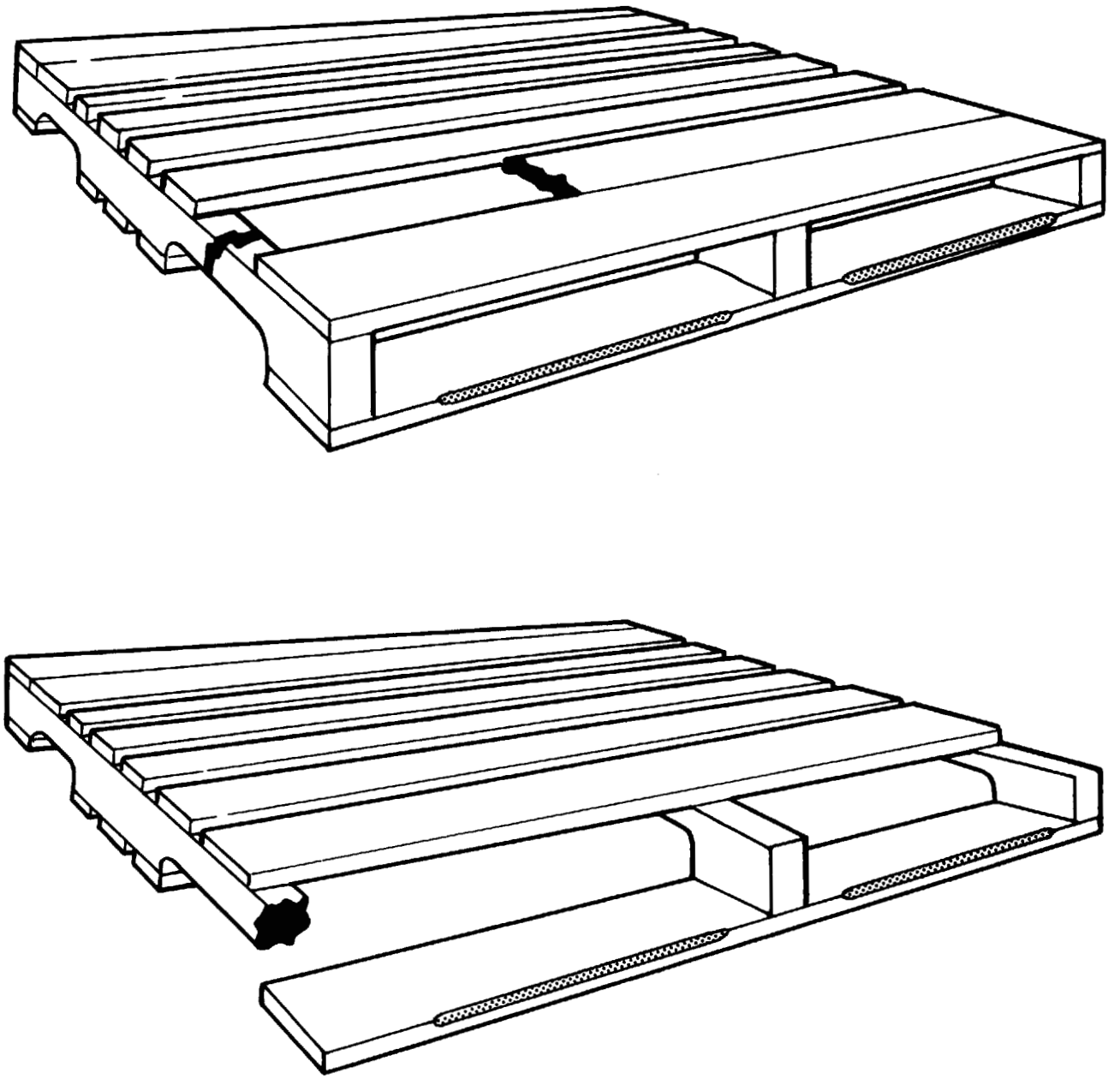


FIG. 7 ALL DECKBOARDS, STRINGERBOARDS, AND STRINGERS BROKEN ACROSS FULL WIDTH, THICKNESS, OR HEIGHT TO BE REPLACED

is limited to ½ of the block length. If the separation is less than ½ of the dimension, the split length is unlimited (see definitions in Part 1).

I-7.5.3.2 Missing Wood (See Part 3, Fig. 9). Only one section of missing wood, up to the maximum size allowed, is permitted for any component. Missing wood that leaves a nail freestanding from the remaining board and, thus, weakens the connection is unacceptable. The maximum amount of missing wood and its dimensions are listed as follows.

(a) Top and bottom deckboards

(1) more than ½ in. (13 mm) of the full length; or

(2) a tapered part of a missing component all the way back to the fastener and running straight to the edge of the board at its center; or

(3) any part of a component of rectangular shape

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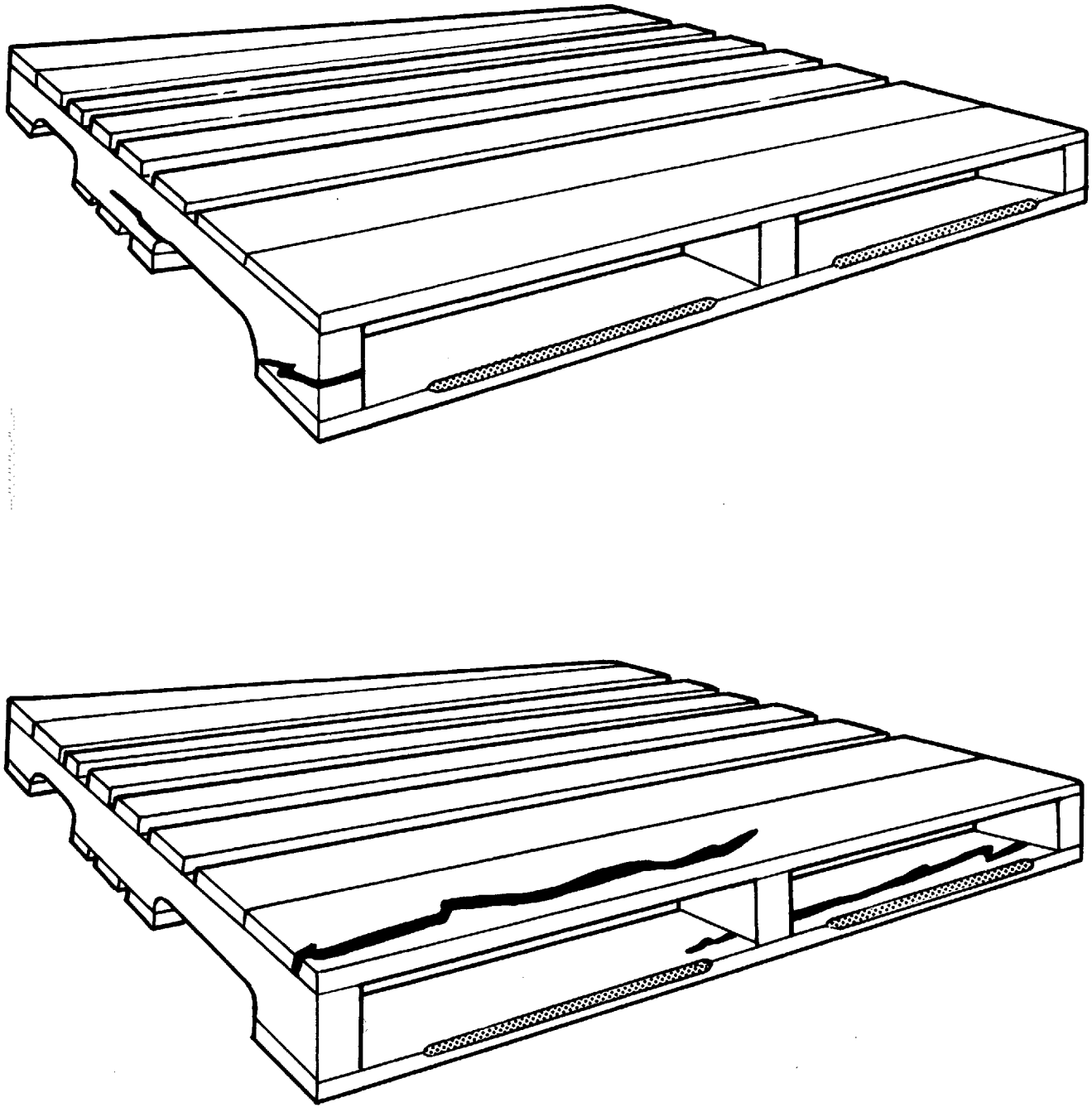
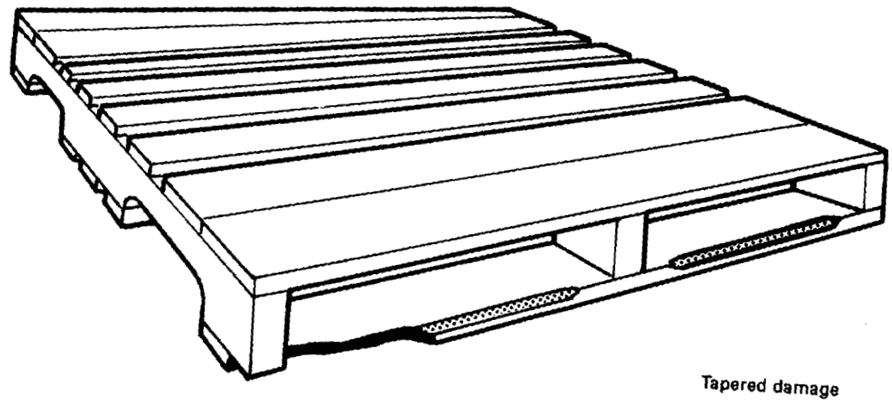


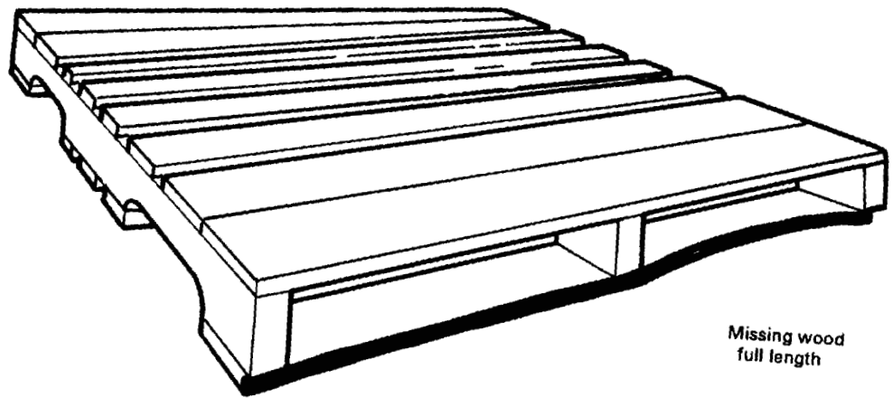
FIG. 8 ALL COMPONENTS WITH SPLITS EXCEEDING THE CRITERIA IN PARAS. I-7.5.3.1 AND I-7.6.3.1 TO BE REPLACED OR REPAIRED

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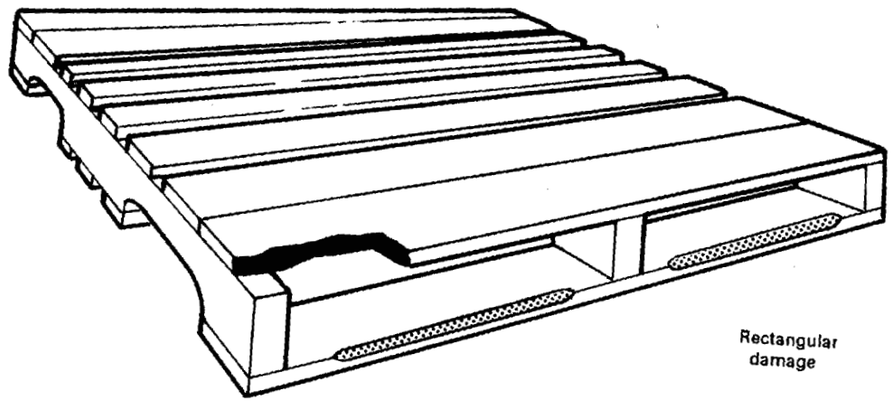
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Tapered damage



Missing wood
full length



Rectangular
damage

FIG. 9 SCHEMATIC DIAGRAMS SHOWING EXAMPLES OF MISSING WOOD DAMAGE DESCRIBED IN PARAS. I-7.5.3.2 AND I-7.6.3.2

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up to 1 in. (25 mm) deep and 10 in. (254 mm) long along the board edge.

(b) Stringers: more than 1/4 of the width and 1/4 of the height for 4 in. (102 mm) length.

(c) Stringerboards: a tapered piece missing all the way back to the fastener and running straight to the board edge along its center.

(d) Blocks: more than 1/4 of the width and 1/4 of the height for 1/4 of the length.

(e) Corner blocks: blocks with butted connections of the bottom boards of pallets of perimeter or cruciform-base design shall have no wood missing at the overlap of the butted board and the block or any baseboards (see Part 3, Fig. 10).

(f) Panel-decks: plywood strip bottom deckboards and areas around cutouts (see Part 3, Fig. 11).

(1) any one area of rectangular shape up to 1 in. (25 mm) deep and 10 in. (254 mm) long in one edge of any component, or up to 1 1/2 in. (38 mm) deep and 20 in. (508 mm) long in aggregate on opposite edges of any component less than 24 in. (610 mm) wide. In areas around cutouts where the strong panel axis does not span the opening between stringer or blocks, the total damage cannot exceed 1 in. (25 mm) deep and 10 in. (254 mm) long on either or both opposite sides; or

(2) any one area of rectangular shape up to 1 1/2 in. (38 mm) deep and 10 in. (254 mm) long in one edge of any component, or up to 2 in. (51 mm) deep and 20 in. (508 mm) long in aggregate on opposite edges of any component 24 in. (610 mm) to 36 in. (915 mm) wide; or

(3) any one area of rectangular shape up to 2 in. (51 mm) deep and 10 in. (254 mm) long in one edge of any component, or up to 3 in. (76 mm) deep and 20 in. (500 mm) long in aggregate on opposite edges of any component more than 36 in. (915 mm) wide.

I-7.5.3.3 Delamination of a Product Defect that Calls for Careful Product Inspection (see Part 3, Fig. 12). In panel-decks, plywood strip bottom deckboards, and areas around cutouts, missing wood due to delamination is limited to a maximum of 1/3 of the panel's thickness, and shall be evaluated in accordance with this section.

Delamination of any panel component at connections is not permitted.

Delamination is limited to a maximum of 2 in. (51 mm) deep and 1/3 the total length of either affected edge or up to 3 in. (76 mm) and 1/2 the length in aggregate on opposite edges of any component less than 24 in. (610 mm) wide. In areas around cutouts where the strong panel axis does not span the openings between the stringer or block, the total delamination shall not exceed:

(a) 2 in. (51 mm) and 1/4 the total length on either or both opposite edges; or

(b) a maximum of 4 in. (100 mm) deep and 1/2 the total length of either affected edge or up to 6 in. (152 mm) and 2/3 the total length in aggregate on opposite edges of any component 24 in. (610 mm) wide up to 36 in. (915 mm) wide; or

(3) a maximum of 6 in. (152 mm) deep and 1/2 the total length of either affected edge, or up to 9 in. (229 mm) and 2/3 the length in aggregate on opposite edges of any component greater than 36 in. (915 mm) wide.

I-7.5.4 Panel-Deck Repair. A minimum width of 3 1/2 in. (89 mm) shall be removed from the entire length or width of a panel deck that is to be repaired. The removed section shall be replaced by a butted leading edge lumber deckboard of the same dimensions. For block-class pallets, the blocks that the replacement deckboard is fastened to shall be twice as long as the width of the replacement deckboard or 7 in. (178 mm) minimum, and oriented with this dimension perpendicular to the replacement deckboard.

Plywood strip bottom deckboards are replaced in kind or lumber bottom deckboards of the same width are used.

Fastener quantities and positioning, including renailing of the remaining panel deck, shall be as required in Part 3, para. I-6.

I-7.5.5 Manufacturing Accuracy, M-R Repair

(a) The placement of all components and fasteners shall conform to Part 3, para. I-6.2.

(1) All leading deckboards shall be within ±1/4 in. (±6 mm) of their specified location.

(2) All other wood components shall be within ±1/2 in. (±13 mm) of their specified location, except that the bottom boards shall not extend into the stringer notch.

(3) Unless otherwise specified, leading deckboards and ends of deckboards shall be flush with the stringer.

(b) Maximum placement deviation shall be limited to one-third of the components in any pallet. All similar components shall be placed parallel unless otherwise specified.

(1) The pallet sizes shall be limited to ±1/4 in. (+6 mm) and −1/2 in. (−13 mm) of the target dimensions, as measured at specific points along the pallet length and width. The pallets shall be flat on their top and bottom surfaces to within ±1/4 in. (±6 mm) maximum deviation from the corner-to-corner straight line.

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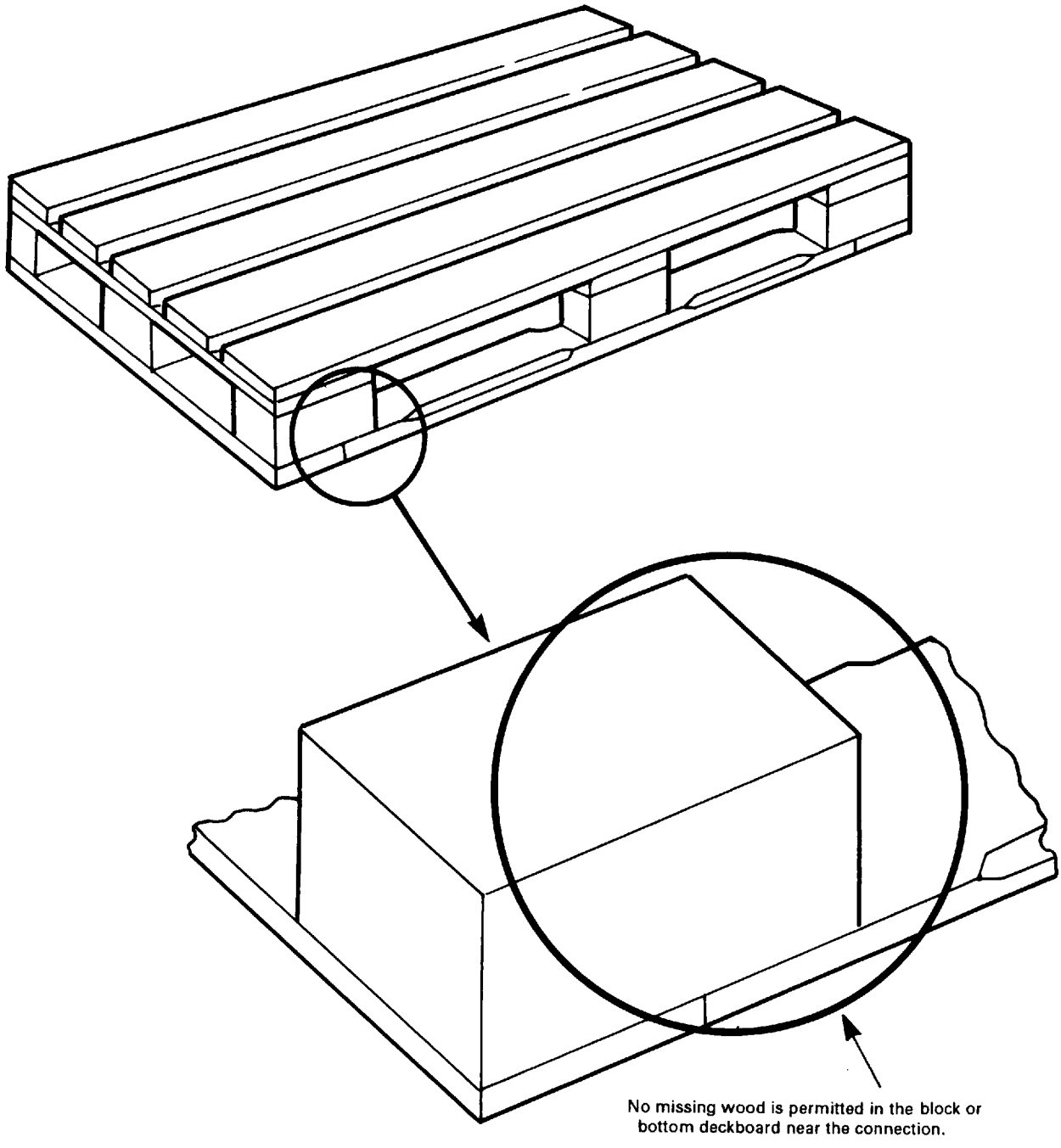


FIG. 10 SCHEMATIC DIAGRAM OF A BLOCK-CLASS PALLET SHOWING THE BUTTED CONNECTION IN THE BOTTOM DECK OF A PERIMETER BASE DESIGN

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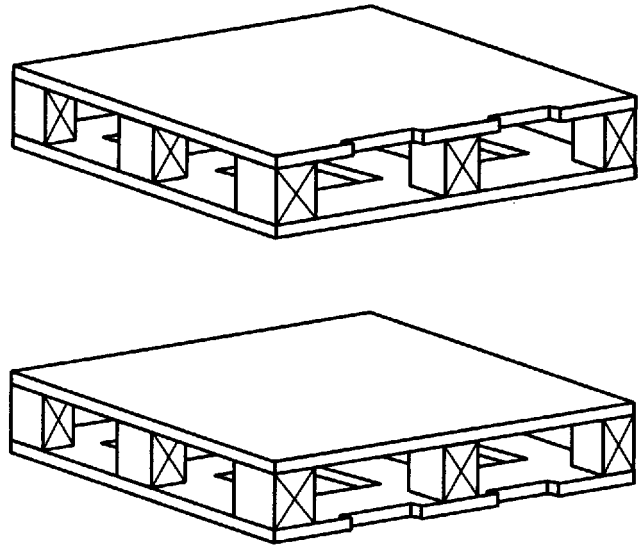


FIG. 11 SCHEMATIC DIAGRAM OF A BLOCK-CLASS PALLET SHOWING THE ALLOWABLE LOCATIONS AND EXTENT OF MISSING WOOD AS DISCUSSED IN PARA. I-7.5.3.2

(2) Square or rectangular pallets shall be limited to 1.5% or 1 in. (25 mm) difference in the measured top deck diagonals of a square pallet part, whichever is greater.

(3) Blocks shall not be twisted more than 10 deg in any dimension from the square of other pallet components.

(c) The pallet overall dimensions, squareness, and flatness limits provided for in this section shall always be met.

(d) The quantities of the fasteners and their locations are given in Part 3, para. I-6. The fasteners shall meet the minimum requirement for multiple-use pallets (see Part 3, para. I-5.3).

(e) The fastening locations and their schedule per connection shall comply with the requirements in Part 3, para. I-6.2.4, including those concerning countersinking and shiner limitations.

(1) Nail heads, staple crowns, bolt heads, nuts, and screw heads shall be flush with or preferably below deck surfaces. Countersinking fastener heads and protruding fastener points shall not significantly affect pallet performance.

(2) No protruding fastener points (shiners) shall be permitted on the exposed face of outside stringers or blocks or in lead deckboard areas. Two protruding fasteners on unexposed surfaces are permitted as long as they do not significantly affect pallet performance.

(3) Protruding fastener points are not permitted when using non-clinched fasteners to attach deckboards to stringerboards in block class pallets. Fasteners not driven into stringers and blocks shall be compensated.

(4) Any open splits in boards (exceeding allowable limits as specified in Part 3, para. I-7.5.3.1) caused by nailing or stapling shall be straddled with nails or staples, respectively. An open split exists if the fastener shank or leg can be seen when viewed along the split and there is a gap that extends beyond the fastener.

(5) No more than one open split with a visible fastener shank or leg per connection shall be permitted and not more than one-third of the components per pallet shall contain open splits with visible fastener shanks at the completion of repair.

NOTE: The underlying requirement is that the connection shall be sound and solid after repair.

I-7.6 R-Type Repair for Limited-Use (L) Pallets

The R repair designations are intended for M pallets, which are not repaired to M-R repair standards, and cover repairs to L pallets and all other pallets.

I-7.6.1 Repair of Limited-Use (L) Pallets, R Repairs. No stringerboard or block companion repairs, or any type of general-service repair, are allowed in block pallets. Repair Types R-1P, R-2, and R-3 concern only stringer pallets.

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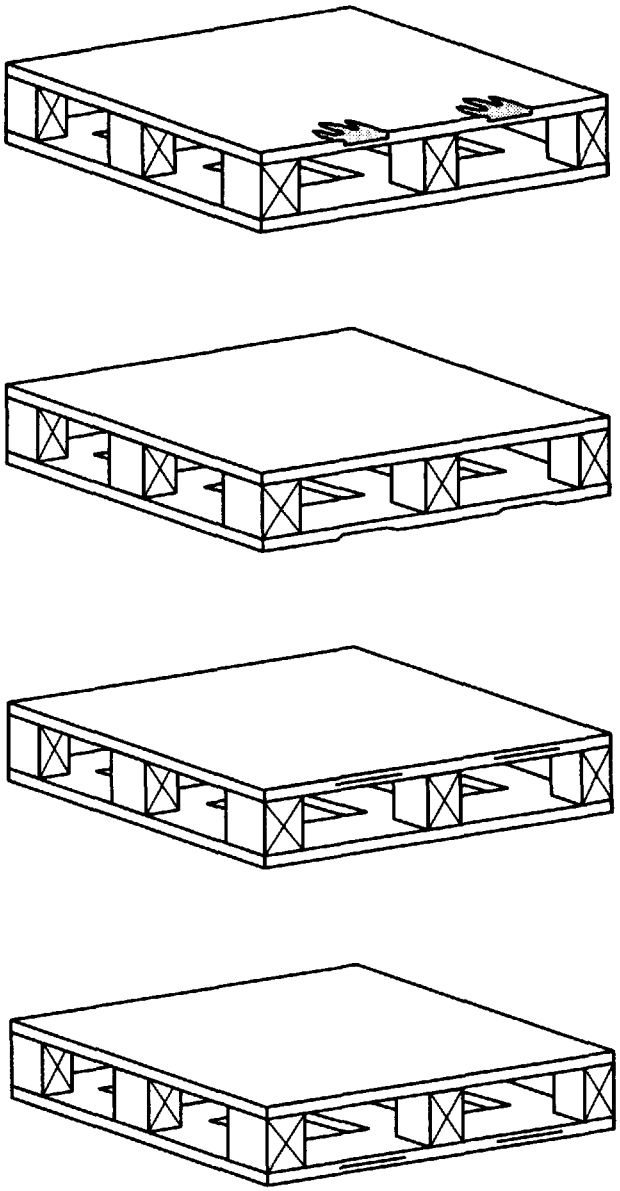


FIG. 12 EXAMPLES OF DELAMINATION DAMAGE IN PALLETS CONTAINING STRUCTURAL PANEL DECKS AS SHOWN BY EXTENT OF INDIVIDUAL DELAMINATION LINES

(a) R-1 Component Replacement with Similar Elements

(1) All missing components shall be replaced.

(2) R-1 does not allow stringer or block repair or plating.

(3) Any component to be replaced shall be replaced with a like component. For example, a 6 in. (150 mm) deckboard shall be replaced with another 6 in. (150 mm) board of the correct thickness; a chamfered board shall be replaced with a chamfered board; a notched stringer shall be replaced with a notched stringer, etc.

A panel-deck pallet component may be replaced by an equivalent lumber component, such as a top-deck leading edge, bottom deckboards, or blocks.

(4) Broken stringers or blocks shall be replaced for R-1 repairs. Plated or companion stringers shall not be used in R-1 repairs.

(b) R-1P Component Replacement and Stringer Plating

(1) R-1P repair is identical in its requirements to R-1, except that properly plated stringers are allowed when they are in accordance with Part 3, para. I-7.7.

NOTE: Block plating is not allowed.

(c) R-2 Single, Full- or Half-Companion Stringer. R-2 repair is identical in its requirements to R-1, except that a broken stringer shall be repaired with a single full- or half-companion stringer. The full-companion stringer shall be equal in length [less than ½ in. (13 mm)] and height and notched where applicable, and in accordance with Part 3, para. I-5.1.4.3 which defines the notch size and position. The full-companion stringer shall be properly nailed to all top and bottom deckboards as required in Part 3, para. I-7.6.4. Only one companion stringer per pallet is permitted (see Part 3, Fig. 13).

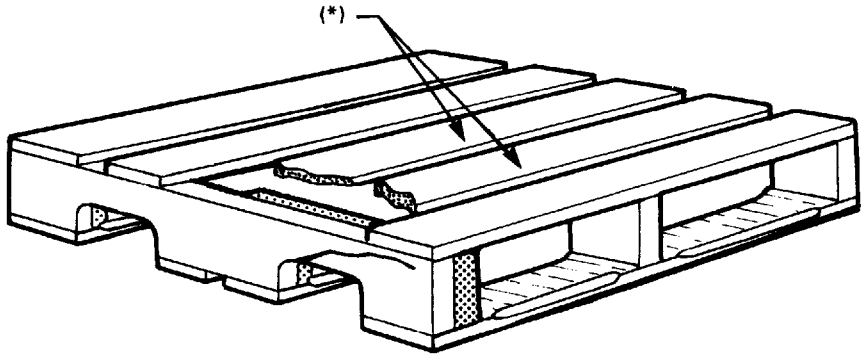
The single half-companion stringer shall be cut 1 in. (25 mm) shorter than half of the stringer length. It shall be equal in height and properly noticed where appropriate. The half-companion stringer shall be properly fastened to all top and bottom deckboards as required in Part 3, para. I-7.6.4. Only a single half-companion stringer per pallet is permitted (see Part 3, Fig. 14).

Plating is allowed as for R-1P repair. In addition, missing end feet of notched stringers shall be repaired by plating wood components equivalent in size to the missing section of the original stringer. The replacement wood shall be of equivalent or stronger species (see Appendix A3-A). A maximum of two stringer feet per pallet, and only one foot per stringer, shall be repaired. Plating is described in Part 3, para. I-7.7.

Replacement boards do not have to be chamfered.

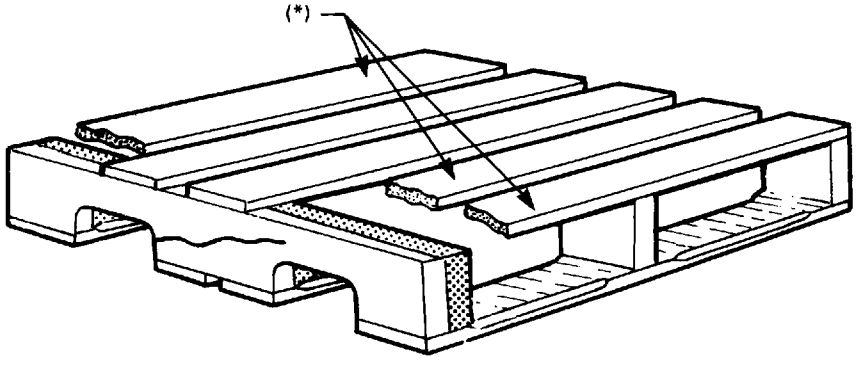
(d) R-3 Half-Companion Stringers. R-3 repair is identical in its requirements to R-2, except that a broken stringer shall be repaired with multiple half-companion stringers that shall be 1 in. (25 mm) shorter than half the length of the original stringer and shall be properly notched where appropriate. These half-companion stringers shall be properly fastened to all top and bottom deckboards, as required in Part 3, para. I-7.6.4.

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*Deckboards shortened for illustrative purposes only.

FIG. 13 SCHEMATIC DIAGRAM OF AN R-2 FULL-LENGTH COMPANION STRINGER REPAIR



*Deckboards shortened for illustrative purposes only.

FIG. 14 SCHEMATIC DIAGRAM OF AN R-2 HALF-COMPANION STRINGER REPAIR

A maximum of two half companion per pallet end shall be used, and not more than one half-companion stringer per opening per end. A maximum of four half-companion stringers per pallet is allowed (see Part 3, Fig. 15).

Stringer plating is allowed as in R-1P and R-2 repair types. In addition, all three stringers of a three-stringer pallet shall have their feet plated to a maximum of three per pallet. Plating is described in Part 3, para. I-7.7.

I-7.6.2 Replacement Component Quality and Sizing for R Repairs

(a) Lumber Quality and Species. For all R pallet repairs, the requirements in Part 3, para. I-5 for Limited-Use (L) pallets is the minimum requirement. Reclaimed lumber shall also comply with Part 3, para. I-5.

NOTE: Part 3, para. I-5.1.4.1 is not applicable to R repairs.

The L classification in para. I-5 and Table 1 of Part 3 shows the permitted limits of growth-related defects allowed. Similar (of the same class) or stronger species shall be used for repair as listed in Appendix A3-A.

(b) Lumber Sizing. The matching of component sizes is required. The dimensional tolerances required for lumber preparation and reclaimed lumber are shown below. The thicknesses of replaced components shall result in a pallet with acceptably even surfaces.

The lengths of replacement components shall show no overhang beyond the overall dimensions of the pallet.

Boards and Panels

Thickness: $\pm 1/8$ in. (±3 mm) maximum

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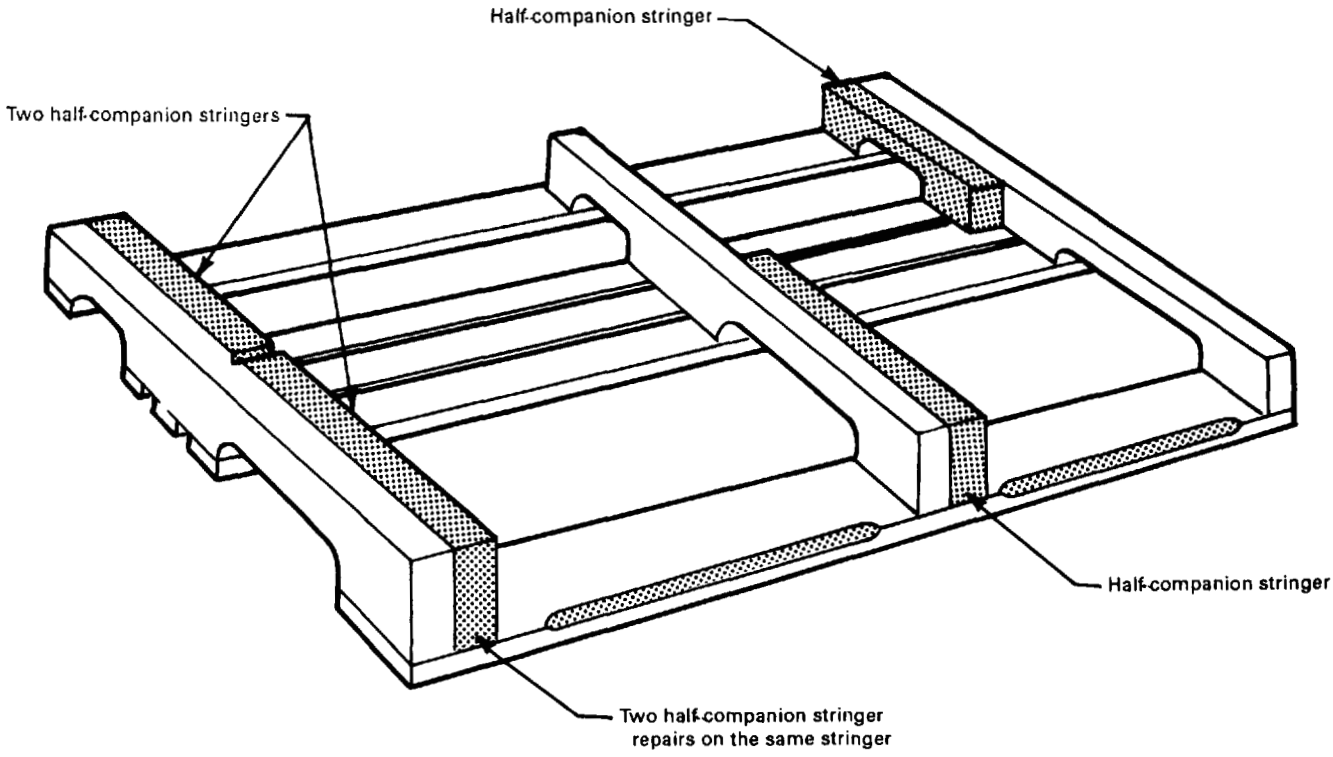


FIG. 15 SCHEMATIC DIAGRAM SHOWING THE MAXIMUM NUMBER OF HALF-STRINGER REPAIRS PERMISSIBLE IN AN R-3 REPAIR

Width:	+ unlimited, $-\frac{1}{4}$ in. (−6 mm) maximum deviation
Length:	$+\frac{1}{8}$ in. (+3 mm), $-\frac{1}{4}$ in. (−6 mm) maximum deviation

Stringers and Blocks

Width:	$\pm\frac{1}{8}$ in. (±1.5 mm) maximum
Height:	+0, $-\frac{1}{4}$ in. (−6 mm) maximum
Length:	$+\frac{1}{8}$ in. (+3 mm), $-\frac{1}{4}$ in. (−6 mm) maximum

(c) Fasteners. The fasteners used in all types of repair shall meet the minimum requirements specified in Part 3, para. I-5.2. The minimum requirements for R-1 and R-1P type repair fasteners are listed in Appendix A3-C, Table C1. The minimum requirements for R-2 and R-3 repair fasteners are listed in Appendix A3-C, Table C2.

Examples of nail sizes and the minimum quantities of fasteners required per connection are given in Appendix A3-C, Tables C1, C2, and C3.

I-7.6.3 Allowable Damage, R Repair. All missing or broken components shall be replaced.

Each pallet component has allowed levels of damage that may remain unrepaired. However, not more than one-third (33%) of the components shall have damage at the maximum limit allowed. All missing components shall be replaced, and all broken or split components, and those with unacceptable damage, shall be repaired or removed and replaced.

The allowable damage limits apply to all species. Any existing component that differs substantially from the rest of the components in grade species, whether damaged or not, shall be replaced. Any existing component that substantially differs in size from the other components shall be replaced.

I-7.6.3.1 Splits (see Part 3, Fig. 8). Allowed splits are permitted in any part of a component. The split dimensions allowed in components are listed as follows.

(a) Top and bottom deckboards: up to full length and $\frac{3}{4}$ in. (19 mm) wide, full thickness.

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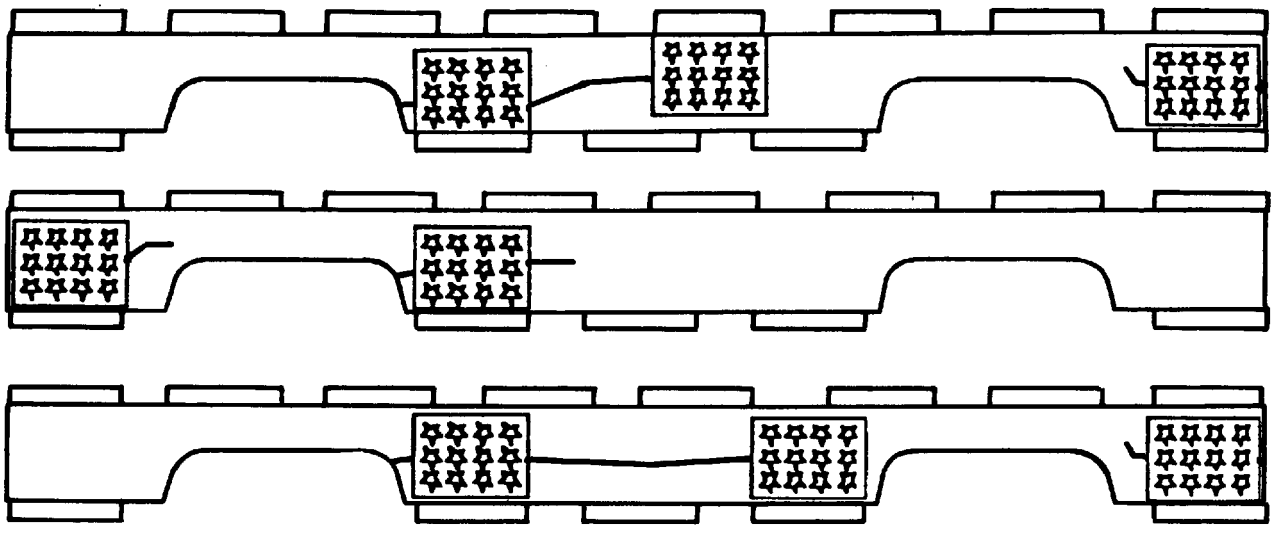


FIG. 16 SCHEMATIC DIAGRAMS SHOWING PROPER PLACEMENT OF METAL PLATES OVER SPLITS

(b) Stringers

(1) Horizontal splits shall be less than 4 in. (104 mm) or 2 × width in length.

(2) Vertical splits are defined as a split if the separation is deeper than ½ of the component height. In that case, the length is limited to ½ of the length of the stringer. If the vertical separation is less than ½ of the height, the length is unlimited (see definitions in Part 1).

(c) Stringerboards: less than full length.

(d) Blocks: limited to half length. A split is defined when the separation is deeper than ½ the dimension. In that case, the split is limited to ½ the block length. If the separation is less than ½ the dimension, then the split length is unlimited (see definitions in Part 1).

I-7.6.3.2 Missing Wood (See Part 3, Fig. 9). Two sections of missing wood, up to the maximum size allowed, are permitted for any component. Missing wood, which leaves a nail freestanding from the remaining board, and thus weakens the connection, is unacceptable. Each missing wood section shall not exceed that specified in Part 3, para. I-7.5.3.2.

I-7.6.3.3 Delamination of a Product Defect that Calls for Careful Product Inspection. With panel-decks and panel bottom deckboards, missing wood due to delamination is limited to a maximum of one-third of the panel thickness, and shall be evaluated in accordance with this section.

Delamination of any panel component at connection is not permitted.

Delamination is limited to a maximum of 3 in. (76 mm) deep and ½ the length of the affected edge or up to 4 in. (104 mm) and ⅔ the length in aggregate on opposite edges of any component less than 24 in. (610 mm) wide. In areas around cutouts where the strong panel axis does not span the openings between the stringers or blocks, the total delamination cannot exceed:

(1) 3 in. (76 mm) and ⅓ the total length on either or both opposite edges; or

(2) a maximum of 8 in. (203 mm) deep and ½ the total length of the affected edge or up to 10 in. (254 mm) and ⅔ the length in aggregate on opposite edges of any component greater than 24 in. (610 mm) wide, up to 36 in. (915 mm) wide; or

(3) a maximum of 12 in. (305 mm) deep and ½ the total length of the affected edge or up to 15 in. (380 mm) and ⅔ the length in aggregate on opposite edges of any component greater than 36 in. (915 mm) wide.

I-7.6.4 Panel-Deck Pallet Repair. R repair for panel-deck L pallets shall be in accordance with Part 3, para. I-7.5.4.

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I-7.6.5 Manufacturing Accuracy, R Repair

(a) The placement of all components and fasteners of R types of repair shall conform to Part 3, para. I-6.2.

(1) All leading deckboards shall be within ±¼ in. (±6 mm) of their specified location.

(2) All other wood components shall be within ±½ in. (±13 mm) of their specified location, except that bottom boards shall not extend into the stringer notch.

(3) Unless otherwise specified, leading, deckboards and ends of deckboards shall be flush with the stringer.

(b) Maximum placement deviation shall be limited to one-third of the components in any pallet. All similar components shall be placed parallel unless otherwise specified.

(1) The pallet sizes shall be limited to +¼ in. (+6 mm) and −½ in. (−13 mm) of the target dimensions, as measured at specific points along the pallet length and width. The pallets shall be flat on their top and bottom surfaces to ±¼ in. (±6 mm) maximum deviation from the corner-to-corner straight line.

(2) Square or rectangular pallets shall be limited to 1.5% or 1 in. (25 mm) difference in their measured top deck diagonals of square pallet part, whichever is greater.

(3) Blocks shall not be twisted more than 10 deg from the square of other pallet components.

(c) The pallet overall dimensions, squareness, and flatness provided for in this section (para. I-7) shall always be met.

(d) The quantities of the fasteners and their locations are given in Part 3, para. I-5. The fasteners shall meet the appropriate minimum requirements in Appendix A3-C, Tables C1, C2, and C3.

(e) The fastener locations and their schedule per connection shall comply with the requirements in Part 3, para. I-6.2.4, including those concerning countersinking and shiner limitations.

(1) Nail heads, staple crowns, bolt heads, nuts, and screw heads shall be flush or preferably below deck surfaces. Countersinking fastener heads and protruding fastener points shall not significantly affect pallet performance.

(2) No protruding fastener points (shiners) shall be permitted on the exposed face of outside stringers or blocks or in lead deckboard areas. Two protruding fasteners on unexposed surfaces are permitted as long as they do not significantly affect pallet performance.

(3) Protruding fastener points are not permitted when using non-clinched fasteners to attach deckboards to stringerboards in block class pallets. Fasteners not driven into stringers or blocks shall be compensated.

(4) Any open splits in boards (exceeding allowable limits as specified in Part 3, para. I-7.5) caused by nailing or stapling shall be straddled with nails or staples, respectively. An open split exists if the fastener shank or leg can be seen when viewed along the split and there is a gap that extends beyond the fastener.

(5) Not more than one open split with a visible fastener shank or leg per connection shall be permitted and not more than one-third of the components per pallet shall contain open splits with visible fastener shanks or legs at the completion of repair.

NOTE: The underlying requirement is that the connection shall be sound and solid after repair.

I-7.7 Metal Plates for the Repair of Wood Stringers (see Part 3, Fig. 17)

I-7.7.1 Minimum Plate Specifications[5]

(a) Size. Plates shall be a minimum of 2¾ in. (70 mm) in length and width and 11 in.^{2} (7100 mm^2) in area as determined by external plate dimensions.

(b) Material. 20-gauge [0.035 in. (0.89 mm)] minimum thickness, of uncoated, commercial-grade sheet steel.

(c) Coating. ASTM A 525, Hot-Dip Galvanized Designation G60.

(d) Teeth. At least 4 teeth per sq in. (645 mm^2) of plate area, as determined by external dimensions. The length of teeth shall be at least 0.325 in. (8.3 mm) excluding plate thickness.

I-7.7.2 Repairable Stringer Damages. Only horizontal or diagonal splits (breaks) shall be repaired. Repairs to vertical splits of any kind are not permissible. The only attachment of a completely separated part, which is permissible, is the stringer end foot (see Part 3, para. I-7.6.1). Repair of damage above the stringer notches is not permissible. Splits at large knots, 1 in. (25 mm) in diameter, or greater, shall not be repaired.

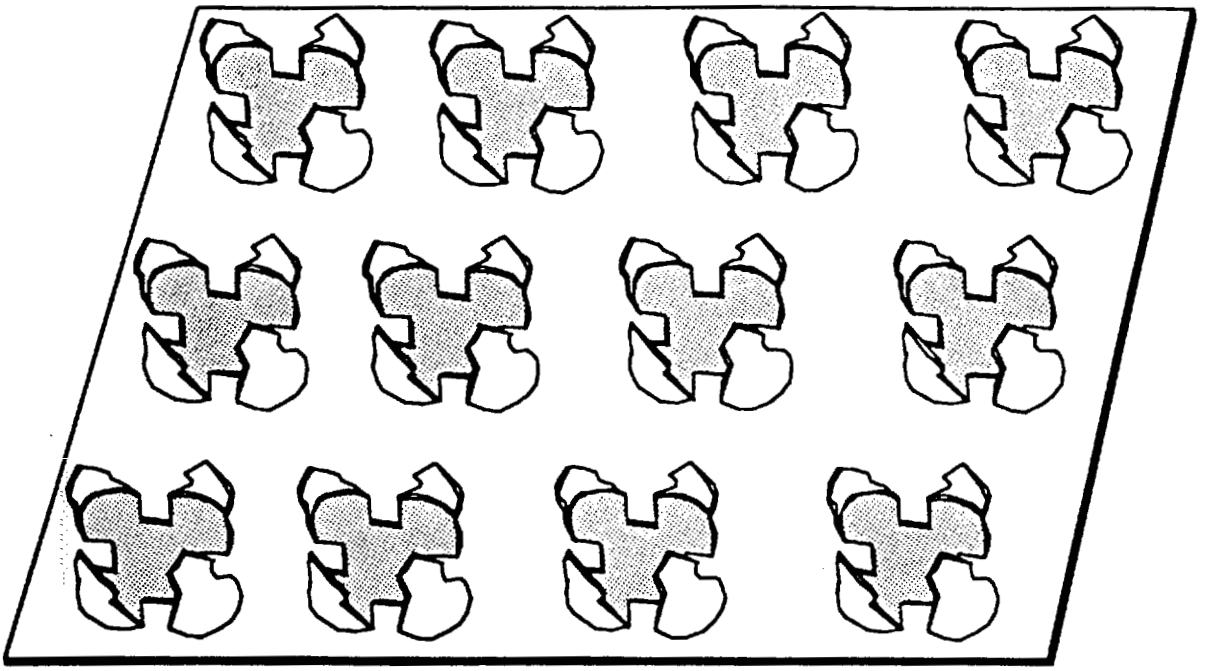
I-7.7.3 Metal Plate Application. Apply plates with mechanical, hydraulic, or pneumatic power, using machinery designed and manufactured for this purpose.

The split shall be closed with a mechanically, hydraulically, or pneumatically operated press prior to plate

[5] Plate as specified in Part 3, para. I-7.7.1 or equivalent as determined by the static bending and impact tests described in J.W. Clarke and P.A. Araman, 1993, Evaluation of Metal Connector Plates for the Repair of Wood Pallets. Forest Products Journal 43(10):15–22.

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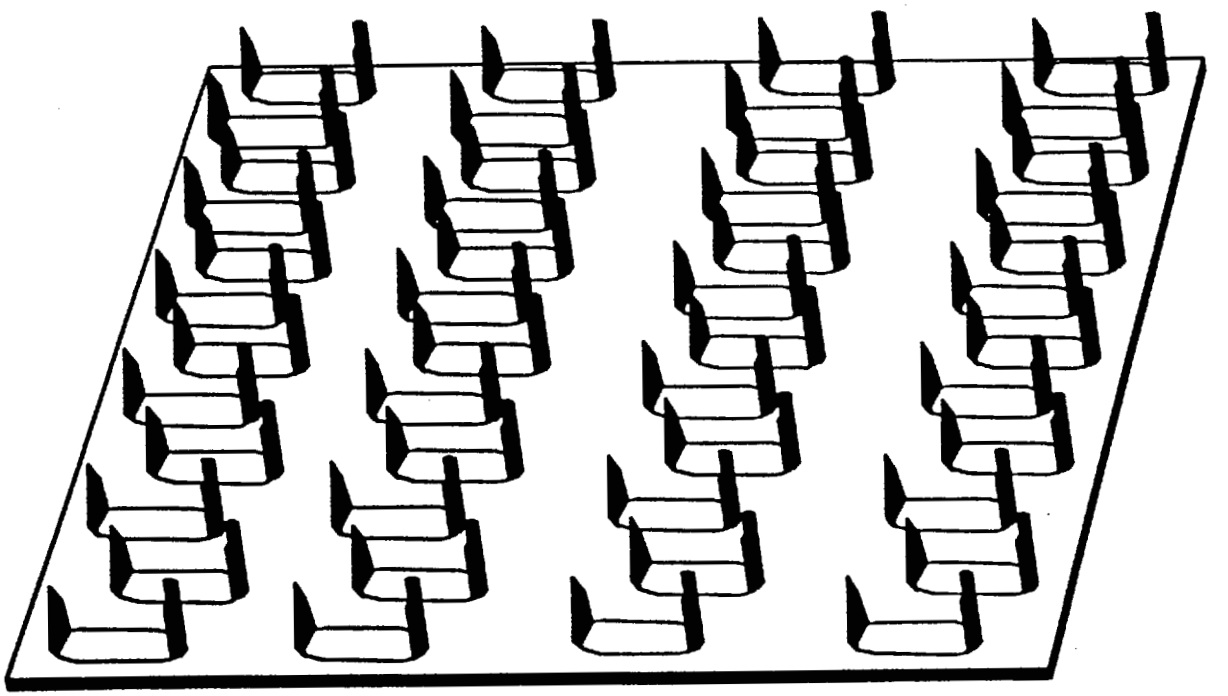


FIG. 17 SCHEMATIC DIAGRAMS OF TWO OF THE COMMON STYLES OF METAL CONNECTOR PLATES USED TO REPAIR WOOD STRINGERS

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application. A minimum of two plates shall be used per repair. The plates shall be applied opposite one another on each stringer side and pressed mechanically, hydraulically, or pneumatically flush with the wood surface as shown in Part 3, Fig. 16. Plates shall be aligned in such a way that they do not overhang the stringer ends or edges. The plate edges or ends shall be approximately parallel to the ends or edges of the stringers. All teeth of each plate shall be pressed into the wood. The longest dimension of the plate shall be in the direction of the split. Each plate applied shall cover the split. Splits longer than 8 in. (200 mm) shall be repaired with four plates. Two opposite plates at each end of the split shall be used, as shown in Part 3, Fig. 16.

Subpart II
Performance Standard

II-1 CONDITIONS OF PALLET USE

The use conditions that pallets shall sustain during unit-load material handling vary. Therefore, the conditions of use shall be specified with performance levels. Where conditions of use vary, the condition that results in the highest stress levels shall be used as a basis for determining performance.

II-1.1 Load Conditions

(a) Provide the description of the packages, containers, or units to be placed on the pallet, i.e., bags, boxes, barrels, bulk containers, blocks, and machinery including the use of load stabilizers.

(b) Provide measurements and location of bearing areas for the packages, containers, or units to be placed on the pallet and the pallet top and bottom decks, stringers or blocks.

(c) Provide maximum and average load levels and load level variations.

II-1.2 Support Conditions

(a) Indicate maximum unsupported free span along the pallet length and width.

(b) Indicate maximum number of unit loads in a stack.

(c) Indicate measurements and locations of bearing areas between the pallet stringers or stringerboards and top and bottom decks and their supports.

II-2 MEASURES OF PALLET PERFORMANCE

(a) Strength. Determine design or safe working loads for each condition of use. When multiple-use conditions exist, the pallet and pallet-component performance shall be based on the minimum design or safe working load.

(b) Stiffness. Determine maximum deflection of pallets and pallet components for each condition of use.

(c) Durability. Category Limited-Use (L) (see Part 3, para. I-3.2); Category Multiple-Use (M) (see Part 3, para. I-3.2).

(1) Limited-Use (L) pallets are intended for a series of handlings up to nine trips (see Part 3, para. I-3.2).

(2) Multiple-Use (M) pallets are intended for repeated uses for more than one unit load with an average minimum "life-to-first-repair" (LFR) of ten trips, assuming an average of five handlings per trip in an average handling environment as defined in the Pallet Design System (PDS)[6] (see Part 3, para. II-3.2).

The criteria for the classification of pallets as L and M are given in the documentation of the test procedures provided in Part 3, para. II-3.

II-3 TEST PROCEDURES

II-3.1 Testing of Physical Models or Prototypes

When possible, actual loads and supports shall be used in the test. However, load and support analogs, based on sound engineering principles, are acceptable. The following test methods and their design criteria are recognized:

[6] The Pallet Design System cannot be used for designing, selecting, and predicting the performance of repaired pallets. The Pallet Design System is available through: National Wooden Pallet and Container Association, 1800 North Kent Street, Suite 911, Arlington, VA 22209-2104, Phone: (703) 527-7667, FAX: (703) 527-7717.

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ISO 8611-1993, General Purpose Flat Pallets for Through Transit of Goods—Test Methods. International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH 1211, Genèva 20, Switzerland/Suisse.

ASTM D 1185-1994, Standard Test Methods for Pallets and Related Structures Employed in Material Handling and Shipping. Vol. 15.09. American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2989.

II-3.2 Testing by Computer Models

A computer model of wood pallets for predicting pallet performance is the Pallet Design System (PDS).[6]

Subpart III
Quality Assurance Auditing Program

III-1 CERTIFICATION OF SHIPMENTS

If the purchaser requests a certification that the pallet received is of the quality specified, each pallet shall be certified as being in conformance with this Part and shall be identified with the quality assurance auditing program[7] as provided for in Part 3, para. III-1.1. Each pallet shall be marked as specified in Part 3, para. III-1.3.

III-1.1 Qualified Auditing and Testing Agency

An authorized and designated inspection service shall act as auditing agency[8] and shall:

(a) have the facilities and trained technical personnel to verify that the grading, measuring, wood species, construction, workmanship, and the characteristics of the products, as determined by auditing, sampling, and testing, comply with all applicable requirements;

(b) have developed procedures to be followed by agency personnel during the auditing and testing;

(c) have no financial interest in, or is not financially dependent upon, any single company fabricating the product being audited or tested; and

(d) is not owned, operated, or controlled by any such company.

III-1.2 Conformance Criteria

For new pallets and M-R repaired pallets, a lot, sample, or inventory is nonconforming if it contains more than 5% critical defects, critical combinations, or a combination of the two within the finished pallet immediately after its manufacture.

(a) Critical Defects. Critical defects are defined as any defect that significantly affects the structural integrity or functionality of a component or a finished pallet. Any component or pallet with a critical defect shall be rejected and noted in audit reports. No more than 5% of a given lot shall contain critical defects. A list of critical and other defects is found in Appendix A3-B.

(b) Critical Combinations. Critical combinations exist in an individual pallet with three or more nonconforming defects in the following categories:

(1) component size and quality (see Part 3, para. I-5);

(2) fasteners (see Part 3, para. I-5); and

(3) general fabrication (see Part 3, para. I-6).

(c) A lot, sample, or inventory is nonconforming if any individual section of the audit covering component size and quality (see Part 3, para. I-5), fasteners (see Part 3, para. I-5.3), and general fabrication (see Part 3, para. I-6), exceeds 7.5% of the nonconforming characteristics, or a combination of the three sections exceeds 20% of such defects.

NOTE: A lot, sample, or inventory carrying a trademark that is nonconforming shall be corrected by the manufacturer.

When inspecting subsequent to manufacture and given the criteria upon which the inspection is based (the condition of the pallet at the time of manufacture) allowance shall be made for changes beyond the reasonable control of the pallet supplier, e.g., allowances for wood shrinkage as a result of drying after the assembly of a pallet fabricated using green timber. The amount of shrinkage will depend on the wood species and moisture content.

[7] The Pallet Association established a quality assurance program which is in conformance with the provisions of this Standard.

[8] Such an agency, having been found acceptable to the Pallet Association is Timber Products (TP) Inspection Service, P.O. Box 919, Conyers, GA 30207.

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TABLE 5 TYPICAL ALLOWABLE WIDTH, THICKNESS, OR HEIGHT SHRINKAGE AS A FUNCTION OF MOISTURE CONTENT FROM FIBER SATURATION POINT (30%) TO DRY (10%)

Pallet Component Moisture Content (Dry Basis), %	Percent of Width, Thickness or Height Shrinkage
30 (Fiber Saturation Point)	0
25	1
20	2
15	3
10 (Dry)	4

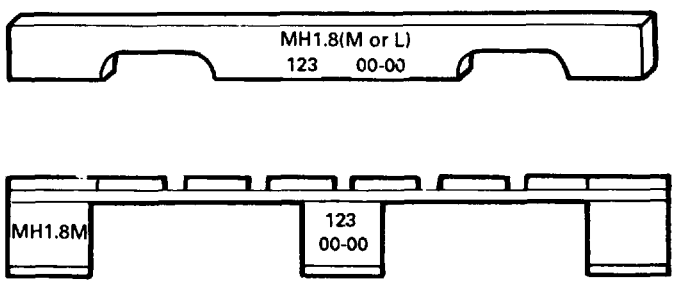


FIG. 18 EXAMPLES OF QUALITY AUDIT PALLET LABELS

Table 5 of Part 3 shows average shrinkage values for the width, thickness, or height of pallet parts as a function of wood moisture content calculated according to the method described in "The Wood Handbook".[9] The maximum shrinkage allowance shall be 4% of the component green target width, thickness, or height. Length shrinkage allowance shall be a maximum of 0.15%.

III-1.3 Pallet Marking

Pallets to be evaluated according to this Part shall have the appropriate mark applied.

(a) The mark M or L on new pallets indicates that evaluation had been made according to Part 3 of this Standard. Evidence of this evaluation shall be on file with both the manufacturer and the inspection service.

(b) If required, a unique identification mark on the pallet shall reference this performance standard and/or specification.

(c) Only devices meeting the requirements of this Part shall be used to mark pallets covered in this Part. These devices include stencils, brands, and ink jet printers.

(d) The markings shall provide the following information:

(1) pallet performance rating: Limited-Use (L) and Multiple-Use (M)

(2) manufacturer's identification number (i.e., 123)

(3) date of manufacture

(4) pallet identification number (optional)

(e) For markings on repaired pallets, see Part 3, para. I-7.4.

(f) Space permitting, the mark shall be a minimum of 2 in. (50 mm) high, with letters 1 in. (25 mm) high. For block pallets, the required information may be divided into two parts and shall appear on adjacent blocks (see examples in Part 3, Fig. 18).

[9] Wood Handbook: Engineering Material Agriculture Handbook No. 72, 1987. U.S. Government Printing Office, Washington, D.C. 20402.

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When necessary, and when it is not possible, due to customer specifications, to place the markings on stringers or blocks, the markings shall be placed on top lead deckboards.

III-1.4 Voiding Marks

Pallets originally marked as conforming to this Part, but subsequently rejected as not conforming or are not properly repaired by the methods described herein, shall have any reference to this Part obliterated.

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MANDATORY APPENDIX A3-A
PALLET-COMPONENT WOOD-SPECIES CLASSES[1, 2]

(This Appendix is an integral part of Part 3 of ASME MH1-1997, and is placed after the main text for convenience.)

NORTH AMERICAN SPECIES[3]

Class 1 (0.69)
- Hickory
- Birch:
  - Yellow
  - Sweet
- Maple:
  - Sugar
  - Black
  - Red
- Ash:
  - Green
  - White
- Elm:
  - Rock
  - Slippery
- American Beech
- Black Locust
- Black Cherry
- Tanoak
- Dogwood
- Persimmon
- Eucalyptus

Class 2 (0.55)
- Bigleaf Maple
- Oregon Ash

Class 3 (0.54)
- Sweetgum
- Tupelo
- Paper Birch
- Ash:
  - Black
  - Pumpkin
- Hackberry
- Sycamore
- Maple:
  - Silver
  - Striped
- Magnolia

Class 4 (0.61)
- Oregon White Oak
- California Black Oak
- Cascara
- Chinquapin
- Myrtle
- Pacific Madrone

Class 6 (0.45)
- Red Alder

Class 7 (0.40)
- Aspen:
  - Bigtooth
  - Quaking
- Catalpa
- Buckeye
- Butternut
- American Basswood
- Cottonwood:
  - Black
  - Balsam Poplar
  - Eastern

Class 11 (0.51)
- Douglas Fir:
  - Coast
  - Interior West
  - Interior North
  - Interior South
  - Western Larch

Class 12 (0.42)
- Hemlock:
  - Western
  - Mountain
- Fir:
  - California Red
  - Grand
  - Noble
  - Pacific Silver
  - White

Class 13 (0.42)
- Spruce:
  - White
  - Black
  - Red
  - Engelmann
  - Sitka
- Pine:
  - Sugar
  - Western White
  - Lodgepole
  - Ponderosa
  - Monterey
  - Jack
  - Norway
  - Eastern White
- Southern Pine:
  - Pitch
  - Pond
  - Spruce
  - Virginia
- Fir:
  - Subalpine
  - Balsam
- Baldcypress
- Eastern Hemlock
- Western Red Cedar
- Redwood

Class 14 (0.36)
- Cedar:
  - Alaska
  - Incense
  - Port Orford
  - Atlantic White
  - Northern White
  - Eastern Red

Class 21 (0.58)
- Eastern Oaks
- Red Oaks
- White Oaks

Class 22 (0.51)
- Southern Pine:
  - Loblolly
  - Longleaf
  - Shortleaf
  - Slash

Class 29 (0.48)
- Yellow Poplar

SOUTHERN ASIAN SPECIES

Class 31 (0.62)
- Mengkulang
- Kapur
- Keruing

EUROPEAN SPECIES

Class 32 (0.63)
- Ash
- Beech
- Oak
- Sycamore (Plane)

Class 33 (0.54)
- Douglas Fir
- Larch
- Pine:
  - Maritime
  - Scots
  - Jack

Class 34 (0.43)
- Poplar:
  - Gray
  - Black Italian
- Elm:
  - Dutch
- Redwood
- Larch:
  - Hybrid
- Pine:
  - Lodgepole
  - Corsican
- Fir:
  - Silver

Class 35 (0.42)
- Elm:
  - English
- Spruce:
  - Sitka
- Whitewood

Class 36 (0.39)
- Pine:
  - Radiata
- Spruce:
  - Black
  - Norway
- Willow:
  - White
- Spruce
  - White
  - Sitka (UK, Eire)

Class 37 (0.36)
- Poplar:
  - Hybrid

---

[1] Oven-dry specific gravity shown in parentheses.
[2] These species classes and class numbers correspond to those used as inputs in the Pallet Design System (PDS), 1995 version.
[3] North American wood species classes ranked according to relative strength and stiffness (in order of strongest to weakest): 21, 1, 2, 11, 29, 4, 6, 3, 12, 7, 13, 14.

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MANDATORY APPENDIX A3-B
DESCRIPTION OF GROWTH-RELATED DEFECTS WHICH AFFECT THE QUALITY OF PALLET COMPONENTS

(This Appendix is an integral part of Part 3 of ASME MH1-1997, and is placed after the main text for convenience.)

1 DEFINITIONS

decay: a disintegration of the wood substance due to actions of wood-destroying fungi, also known as dote, rot, and unsound wood.

sound knot: a knot that is tight, solid, without voids, and at least as hard as the surrounding wood in at least one face, exhibiting structural strength.

split or shake: separation within a wood member not confined to the wood surface, usually intersecting two surfaces. For the purposes of this Standard, a crack intersecting only one face of the pallet part will be treated as a split only when it exceeds ½ the depth, width, or thickness of the piece.

unsound knot: a knot that is loose and/or due to decay, has little, if any, structural strength.

wane: bark or lack of wood from any cause, except eased edges, on the edges or corners of the pallet component.

2 DEFECT CLASSIFICATIONS

(a) Critical Defects

(1) broken component

(2) protruding nail along the outer stringers, stringerboards, blocks, or deckboards

(3) nonconforming pallet due to size, flatness, or squareness

(4) missing wood exceeding allowable limits

(5) notch area defect (splits, decay, excess knot)

(b) Other Defects

(1) check

(2) component placing

(3) compression wood

(4) crook

(5) decay

(6) decayed knot

(7) fastener in decay

(8) fastener in maximum wane

(9) hole

(10) honeycomb

(11) inside shiner

(12) knot

(13) missing nail

(14) moisture content

(15) overhang

(16) pitch

(17) sawcut

(18) shake

(19) slope of grain

(20) split

(21) step

(22) underhang

(23) wane

(24) wane above notch

(25) wane on edge of leading deckboard or exposed stringer

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NONMANDATORY APPENDIX A3-C
PHYSICAL DESCRIPTION OF TYPICAL FASTENERS MEETING CRITERIA IN TABLE 3 AND PARA. I-5 OF PART 3

(This Appendix is not part of Part 3 of ASME MH1-1997, and is included for information purposes only.)

Tables C1, C2, and C3 follow.

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Table C1 Examples of Fasteners and Fastening Schedules Which Meet the Minimum Performance Requirements Provided in Para. I-5.2 and Table 3 of Part 3 for Category M (New Pallets), and Categories M-R, R-1, and R-1P (Repaired Pallets),[1] With Minimum FWI = 65 and FSI = 55

Fastener Type/Size	Fastener Physical Characteristics [Note (2)]	Minimum Fastener Schedule (Para. I-6.2.4.1)		One Additional Fastener/Connection [Note (3)]	Double the Minimum Fastener Schedule [Note (3)]
Helically threaded nail, 12½ gauge	Wire diameter (in.)			0.099	0.099
	Thread diameter (in.)			0.108	0.104
	Thread angle (deg)			70	70
	MIBANT angle (deg)			55	75
	FWI per nail			51	38
	FSI per nail			40	40
Helically threaded nail, 12-gauge	Wire diameter (in.)	0.105	0.105	0.105	
	Thread diameter (in.)	0.122	0.118	0.115	
	Thread angle (deg)	68	64	68	
	MIBANT angle (deg)	41	41	57	
	FWI per nail	68	6	51	
	FSI per nail	55	55	55	
Helically threaded nail, 11½ gauge	Wire diameter (in.)	0.112	0.112 [Note (4)]	0.112	
	Thread diameter (in.)	0.127	0.122	0.122	
	Thread angle (deg)	68	60	68	
	MIBANT angle (deg)	46	46	46	
	FWI per nail	66	65	53	
	FSI per nail	55	55	55	
Helically threaded nail, 11-gauge	Wire diameter (in.)	0.120			
	Thread diameter (in.)	0.134			
	Thread angle (deg)	68			
	MIBANT angle (deg)	52			
	FWI per nail	65			
	FSI per nail	56			
Annularly threaded nail, 11-gauge	Wire diameter (in.)	0.120			
	Thread diameter (in.)	0.130			
	Thread angle (deg)	20			
	MIBANT angle (deg)	51			
	FWI per nail	67			
	FSI per nail	57			

NOTES:

(1) When repairing connections to M-R, R-1, and R-2 categories, it is assumed the original fasteners in the connections which are still effective meet the minimum requirements in para. I-5.2 and Table 3 of Part 3 for wood pallets for new Category M pallets.

(2) Fastener length and the ratio of head to wire diameter shall conform to the criteria in para. I-5.2 and Table 3 of Part 3. These examples include both the four- and five-flute fasteners.

(3) When repairing connections, using an excessive number of fasteners, which would degrade overall connection integrity, shall be avoided.

(4) Or the same fastener with a 68 deg thread angle and 9% greater length.

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Table C2 Examples of Fasteners and Fastening Schedules Which Meet the Minimum Performance Requirements Provided in Para. I-5.2 and Table 3 of Part 3 for Wood Products for Category L (New Pallets), and Types R2 and R3 (Repaired Pallets),[1] With Minimum FWI = 50 and FSI = 40

Fastener Type/Size	Fastener Physical Characteristics [Note (2)]	Minimum Fastener Schedule (Para. I-6.2.4.1)		One Additional Fastener/Connection [Note (3)]		Double the Minimum Fastener Schedule [Note (3)]
Helically threaded nail, 12½ gauge	Wire diameter (in.)	0.099	0.099	0.099	0.099	0.099
	Thread diameter (in.)	0.108	0.106	0.104	0.102	0.102
	Thread angle (deg)	70	60	70	60	70
	MIBANT angle (deg)	55	55	75	75	85
	FWI per nail	51	58	38	38	32
	FSI per nail	40	40	31	31	28
Helically threaded nail, 12-gauge	Wire diameter (in.)	0.105	0.105	0.105		
	Thread diameter (in.)	0.115	0.112	0.110		
	Thread angle(deg)	70	62	70		
	MIBANT angle (deg)	59	59	81		
	FWI per nail	49	60	37		
	FSI per nail	41	41	32		
Helically threaded nail, 14-gauge	Wire width (in.)	0.080				
	Wire thicknesses (in.)	0.075				
	MIBANT angle (deg)	55				
	FWI per nail	44				
	FSI per nail	61				
Adhesive-coated staple, 15-gauge	Wire width (in.)			0.073		
	Wire thicknesses (in.)			0.067		
	MIBANT angle (deg)			85		
	FWI per nail			39		
	FSI per nail			36		
Adhesive-coated staple, 16-gauge	Wire width (in.)					0.062
	Wire thicknesses (in.)					0.065
	MIBANT angle (deg)					100
	FWI per nail					33
	FSI per nail					24

NOTES:

(1) When repairing connections to R-1 and R-2 categories, it is assumed the original fasteners in the connections which are still effective meet the minimum requirements in para. I-5.2 and Table 3 of Part 3 for wood pallets for new Category L pallets.

(2) Fastener length and the ratio of head to wire diameter shall conform to the criteria in para. I-5.2 and Table 3 of Part 3. These examples include both the four- and five-flute fasteners.

(3) When repairing connections, using an excessive number of fasteners, which would degrade overall connection integrity, shall be avoided.

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Table C3 Examples of Fasteners and Fastening Schedules Which Meet the Minimum Performance Requirements Provided in Para. I-5.3 and Table 3 of Part 3 for Clinched Fasteners[1]

Pallet Category	Fastener Type/Size	Fastener Physical Characteristics [Note (2)]	Minimum Fastener Schedule (Para. I-6.2.4.1)	One Additional Fastener/Connection [Note (3)]
M, R-1, R-1P	Staple, 16-gauge	Wire width (in.)		0.062
		Wire thicknesses (in.)		0.055
		MIBANT angle (deg)		130
		FWI per staple		33
		FSI per staple		19
	Staple, 15-gauge	Wire width (in.)	0.073	
		Wire thicknesses (in.)	0.067	
		MIBANT angle (deg)	95	
		FWI per staple	39	
		FSI per staple	33	
	Plain nail, 12-gauge	Wire diameter (in.)	0.105	
		MIBANT angle (deg)	85	
		FWI per nail	23	
		FSI per nail	30	
R-2, R-3	Staple, 16-gauge	Wire width (in.)	0.062	
		Wire thicknesses (in.)	0.055	
		MIBANT angle (deg)	115	
		FWI per staple	33	
		FSI per staple	21	
	Plain nail, 12-gauge	Wire diameter (in.)	0.099	
		MIBANT angle (deg)	115	
		FWI per nail	22	
		FSI per nail	21	

NOTES:

(1) When repairing connections to any of the categories, it is assumed the original fasteners in the connections which are still effective meet the minimum requirements in para. I-5.2 and Table 3 of Part 3 for new Category M and Category L pallets.

(2) Fastener length and the ratio of head to wire diameter shall conform to the criteria in para. I-5.2 and Table 3 of Part 3. These examples include both the four- and five-flute fasteners.

(3) When repairing connections, using an excessive number of fasteners, which would degrade overall connection integrity, shall be avoided.

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NONMANDATORY APPENDIX A3-D
SPECIFICATIONS AND STANDARDS RELATED TO WOOD PALLETS

(This Appendix is not part of Part 3 of ASME MH1-1997, and is included for information purposes only.)

ASTM D 1185-1994, Test Methods for Pallets and Related Structures Employed in Material Handling and Shipping

ASTM F 680-1993, Test Methods for Nails

ASTM F 1575-1995, Test Method for Determining Bending Yield Moment of Nails

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428

ISO 445-1996, Pallets for Materials Handling—Vocabulary

ISO 6780-1988 (1994), General-Purpose Flat Pallets for Through Transit of Goods—Principal Dimensions and Tolerances

ISO 8611-1988 (1993), General-Purpose Flat Pallets for Through Transit of Goods—Test Methods

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1121, Genève 20, Switzerland/Suisse

AIAG RC-8-1989, Expendable Containers and Expendable Container Systems

Publisher: Automotive Industry Action Group (AIAG), Department 77839, P.O. Box 77000, Detroit, MI 48277

PP-61-80, Specification for Softwood Plywood Pallets

Publisher: APA, The Engineered Wood Association (formerly American Plywood Association), P.O. Box 11700, Tacoma, WA 98411

Recommended Hardwood Pallet Specifications for the Grocery Industry (1978)

Publisher: Grocery Manufacturers of America, 101 Wisconsin Avenue, Washington, DC 20007

Standard Grading Rules, Expendable Produce Pallets (1976)

Publisher: Western Wooden Box Association, 430 Sherman Avenue, Palo Alto, CA 94306

Standards for Agricultural Pallet Bins (1975)

Publisher: American Society of Agricultural Engineers (ASAE), 2950 Niles Road, St. Joseph, MI 49085

Recommended Practices for Air-Land Demountable Cargo Pallets (1977)

Pallet Sizes (1967)

Minimum Requirements of Air Cargo Pallets (1967)

Publisher: Society of Automotive Engineers (SAE), 400 Commonwealth Drive, Warrendale, PA 15096

PPP-P-1660A-1973, Pallet, Expendable (Amendment 1975)

A-A-889-1981, Pallet, Material Handling—Wood, Double Faced, Stringer Construction

NN-P-71CE-1973, Pallets, Material Handling, Wood, Stringer Construction, 2-Way and 4-Way (Partial) (Amendment 1977)

MIL-P-27443E-1967, Pallet, Cargo, Aircraft, Type HCU-6/E, HCU-12/E, and HCU/10C

MIL-P-52910A-1983, Pallet, Cargo, for Ribbon Bridge Transporter

MIL-P-52971-1979, Pallet, Material Handling, General Cargo 40 × 48 Inch, Non-Wood, 4-Way

MIL-P-23312C-1976, Pallet, Material Handling, Metal (For Ordinance Items) Mar 3 Mod 0, and Mar 12 Mod 1

MIL-P-52999-1981, Pallet, Material Handing, Wood Stringer Construction, 4-Way, Partial, 48 × 40 Inch

MIL-P-15011H-1981, Pallet, Material Handling, Wood, Post Construction, 4-Way Energy, 48 × 40 Inch

MIL-P-43465-1966, Pallet, Material Handling, Wood, Double Food (Special Design for Use with Conex Containers)

MIL-P-15943D-1982, Pallet, Material Handling, Wood, Ship Cargo, Stevedoring, 48 in. Long by 72 in. Wide, 2-Way Entry

MIL-P-45449A-1972, Pallet, Units, Wood, for Shipment of Projectile Metal Parts and Projectile Ammunition

MIL-P-87089-1981, Pallets, Material Handling, Molded Wood Particles 40 × 48 in., 4-Way

MIL-STD-731-1959, Quality of Wood Members for Containers and Pallets

Publisher: U.S. Department of Defense, Publications and Form Center, 5801 Tabor Avenue, Philadelphia, PA 19120

Uniform Voluntary Standard for Wood Pallets (1996)

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Publisher: National Wooden Pallet and Container Association, 1800 North Kent Street, Arlington, VA 22209-2104

Rules and Regulations for Manufacturing SPEQ™ Pallets (1992)

Publisher: Timber Products (TP) Inspection Service, P.O. Box 919, Conyers, GA 30207-0919

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Part 4
Export Pallets

(a)

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PART 4
EXPORT PALLETS

1 SCOPE

(a) Part 4 of this Standard presents background information that provides minimum phytosanitary requirements for wood and wood-based products used in the manufacture of pallets. These requirements were agreed to and established by the International Plant Protection Convention (IPPC) in 1990. Part 4, in conjunction with Part 3, describes wood pallets, wood materials used in manufacturing pallets, and the types, grades, styles, and sizes applicable to pallets which are:

(1) destined for export; and

(2) used in exporting unitized stores and items.

(b) General pallet testing procedures are not included in Part 4, since those testing procedures described in Part 7 apply. However, specific export-oriented test procedures are described herein.

(c) This Part does not address safety problems, if any, associated with its use. The user shall bear full responsibility to establish appropriate safety and health practices and determine the applicability of prevailing regulatory limitations prior to use of Part 4.

2 PURPOSE

(a) The objective of Part 4 of this Standard is to describe wood and wood-based pallets that meet the export requirements of the shippers and receivers and the certification requirements of the IPPC.

(b) The export pallet description minimizes pallet variations and facilitates pallet uniformity, inspection, testing, and acceptance, thereby fostering universal use of export pallets in international commerce with minimal restrictions.

3 DEFINITIONS AND TERMINOLOGY

Definitions and terminology that are included in Part 1 of this Standard apply to Part 4.

4 SIGNIFICANCE AND USE

(a) Wood pallet design and fabrication require that the complete requirements of the shipper, transporter, handler, and receiver be addressed and included in the design and construction of the pallet. Additionally, in international commerce, phytosanitary considerations require that all components of pallets be free of live pests, i.e., insects, worms, marine borers, termites, ants, as well as, pathogens (molds and wood-destroying fungi). These insects may spread throughout the commercial sphere of worldwide distribution. Nations have determined that specific preventive requirements are necessary to satisfy national needs. Phytosanitary requirements have been enforced for pallet imports into Australia and New Zealand for many years. Similar requirements were implemented for pallet imports from North America to European Community (EC) nations, effective January, 1991. Appendix A4-A provides specific national requirements. These requirements were based on decisions made by the Standing Plant Health Committee of the EC Commission, August 17, 1990, and documented in PN 360. Under EC Plant Health Directive 75/93, as amended, certain wood species require phytosanitary inspection and certification or they shall meet other specific requirements when originated in North America. Special inspection procedures were established in the Export Certification Manual of the Export Certification Unit of the Plant Protection and Quarantine Agency of the U.S. Department of Agriculture. If these requirements are not met, it is likely that an export shipment using wood pallets will be rejected at the destination country port of entry or require treatment at the destination port.

(b) Plant Health Certification, required to prevent the spread of plant disease(s), may be obtained from the Animal and Plant Health Inspection Service, USDA (see Appendix A4-D, para. D4), which supervises U.S. grading and inspection agencies execution of the mill certification system.

5 GENERAL REQUIREMENTS FOR WOOD COMPONENTS AND PALLETS FOR EXPORT

The provisions included in Parts 2, 3, 5, 6, and 7 are applicable to Part 4.

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6 ADDITIONAL SPECIFIC REQUIREMENTS FOR WOOD COMPONENTS AND PALLETS FOR EXPORT

(a) All wood components shall be free of bark, as required in ISO/TR 10234-1989 [see Appendix A4-D, para. D2(c)] and CPC Pallet Sanitation Guidelines (see Appendix A4-D, para. D3) and subsequent revisions.

(b) If required, all wood components shall be treated as stated in Part 4, para. 8.

(c) Special requirements for wood pallets manufactured in, or imported by, Germany were introduced by the German Government during 1991 and are summarized in Appendix A4-C.

7 PHYTOSANITARY GUIDELINES

(a) Bark shall not appear on any timber (lumber) member of a pallet. Wane is permitted as much as its extent does not structurally weaken the pallet below the minimum requirements of ISO/TR 10233-1989 [see Appendix A4-D, para. D2(b)]. Grub and worm holes greater than 0.12 in. (3.0 mm) in diameter shall not appear on any surface of a softwood component of a pallet.

(b) When specified by the purchaser, wood pallets shall be stored in a covered, well-ventilated area, protected from adverse environmental conditions and away from potential pest-breeding or harborage sites. The storage of pallets in outdoor locations is not recommended because of the increased potential for contamination by dust, birds, insects, rodents, and other potentially harmful or objectionable substances.

8 PHYTOSANITARY REQUIREMENTS

Wood pallets, subject to regulatory phytosanitary controls, shall conform to at least one of the following requirements.

8.1 Alternative A

Wood pallets manufactured entirely of secondary manufactured wood products, such as kiln-dried timber (lumber), plywood, waferboard, and chipboard, shall include pressing or drying with heat above 100°C as an integral phase in the manufacture of the product.

8.2 Alternative B

Timber (lumber) components of a wood pallet shall be free of bark and kiln-dried by a commercially recognized schedule to a moisture content of 20(±2)% (except for destinations in Australia and New Zealand). The components can be kiln-dried prior to or after assembly of the pallet. Components/pallets that have been kiln-dried shall be so certified.

8.3 Alternative C

Green or dry timber (lumber) components of a wood pallet shall be free of bark and sealed with thermosetting epoxy or urethane wood sealants approved for indirect contact with food. The minimum required dry film thickness for the side grain of ring-porous hardwoods with sawn, planed, or sanded surfaces and that of other woods with sawn surfaces shall be 0.004 in. (0.10 mm) and that for the side grain of other woods with planed or sanded surfaces shall be 0.003 in. (0.08 mm). For the end grain of all woods, the dry film thickness shall be 0.008 in. (0.20 mm). The pallet parts shall be sealed prior to assembly. The sealants shall be applied by spray treatment.

8.4 Alternative D

Green or dry timber (lumber) components of a wood pallet shall be free of bark. Additionally, softwoods shall be free of grub and worm holes larger than 0.12 in. (3.0 mm) in diameter.

8.5 Alternative Combinations

Wood pallets shall be deemed conforming to the above requirements when manufactured and assembled using combinations of the above requirements, e.g., pallets having blocks treated with an approved sealant and decking of secondary manufactured wood panels.

9 PHYTOSANITARY ENFORCEMENT

The enforcement of these requirements shall be the responsibility of all parties involved. Nonconforming wood pallets used in trade between nations where phytosanitary regulations exist can be subject to quarantine or other regulatory action.

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10 TREATMENT OF WOOD COMPONENTS AND PALLETS FOR EXPORT

10.1 Softwoods and Hardwoods

If required, i.e., for shipments to Australia and New Zealand (see Appendix A4-A), wood-base components of loaded export pallets, or pallets assembled for export, shall be pressure-tested with acceptable chemicals to ensure that phytosanitary requirements are completely satisfied. Instead of pressure treatment, such processes as fumigation, heat-treatment, steam-treatment, immersion in borate solution, chemical immunization, and kiln-drying to 14% moisture content or less can be employed for killing live pests in pallet components provided they will be in use no longer than 21 days after treatment (see Appendix A4-B). Where pressure treatment is not required, wood components and pallets, especially those for European Community countries [see Appendix A4-D, para. D4 and para. 4(a) of Part 4], shall be subjected to treatment as specified for softwoods and certain hardwoods (see Appendix A4-B).

10.2 Softwoods

All softwood (coniferous) timber (lumber) used for pallet components and assembled pallets destined for export or used as loaded pallets for exported goods shall be kiln-dried to 20(±2)% moisture content based on oven-dry weight and volume, determined in line with the methods described in ASTM D 4442 [see Appendix A4-D, para. D1(b)].

10.3 Hardwoods

All oak, chestnut, sugar or hard maple, sycamore, and eucalyptus timber (lumber), pallet components, and assembled pallets destined for export or used as loaded pallets for export, shall be tested as specified for each species in Appendix A4-B.

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MANDATORY APPENDIX A4-A
NATIONAL PHYTOSANITARY REQUIREMENTS FOR WOOD PALLETS

(This Appendix is an integral part of Part 4 of ASME MH1-1997, and is placed after the main text for convenience.)

The following nations have published phytosanitary requirements for wood pallets and pallet components imported into the nation:

Australia (see requirements on following page)
New Zealand

The following European Community (EC) nations have based their phytosanitary requirements on decisions made by the Standing Plant Health Committee of the EC Commission on August 17, 1990, and documented in PN 360:

Belgium
Denmark
France
Germany
Greece
Ireland
Italy
Luxembourg
The Netherlands
Portugal
Spain
United Kingdom

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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
AGRICULTURE QUARANTINE INSPECTION DIVISION
HYATTSVILLE, MARYLAND 20782

July 19, 1971

Cargo Containers, Pallets, etc.

This TM provides general information on Australia's quarantine requirements for cargo containers and unit loads. For more detailed information, exporters should be referred to the Hyattsville office, or to the Director-General, Department of Health, Canberra, A.C.T., Australia.

Australian quarantine officials are concerned about the possible introduction of timber pests, storage pests, and livestock diseases with imported cargo containers and unit loads (including those used in aircraft).

Treatment of exposed timber (lumber) used in the construction of containers is strongly recommended, before shipment to Australia. Pallets, flats, skids, etc., should also be treated. A number of treatments have been approved for the permanent protection of the exposed timber component of cargo containers. In addition, specific temporary treatments have been approved for wooden crates, cases, dunnage, and pallets used in packaging in cargo containers. The use of treated crate material, or the avoidance of wooden crates and cases, is encouraged. See Subparts 1 and 2 of Appendix A4-A for approved treatments.

Specific quarantine requirements for containers and unit loads may depend on the type of construction of containers, kind of crating, packaging, or dunnage used, kind of pre-treatment used (if any), destination, and nature of the commodity.

Documentation for containers is required, including container manifests giving details concerning timber component of containers, presence and treatment status of crates, cases, pallets, and dunnage, and presence of straw packing, rice hulls, or other prohibited materials.

Phytosanitary certificates are not required for containers, pallets, etc. All required documentation should be provided by the exporter or shipping company. This includes the certificate or declaration of treatment issued by the exporter or shipping company.

All containers, pallets, flats, dunnage, etc., are subject to inspection in Australia, and to treatment if necessary. They must be free from soil and prohibited plant and animal materials.

Subpart 1 APPROVED TREATMENTS FOR THE PERMANENT PROTECTION OF THE EXPOSED TIMBER COMPONENT OF CARGO CONTAINERS

The treatments detailed below are approved by the Commonwealth Department of Health for the exposed timber component of containers. Containers constructed with all exposed timber protected with one of these treatments will be exempted from quarantine requirements as far as such timber is concerned.

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1-1 ARSENIC-BASED PRESERVATIVES

Preservative	Percent Elemental Arsenic in Preservative	*Calculated Minimal Charge Retention of Preservative, lb/cu ft
Ascu A	7.05	0.56
Basilit CCA Type 'A'	5.85	0.67
Basilit U.A.	12.90	0.30
Basilit U.A. No. 132	20.54	0.19
Boliden K33, Osmose K33	22.17	0.17
Celcure A	14.80	0.26
Celcure AN	20.09	0.19
Celcure Z	19.56	0.20
Chemonite	32.73	0.12
Copas LC/A	14.80	0.26
Crytogil C	11.27	0.35
Fujisolute	5.64	0.70
Fujisolute CCA Type 'B'	7.38	0.54
Hager K33	25.49	0.15
Neo Malenit	8.86	0.45
Nissan CCA	7.33	0.54
Osmosalts	10.07	0.39
Pentagreen	7.33	0.54
Protim Slats	11.27	0.35
Tanalith C	11.27	0.35
Tanalith CA	21.02	0.18
Tanalith NCA	20.03	0.19
Tanalith U	10.07	0.39
Treatie CCA	11.27	0.35
Wolman CCA	6.20	0.64
Wolman CCA Type 'O'	20.53	0.19
Wolman CCA Type 'S'	13.51	0.29
Wolmanit FCAP	10.11	0.39
Wolmanit CKA	12.40	0.31
Wolmanit UA-B	22.16	0.18
Yoneda	6.26	0.62

*These are minimum charge loadings of commercial preservative (dry salt or paste) based on treated wood volume.

GENERAL NOTES:

(a) Arsenic does not volatilize; so toxic arsenical gases would not develop in closed containers.

(b) No evidence has been produced to show that CCA treatments of timber components in containers constitute a toxic hazard. The chemically treated timber is used in dry containers and not in exposed situations in refrigerated or wet containers.

1-2 Non-Arsenical Preservatives

Gamma B.H.C. (Lindane): with a minimal charge retention of 0.10 lb gamma B.H.C. per cu ft.

T.B.T.O. (Tributyltin oxide): by the "Drilon" or other approved method of application to a minimal charge retention of 0.30 lb Tributyltin oxide per cu ft.

Gamma B.H.C. (Lindane): T.B.T.O. with a minimal charge retention of 0.10 lb gamma B.H.C. per cu ft.

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Basileum S.P.I.: applied at the rate of 12 to 15% of wet glue weight; to give a minimal retention of 0.70 lb Basileum S.P.I. per cu ft. This treatment is acceptable for plywood with a maximum veneer thickness of $^3/_{16}$ in. only and will not be accepted for other timbers including laminated timber.

Niedo-Woodgard: with a minimal charge retention of 0.75 lb. boric acid equivalent per cu ft plus 0.75 lb paraffin wax per cu ft.

Dieldrin Treated Particle Board: Particle board treated during manufacture at an average content of 0.05% based on oven-dry weight. Dieldrin must be evenly distributed throughout particle board.

Subpart 2 APPROVED TREATMENTS FOR WOODEN CRATES, CASES, DUNNAGE, AND PALLETS USED AS PACKAGING IN CARGO CONTAINERS

The following treatments have been approved by the Commonwealth Department of Health for the destruction of wood-boring insects in timber used in packaging in cargo containers. Timber treated with one of these methods *must be utilized within 21 days of treatment.* (This does not apply to processed panels.)

(1) Fumigation with methyl bromide at 3 lb per 100 cu ft of space (enclosed by gas proof sheet or chamber) at a temperature of 70°F (21°C) for 24 hours. For every 10°F, the minimum temperature expected to fall below 70°F, the dosage of methyl bromide should be increased by $^1/_2$ lb per 1000 cu ft of space to a maximum dosage of 4 lb per 1000 cu ft at a minimum temperature of 50°F (10°C). No fumigation with methyl bromide should be attempted at temperatures below 50°F. The methyl bromide should be applied as a hot gas through a vaporizer or circulation fans should be used to ensure even distribution of the fumigant.

This treatment can be applied to timber with a maximum thickness of 4 in., stacked to allow adequate penetration amongst the timber.

(2) Heat applied at a temperature of 165°F (74°C) and maintained for a period, which is determined by the maximum thickness of the timber, as shown below:

Thickness of Timber, in.	Length of Treatment, hr
Less than 2	6
Less than 3, more than 2	8
Less than 4, more than 3	10
Less than 6, more than 4	14
Less than 12, more than 6	26

The temperature in the center of the stack must reach 165°F (75°C) before the period of treatment commences.

(3) Kiln drying to 14% moisture content or lower. The timber must be dried according to the standard kiln drying procedure and the amount of heat applied must be equal to that outlined in subpara. (2) above.

(4) Steaming in a chamber at 180°F (82°C) for at least 4 hr before introducing a cold borate solution. This treatment is applicable to timber up to 2 in. thick and the pockets of timber must be fully filleted or stickered.

(5) Immersion in a borate solution at a minimum temperature of 200°F (93°C) for at least $3^1/_2$ hr. The solution must then be allowed to cool through 40°F before the timber is removed. This treatment is applicable to timber up to 2 in. in thickness and the packets of timber must be fully filleted or stickered.

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NOTE: Treatments 4 and 5 are acceptable because of the heat applied, not because of the boron treatment.

(6) Chemical immunization of timber as listed in Subpart 1 for the timber components of containers, may be used for timber packaging if the treatments are applied overseas.

F. A. Johnston
Director

CONVERSION TABLE

1 in. = 25.4 mm
1 lb (1 lbf) = 4.45 N
1 cu ft = 0.0283 m^3
1 lb/cu ft (1 lbm/ft^3) = 16.0 kg/m^3

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MANDATORY APPENDIX A4-B
PHYTOSANITARY TREATMENT FOR CERTAIN SPECIES OF WOOD

(This Appendix is an integral part of Part 4 of ASME MH1-1997, and is placed after the main text for convenience.)

B1 TREATMENT FOR SOFTWOODS (CONIFEROUS SPECIES)

All softwood timber (lumber), pallet components, and assembled pallets shall be kiln-dried to 20(±2)% moisture content.

Final moisture content (MC) shall be verified by one of the methods provided in ASTM D 4442 [see Appendix A4-D, para. D1(b)].

B2 TREATMENT FOR HARDWOODS

Treatment	Oak, Chestnut	Sugar Maple
Kiln-dried (KD)	Below 20% MC	Below 20% MC
KD time	Not specified	As specified
KD temperature	Not specified	As specified

Treatment	Sycamore	Eucalyptus
Kiln-dried (KD)	Below 20%	Treatment
KD time	As specified	Appropriate
KD temperature	As specified	Appropriate

Alternative Treatment	
Wane	None
Hot air	109°F for 48 hr
Hot air	129°F for 25 hr
Hot water	109°F for 48 hr
Hot water	120°F for 12 hr
Fumigated	As specified
Pests and pathogens	Inspection required

B3 ALTERNATIVES TO PRESSURE-TREATMENT

Instead of pressure-treatment, alternative processes such as fumigation, heat-treatment, steam-treatment, immersion in borate solution, chemical immunization, and kiln-drying to 14% moisture content or less can be employed for killing live pests in pallet components *provided the pallets/pallet components will be in use not more than 21 days after treatment* (see Appendix A4-A for national requirements).

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NONMANDATORY APPENDIX A4-C
SPECIAL REQUIREMENTS FOR WOOD PALLETS DESTINED FOR GERMANY

(This Appendix is not part of Part 4 of ASME MH1-1997, and is included for information purposes only.)

The requirements by the German Government for wood pallets were initiated to alleviate existing environmental problems. These requirements are based on:

(a) Directive for Packaging approved by the German Federal Cabinet, November 14, 1990, and by the German Bundesrat, April 19, 1991, concerning the returning, recycling, reusing, and disposing of all packaging materials and products; and

(b) Ordinance for Avoiding Packaging Waste approved by the German Federal Government, June 12, 1991.

All pallets and slip sheets (plastic sheets) shall be returned to the importer, distributor, or manufacturer, or made available to a collecting, removing, or recycling agency (Entsorger), such as:

(a) VHP—Verwertungsgesellschaft fuer Holz-packmittel und Paletten, organized by the Bundesverband Holzpackmittel—Paletten—Exportverpackung of Frankfurt/Main, Germany; or

(b) Interseroh of Cologne (Koln), Germany, with more than 600 partners (Ansprechpartner) for reuse or recycling.

Accepted are clean, repairable pallets of all types and sizes and made of solid wood with or without molded wood-particle blocks.

Not accepted by VHP are pallets more than 1 year old; pallets contaminated by oil, paint, etc. (which presumably includes painted or stained pallets); pallets made of wood treated with preservatives; pallets containing plastics; pallets with non-wood blocks or spacers: pallets with fastener elements of diameters larger than 12 mm (½ in.) or any aluminum fasteners. (No mention is made of such fasteners as hardened-steel nails and metal connector plates used in the U.S.A., however, not common in Germany.)

Not accepted by Interseroh are the pallets described above as well as solid wood pallets which include composite wood elements, such as plywood, particleboard, fiberboard, flakeboard, and hardboard, as well as pallets containing metal parts, such as metal nails, staples, screws, bolts, and sheet metal connectors of sizes larger than 10 mm (0.4 in.) in diameter or thickness. Pallets containing composite wood elements shall be separated from those made of solid wood.

Since the 800 by 1200 mm (31¼ by 47¼ in.) European Pool Pallet (EUR) is the pallet most commonly used in Germany, it may be good practice to use these pallets for export to Germany, if it is feasible to place the export goods on these pallets. Another common German pallet is the 1000 by 1200 mm (39½ by 47¼ in.) pallet which is, of course, similar in size to the 40 by 48 in. American pallet.

Loaded EUR pallets used for exporting goods to Germany do not require an EUR manufacturing license. However, EUR pallets shipped to Germany for sale require an EUR manufacturing license.

If possible, both shrink wrap and stretch wrap should be replaced by steel or plastic strapping.

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NONMANDATORY APPENDIX A4-D
REFERENCED DOCUMENTS

(This Appendix is not part of Part 4 of ASME MH1-1997, and is included for information purposes only.)

D1 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

ASTM D 1185-1994, Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping

ASTM D 4442-1992, Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

Publisher: American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

D2 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) STANDARDS

ISO 6780-1988/1994, General Purpose Flat Pallets for Through Transit of Goods—Principle Dimensions and Tolerances

ISO/TR 10233-1989, General Purpose Flat Pallets for Through Transit of Goods—Performance Requirements

ISO/TR 10234-1989, General Purpose Flat Pallets for Through Transit of Goods—Phytosanitary (Plant Health) Requirements for Wooden Pallets

ISO/TR 11444-1995, Quality of Sawn Wood Used for the Construction of Pallets

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1211, Genèva 20, Switzerland/Suisse

D3 CANADIAN PALLET COUNCIL (CPC) PUBLICATIONS

1988 Sanitary Guidelines for the Storage, Handling and Manufacturing/Repair of CPC Pallets

Publisher: Canadian Pallet Council, 145 The West Mall, Etobicoke, Ontario M9C1C2, Canada

D4 ANIMAL AND PLANT HEALTH INSPECTION SERVICES (APHIS) PUBLICATIONS

1990 Current EC Phytosanitary Requirements, Phytosanitary Notes PN 360

Publisher: Animal and Plant Health Inspection Services, USDA Plant Protection and Quarantine, NAPPO, Washington, DC 20250

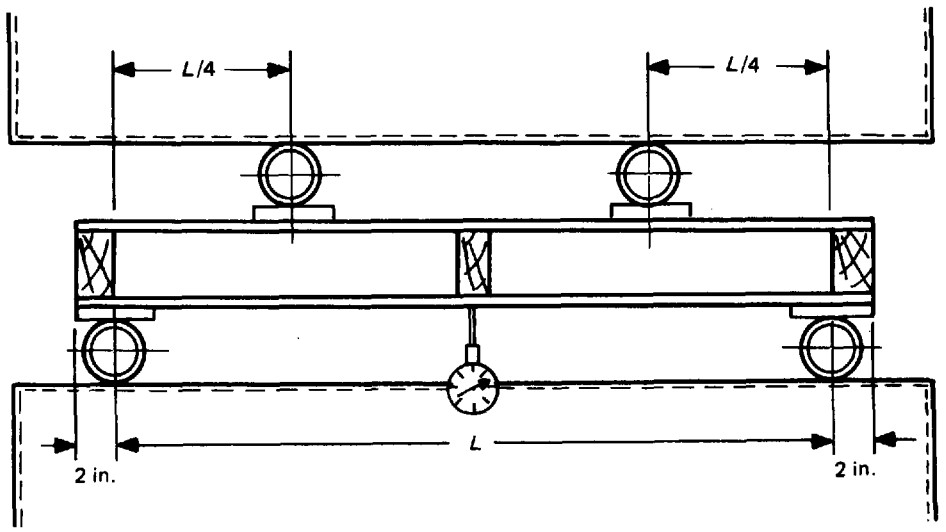
D5 FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS (FAO)

International Plant Protection Convention of Rome of 1952, as amended in 1977, effective April 1991

Publisher: Food and Agricultural Organization of the United Nations, Via Della Terma di Caracalla, 00100 Rome, Italy

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GENERAL NOTE: See text for metric dimensions.

FIG. 14 STIFFNESS AND FLEXURAL STRENGTH TEST, USING TESTING MACHINE WITH LARGE PLATENS

(a) **8.1 Pallet Stiffness and Flexural Strength Test (See Part 7, Figs. 14 Through 14D)**

(a) This test procedure is applicable to determining the relative stiffness and flexural strength of a pallet when loaded as a beam at the one one-quarter points of the span.

(b) The use of the following test equipment is required:

(1) a universal testing machine with large platens, a suitable test rack, as shown in Part 7, Figs. 14A and 14B, or a dead-weight loading setup;

(2) four 3.0 in. (76 mm) diameter steel pipes for support and loading;

(3) four bearing plates, each a 0.5 in. (12.7 mm) by 4.0 in. (102 mm) plywood piece; and

(4) two dial micrometer gages, allowing deflection readings of 0.001 in. (0.025 mm), with suitable mounting stands. The pipes and bearing plates shall be at least as long as the pallets.

(c) Each pallet shall be tested consecutively four times:

(1) with the pallet spanning 4.0 in. (102 mm) less than the width and with the top deck up;

(2) with the pallet spanning 4.0 in. (102 mm) less than the length and with the top deck up;

(3) with the pallet spanning 4.0 in. (102 mm) less than the width and with the top deck down;

(4) with the pallet spanning 4.0 in. (102 mm) less than the length and with the top deck down.

The supports shall be 3.0 in (76 mm) diameter pipes, placed crosswise to the span and 2.0 in. (51 mm) from each end. The loads shall be applied through 3.0 in. (76 mm) diameter pipes, placed crosswise to the span at the one-quarter points of the span.

(d) All pipes shall be separated from the pallets with plywood load-bearing plates centered on and oriented along the axis of the pipes. The specimen shall be loaded to its rated load at a uniform rate of crosshead or piston movement of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min]. A load deflection record shall be maintained in a suitable manner.

(e) Another procedure is applicable when a uniformly distributed load is to be applied to the whole pallet surface (see Part 7, Fig. 14D). The pallet is installed above the pallet supports and below an inflatable air bag. The load can be measured with strategically located load cells and the deflection can be measured with satisfactorily located potentiometers, as is indicated in Part 7, Fig. 14D.

8.2 Deckboard Stiffness Test (See Part 7, Figs. 15 Through 15B) (a)

(a) This test procedure is applicable to determining the adequacy of decks of pallets to resist bending stresses resulting from superimposed loads such as stacks of similarly loaded pallets in storage.

(b) In conducting the deckboard stiffness and flexural strength test, any convenient procedure may be used

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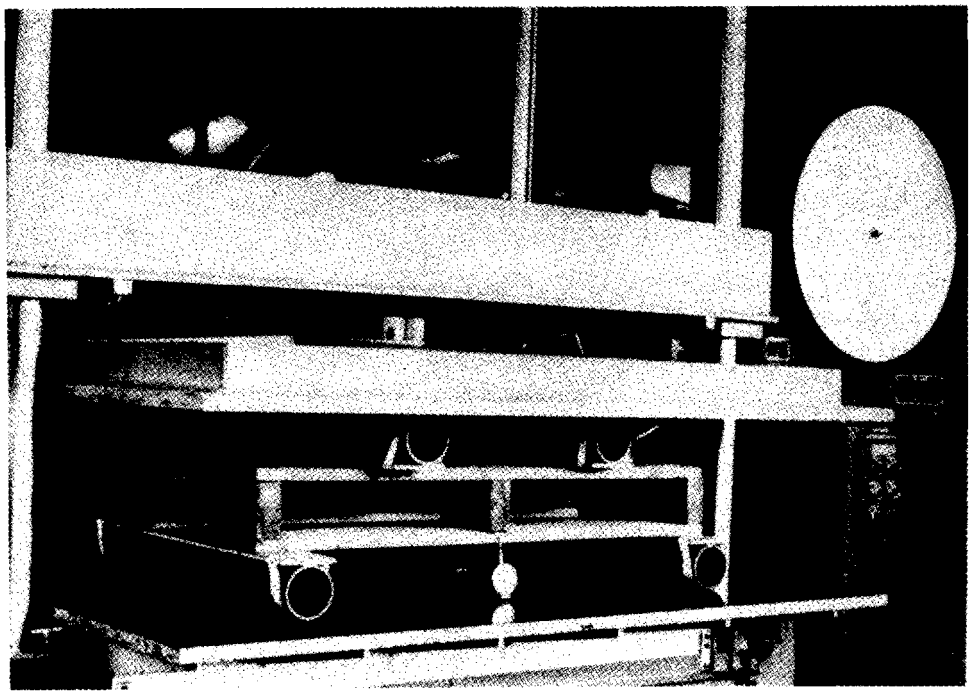


FIG. 14A STIFFNESS AND FLEXURAL STRENGTH TEST, USING TESTING MACHINE WITH LARGE PLATENS

for placing the load on the pallet, such as with a hoist, a block and tackle, a forklift truck, or manually. The load may also be applied and maintained by means of a suitable testing machine. Use of the following additional test equipment is required:

(1) two 3.0 in. (76 mm) diameter pipes for loading:

(2) two load-bearing plates, each a 0.5 × 4.0 in. (12.7 × 102 mm) plywood piece; and

(3) two dial micrometer gages, or similar sensing devices, allowing deflection readings of 0.001 in. (0.025 mm), with suitable stands.

The pipes and bearing plates shall be at least as long as the pallets.

(c) The pallet shall be placed with its bottom on a flat, level, rigid floor or testing machine bed. The pipes and bearing plates shall be positioned at the one-third points of the span, as shown in Part 7, Fig. 15. A load, twice the rated load capacity of the pallet, shall be placed evenly. If a testing machine is used, the rate of loading shall be uniform at 0.100 (±0.050) in./min [2.54 (±1.27) mm/min]. The maximum deflection of the deckboards and any damage shall be recorded. The load shall be removed and any residual deformation shall be measured. The same load shall be reapplied in a like manner and the maximum deckboard deflection shall be recorded. Any abnormalities or residual deformations shall be recorded on a suitable data sheet. For evaluating the bottom deck, the pallet shall be turned upside down and the test conducted in a similar manner with a load equal to one and one-half times the rated load capacity of the pallet.

(d) Another procedure of loading the deckboards or deck in a uniform manner is by using vacuum loading (see Part 7, Fig. 15B). The pallet is installed in an enclosure with a plastic membrane taped over the deckboards or deck to attain a vacuum-tight enclosure. A satisfactory clearance between the pallet deckboards or deck and the enclosure is provided. A certain amount of slack in the plastic membrane shall ensure uniform load application. Deflection measurements shall be taken of the surface of the deck structure relative to points directly above the pallet supports.

8.3 Combined Deckboard, Stringer, and Pallet Stiffness and Flexural Strength Test (See Part 7, Figs. 16 and 16A)(VPI&SU Pallet and Container Research Laboratory Bulletins Nos. 123 and 131) (a)

(a) This test procedure is applicable to determination of the relative stiffness and flexural strength of the deckboards, the stringers, and the whole pallet under load. It may serve as an alternative or supplementary

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NONMANDATORY APPENDIX A7-B
IMPACT TESTS ON PALLET SECTIONS
Forest Products Journal 5(6); 243-4; also VPI&SU William H. Sardo, Jr., Pallet and Container Research Laboratory Bulletins Nos. 126 and 139

(This Appendix is not part of Part 7 of ASME MH1-1997, and is included for information purposes only.)

(a) B1 GENERAL

In many instances, especially in developmental work as well as during the performance of control tests, the desired test data can be obtained by testing pallet sections instead of assembled pallets.

(a) Two basic types of tests have been advanced:

(1) deckboard-stringer separation test; and

(2) deckboard-stringer torsion test.

(b) Whereas the testing of pallets calls for the dropping of the pallets, the testing of pallet sections requires the dropping of a given mass onto the pallet sections. The latter procedure has the advantage of making it possible to disregard the weight of the assembly under observation during the evaluation of the test data.

(a) B2 DECKBOARD-STRINGER/BLOCK SEPARATION TEST (SEE APPENDIX A7-B, FIG. B1)

(a) The test is performed to determine the resistance to separation of pallet deckboard from pallet stringer or block during application of impact forces, in the direction perpendicular to the plane of the deckboard. The forces applied simulate the action of the forks of forklift trucks under given conditions. In most instances, this test indicates the head pull-through impact resistance of the fasteners in the deckboard or the shank withdrawal impact resistance of the fasteners from the stringer or block.

(b) The deckboard-stringer or block connection is placed into a testing device in such a way that given impact forces can be applied onto both deckboard ends extending beyond both sides of the stringer or block being firmly supported or vice versa. This is accomplished by dropping a given weight from given heights onto a hard maple or similar loading block straddling the stringer, block, or deckboard in such a way that friction cannot occur between loading block and stringer, block, or deckboard.

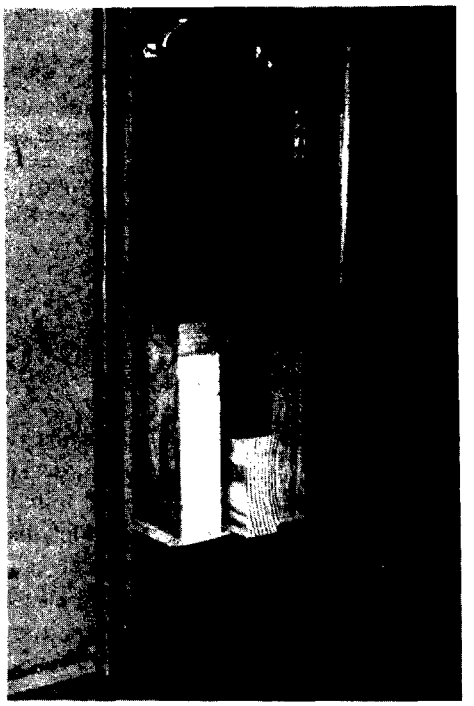


FIG. B1 DECKBOARD-STRINGER SEPARATION TEST

(c) The test is performed by dropping a steel weight, usually of 15.0 or 40.0 lb (6.8 or 18.1 kg) from a height of 4.0 in. (102 mm) between the bottom of the weight and the top of the loading block after release by hand or by a mechanism, such as a solenoid release. Subsequently, this same weight is dropped from heights of 8.0, 12.0, 16.0, 20.0, 24.0, 24.0, and 24.0 in. (203, 305, 406, 508, 610, 610, and 610 mm) above the

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loading block until failure occurs, that is, until the deckboard is separated completely from the stringer or block. In certain instances, it is advisable to apply a smaller or larger increment of energy input by using a smaller or larger weight or a smaller or larger drop height or by increasing or decreasing both weight and height. The selection of the energy-impact levels depends on the type of connection under scrutiny, in order to allow satisfactory evaluation of the test data.

(d) The total energy required to achieve failure and the types of failure observed are recorded. In addition, the actual separation of the deckboard from the stringer or block during progress of the test, that is, after the application of each impact, may be recorded and plotted in a drop height/separation diagram in order to allow a visual comparison of the test results.

NOTE: Under certain conditions, it may be desirable to perform a similar test under static loading conditions by pushing the deckboard from the stringer or block, in the direction perpendicular to that of the plane of the deckboard, using a suitable testing machine and applying the load at a constant rate of motion of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min] of the cross-head of this testing machine.



FIG. B2 DECKBOARD-STRINGER TORSION TEST

B3 DECKBOARD-STRINGER TORSION TEST (SEE APPENDIX A7-B, FIG. B2)

(a) This test is performed to determine the rigidity and torsional resistance of the pallet corner, deckboard-stringer connection during application of impact and racking forces in the direction of the pallet diagonal in the plane of the pallet.

(b) The deckboard-stringer connection is placed into the same testing device as used for the performance of the deckboard-stinger/block separation test to allow application of given impact forces onto the slightly rounded outer edge of the three-member connection, while the rounded far edges of both 10.75 in. (273 mm) long and 5.5 in. (140 mm) wide deckboards and the 12.0 in. (305 mm) long stringer are placed on the bed of the testing device without being restricted from spreading.

(c) The test is performed by dropping a steel weight, usually of 15.0 or 40.0 lb (6.8 or 18.1 kg) from a height of 4.0 in. (102 mm) between the bottom of the weight and the top of the loading block after release by hand or by a mechanism, such as a solenoid release. Subsequently, this same weight is dropped from heights of 8.0, 12.0, 16.0, 20.0, 24.0, 24.0, and 24.0 in. (203, 305, 406, 508, 610, 610, and 610 mm) above the connection edge until failure occurs. Failure is considered to have taken place after the angle between the deckboard and stringer has increased from the original angle of 90 to 120 deg. In certain instances, it is advisable to apply a smaller increment of energy input by using a smaller weight or a smaller drop height or by decreasing both weight and height. The selection of the energy-impact levels depends on the type of connection under scrutiny, in order to allow satisfactory evaluation of the test data.

(d) The total energy required to achieve failure and the types of failure observed are recorded. In addition, the actual angular distortion of the connection during progress of the test, that is, after the application of each impact, may be recorded and plotted in a drop height/distortion diagram in order to allow a visual comparison of the test results. A typical drop height/distortion diagram is presented in Appendix A7-B, Fig. B3.

NOTE: Under certain conditions, it may be desirable to perform a similar test under static loading conditions by pushing against the slightly rounded upper edge of the three-member connection, using a suitable testing machine and applying the load at a constant rate of motion of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min] of the cross-head of the testing machine.

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Part 8
Slip Sheets

(a)

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PART 8
SLIP SHEETS

1 SCOPE

Part 8 is applicable to the assembling, handling, storing, and transporting of products and goods in unit load form, with a unit, placed on a slip sheet, being a collection of one or more pieces of a product whose mass or weight is too great for a single person to handle without using a mechanical device. Part 8 defines terms, sizes, materials, testing, and specific characteristics relevant to slip sheets and the appropriate type and operation of material handling equipment.

The system of slip sheet unit load handling involves the use of a thin sheet of material, the slip sheet, as a base on which items are assembled as a unit load for handling, storage, and transport. Pallets provide a unique approach to a material handling base. Slip sheeting provides another technique for assembling, handling, storing, and shipping of goods in unit load form.

To use slip sheets, a conventional industrial lift truck shall be equipped with a special attachment for gripping, pulling, and pushing of the slip-sheeted unit loads. This attachment may be removable or permanent depending on the application and circumstances.

The slip sheet is used in conjunction with a pallet, if desired, at certain stages in the distribution cycle. If all lift trucks in the cycle are equipped with the proper attachment, an appropriate slip sheet is the only material handling base required. Unit loads on slip sheets are lifted and stacked depending on the strength of the unit load packaging, and then retrieved and handled singularly. The stacking height can be as high as five unit loads.

Originally developed in the United States, the use of slip sheets has spread to other countries. It provides an inexpensive and lightweight unit load base that occupies little shipping cube and is more easily disposed of than conventional pallets. If both the shipper and receiver have the appropriate equipment, and other basic requirements are met, the benefits of unitized load handling can be realized.

2 PURPOSE

The purpose of Part 8 is to provide a basis for understanding, evaluating, and selecting slip sheets and choosing the correct unit load handling equipment.

3 REFERENCED STANDARDS

3.1 ASTM Standards on Pallets

ASTM D 1083-1988, Methods of Testing the Mechanical Handling of Unitized Loads and Large Shipping Cases and Crates, Section 9.4.2, "Slip Sheet Tab Clamp and Pull"

ASTM D 1185-1994, Methods of Testing Pallets and Related Structures Employed in Materials Handling and Shipping

ASTM D 4727-1996, Standard Specification for Corrugated and Solid Fiberboard Sheet Stock (container grade) and Cut Shapes

ASTM D 6055-1996, Standard Test Methods for Mechanical Handling of Unitized Loads and Large Shipping Cases and Crates

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

3.2 TAPPI Standards on Paperboard

T 494-1988, Tensile Breaking Properties of Paper and Paperboard

Publisher: Technical Association of the Pulp and Paper Industry (TAPPI), Technology Park/Atlanta, P.O. Box 105113, Atlanta, Georgia 30348

3.3 ISO International Standards and Technical Reports

ISO 6780-1994, General Purpose Flat Pallets for Through Transit of Goods—Principal Dimensions and Tolerances

ISO 8611-1992, General Purpose Flat Pallets for Through Transit of Goods—Test Methods

ISO/TR 10232-1992, General Purpose Flat Pallets for Through Transit of Goods—Design Rating and Maximum Working Load

ISO/TR 10233-1992, General Purpose Flat Pallets for Through Transit of Goods—Performance Requirements

ISO/TR 10234-1990, General Purpose Flat Pallets for Through Transit of Goods—Phytosanitary (Plant Health) Requirements for Wooden Pallets

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ISO/TR 12776-1995, Slip Sheets
ISO 3676-1983, Unit Load Sizes—Dimensions
ISO 534-1988, Paper and Board—Determination of Thickness and Bulk Density or Apparent Sheet Density
ISO 1924-1-1992, Paper and Board—Determination of Tensile Properties
ISO 2493-1992, Paper and Board—Determination of Resistance to Bending
ISO 2759-1983, Board—Determination of Bursting Strength
ISO 3034-1975, Corrugated Fiberboard—Determination of Thickness
ISO 5629-1983, Paper and Board—Determination of Bending Stiffness—Resonance Method
ISO 5638-1978, Solid Fiberboard—Determination of Grammage of Single Layers
ISO/TR 527-1966, Plastics—Determination of Tensile Properties
ISO 178-1993, Plastics—Determination of Flexural Properties
ISO 3268-1978, Plastics—Glass—Reinforced Materials—Determination of Tensile Properties

Publisher: International Organization for Standardardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1211, Genèva 20, Switzerland/Suisse

4 DEFINITIONS AND TERMINOLOGY

Definitions and terminology which are included in Part 1 of this Standard apply to Part 8. Additional items are given below.

4.1 Slip Sheet

slip sheet: a flat sheet of material with a tab on one or more sides, used as a base for assembling, handling, storing, and transporting goods and products in unit load form. Slip sheets are related to pallets and can be used in conjunction with pallets or handled separately.

expendable slip sheet: a sheet intended to be discarded after a single cycle of use.

reusable slip sheet: a sheet intended for multiple cycles of use.

recyclable slip sheet: sheet material which can be reprocessed.

score line: an impression or crease in slip sheet material that is provided to locate and facilitate folding to create a tab.

slip sheet load surface: that portion of the slip sheet under the unit load of goods or products. The surface can be solid or provided with ventilation holes of appropriate size, configuration, and location.

slip sheet tabs: those parts of the slip sheet that extend beyond the unit load dimensions to facilitate material handling by a pulling device equipped with a gripper jaw. In some locales, the terms *lip* or *flap* are used to designate the slip sheet tab.

double thickness tab: a tab having twice the thickness of the flat sheet, formed by folding excess sheet material 180 deg to allow a portion of it to be under the unit load. The tab can be secured in place by fastening materials.

laminated tab: a tab whose thickness is increased by fastening paper, plastic, fabric, or similar material to the tab and sheet load surface, allowing a portion of it to be under the unit load. Normally, the width of the extra material is twice the tab width.

4.2 Push Pull

push pull: a generic term for a mechanically/hydraulically powered attachment on an industrial truck to retrieve or discharge a slip sheet unit load.

gripper jaw: the hydraulically powered mechanical assembly of a push pull attachment that clamps the tab of the slip sheet uniformly along the tab length to pull the unit load onto the load plate during load retrieval. The jaw's clamp is opened during unit load discharge.

slip sheet retainer: a modified gripper jaw which disconnects from the pusher rack but retains its clamping hold on the slip sheet and allows the unit load to be discharged from the slip sheet and load plate by the pusher rack.

load plate: a rigid metal component, usually of steel, of the push pull that supports a slip sheet unit load. Normally, the plate is finished smoothly and has a chisel tip and a tapered configuration to its mounting point.

adjustable load plate: a load plate with platens which can be moved together or apart in the same horizontal plane to change the overall width of the load plate. This load plate allows insertion of the platens and handling of compatible pallet sizes.

food industry forks: a substitute for a load plate, consisting of four or six tapered and polished tines, equally spaced laterally in the same horizontal plane and permitting handling of slip sheet unit loads and compatible pallet sizes.

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platens: two or more component assemblies with open space between them, comprising a load plate.

side shift load plate: a load plate which moves independently of the pusher rack, with or without its unit load, in a lateral direction to the longitudinal axis of the lift truck.

slotted load plate: a load plate consisting of two or more platens in the same horizontal plane, spaced apart to allow a void between the platens. This load plate allows insertion of the platens into pallet openings and handling of compatible pallet sizes.

pusher rack: a vertical mechanical assembly of the push pull, moveable forward and backward, providing the means and force to discharge or retrieve a slip sheet unit load. The rack can be extended beyond the tip of the load plate or fully retracted.

faceplate: term for *pusher rack.*

multi-stop pusher rack: a pusher rack with one or more retracting stop positions, between fully extended and retracted positions, to accommodate different lengths of slip sheet unit loads.

4.3 Slip Sheet Dispenser

slip sheet dispenser: a powered mechanical device, holding multiple slip sheets, which automatically discharges one sheet at a time to form the base to accommodate a unit load of goods or products. The dispenser is normally used in conjunction with an automatic or semi-automatic product unitizer.

4.4 Slip Sheet Caliper

slip sheet caliper: the measured thickness of slip sheet material. Caliper is frequently expressed as a decimal.

4.5 Slip Sheet Tensile Strength

slip sheet tensile strength: the resistance to tearing of a slip sheet subject to an applied pulling force.

5 MATERIALS

5.1 Typical Materials

Typical materials used for the manufacture of slip sheets are those described below.

5.1.1 Corrugated Fiberboard. Corrugated fiberboard is a board with paperboard facings bonded to a fluted or corrugated medium providing adequate tensile strength. The board is often referred to in terms of flute size and board test or basis weight and tensile strength. For slip sheet applications, corrugated fiberboard shall be specified using tensile strength (see Part 8, para. 7). To obtain adequate performance where high moisture conditions exist, the flutes and paperboard facings, impregnated or coated with a water-repellent material, shall be bonded to each other using a weather-resistant (see ASTM D 4727-1996) adhesive. If additional strength is required, nylon string can be incorporated into the slip sheet during its manufacture, with the nylon string oriented in the pulling direction of the slip sheet.

5.1.2 Solid Fiberboard. Solid fiberboard is defined as plies of paperboard laminated together to provide adequate tensile strength for slip sheet requirements. Caliper is expressed in points, where 1 point = 0.025 mm (0.001 in.). To obtain adequate performance where high moisture conditions exist, the plies of the slip sheet, impregnated or coated with a water-repellent material, shall be bonded to each other using a moisture-resistant adhesive.

5.1.3 Plastics. Plastics are any kind or combination of polymerized materials in sheet form, including but not limited to polyethylene or polypropylene, that provides adequate tensile strength and other requirements of the slip sheet. Caliper is expressed in mils, where 1 mil = 0.025 mm (0.001 in.).

5.2 Other Materials

Such materials as a woven fabric with a laminated tab or paper overlayed veneer, for example, can be used provided tensile strength and caliper requirements are met. Sheet metal shall not be used for slip sheets.

6 DIMENSIONS

6.1 Base Size

The load surface size of a slip sheet, which excludes tab(s), shall approximate the plan view (footprint) dimensions of the unit loads. The longer of the two dimensions shall be the length and the shorter of the two dimensions, excluding tab(s), shall be the width. The length shall at least equal the unit load length dimension and may exceed the load length by a maximum of 50 mm (2 in.). The width shall not be more than 50 mm (2 in.) smaller than the load width nor more than 25 mm (1 in.) greater than the load width.

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6.2 Unit Load Size

Reference is made to ISO 6780, ISO 3676, and Part 2 of ASME MH1 for guidance in selecting the appropriate load surface dimensions.

6.3 Tab Width

The width of the tabs shall be a minimum of 75 mm (3 in.) and a maximum of 105 mm ($4^1/_8$ in. or 4.125 in.). A shorter width makes the sheet difficult for the operator to see and grab.

6.4 Overall Size

The combination of the base and tab dimensions determines the full slip sheet size.

6.5 Tolerances

The overall size of the slip sheet shall be within ±7 mm ($\pm^9/_{32}$ in. or 0.2503 in.) of the dimensions specified by the user.

6.6 Slip Sheet Thickness

The minimum caliper of the three common materials used for slip sheets shall be as follows.

6.6.1 Corrugated Fiberboard. 3.0 mm (0.118 in.); more for double-wall and triple-wall corrugated fiberboard

6.6.2 Solid Fiberboard. 1.0 mm (0.039 in.)

6.6.3 Plastics. 1.0 mm (0.039 in.)

7 PERFORMANCE REQUIREMENTS

7.1 Tensile Strength

Tensile strength is the maximum pulling strength developed prior to failure of the slip sheet. For a particular unit load, the slip sheet shall possess sufficient tensile strength to avoid rupture when the tab is properly pulled by the gripper jaw and the unit load is in place.

7.1.1 Tensile Strength Guidelines. Tensile strength cannot be considered a performance determinant by itself. Other factors such as scoring, stiffness, moisture, and sheet construction interrelate and affect slip sheet performance. In general, higher tensile strengths are required for heavier unit loads or loads subjected to repeated handling by push pull equipment.

TABLE 1 RANGE OF TENSILE STRENGTH VALUES

	Grain Direction of Paperboard	
Type of Paperboard	Machine	Cross
Corrugated fiberboard	40–65 kN/m (230–370 lbf/in.)	25–40 kN/m (140–230 lbf/in.)
Solid fiberboard	45–95 kN/m (260–540 lbf/in.)	20–40 kN/m (115–230 lbf/in.)

7.1.2 Tensile Strength Values. Depending on the type of paperboard used, the tensile strength values shall range as shown in Part 8, Table 1, when tested according to the constant rate of elongation method (see TAPPI T 494 and ISO 1924).

7.2 Stiffness

Adequate stiffness of the slip sheet is required for handling certain products such as bagged goods or irregularly shaped materials to avoid deformation of the tab, which can prevent proper clamping by the gripper jaw. Additional stiffness is normally obtained by increasing the thickness of the slip sheet.

7.3 Markings

No markings are set forth as requirements. Individual manufacturers of slip sheets or the user may designate appropriate markings for their own purposes.

8 TESTING

8.1 Maximum Tensile Strength of Solid Fiberboard

Maximum tensile strength of solid fiberboard is obtained by pulling in the machine direction of the fibers.

8.2 Maximum Tensile Strength of Corrugated Fiberboard

Maximum tensile strength of corrugated fiberboard is obtained by pulling in the machine direction of the paper faces, that is, at a right angle to the direction of the flutes.

8.3 Tensile Strength at Right Angle to the Slip Sheet Score Line

Tensile strength at right angle to the slip sheet score line is obtained after bending the tab along the score

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line 90 deg in either the up or down direction. The test sample of the material shall include the score line.

8.4 Durability of Tab

Durability is tested by bending the tab a minimum of 15 times along the score line from horizontal to a 90 deg vertical position, then returning the tab to the horizontal position prior to application of tension for tensile strength testing. The tab shall remain functional throughout the slip sheet unit load distribution cycle.

8.5 Stiffness Testing

Stiffness testing is a function of the bending stresses imposed on the slip sheet by bagged goods or irregularly shaped materials and is influenced by whether or not the tab can be properly inserted into the gripper jaw for clamping.

8.6 Final Test

The final test is a function of performance throughout the actual distribution cycle.

9 DESIGN

9.1 Tabs

Tabs are located on one or more sides of a slip sheet to facilitate handling.

9.2 Tab Configurations

Tab configurations are described and illustrated in Part 8, Figs. 1 through 5, with broken lines representing score lines.

9.2.1 One-Tab Slip Sheet. A one-tab slip sheet has a single tab located at one edge of the sheet. This design is popular where a uniform in-a-row loading pattern in transport vehicles is prevalent. See Part 8, Fig. 1.

9.2.2 Two-Tab Slip Sheet, Opposite. In a two-tab slip sheet, opposite, tabs are located at opposite edges of the sheet. This design is used for uniform in-a-row loading pattern in transport vehicles. In addition, it provides a safety factor against damage to one tab. See Part 8, Fig. 2.

9.2.3 Two-Tab Slip Sheet, Adjacent. In a two-tab slip sheet, adjacent, tabs are located at adjacent edges of the sheet. This design is used where unit loads are loaded in a pin-wheel pattern in transport vehicles having different interior widths such as railroad cars and highway trucks. See Part 8, Fig. 3.

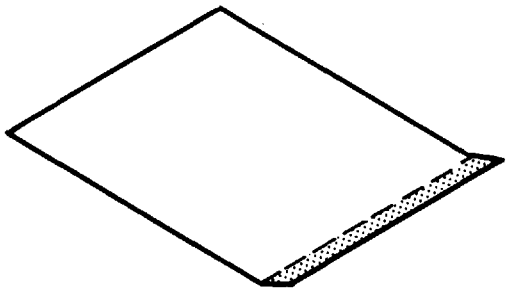


FIG. 1 ONE-TAB SLIP SHEET

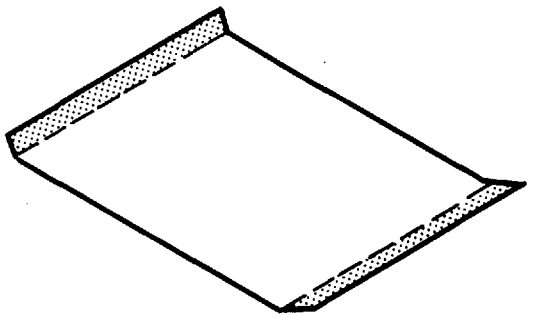


FIG. 2 TWO-TAB SLIP SHEET, OPPOSITE

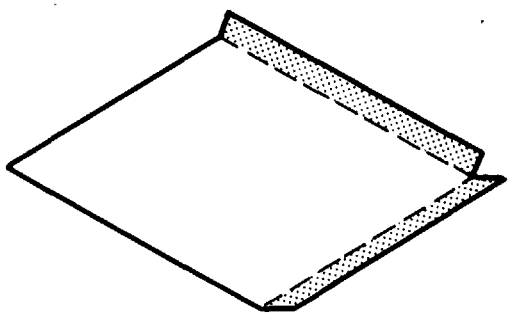


FIG. 3 TWO-TAB SLIP SHEET, ADJACENT

9.2.4 Three-Tab Slip Sheet. In a three-tab slip sheet, tabs are located at three adjacent edges of the sheet. This design is occasionally used to capture the features and advantages of tab locations shown in Part 8, Figs. 2 and 3. See Part 8, Fig. 4.

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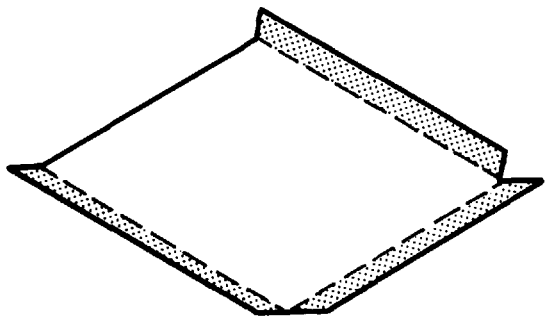


FIG. 4 THREE-TAB SLIP SHEET

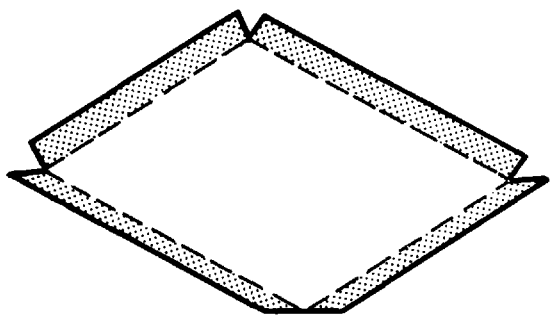


FIG. 5 FOUR-TAB SLIP SHEET

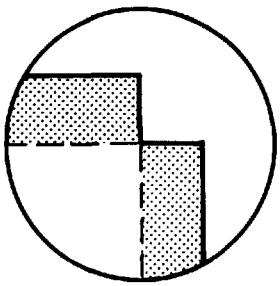


FIG. 6 NINETY-DEGREE CORNER CUTOUT

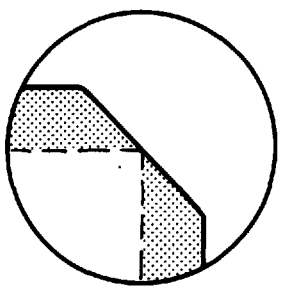


FIG. 7 DIAGONAL CORNER CUTOUT

9.2.5 Four-Tab Slip Sheet. In a four-tab slip sheet, tabs are located at all four edges of the sheet. This design is occasionally used to capture the features and advantages of tab locations shown in Part 8, Figs. 2 and 3. It is used for reusable slip sheets. Sometimes, two opposite tabs are folded up against the sides of the unit load for load stability and are secured in place by fastening materials. See Part 8, Fig. 5.

9.3 Tab Corner Configurations

Tab corner configurations are described and illustrated as follows, with broken lines representing score lines. Examples shown are slip sheets with tabs on adjacent edges. See Part 8, Figs. 6 through 8.

9.3.1 Ninety-Degree (90 deg) Corner Cutout. Ninety-degree (90 deg) corner cutout is a common design which is easily produced. This design permits tabs to be folded independently of each other. Independent folding is required to avoid crushing or tearing of tabs which can result in tab failure. See Part 8, Fig. 6.

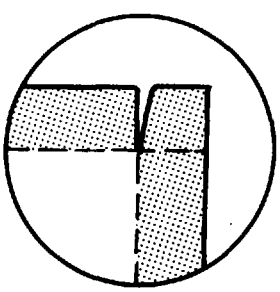


FIG. 8 SLIT-CORNER DESIGN

9.3.2 Diagonal Corner Cutout. A majority of slip sheets have the diagonal corner cutout design which reduces potential of damage of adjacent tabs. This design also permits tabs to be folded independently of each other. See Part 8, Fig. 7.

9.3.3 Slit-Corner Design. Slit-corner design is used occasionally when the adjacent tab is to be folded up against the side of the unit load. See Part 8, Fig. 8.

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MANDATORY APPENDIX A8-A
GUIDELINES FOR SLIP SHEET USES

(This Appendix is an integral part of Part 8 of MH1-1997, and is placed after the main text for convenience.)

	Slip Sheet Material			
Type of Product and Condition	Corrugated Fiberboard	Corrugated Fiberboard Sheet With Laminated Tab	Plastic	Solid Fiberboard
Heavy and wet	P	P	G	P
Heavy and dry	F	G	G	G
Lightweight and wet	P	P	G	F
Lightweight and dry	G	G	G	G
Frozen goods	F	F	G	G
Refrigerated goods	F	F	G	F
Bagged goods	F	F	G	G
Boxed or case goods, dry	G	G	G	G
Crated	G	G	G	G
Steel or fiber drums	P	P	G	G
Bulk bin	G	G	G	G
Fiberboard sheets	G	G	G	G
Masonry products	P	P	G	F
Bales	P	P	G	G

GENERAL NOTES:

(a) Rating method: G = Good; F = Fair; P = Poor

(b) Note potential influence of moisture content of slip sheet on its performance.

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MANDATORY APPENDIX A8-B
GUIDELINES FOR STARTING A SLIP SHEET UNIT LOAD HANDLING SYSTEM

(This Appendix is an integral part of Part 8 of MH1-1997, and is placed after the main text for convenience.)

The following factors shall be taken into consideration when selecting slip sheets and starting a system for shipping goods and products on slip sheets:

(a) type
(b) characteristics
(c) dimensions
(d) packing
(e) unit load mass, weight, composition, and stability
(f) adverse exposure
(g) type of available handling equipment
(h) equipment operator experience
(i) receiver requirements
(j) number of times unit load is to be handled

The following factors shall be considered when receiving unit loads on slip sheets:

(a) size and load capacity of slip sheet handling equipment dictated by unit load sizes
(b) height of storage of unit loads
(c) deposit of unit loads on pallets for storage or future handling by fork tines
(d) equipment operator skill to unload slip sheet unit loads
(e) scooping of loads by chiseling the load plate underneath the slip sheet or pulling of load onto the load plate with gripper jaw clamping onto the sheet tab
(f) reloading of unit loads into another transport vehicle
(g) disposition of slip sheets

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MANDATORY APPENDIX A8-C
CORRECT OPERATING PROCEDURES FOR HANDLING UNIT LOADS ON SLIP SHEETS

(This Appendix is an integral part of Part 8 of MH1-1997, and is placed after the main text for convenience.)

C1 GENERAL

Unit load handling on slip sheets is an effective and efficient means of handling goods and products for storage and through transit; however, it requires attention to detail and adherence to proper procedures. The process includes: selection of the slip sheet material, placement of cases, bags, or drums on the sheets, and, finally, handling of the unit loads with industrial lift trucks equipped with slip sheet handling devices.

Once a specific slip sheet material has been selected, placement of goods on the sheet requires some care. Cases of goods or products should be placed on the slip sheet up to the tab score line, but should not cover the score line. Figures C1, C2, and C3 of Appendix A8-C illustrate typical slip sheet dimensions, placement of cases, and the protruding portion of the sheet at the rear of the load acting as a bumper.

The components of a rider-type industrial lift truck which provide the motions for a slip sheet handling device are: the lifting mast, pusher rack or faceplate, load plate or platens, and gripper jaw. These operate separately or in conjunction with each other. Figures C4, C5, and C6 of Appendix A8-C illustrate the components and the motions of each.

The load plate or platens move up and down the mast of the forklift truck and are used for lifting or lowering the load. They are inserted under the slip sheet or retracted as required (see Appendix A8-C, Fig. C5).

Lateral shifting of load plate or platens is a desirable feature to aid in positioning a unit load. It is not required, but it must be specified when selecting a push pull device (see Appendix A8-C, Fig. C6).

The pusher rack or face-plate is the hydraulically powered component of the push pull that moves backward and forward, retrieving and discharging a unit load by pulling the load onto the load plate or platens and pushing it off. The gripper jaw is on the bottom edge of the rack (see Appendix A8-C, Fig. C7).

The lower end of the lift truck mast is fixed, but the upper portion tilts backward and forward. Since the vertical motion of the load plate is controlled by the mast, a tilt backward raises the tip of the load plate (see Appendix A8-C, Fig. C8) and a tilt forward

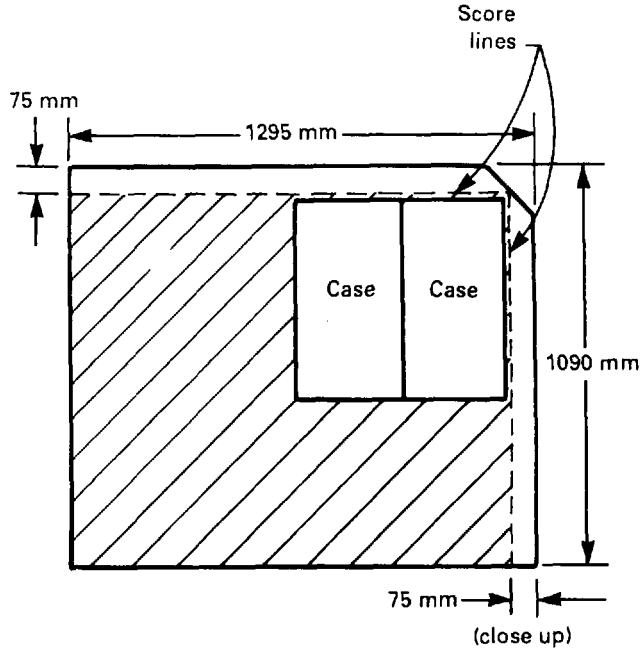


FIG. C1

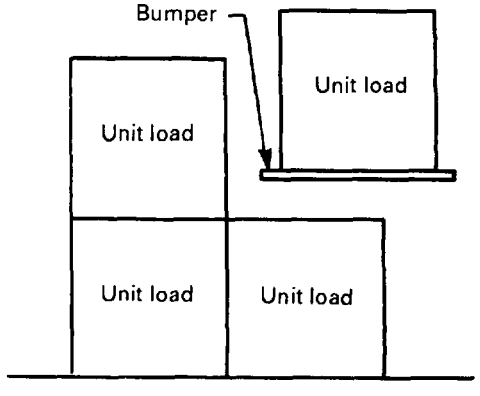


FIG. C2

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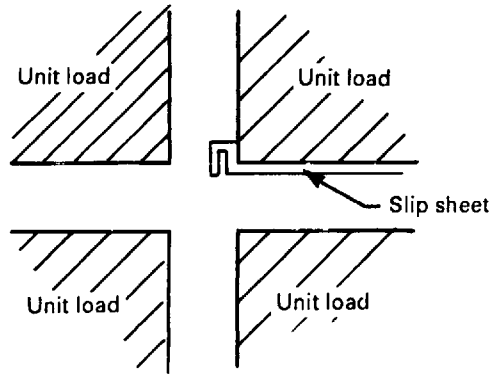


FIG. C3

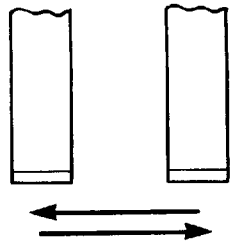


FIG. C6 LATERAL MOTION OF LOAD PLATE OR PLATENS

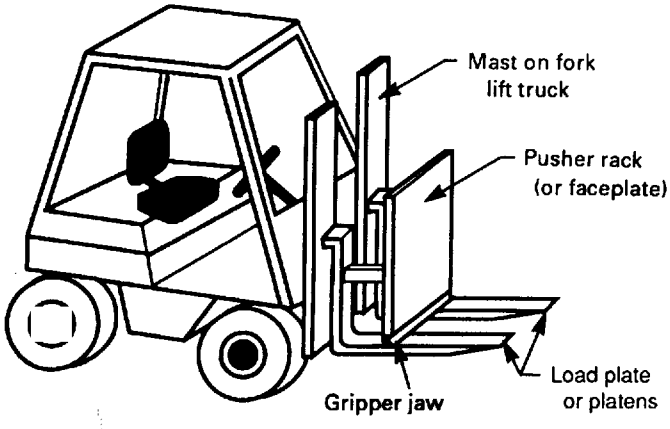


FIG. C4 RIDER TYPE INDUSTRIAL LIFT TRUCK

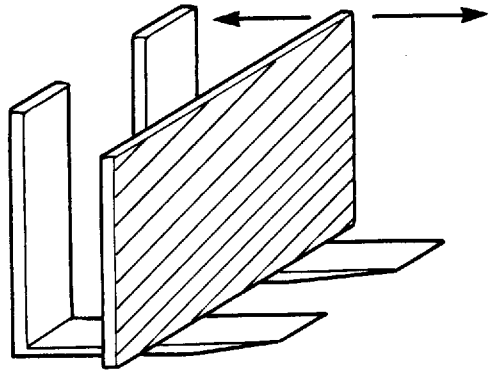


FIG. C7 PUSHER RACK OR FACEPLATE

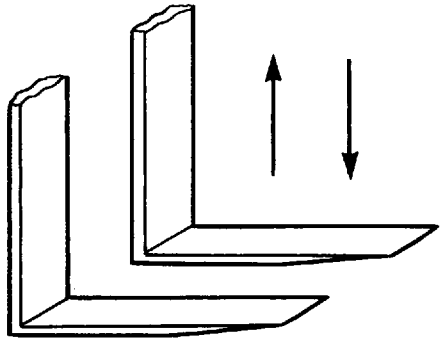


FIG. C5 VERTICAL MOTION OF LOAD PLATE OR PLATENS

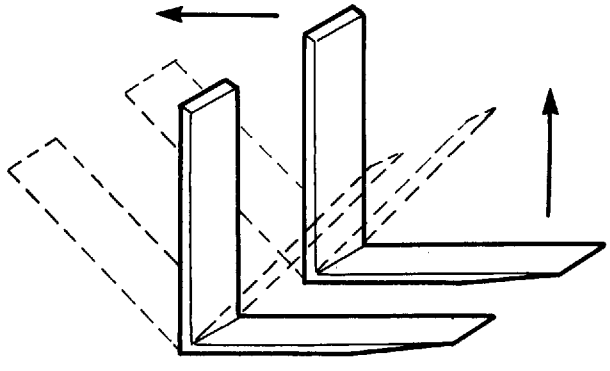


FIG. C8 LOAD PLATE TIP RAISED

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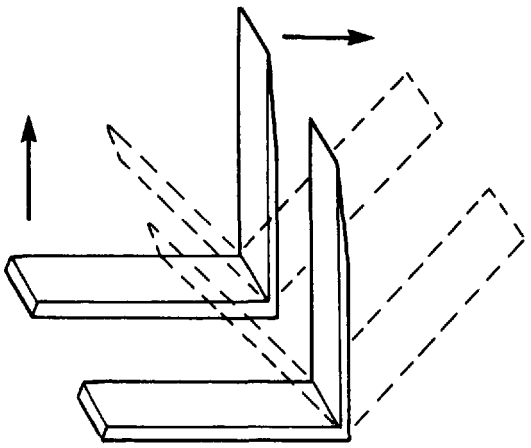


FIG. C9 LOAD PLATE TIP LOWERED

lowers the tip of the load plate (see Appendix A8-C, Fig. C9).

As the push pull device is used, the tip of the load plate or platens can become rough and nicked. Any rough edges or burrs shall be removed by grinding or filing to avoid damage to slip sheets and product packages. To reduce friction between load plate and slip sheets, the top surface of the load plate shall be coated from time to time with paraffin wax or fine powder, and then the entire surface shall be rubbed with steel wool to remove excess amounts. This is a brief but valuable maintenance operation. The load plate shall be level from side to side for proper operation. If it is not, check the fork carriage on the lift truck.

The greatest single cause of product damage is improper use of lift trucks when handling unit loads. It frequently is the result of improper or lack of driver training. The correct procedures for handling unit loads on slip sheets require training and practice in addition to that required for conventional lift trucks. Even experienced lift truck drivers need training and practice to make a slip sheet unit load system work smoothly and efficiently.

The operating procedures and instructions presented here are not intended to take the place of a lift truck driver training course. They are meant to present ideas

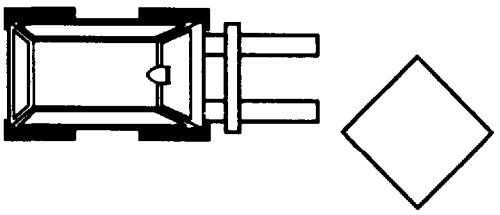


FIG. C10 INCORRECT RETRIEVAL POSITION

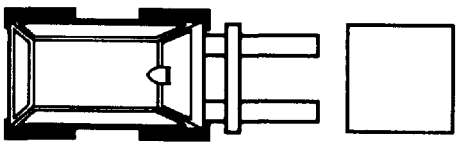


FIG. C11 CORRECT RETRIEVAL POSITION

of the functions and the moves required to make the best use of push pull devices for slip sheet unit load handling.

In addition to the normal lift truck driver safety rules and instructions, a few that apply specifically to the push pull lift truck are listed below.

(a) Do not overload the lift truck. The push pull device weight shall be subtracted from the normal lift truck chassis rating. Make sure the weight of the slip sheet unit load is within the lower-rated lift truck capacity.

(b) Do not use the push pull device to open doors on transport vehicles, particularly those of railroad cars.

(c) Do not clamp onto anything other than a slip sheet with the gripper jaw.

(d) Always travel with the pusher rack or face-plate fully retracted, never in an extended position.

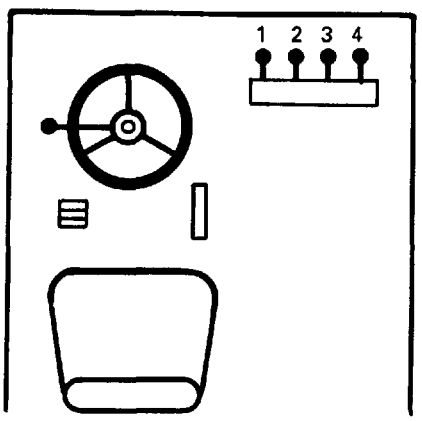
(e) Do not use the push pull device and the pusher rack as a bulldozer or ram to move something.

(f) Do not try to retrieve a slip sheet unit load at an angle. The lift truck must be square to the load for the gripper jaw to clamp onto the slip sheet tab (see Appendix A8-C, Figs. C10 and C11).

The typical lift truck with a push pull device, whether permanently mounted or of quick change design, has four basic levers to control hydraulically powered motions, or sometimes five levers if a sheet retainer feature is required. The levers control movements of the lift

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Lever	Component	Lever Motion	Action
1	Load plate, vertical motion	Forward	Lower
		Backward	Raise
2	Mast	Forward	Tilt forward
		Backward	Tilt backward
3	Load plate, lateral motion	Forward	Lateral shift right
		Backward	Lateral shift left
4	Gripper jaws and pusher rack	Forward	Open jaws, move rack forward
		Backward	Close jaws, move rack backward

FIG. C12 TYPICAL LIFT TRUCK PUSH PULL CONTROLS

truck mast, load plate or platens, and the pusher rack or faceplate. In most designs, the movement of the lever corresponds with the movement of the component it controls (see Appendix A8-C, Fig. C12). The gripper jaw on the pusher rack has no control of its own. The jaw closes and clamps onto the tab just before the pulling motion begins, and it opens before the pushing motion starts.

C2 RETRIEVING UNIT LOAD FROM FLOOR

Align the lift truck and load plate or platens square to the load on the tab side of the slip sheet. Raise the rear of the load plate to approximately 80 mm (3 in.) above the floor. Tilt the mast forward until the tip of the load plate touches the floor (see Appendix A8-C, Fig. C13). Do not try to retrieve a load with the load plate or platens flat on the floor. Doing so may tear the slip sheet tab or gouge the bottom layer of goods.

Move the pusher rack all the way forward. With the lift truck in gear, drive forward slowly until the tab of the slip sheet is inserted into the gripper jaw opening. Hold the position with the foot brake (see Appendix A8-C, Fig. C14).

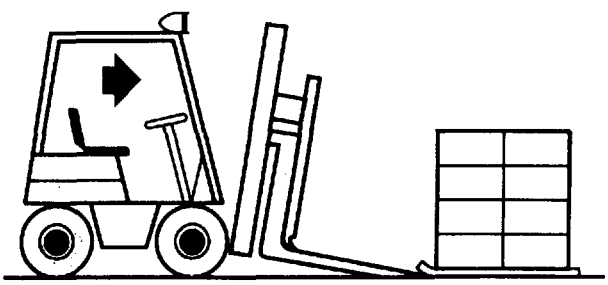


FIG. C13

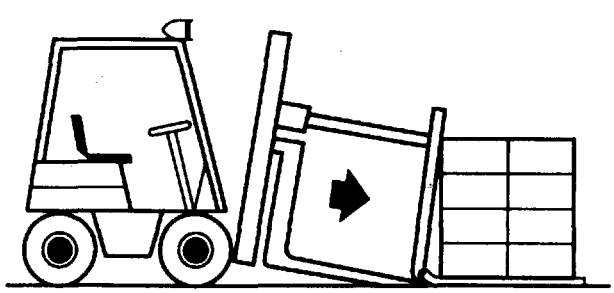


FIG. C14

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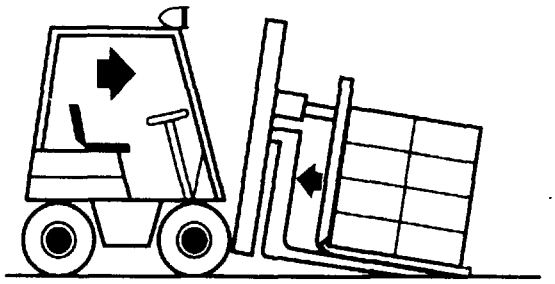


FIG. C15

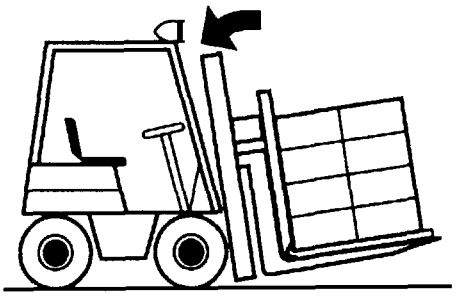


FIG. C17

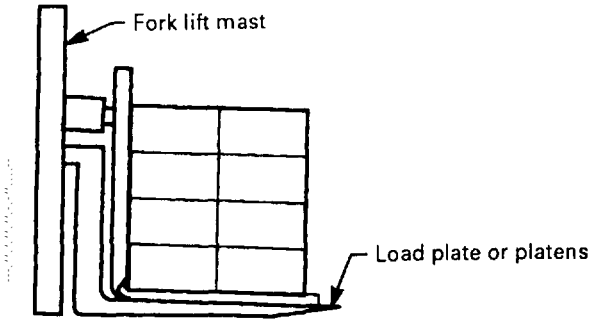


FIG. C16

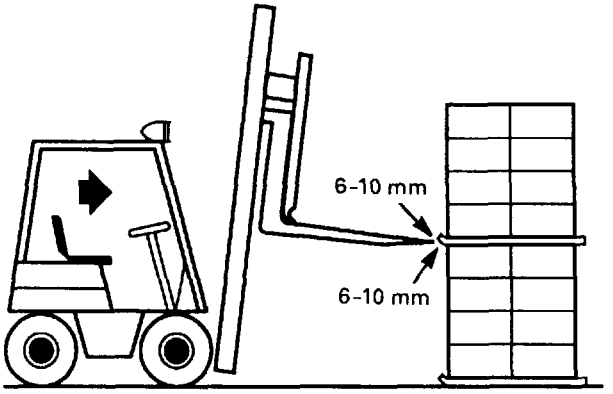


FIG. C18

Pull the pusher rack control lever backward to automatically close the gripper jaw onto the slip sheet tab and retract the pusher rack. Release the foot brake and drive forward slowly at the same speed as the pusher rack is being retracted backward with the load being pulled onto the load plate or platens (see Appendix A8-C, Fig. C15). This is a coordination of pulling and chiseling movements and probably requires some practice by the lift truck driver. If the unit load is against a wall, pulling alone may be sufficient.

As the weight of the unit load is transferred onto the load plate or platens, there is some downward deflection. To compensate, tilt the carriage back slightly to prevent the load plate tip from digging into the floor. The load plate shall be flat on the floor when the unit load and pusher rack are all the way backward (see Appendix A8-C, Fig. C16).

Raise the load or platens 80 to 100 mm (3 to 4 in.) above the floor. Tilt the lift truck mast backward at least 6 deg, to carry the load in transport. Put the truck in reverse gear, back up, and turn into the direction of travel. Watch for any loose packages and correct load integrity (see Appendix A8-C, Fig. C17).

Sometimes it may be possible to "scoop" the load off the floor without using the pusher rack and gripper jaw. It must be done, however, with the pusher rack fully retracted. If the pusher rack is extended forward, damage to it and the unit load can occur. Scooping is usually only possible with lightweight loads and smooth floor conditions.

C3 RETRIEVING UNIT LOAD FROM STACK

Align the lift truck and load plate or platens square to the load to be retrieved. Raise the load plate and tilt the mast forward 3 to 14 deg. Drive the truck forward until the tip of the load plate is approximately 6 to 10 mm ($^1/_4$ to $^1/_2$ in. or 0.25 to 0.50 in.) from the load to be retrieved and below the slip sheet tab. Hold the truck in position with the foot brake (see Appendix A8-C, Fig. C18).

Move the pusher rack or faceplate all the way forward, adjust height of the load plate, up or down as required, in such a way that the slip sheet tab can be inserted into the gripper jaw opening. Pull the pusher rack control lever backward to close automatically the

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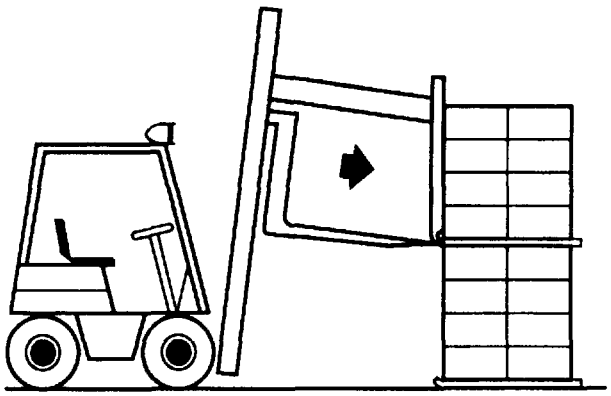


FIG. C19

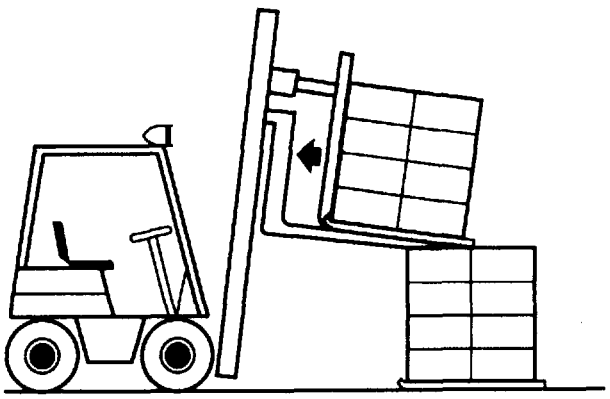


FIG. C20

gripper jaw into the slip sheet tab and pull the unit load onto the load plate (see Appendix A8-C, Fig. C19).

With the gripper jaw clamped onto the slip sheet tab, start pulling the unit load onto the load plate or platens. As the weight of the load is transferred onto the load plate, a downward deflection occurs. Raise the load plate slightly by raising the lift truck carriage. Do not change the tilt angle. Do not allow the lift truck to be pulled forward as the unit load is pulled onto the load plate. Otherwise, the tip of the load plate or platens can gouge the load underneath (see Appendix A8-C, Fig. C20).

With some loads, it is possible to alter the foregoing procedure by raising the tip of the load plate slightly above the top of the load underneath, after 200 to 300 mm (8 to 12 in.) of the retrieved load has been placed on the load plate. Permit the lift truck to move forward 100 to 150 mm (4 to 6 in.) and allow the tip of the load plate to rest gently on the load underneath until the load is fully transferred onto the load plate. This procedure requires skill and practice to avoid damage to goods or products.

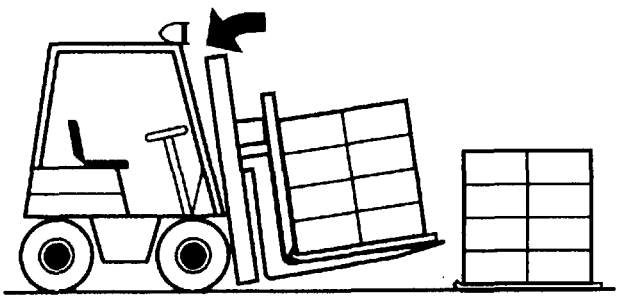


FIG. C21

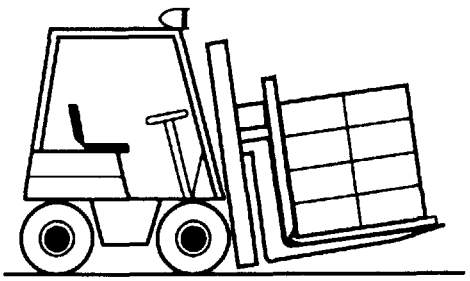


FIG. C22

In some instances, two slip sheets are placed between the stacked unit loads. In this case, once the slip sheet tab is clamped onto by the gripper jaw, the load plate can be raised slightly and inserted between the slip sheets. The lift truck then moves forward at the same speed as the retraction of the pusher rack or faceplate. This procedure is similar to that illustrated in Appendix A8-C, Fig. C15.

Once the unit load is completely placed on the load plate or platens, tilt the mast backward 3 to 6 deg into transport position, release the foot brake, and move the lift truck backwards until the load clears the stack and can be lowered. Lower until the rear of the load plate is approximately 80 mm above the floor. The unit load is now ready to be transported (see Appendix A8-C, Fig. C21).

C4 DISCHARGING UNIT LOAD ONTO FLOOR OR STACK

The procedure is the same for discharging unit load onto the floor or onto a stack. Carefully position the unit load to be discharged exactly above the position where it is to be placed. Accomplish this by moving the lift truck forward square to the stack, raising the load plate, if necessary, to the desired height, and

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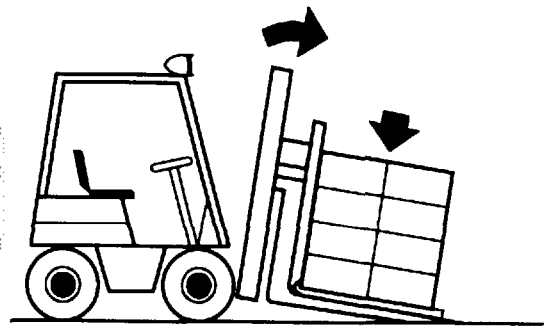


FIG. C23

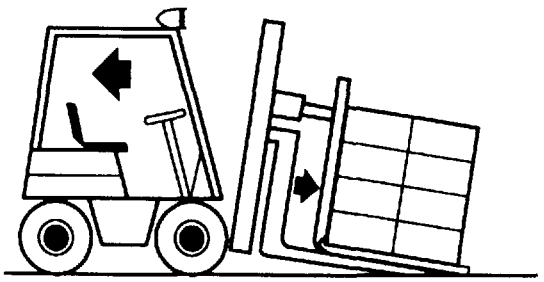


FIG. C24

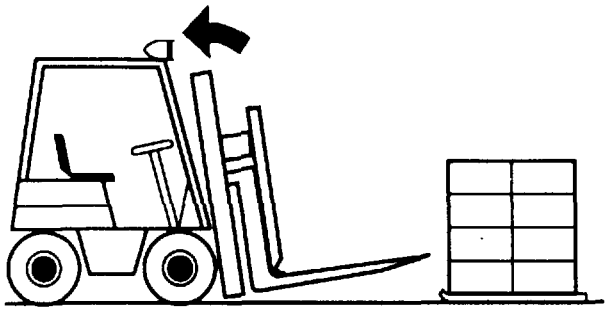


FIG. C25

moving the load laterally by side shifting the load plate (see Appendix A8-C, Fig. C22).

Once the unit load is in position, tilt the lift truck mast forward approximately 4 deg and lower the load until the tip of the load plate or platens is approximately 6 mm (¼ in. or 0.25 in.) above the floor or above the stacked unit load underneath (see Appendix A8-C, Fig. C23).

Hold the truck in position by applying the foot brake. Put the lift truck in reverse gear in preparation for moving backward. Then, put the pusher rack control lever in forward position, which automatically opens the gripper jaw. Allow the pusher rack to move the unit load forward until it contacts a wall or stack of goods, release the foot brake, and coordinate the backward speed of the truck with the same forward speed of the pusher rack or faceplate. Sometimes the lift truck does not need to be in gear to accomplish the backward motion. As the load weight is removed from the load plate or platens, there is an upward deflection of the load plate. Compensate for this by slightly lowering the lift truck carriage (see Appendix A8-C, Fig. C24).

Do not use the pusher rack or faceplate as a hydraulic ram to pack the unit load tighter against adjacent forward loads.

Once the unit load is discharged, immediately retract the pusher rack or faceplate completely, tilt the mast backward 3 to 4 deg, and lower the load plate to approximately 80 mm (3 in.) above the floor for travel (see Appendix A8-C, Fig. C25).

C5 HOW TO STACK UNIT LOADS IN STORAGE

Occasionally, it may be necessary to place two unit loads together on top of a storage stack. This requires a slightly different procedure than previously discussed. The two loads to be stacked must first be perfectly aligned with each other. One load shall not be skewed from the other. With the two unit loads on the load plate or platens, move the lift truck forward until the loads are approximately 150 to 200 mm (6 to 8 in.) from the stack and square on the stack. Apply the foot brake and keep the truck from moving forward. Keep the mast vertical, and raise the two loads above the height of the stack.

Release the foot brake and move the lift truck forward until the loads are aligned with the stack underneath. Lower the load plate or platens until the bottom surface is approximately 10 mm (½ in. or 0.50 in.) above the stack. Tilt the mast forward until the tip of the load plate touches the underneath stack. Then, tilt the mast backward enough to raise the tip off the stack. If stacking against a wall, put the truck in neutral gear and move the pusher rack forward to discharge the two-unit load. If the stack is freestanding, put the lift truck in reverse gear and move backward at the same speed as the pusher rack is moving forward to discharge the load. All slip sheet tabs shall face the same direction (see Appendix A8-C, Fig. C26).

The most common operation when placing slip sheet unit loads in storage is stowing loads against an existing stack (see Appendix A8-C, Fig. C27). Certain proce-

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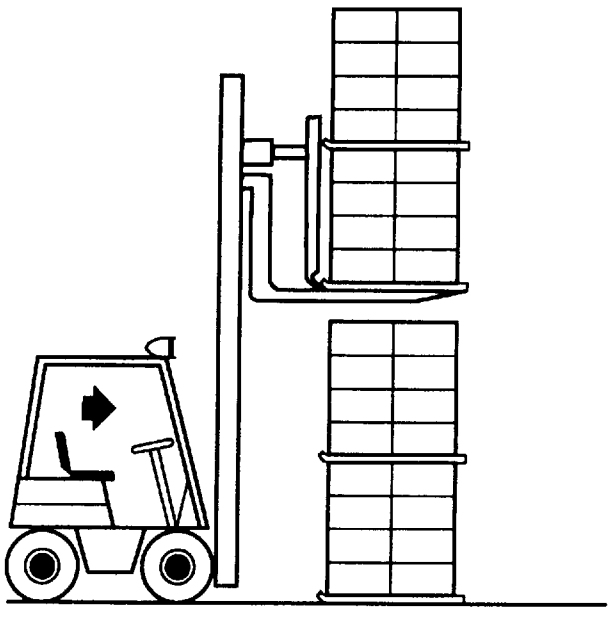


FIG. C26

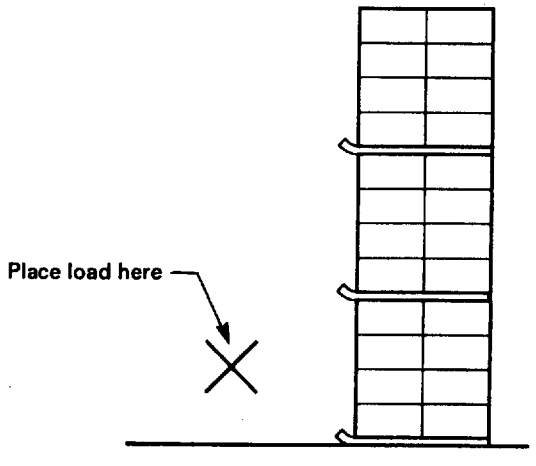


FIG. C27

dures are required to prevent damage to slip sheet tabs and to assure a stable storage stack.

Move the lift truck and unit load forward square to the storage stack. Operate the load plate side shift lever to align the unit load with the stack. If the push pull device has a sheet retaining feature, it will be necessary to release the clamping pressure on the slip sheet tab before side shifting (see Appendix A8-C, Fig. C28).

The unit load shall be approximately 150 to 200 mm (6 to 8 in.) off the floor. Move the lift truck forward until the front edge of the unit load is approximately 150 mm (6 in.) from the stack. Stop the lift truck forward motion with the foot brake and hold it temporarily. Move the pusher rack of faceplate lever forward, which automatically opens the gripper jaw, and push the unit load slightly forward until its forward edge is off the load plate or platens. Start lowering the unit load slowly, and release the foot brake allowing the lift truck to move forward until the forward face of the unit load makes contact with the stack. The slowly descending unit load must make downward contact with the slip sheet tab of the unit load in the storage stack. The unit load being placed in storage must rest on the slip sheet tab of the rear load (see Appendix A8-C, Fig. C29). Do not permit the tip of the load plate or platens to protrude beyond the forward edge of the unit load on the load plate or platens in this procedure, because damage to the storage stack will result.

Tilt the lift truck mast slightly forward in preparation for discharging the unit load.

Put the lift truck in neutral gear and the pusher rack or face-plate control lever in forward position, and let the pusher rack discharge the unit load. Control the speed of discharge with the control lever. It is not always necessary to have the lever in full-forward position. The forward motion of the pusher rack moves the lift truck backward and withdraws the load plate or platens from under the load (see Appendix A8-C, Fig. C30).

C6 WRONG PROCEDURES IN STORING OR STACKING SLIP SHEET UNIT LOADS

(a) Failure to align the lift truck and unit load square to the stack (see Appendix A8-C, Fig. C31).

(b) Failure to use load plate or platens side shift to align unit load with stacked unit load underneath. Misaligned stacks cause too much floor space when stowing adjacent unit load and result in unstable stacks, which are dangerous (see Appendix A8-C, Fig. C32).

(c) Failure to approach storage stack with load plate or platens and unit load parallel to the floor. Damage to slip sheet tabs of stacked loads and damage to the tip of the load plate or platens or unit load thereon can result (see Appendix A8-C, Fig. C33).

(d) Damage can result from discharging slip sheet unit load improperly by either withdrawing load plate or platens from under load by partial forward movement

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of pusher rack or faceplate and reversing lift truck direction in gear and moving backward; or by not approaching the stack closely and pushing the load off the load plate and sliding it on the floor against the storage stack; or by tilting the lift truck mast more than 4 deg forward and raising the rear of the load plate (see Appendix A8-C, Fig. C34).

(e) Failure to follow proper lift truck operating procedures and ignoring lift truck safety rules recommended by the manufacturer can be dangerous and costly.

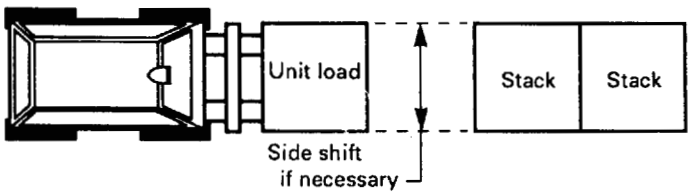
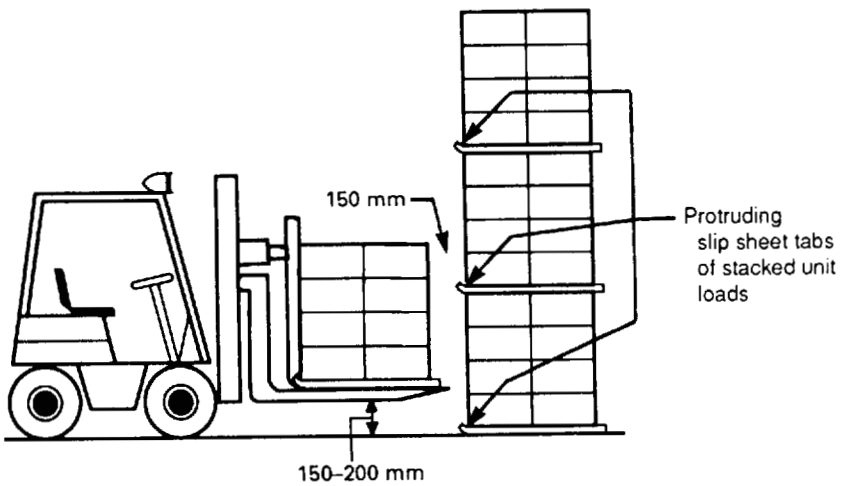
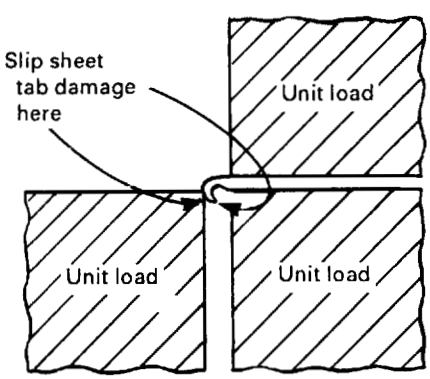


FIG. C28





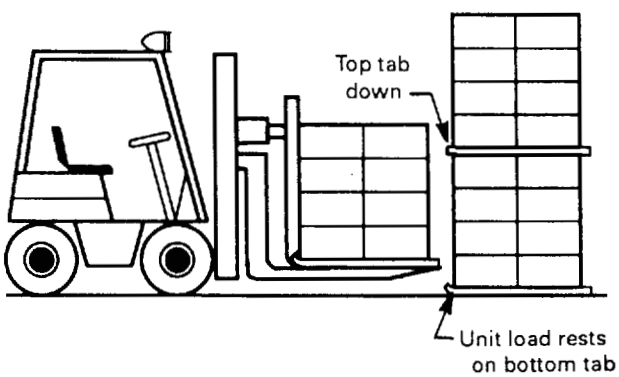


FIG. C29

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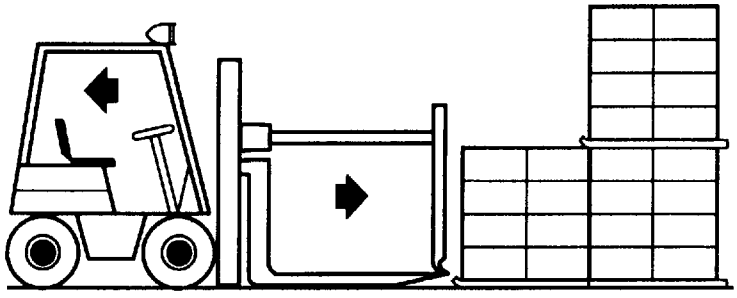


FIG. C30

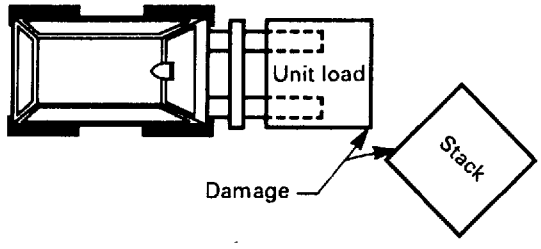
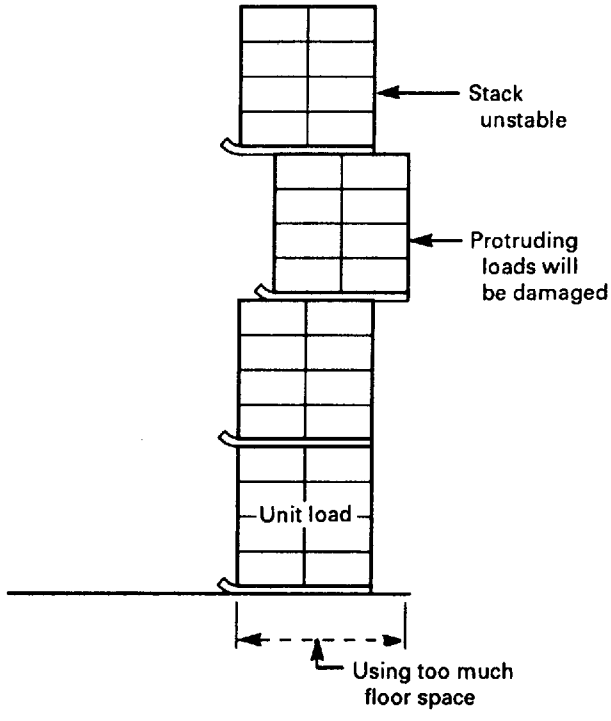


FIG. C31



Front View

FIG. C32

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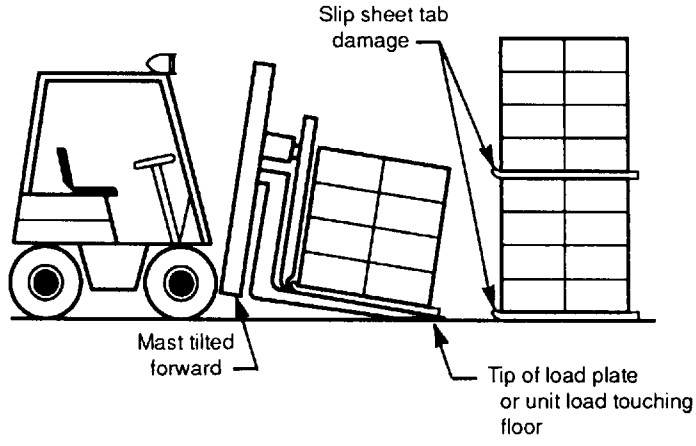


FIG. C33

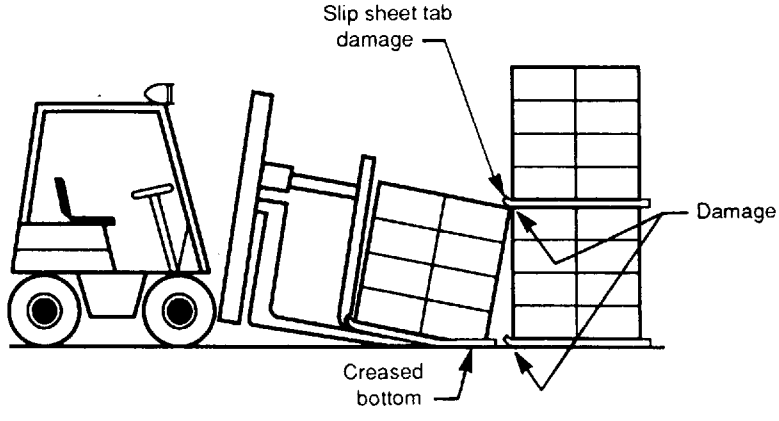


FIG. C34

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NONMANDATORY APPENDIX A8-D
DEVELOPMENT OF THE SLIP SHEET HANDLING CONCEPT

(This Appendix is not part of Part 8 of ASME MH1-1997, and is included for information purposes only.)

What is now known as slip sheet handling of unitized loads was created in 1946 by three sales and engineering employees of Clark Equipment Company to meet a customer's need to transfer palletized loads of bagged goods into a rail car without losing the pallet or expending labor to hand stack the goods. After extensive experimentation, a visit to fiberboard manufacturer by the group's leader, Glen R. Johnson, produced the idea of using kraft paper as a material handling base, since it had good tensile strength.

Design of the device to handle unit loads on a piece of kraft paper began with the need for a solid base rather than conventional pallet forks. A flat plate attached to a scissor device provided the pushing action, and an "alligator jaw" clamp at the base of the pusher plate provided the pulling action. Making the kraft paper base slightly longer than the unit load provided a surface to be grabbed by the alligator jaw clamp.

Like most new concepts, this project was viewed by peers with skepticism and curiosity, but the first formal test of the concept was successful. The unit load was pulled onto the platens and pushed off several times, then another unit load was pulled onto the platens and placed atop the first and the platens were withdrawn. The top unit load was then retrieved and placed beside the first. This success sparked enthusiasm among witnesses, and prototypes were soon on the drawing board, in production, and ultimately on display at an industry show.

Many companies began experimenting with alternatives to kraft paper. Solid fiberboard, corrugated fiberboard, canvas, thin laminated plywood, multiple-ply newspaper, galvanized sheet metal, and sheet aluminum were tried as material handling bases. Plastics were not initially considered, because that industry was not as fully developed as it is today.

Clark Equipment trademarked the name *PUL-PAC* to designate the new technique in 1947, and patents were secured in the names of the three men who originated the concept. The generic name *push pull* eventually gained prominence as more lift truck manufacturers began producing the attachments.

Over the next ten years, the process gained popularity with the refinement of the material handling base. The term *slip sheet* survived to become the general name of the concept, but the product that it originally described has faded into history.

Popularity of slip sheet handling waned while squeeze clamps became popular for some of the same reasons that slip sheets were initially designed. Pallet users wanted the advantage of unitizing, but did not want the weight, cube, or expense of managing a pallet inventory. Over time, palletless unit load handling techniques sorted themselves out along product and use lines. Today, both concepts are used singularly and together. In general, clamping applications are for in-house use and slip sheets are for dual warehouse and transport applications.

Technology has kept pace with increased shipper interest, offering improvements in both the handling equipment and the slip sheets. Plastics are now part of the slip sheet industry. Not only has the concept grown in the United States, but it has spread, to some extent, worldwide. Unitized handling, a major labor-saving technique in any country, generally starts with the use of pallets. As the unit load concept spreads and develops, the need for an alternative to pallets will arise aboard, just as it did domestically in 1946.

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NONMANDATORY APPENDIX A8-E
PUBLISHED DOCUMENTS COVERING SLIP SHEETS

(This Appendix is not part of Part 8 of ASME MH1-1997, and is included for information purposes only.)

ANSI MH1.5M-1980 (R1987), Slip Sheets

Publisher: American Society of Mechanical Engineers (ASME International), Three Park Avenue, New York, NY 10016-5990

JIS Z0607-1983, Sheet Pallets

Publisher: Japan Pallet Association, 2-14-12 Chuo-ku, Tokyo, Japan

What is a Slip Sheet? Questions and Answers About Slip Sheets
Why Slip Sheets?
How to Specify Slip Sheets
The Slip-Sheet Driver Training Manual

Publisher: American Paper Institute, 260 Madison Avenue, New York, NY 10016

Bouma, John C., and Paul F. Shaffer. Evaluation of Slip Sheet for Unitized Shipment of Groceries in Trailers. Marketing Research Report Number 1121, Agricultural Marketing Service.

Ris, R.E., and R. T. Hinsch. Slip-Sheet Handling of California Nectarines and Cantaloupes. AAT-W-15 (September 1980) Science and Education Administration Advances in Agricultural Technology.

Publisher: U.S. Department of Agriculture

Other Publications

American Frozen Food Institute. The Unitized Handling of Frozen Foods Using Slip Sheets. Suite 100, 1700 Old Meadow Road, McLean, VA 22102.

Container Corporation of America, Container Division. Palapad Slip Sheets. 500 East North Avenue, Carol Stream, IL 60187.

Dynamit Nobel AG. Transport and Stacking With Trovidur PE 200. DIN Deutsches Institute fr Normung E.V., Postfach 1107, D-1000, Berlin 30, Germany.

Lydall, Inc. Ly-Pak™ Slip Sheets. P.O. Box 9350, Richmond, VA 23228.

Union Camp Corporation. Fibrelift Slip Sheets. P.O. Box 558, Monroe, MI 48161.

Journal Articles

Bouma, John C. "Potential for Slip Sheet Shipment of Groceries in Trailers." Journal of Food Distribution Research (February 1980): 61; Food Distribution Research Society, Inc., P.O. Box 441110, Fort Washington, MD 20744.

Ebeling, C.W. "Push-Pull or Pallets? Distribution's Dilemma." Handling & Shipping Management (October 1978); Penton Publishing, 1100 Superior Avenue, Cleveland, OH 44114.

_____. "Push-Pull's Global Progress." Handling & Shipping Management. Penton Publishing, 1100 Superior Avenue, Cleveland, OH 44114.

Johnson, Glen R. "Slip Sheets, Pros & Cons." Western Material Handling Packaging/Shipping (December 1980): 18; Baymer Publications, Inc., 606 Larchmont Boulevard, Los Angeles, CA 90004, USA. (Also published in Food Engineering (November 1980): 122; Clinton Co., Chilton Way, Box 2035, Radnor, PA 19084; and in Grocery Distribution (March/April 1980): 13; 39 LaSalle Street, Chicago, IL 60603.)

Schwind, Gene F. "Slip-Sheet Attachments, More Choices." Material Handling Engineering (November 1989); Penton Publishing, 1100 Superior Avenue, Cleveland, OH 44114.

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Part 9
Wood Pallets for U.S. Government Use

(a)

(Commercial and Government Entity (CAGE) Code For ASME: 05047)

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PART 9
WOOD PALLETS FOR U.S. GOVERNMENT USE

1 SCOPE

Part 9 (which identifies ASME MH1-1997, Wood Pallets; Part 9, Pallets for U.S. Government Use) applies to light- and heavy-duty, limited- and multiple-use wood pallets used by the Department of Defense and DOD contractors. Federal agencies (including General Services Administration) and commercial entities may find this Part useful but are not required in any way to use the pallets described herein. These pallets are commonly used by DOD activities for handling, storage, and transportation of general supplies and ammunition in worldwide logistics.

This Part replaces Military Specification MIL-P-15011, Pallets, Material Handling, Wood Post Construction, 4-Way Entry, and Federal Specification NN-P-71, Pallets, Material Handling, Wood Stringer Construction, 2-Way and 4-Way Partial, for public use. Part 9 was developed to cover the basic requirements for pallets previously procured by both specifications. Part 1, Definitions and Terminology Covering Pallets and Related Structures, shall apply to Part 9.

2 PURPOSE

The purpose of Part 9 is to provide the relevant physical details for construction of pallets used by the U.S. Government. It provides the minimum standards for construction of lumber-deck stringer and block pallets. This Part defines the size, class, type, style, species class, minimum nails required, preservation, marking, and quality of the assembled pallets.

3 SIZES

Most of the pallets described in this Part are 40 by 48 inch platform size; other platform sizes are used in limited quantities. Part 9, Table 1, U.S. Government Pallet Sizes, lists the commonly used sizes.

4 CONSTRUCTION DETAILS

TABLE 1 U.S. GOVERNMENT PALLET SIZES

Size	Length x Width, in.
1	32 x 40
2	40 x 48
3	48 x 48
4	48 x 60
5	44 x 44
6	35 x 45.5
7	42 x 53
8	48 x 40

4.1 Wood Components

Wood components for pallet manufacture are to be per Part 3, para. I-5.1, Lumber Components and Table 1, Minimum Pallet Component Quality, except that no decay or bark is allowed due to the anticipated overseas destinations for military shipments.

4.2 Pallet Construction

Part 9, Tables 2 and 3 cover the size and number of deckboards and stringers/blocks required in constructing pallets. The basic pallet class, type, style, wood quality, and other essential pallet design features are explained in Part 3, para. I-3. Part 9, Table 4 lists the pallets commonly used.

5 PRESERVATION (REQUIRED FOR CERTAIN PALLETS LISTED IN TABLE 4)

5.1 Wood Pallet Preservation

When specified in Table 4, the assembled pallets (or unassembled pallet components) shall be preserved and preservative marking applied to one side-center block of the pallet (see Part 9, Figs. 4, 6, or 8). Moisture content of the wood shall not exceed 19% prior to treatment. The wood shall not be cut after treatment.

5.2 Preservative Materials

Pallet components (or assembled pallets) shall be completely immersed for a minimum of one minute in one of the following listed wood preservative solutions:

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TABLE 2 STRINGER AND BLOCK SIZES
(See ASME MH1-1997, Part 3, Para. I-3 for explanations of Class, Type, Style of Pallets and Part 9, Table 1 for Pallet Size)

Class	Type	Style	Pallet Size	Stringers and Blocks No.	Stringers and Blocks Size, in. [See Note (5)]	Reference
1	1	2	1	3	1.5 x 3.5 x 32	See Notes (1), (2), and (4)
1	1	2	2	3	1.5 x 3.5 x 40	
1	1	2	2	4	1.5 x 3.5 x 40	
1	2	2	2	3	1.5 x 3.5 x 40	See Fig. 1
1	1	2	3	3	1.5 x 3.5 x 48	
1	2	6	3	3	1.5 x 3.5 x 48	
1	1	2	4	5	1.5 x 3.5 x 48	See Note (3)
1	1	2	5	3	1.5 x 3.5 x 44	See Fig. 2
1	1	6	2	3	1.5 x 3.5 x 40	
1	1	6	3	3	1.5 x 3.5 x 48	
1	2	6	1	3	1.5 x 3.5 x 32	
1	2	2	1	3	1.5 x 3.5 x 32	
1	2	6	2	4	1.5 x 3.5 x 40	See Fig. 3
1	2	6	2	3	1.5 x 3.5 x 40	
1	2	2	2	3	1.5 x 3.5 x 40	
2	3	6	2	3	7.25 x 3.50 x 3.50	Center Blocks
...	...	...	2	6	5.50 x 3.50 x 3.50	Side Blocks
2	3	6	6	3	7.25 x 3.50 x 3.50	Center Blocks
...	...	...	6	6	5.50 x 3.50 x 3.50	Side Blocks
2	3	6	7	3	7.25 x 3.50 x 3.50	Center Blocks
...	...	...	7	6	5.50 x 3.50 x 3.50	Side Blocks
1	2	2	8	3	1.50 x 3.50 x 48	

NOTES:

(1) Strapping slots shall be provided in the upper surface of all stringers for all wing (Class 1) pallets (except recycled or reclaimed wood pallets) as shown in Part 9, Figs. 3, 10, 11, and 12. Strapping slots for Class 2 (block) pallets are shown in Part 9, Figs. 4 through 9 and Fig. 17.

(2) See para. I-5.1.4.3 of Part 3, for size of stringer (fork entry) notches on the bottom of stringers. Notch openings shall begin 6 inches from the end of the stringer, except for the Size 1 pallet. Notch openings for the Size 1 pallet will begin 5 inches from the end of the stringer and will be 8½ in. in length.

(3) Stringers shall be equally spaced, unless otherwise noted on drawing(s).

(4) For all untreated pallets, unless otherwise specified, moisture content of all pallet components shall be as listed in the Moisture Content column of Table 4 of Part 9 at the time of shipment. For treated pallets, the moisture content shall not exceed 19% prior to preservative applications.

(5) Deckboards and stringers/blocks of any one pallet shall be uniform in thickness and width. Note that Part 9, Table 2 does not apply to recycled-wood pallets (Part No. MH1/9-144048R as listed in Part 9, Table 4).

(a) copper-8-quinolinolate reduced (diluted) with water down to a solution of 1.8% copper (as a metal) by volume in water. (This compound is also known as oxine copper.)

(b) zinc naphthenate reduced (diluted) with water down to a solution of 3% zinc (as a metal) by volume in water.

(c) copper naphthenate reduced (diluted) with water down to a solution of 2% copper (as a metal) by volume in water.

5.3 Requirements

All interior and exterior surfaces of the assembled pallet are to be completely immersed in the preservative solution. Care shall be exercised to assure complete

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TABLE 3 ACTUAL DECKBOARD SIZES, in.

Class	Type	Pallet Size	Top and Bottom Lead End Deckboards (Min. Width) [Notes (1) and (2)]	Deckboard Thickness (min.) [Note (3)]	Deckboards Over Strapping Slots (Min. Width)	Top and Bottom Interior Deckboards (Random Width)	Side Stringerboard Size	Center Stringerboard Size	Deckboard Spacing (max.)
1	1	1	5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	2	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	3	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	4	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	1	5	3.5	0.75	N/A	See Fig. 2	N/A	N/A	See Fig. 2
1	2	1	5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	2	2	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
1	2	3	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5
2	3	2	5.5	0.75	See Fig. 5	3.5 to 7.5	0.75 x 7.25	0.75 x 3.50	1.5
2	3	6	See Fig. 7	0.75	See Fig. 7	5.5	0.75 x 7.25	0.75 x 3.50	1.5
2	3	7	5.5	0.75	See Fig. 9	3.5 to 7.5	0.75 x 7.25	0.75 x 3.50	1.5
1	2	8	5.5	0.69	4.5	3.5 to 7.5	N/A	N/A	1.5

NOTES:

(1) Except for pallet size 4, the upper edges of all bottom deckboards shall be chamfered in accordance with Part 3, para. I-5.1.4, Preparation of Pallet Components. Upper edges of bottom deckboards shall not be chamfered for Part Nos. MH1/9-02SW4048 and MH1/9-14SW4048.

(2) Top and bottom lead deckboards shall be of the same thickness and width except for Size 1 pallets. Bottom lead deckboards, of Size 1 pallets, shall be 5 in. in width. See Part 9, Fig. 10.

(3) Deckboard length shall correspond to the width of the size pallet being fabricated, e.g., a 40 x 48 pallet requires 48 in. deckboards.

(4) Unless otherwise specified, moisture content of all pallets components shall be as listed in the Moisture Content column in Part 9, Table 4.

(5) See Figs. 1 through 16 of Part 9 for size and location of bottom interior deckboards.

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TABLE 4 U.S. GOVERNMENT PALLETS, BY PART NUMBER

ASME Part No. [See Note (7)]	Class	Type	Style	Size	No. of Stringers	Species Class (Per Part 3) [See Note (3) for equivalents]	Moisture Content of Wood (%, Maximum) [See Note (4)]	Nails Req'd (Note No.)	Preserv. Req'd (Note No.)	Load Rating, lb [Note (2)]
MH1/9-01SW3240	1	2	6	1	3	1, 3, 4, 21	30	(5)	No	1,500
MH1/9-02SW4048	1	2	6	2	3	1, 3, 11, 12, 29	30	(5)	No	1,500
MH1/9-03SW4048	1	2	6	2	4	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-04SF4048	1	1	2	2	3	3, 11, 12	30	(5)	No	3,000
MH1/9-05SW4048	1	2	6	2	3	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-06SW4048	1	2	6	2	4	11, 12, 13	25	(5)	No	3,000
MH1/9-07SW4848	1	1	6	3	3	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-08SF4860	1	1	2	4	5	1, 3, 4, 21	30	(5)	No	3,000
MH1/9-09SF4444	1	1	2	5	3	11, 12, 13	25	(5)	No	3,000
MH1/9-10BW4048	2	3	6	2	0, Note (1)	1, 3, 4, 21	19	(7)	No	4,000
MH1/9-11BW4048P	2	3	6	2	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-12BW3545P	2	3	6	6	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-13BW4253P	2	3	6	7	0, Note (1)	1, 4, 21	19	(7)	Yes, Note (8)	4,000
MH1/9-14SW4048R	1	2	6	2	3, Note (9)	1, 3, 11, 12, 29	30 (stringers)	(5), (9)	No	1,500
MH1/9-15SF4840	1	2	2	8	3	1, 3, 4, 21	25	(5)	No	2,500

NOTES:

(1) *Part No. Codes:* B = block; S = stringer; F = flush; W = wing;
P = preservative used; R = reclaimed- or recycled-wood content

(2) Load Rating: The loaded pallet weight is limited to a maximum number of pounds as shown in the Load Rating column of Part 9, Table 4.

(3) Preferred wood species are listed by Species Class. Equivalent wood species, in terms of strength and stiffness, are also allowed except for block pallets used for ammunition loads (Part Nos. MH1/9-11BW4048P, MH1/9-12BW3545P, and MH1/9-13BW4253P).

(4) For all untreated pallets, unless otherwise specified, moisture content of all pallet components, at the time of shipment to the Government, shall be as listed in the Moisture Content column in Part 9, Table 4. For treated pallets (Part Nos. MH1/9-11BW4048P, MH1/9-12BW3545P, and MH1/9-13BW4253P), the moisture content shall not exceed 19% (19% maximum) prior to preservative application (immersion).

(5) Minimum nail requirements (for all stringer pallets) are listed in Part 3, Appendix A3-A, Table A1 for Category M (new, multiple-use) pallets. They are 11½ gauge, 0.112 in. wire diameter, helically threaded nails.

(6) Denotes block pallets which require 9 blocks per pallet.

(7) Hardened nails, fabricated of suitable steel wire, are required for block pallets that are primarily used for ammunition loads. Nails shall be staggered and evenly spaced throughout the joint area per Part 9, Fig. 16. The hardened nails are specified in ASTM F 1667, Table 25, and are designated as Type 1, Style 18 pallet nails:

ASTM F 1667 (Dash No.)	Length (in.)	Diameter (in.)
NL PL-01D	1.500	0.120
NL PL-04D	2.250	0.120
NL PL-10D	3.250	0.135

(8) Preservative treatment of finished, nailed pallets or pallet components (for ammunition pallets) is required for the part numbers listed. See para. 5, Preservation, of Part 9 for requirements and process.

(9) Pallet (Part No. MH1/9-14SW4048R) is constructed of reclaimed- or recycled-wood deckboards, nails, and new stringers (moisture content—30% max.). Interior top- and bottom-deckboards may be of two-piece construction (i.e., two 24 in. deckboards, butted at center stringer). Outside stringers may be fabricated of 1.25- by 3.5- by 40-in. length hardwood or 1.50- by 3.5- by 40-in. length hardwood or softwood. The center stringer is fabricated of 1.50- by 3.5- by 40-in. length wood (Species Class 1, 3, or 11) or 1.50- by 3.5- by 40-in. length wood (Species Class 1, 3, 11, 12, or 29). The center stringer is fabricated of 1.50- by 3.5- by 40-in. wood (Species Class 1, 3, 11, 12, or 29). Chamfers on top of bottom deckboards and strap slots on top of stringers are not required. On all reclaimed-/recycled-wood components, cut-off nails shall be flush with, or below, the surface of the wood. Presence of sharp end(s) of cut-off nails is cause for rejection of the pallet.

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coverage of all surfaces of the pallets or pallet components. After immersion, pallets shall be air dried for 24 hours (minimum) in a well-ventilated area allowing free air circulation around all surfaces of the wood. Accelerated drying in an oven or kiln is permitted, provided that oven or kiln temperatures do not exceed 160°F. The preservative on the pallets shall be thoroughly dried to the touch prior to shipment to the customer.

5.4 Concentration Level

The concentration of the applicable preservatives shall be checked in accordance with the manufacturer's recommendations prior to utilization of the dipping tank and every 8 hours of use thereafter.

5.5 Preservative Treatment Markings

Each pallet shall be marked near the center of the outside stringer, or side-center block, in 1-in. high (minimum) letters. The letters "PA" shall be marked on all pallets immersed in copper-8-quinolinolate preservative; the letters "PB" shall be marked on all pallets subjected to zinc naphthenate preservative; and the letters "PC" shall be marked on all pallets immersed in the copper naphthenate preservative.

6 MARKING

6.1 Marking

All pallets shall be marked per Part 3, Wood Pallets, para. III-1.3, Pallet Marking, except as noted in this section. Marks for Government Part No., month/year of manufacture, and "L" (for Limited-Use pallets) shall be included. "M" marks for Multiple-Use pallets are not required. Preservative treatment marking, as described in Part 9, para. 5, shall be included for block pallets treated with a preservative.

7 QUALITY ASSURANCE PROVISIONS

7.1 Wood Quality

Materials shall comply with the minimum requirements of Part 3, para. I-5, Materials and para. I-6, Manufacture, and the specific requirements of this Part. Wood shall be free of decay that can be visually detected or detected by normal brashness when picked with a sharp instrument.

7.2.1 Wood shall be free from insects, beetles, powder-post beetles, and any other infestation, which may result in subsequent pallet deterioration, at time of delivery to the Government.

7.2.2 Wood components shall be bark-free for all pallets in this Part to insure that the pallet is free from the "oak wilt fungus." Bark shall not appear on any timber (lumber) member of the assembled pallet.

7.2 Moisture Content

Unless specified in the contract or order, moisture content of all pallet components or assembled pallets shall be as listed in the Moisture Content of Wood column of Part 9, Table 4 (including pertinent notes) at the time of pallet shipment to the U.S. Government. Note that for two high-demand pallets (Part Nos. MH1/9-02SW4048 and MH1/9-05SW4048) (see Moisture Content column on Table 4), the moisture content shall not exceed 30% at time of pallet shipment.

7.3 Cut-off Nails

On all reclaimed-/recycled-wood components, cut-off nails shall be flush with, or below, the surface of the wood at time of delivery to the Government. Presence of sharp end(s) of cut-off nails is cause for rejection of the pallet.

7.4 Contractor Certification

The contractor shall certify and maintain substantiating evidence that: the product (pallet) meets the requirements of Tables 1, 2, 3, and 4 and all pertinent sections of Part 9; the finished pallet conforms to the Government drawings, specifications, workmanship standards; and, the finished pallets meet standard industry quality assurance practices. Pallets with known defects shall not be submitted for Government acceptance. The Government reserves the right to perform or witness any of the inspections it deems necessary to insure supplies and services conform to prescribed requirements.

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Stringer Pallet Construction Details
(See Para. I-3, Part 3, for Classes, Types, and Styles)

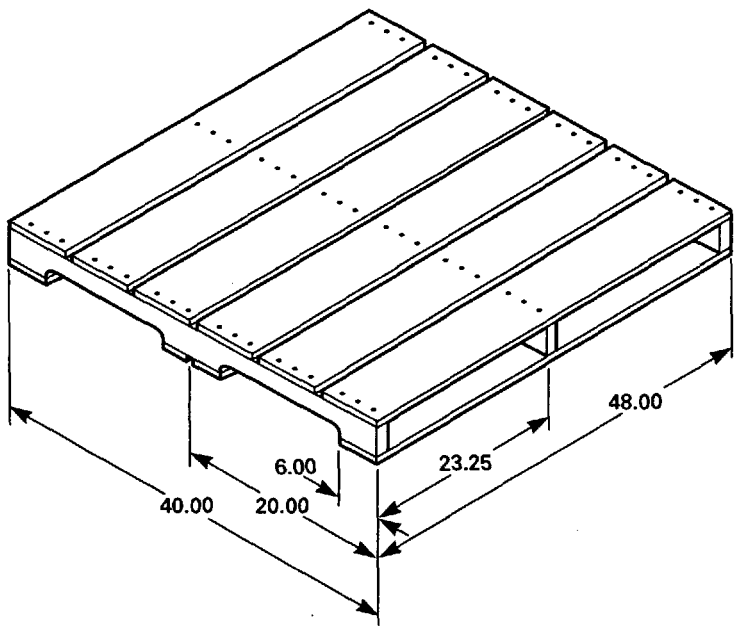


FIG. 1 ISOMETRIC VIEW, PARTIAL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET

[Shown is a Class 1, Type 2, Style 2, Size 2 (40 x 48 in.), 3-stringer pallet. All dimensions are in inches.]

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Stringer Pallet Construction Details
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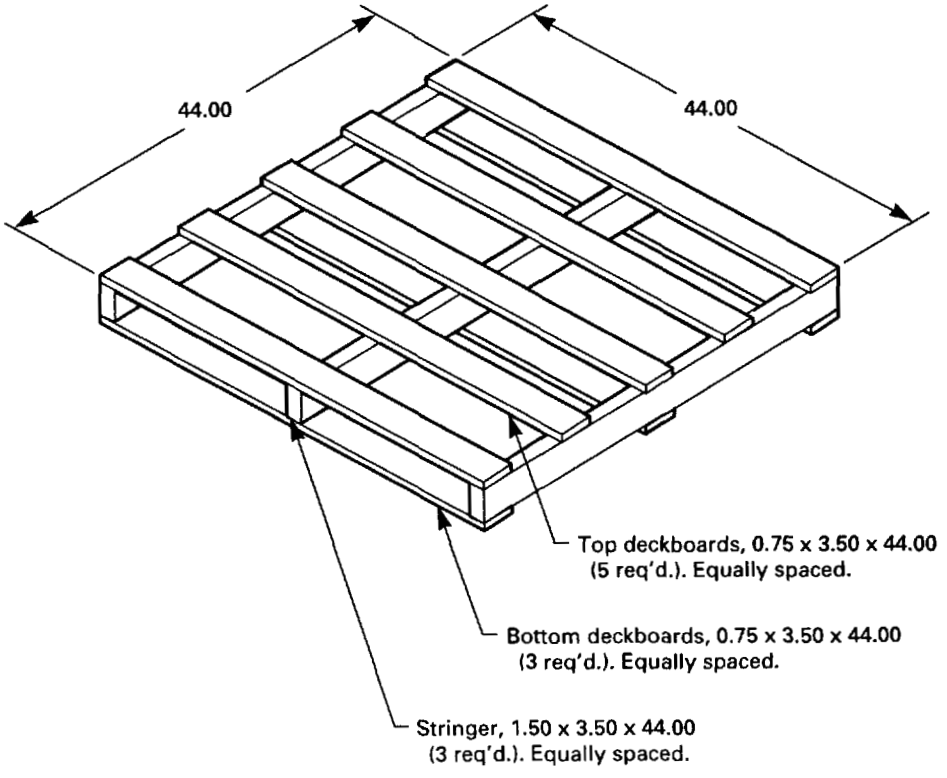


FIG. 2 ISOMETRIC VIEW, 2-WAY ENTRY, SIZE 5, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET

[Shown is a Class 1, Type 1, Style 2, Size 5 (44 × 44 in.), 3-stringer pallet. All dimensions are in inches.]

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Stringer Pallet Construction Details
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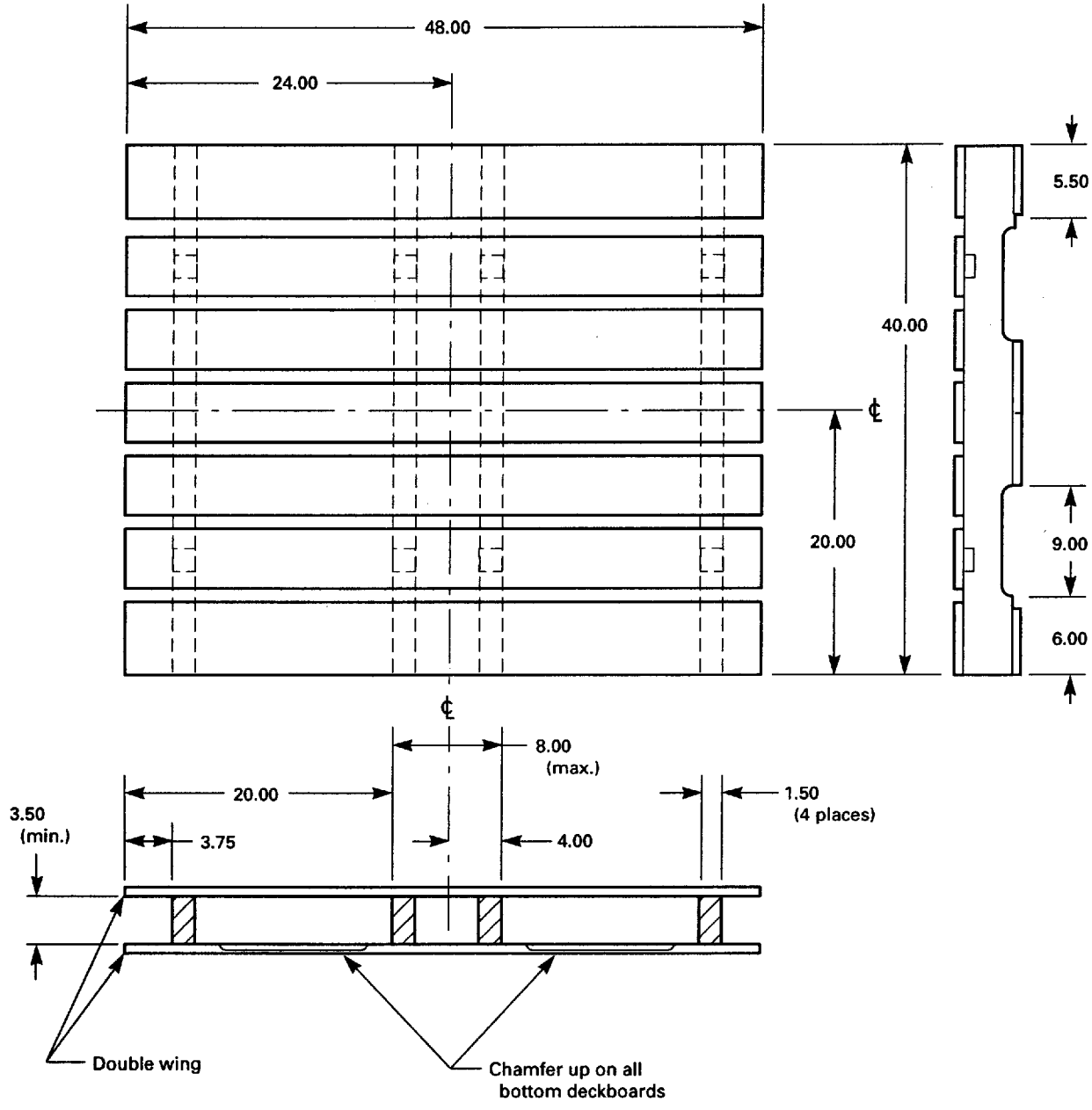
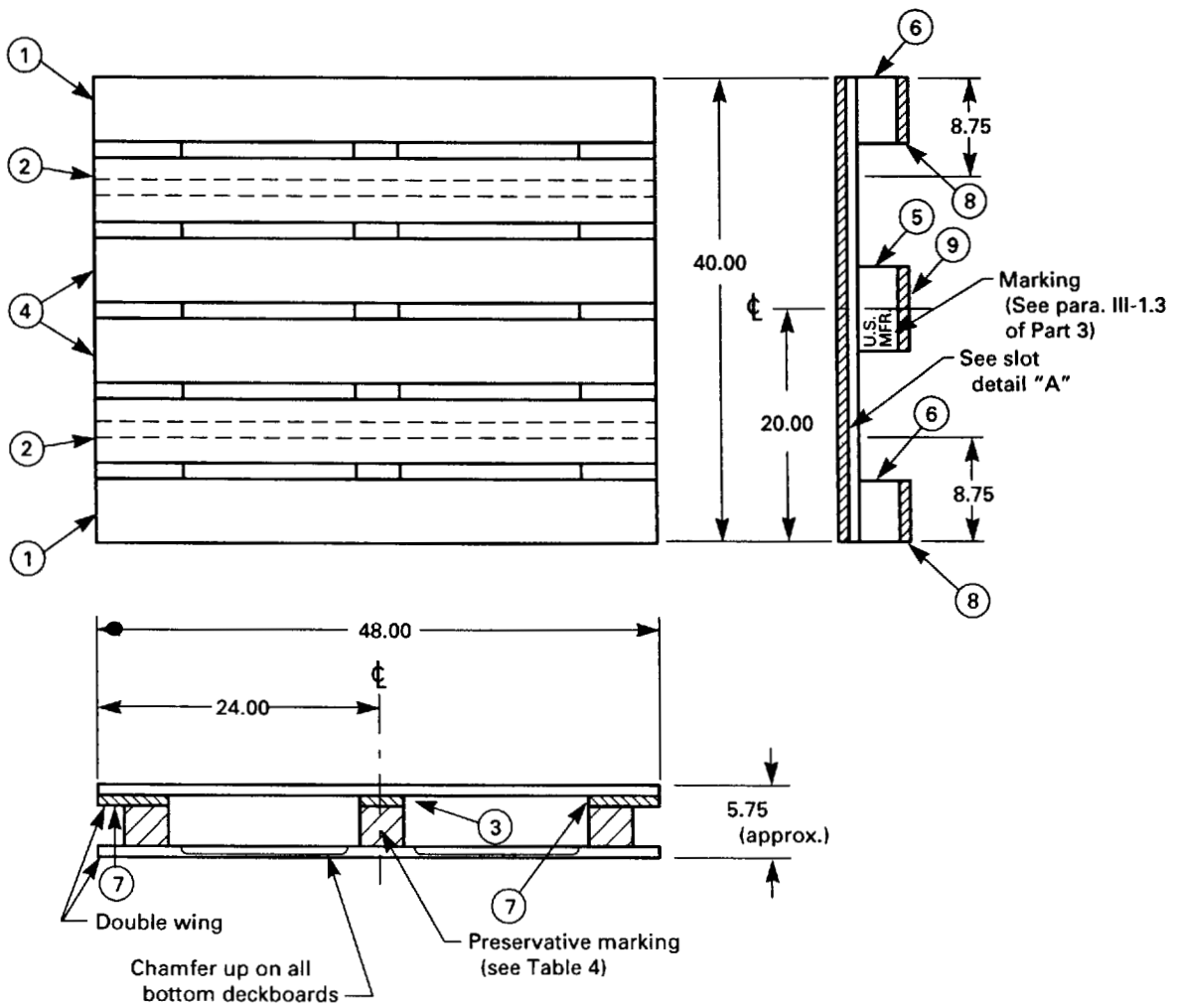


FIG. 3 TOP AND SIDE VIEW, PARTIAL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING PALLET

[Shown is a Class 1, Type 2, Style 6, Size 2 (40 × 48 in.), 4-stringer pallet. Strapping slots shall be included, as shown in Fig. 3. All dimensions are in inches.]

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Stringer Pallet Construction Details
(See Para. I-3, Part 3, for Classes, Types, and Styles)



GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

FIG. 4 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown is a Class 2, Type 3, Style 6, Size 2 (40 × 48 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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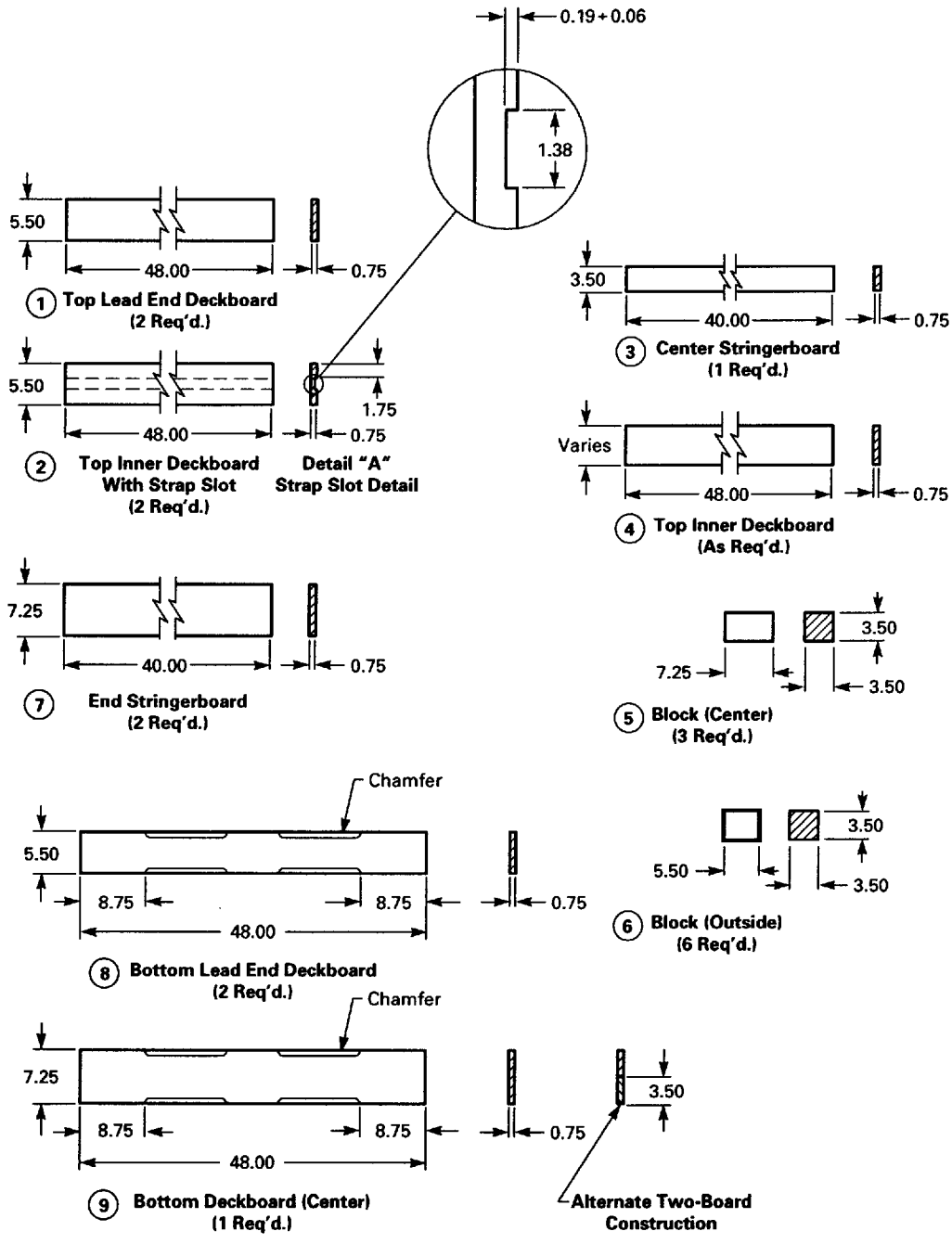
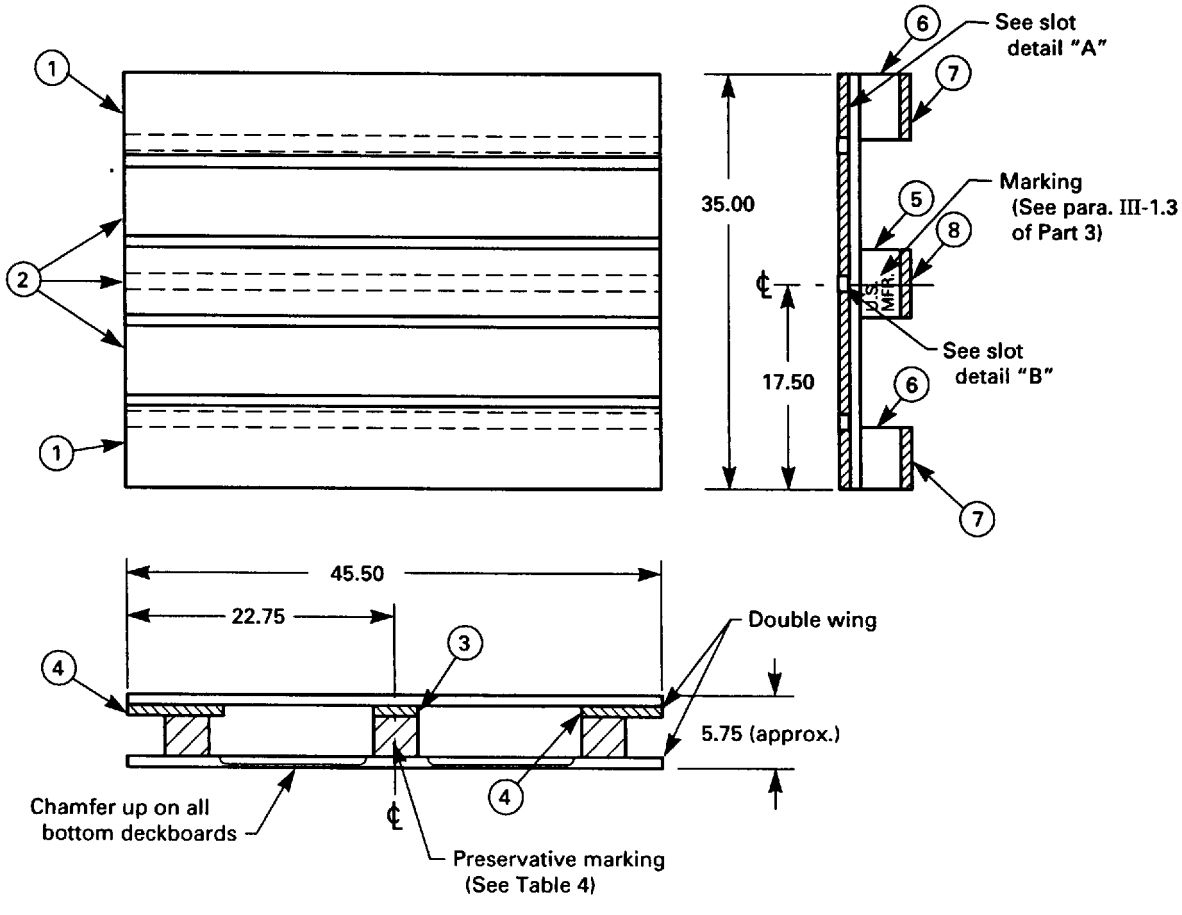


FIG. 5 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 2, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 2 (40 × 48 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
(See Para. 3, Part 3, for Classes, Types, and Styles)



GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

FIG. 6 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 6, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown is a Class 2, Type 3, Style 6, Size 6 (35 × 45.5 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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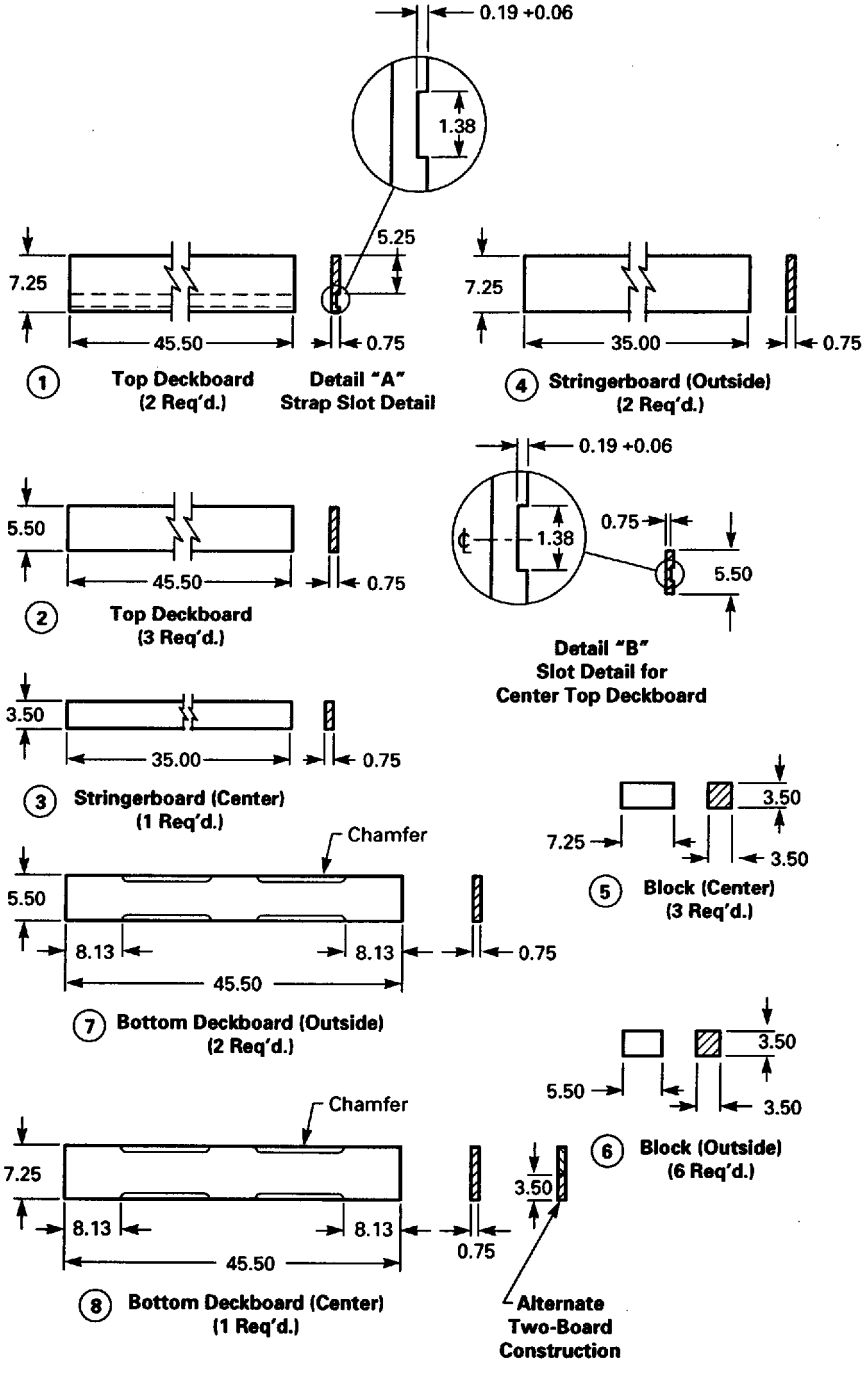
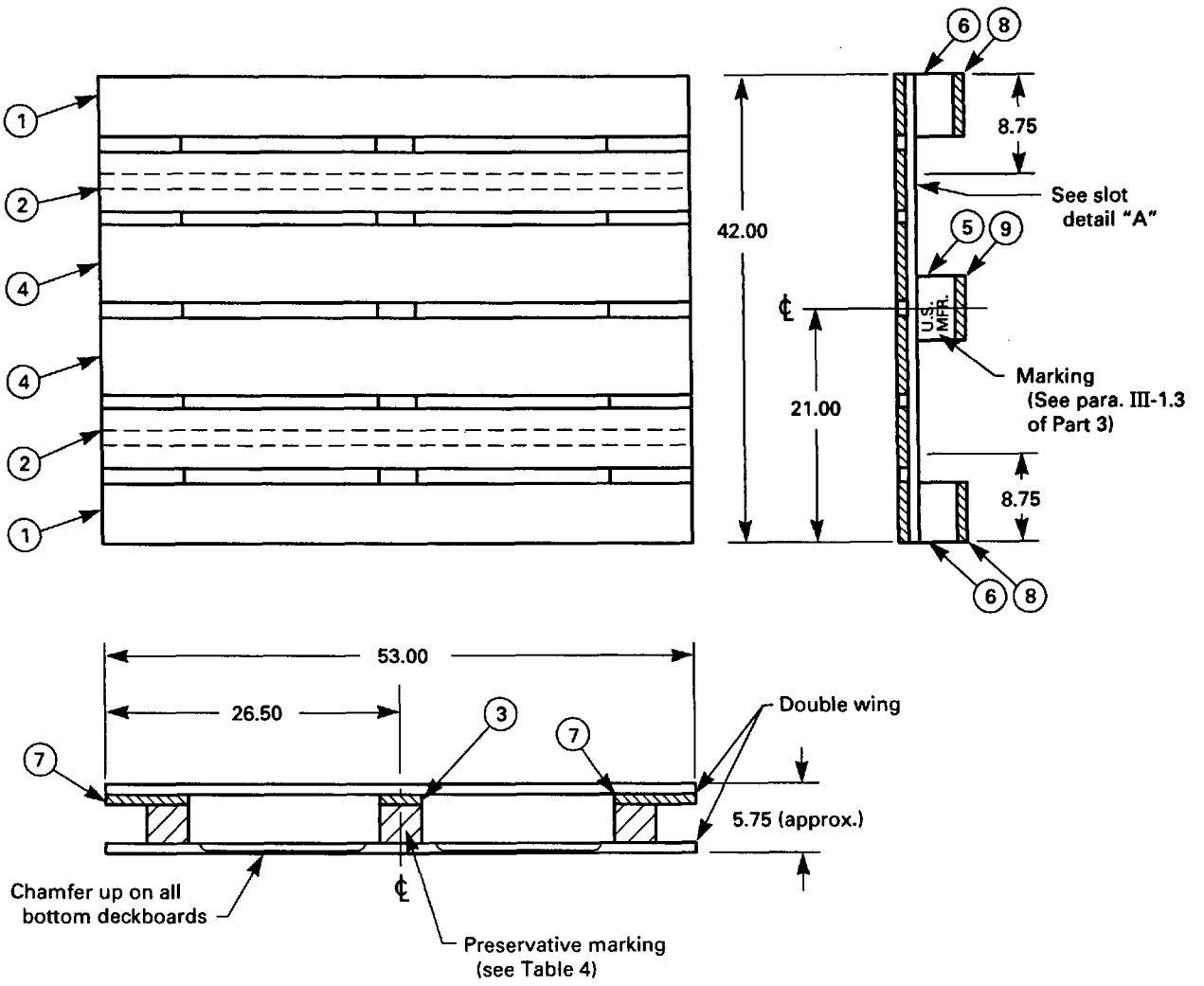


FIG. 7 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 6, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 6 (35 x 45.5 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
(See Para. 3, Part 3, for Classes, Types, and Styles)



GENERAL NOTE: For nail quantities and nailing pattern, see Fig. 17 of Part 9.

FIG. 8 TOP, SIDE, AND END VIEWS, FULL 4-WAY ENTRY, SIZE 7, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown is a Class 2, Type 3, Style 6, Size 7 (42 x 53 in.), block pallet. All dimensions are in inches.]

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Block Pallet Construction Details
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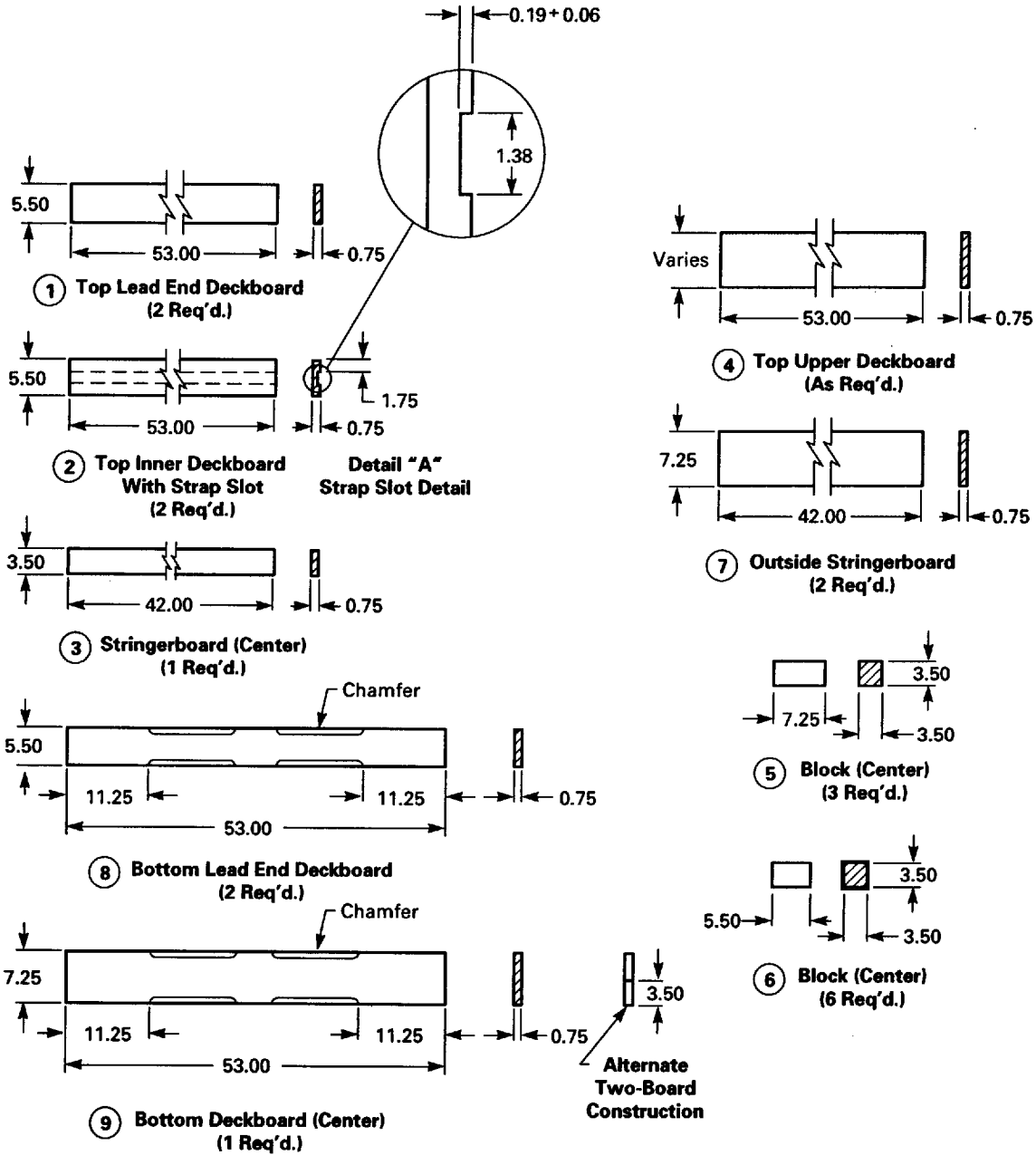


FIG. 9 COMPONENTS FOR A FULL 4-WAY ENTRY, SIZE 7, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE BLOCK PALLET

[Shown are components for a Class 2, Type 3, Style 6, Size 7 (42 x 53 in.), block pallet. All dimensions are in inches.]

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Stringer Pallet Construction Details
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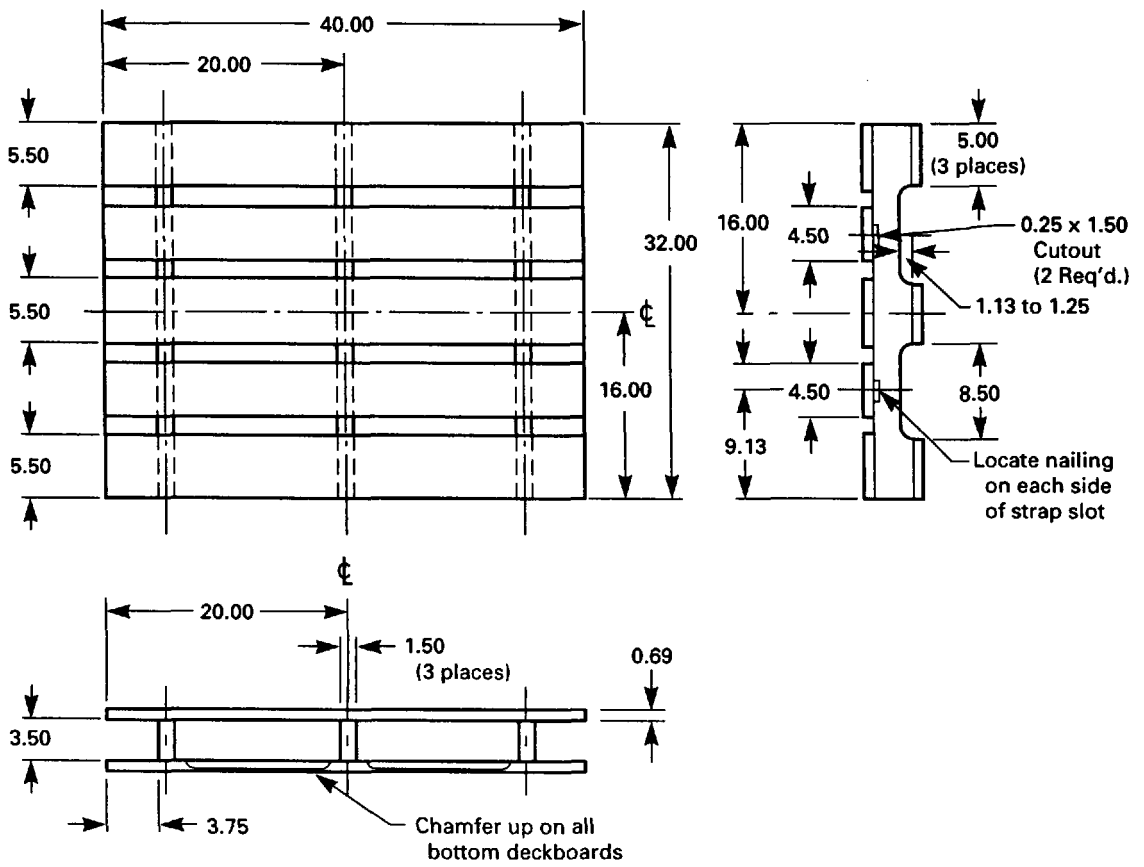


FIG. 10 TOP, FRONT, AND SIDE VIEW OF PARTIAL 4-WAY ENTRY, SIZE 1, DOUBLE-WING PALLET
[Shown is a Class 1, Type 2, Style 6, Size 1 (32 x 40 in.), 3-stringer pallet. All dimensions are shown in inches.]

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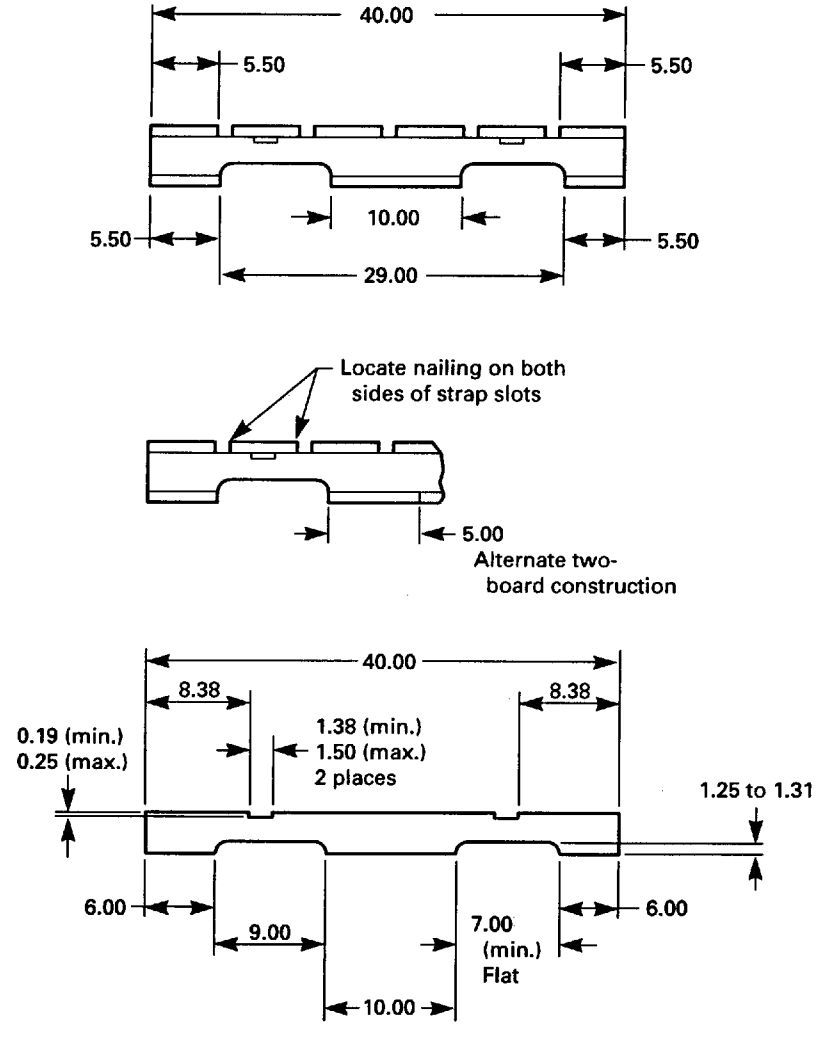


FIG. 11 END VIEWS, PARTIAL 4-WAY ENTRY, FLUSH OR DOUBLE-WING, STRINGER PALLET
[Detail shows a stringer for a Size 2 (40 x 48 in.) pallet and the location and size of the strapping slots. All dimensions are in inches.]

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Stringer Pallet Construction Details
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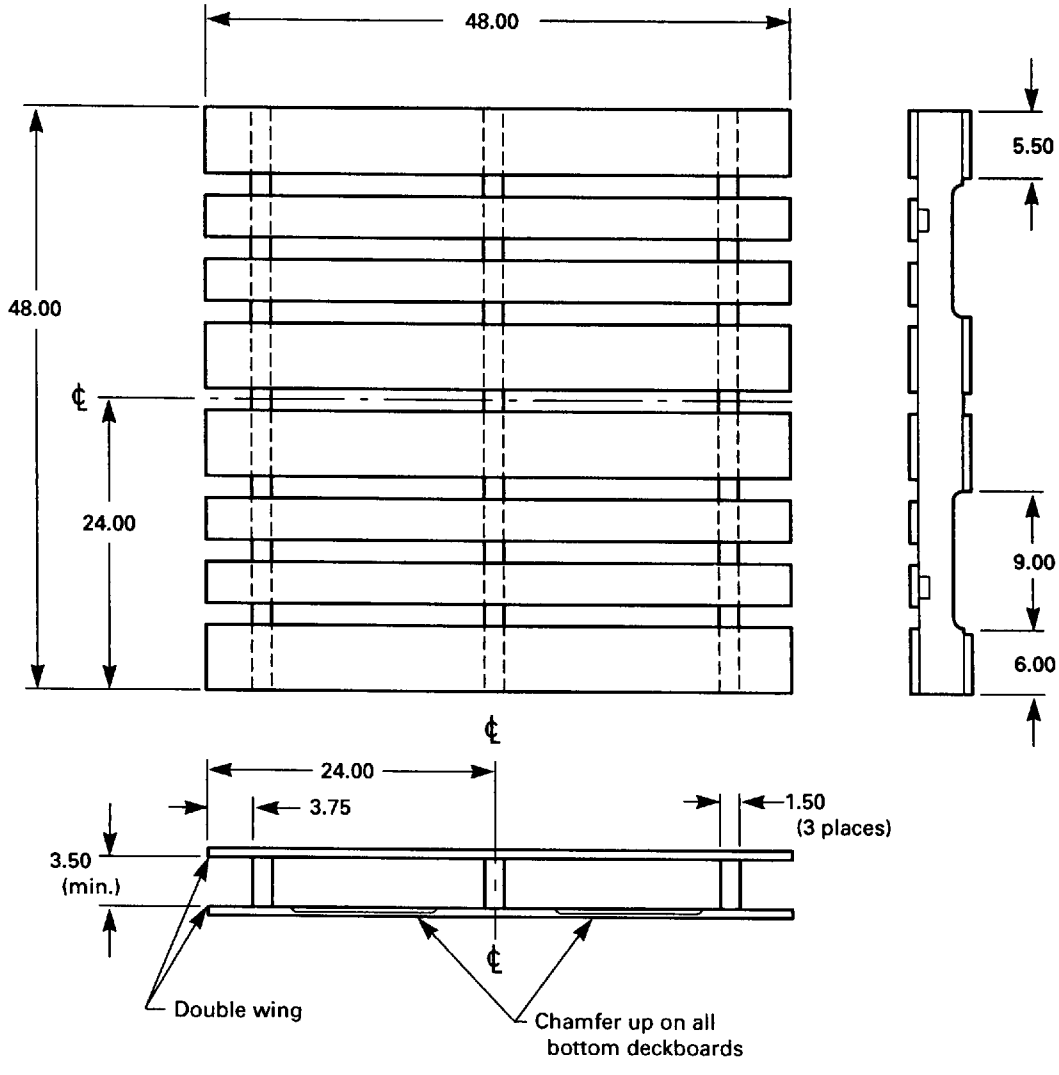


FIG. 12 TOP, END, AND SIDE VIEWS, PARTIAL 4-WAY ENTRY, SIZE 3, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE STRINGER PALLET

[Detail shows a Class 1, Type 2, Style 6, Size 3 (48 × 48 in.), 3-stringer pallet. Two or three bottom-interior deckboards may be used. Strapping slots shall be included, as shown in this figure. All dimensions are in inches.]

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Stringer Pallet Construction Details
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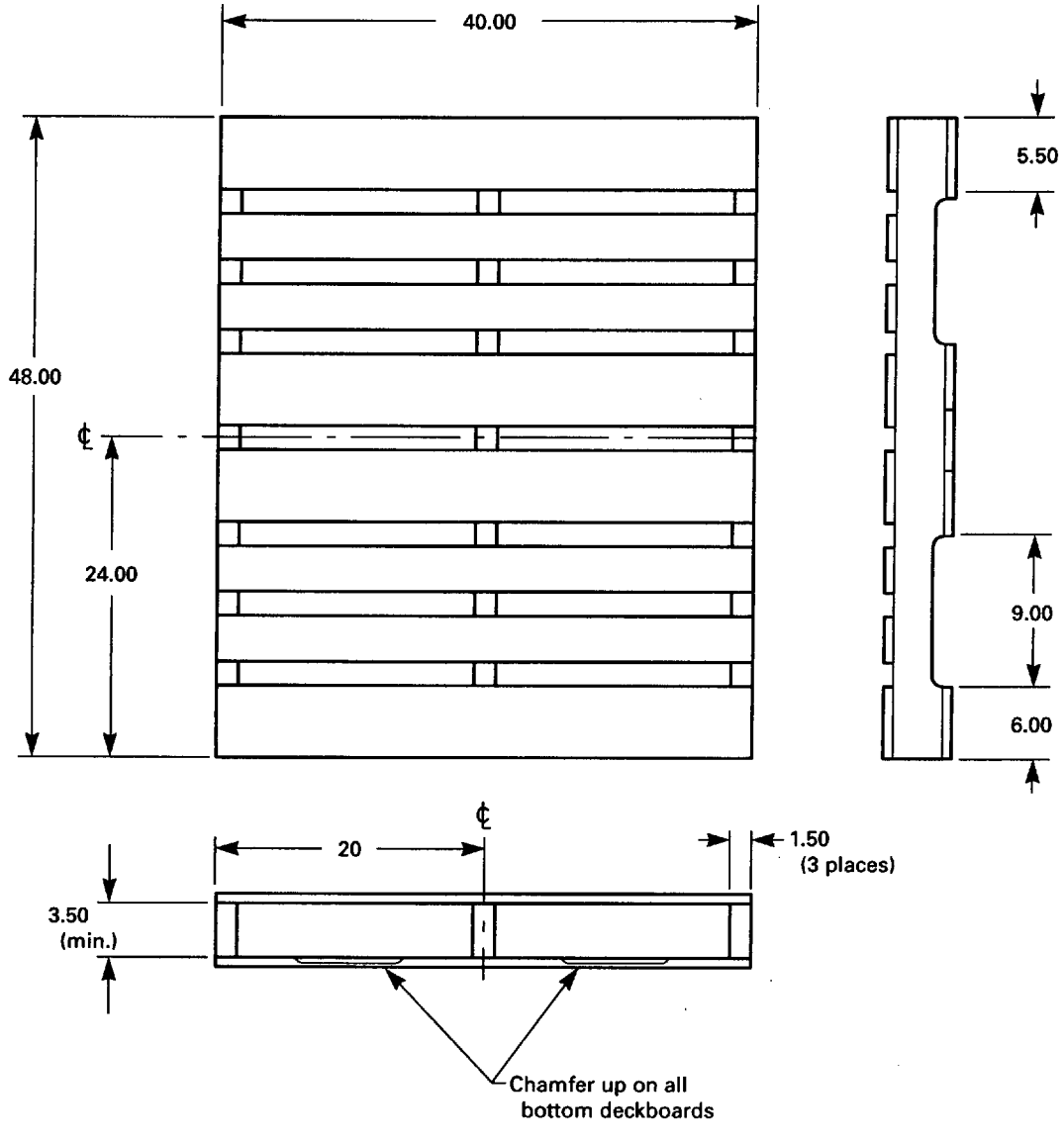


FIG. 13 TOP, END, AND SIDE VIEWS, PARTIAL 4-WAY ENTRY, SIZE 8, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE STRINGER PALLET

[Detail shows a Class 1, Type 2, Style 2, Size 8 (48 × 40 in.), 3-stringer pallet. Two or three bottom-interior deckboards may be used. All dimensions are in inches.]

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Stringer Pallet Construction Details
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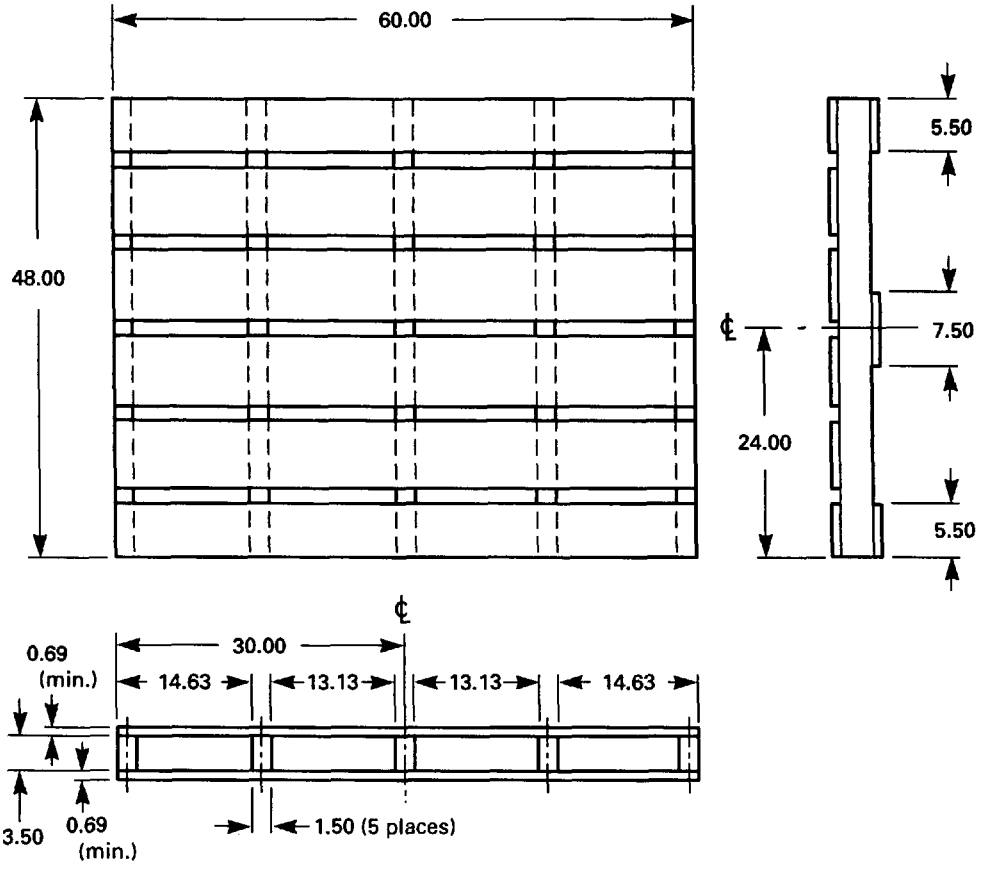


FIG. 14 TOP, END, AND SIDE VIEWS, 2-WAY ENTRY, SIZE 4, DOUBLE DECK, FLUSH, NONREVERSIBLE STRINGER PALLET

[Detail shows a Class 1, Type 1, Style 2, Size 4 (48 x 60 in.), 5-stringer pallet. All dimensions are in inches.]

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Recycled-Wood Stringer Pallet Construction Details
(See Para. 7, Part 3, for Pallet Repair and
Para. 3, Part 9 for Classes, Types, and Styles)

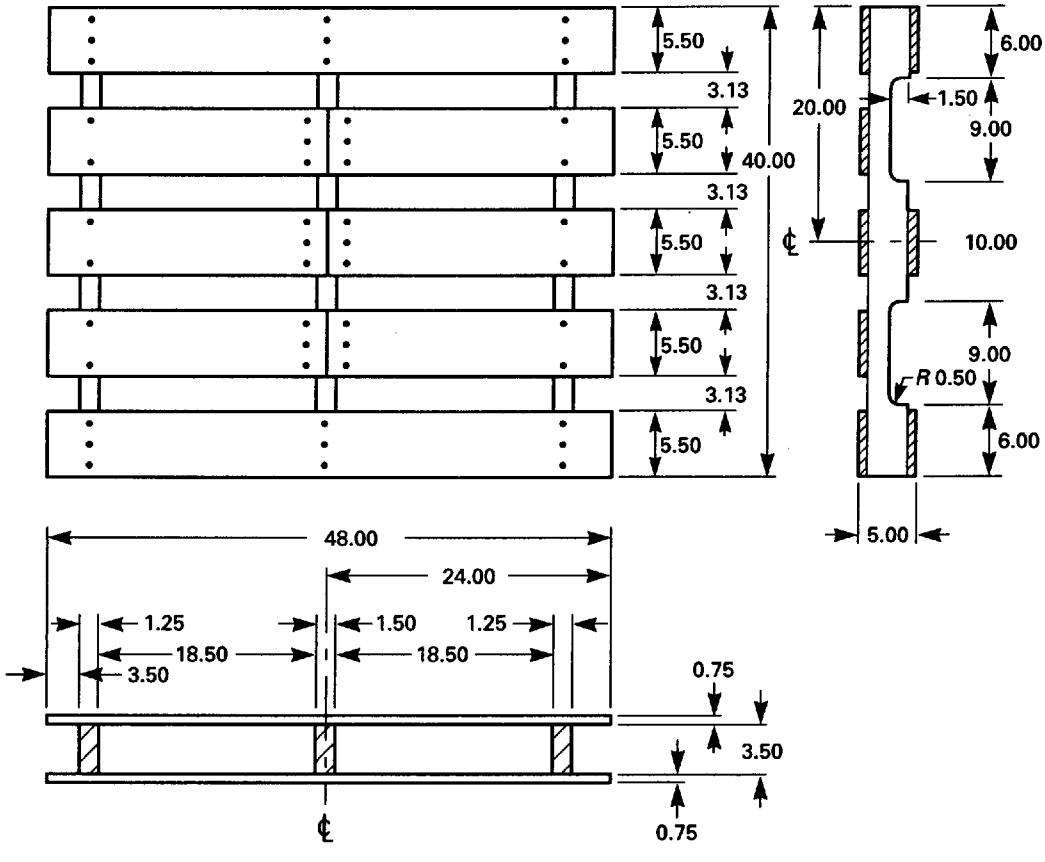


FIG. 15 TOP, SIDE, AND END VIEWS, PARTIAL 4-WAY ENTRY, DOUBLE DECK, DOUBLE-WING, NONREVERSIBLE, STRINGER PALLET WITH RECLAIMED-/RECYCLED-WOOD DECKBOARDS
[Detail shows a Class 1, Type 2, Style 6, Size 2 (40 x 48 in.), 3-stringer pallet constructed with reclaimed-/recycled-wood deckboards and new stringers. Stub, or cut-off, nails remaining in deckboards used in pallet construction shall be flush or below the deckboard surface at time of manufacture. All dimensions are in inches.]

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Stringer Pallet Construction Details
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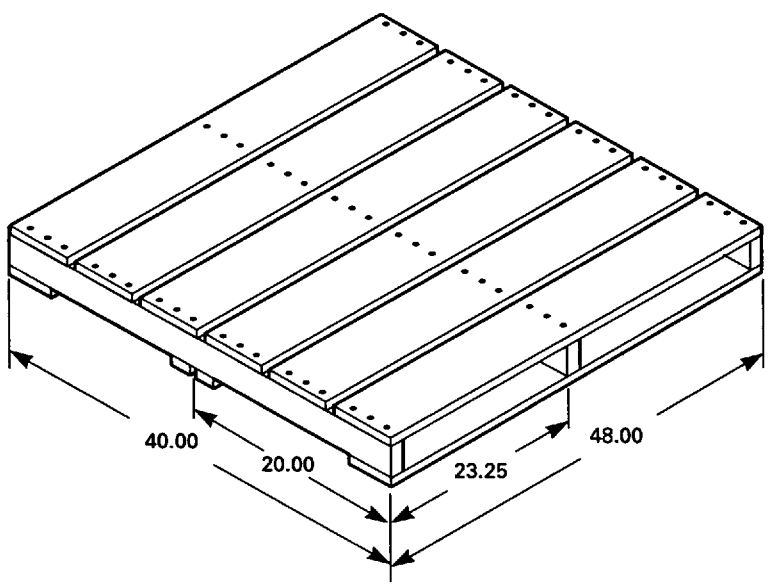
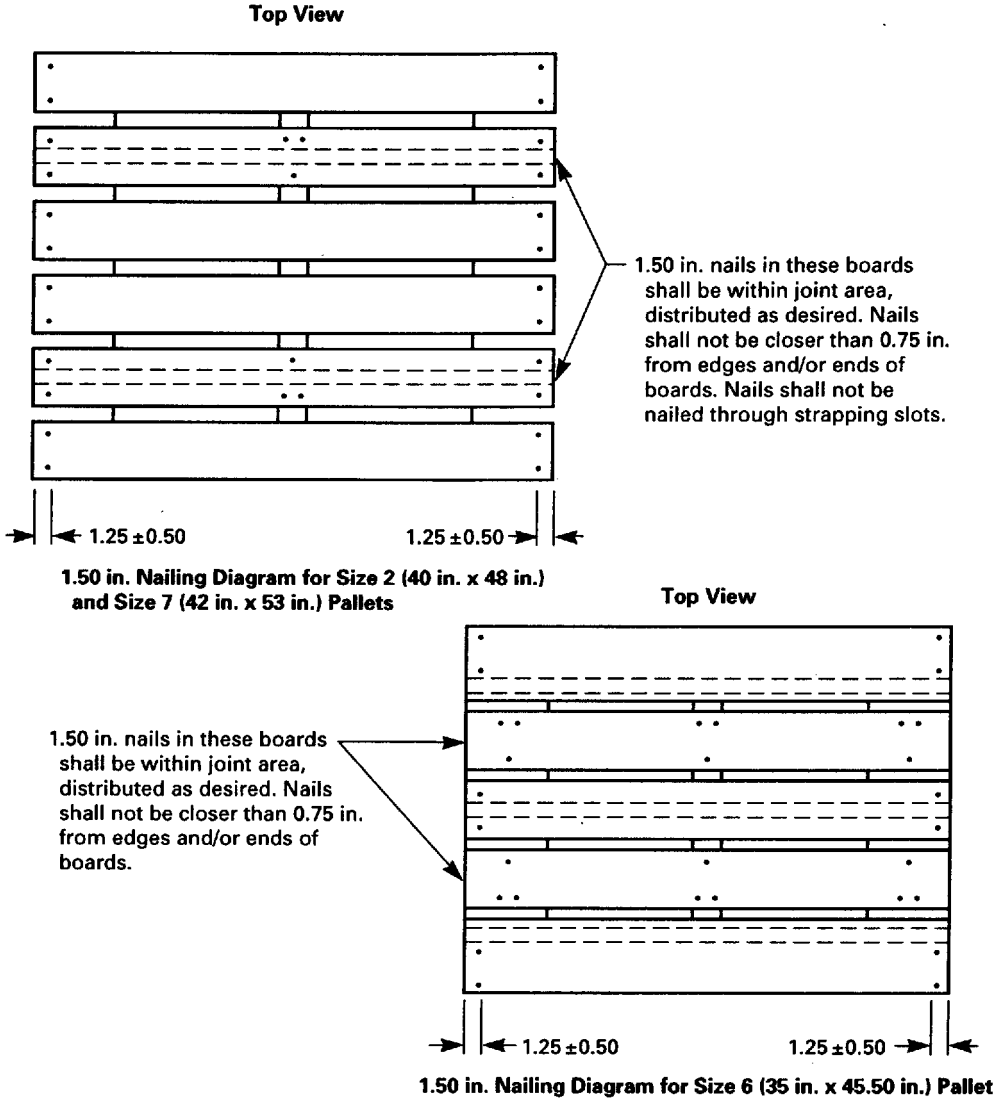


FIG. 16 ISOMETRIC VIEW, SIZE 2, DOUBLE DECK, FLUSH, NONREVERSIBLE PALLET
[Shown is a Class 1, Type 1, Style 2, Size 2 (40 x 48 in.), 3-stringer pallet. Bottom intermediate deckboards may be either two 3.5 in. wide deckboards or one 7.25 in. wide deckboard. All dimensions are in inches.]

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Block Pallet Nailing Diagrams
(Reference Figs. 4 to 9 of Part 9.)



NOTE:
Top deckboards shall be fastened to stringerboards with 1.50 in. nails. For quantities and locations, please see diagrams above. Top deckboards and stringerboards shall be nailed to blocks with 3.25 in. nails. These nails are not shown in the diagrams above, only 1.50 in. nails are shown. Three nails shall be used for the 5.50 in. blocks and four nails shall be used for the 7.25 in. blocks with the nails to be evenly distributed throughout the joint area. No nails shall be nailed through the strapping slots. Bottom deckboards shall be nailed to blocks with 2.25 in. nails or alternatively 3.25 in. nails may be used. Three nails shall be used for the 5.50 in. block and four nails shall be used for the 7.25 in. blocks with the nails to be evenly distributed throughout the joint area. All nails shall not be closer than 0.75 in. from edges and/or ends of boards.

FIG. 17 NAILING DIAGRAMS AND NAIL SIZES FOR SIZES 2, 6, AND 7, NONREVERSIBLE BLOCK PALLETS
(All dimensions are in inches.)

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NONMANDATORY APPENDIX A9-A
CROSS REFERENCE LIST AND CHARACTERISTICS, PART NO. TO NATIONAL STOCK NUMBER

(This Appendix is not part of Part 9 of MH1-1997, and is included for information purposes only.)

Part No., ASME [See Note (1)]	National Stock No.		Class	Type	Style	Size	No. of Stringers	No. of Blocks	Species Class [See Part 3 and Note (5)]	See Figure
	FSC	NIIN								
MH1/9-01SW3240	3990	00-542-3294	1	2	6	1	3	0	1, 3, 4, 21	10
MH1/9-02SW4048	3990	00-935-7960	1	2	6	2	3	0	1, 3, 11, 12, 29	3 [Notes (2), (4)]
MH1/9-03SW4048	3990	00-599-5326	1	2	6	2	4	0	1, 3, 4, 21	3
MH1/9-04SF4048	3990	00-555-0458	1	1	2	2	3	0	3, 11, 12	1 [Note (3)]
MH1/9-05SW4048	3990	01-041-8803	1	2	6	2	3	0	1, 3, 4, 21	3 [Note (2)]
MH1/9-06SW4048	3990	01-320-1436	1	2	6	2	4	0	11, 12, 13	3
MH1/9-07SW4848	3990	00-959-0743	1	1	6	3	3	0	1, 3, 4, 21	12
MH1/9-08SF4860	3990	00-222-1044	1	1	2	4	5	0	1, 3, 4, 21	14
MH1/9-09SF4444	3990	01-025-1568	1	1	2	5	3	0	11, 12, 13	2
MH1/9-10BW4048	3990	00-141-7261	2	3	6	2	0	9	1, 3, 4, 21	4, 5
MH1/9-11BW4048P	3990	00-935-7826	2	3	6	2	0	9	1, 4, 21	4, 5
MH1/9-12BW3545P	3990	01-090-0611	2	3	6	6	0	9	1, 4, 21	6, 7
MH1/9-13BW4253P	3990	01-093-6848	2	3	6	7	0	9	1, 4, 21	8, 9
MH1/9-14SW4048R	3990	01-448-4254	1	2	6	2	3	0	1, 3, 11, 12, 29	15
MH1/9-15SF4840	3990	01-105-9584	1	2	2	8	3	0	1, 3, 4, 21	13

NOTES:

(1) ASME Part No. codes are shown in Part 9, Table 4.

(2) Fig. 3 of Part 9 is a partial 4-way pallet with 4 stringers. Part No. MH1/9-02SW4048 and MH1/9-05SW4048 have 3 stringers.

(3) Fig. 1 of Part 9 depicts a partial 4-way pallet; however, Part No. MH1/9-04SF4048 describes a 2-way pallet for procurement purposes.

(4) Part No. MH1/9-02SW4048 has a 30% limit on moisture content (see Part 9, Table 4) and top deckboards shall be 3 in. (maximum) apart.

(5) Preferred wood species, in terms of strength and stiffness, are also allowed, except for block pallets for ammunition loads (Part Nos. MH1/9-13BW4253P).

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STD.ASME MH1A-ENGL 1999 ■ 0759670 0612667 478 ■

NONMANDATORY APPENDIX A9-B
REFERENCED DOCUMENTS

(This Appendix is not part of Part 9 of ASME MH1-1997, and is included for information purposes only.)

The following documents were reviewed during the preparation of this Part:

MH1-1997, Pallets, Slip Sheets, and Other Bases for Unit Loads

Publisher: American Society of Mechanical Engineers (ASME International), Three Park Avenue, New York, NY 10016-5990

ASTM D 1185-94, Standard Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428

ISO 6780-1988/1994, General Purpose Flat Pallets for Through Transit of Goods—Test Methods—Principal Dimensions and Tolerances

ISO 8611-1991, General Purpose Flat Pallets for Through Transit of Goods—Test Methods—Amendment 1: Wing Pallets

Publisher: International Organization for Standardization (ISO), 1 rue de Varembé, Case Postale 56, CH-1121, Genvève 20, Switzerland/Suisse

MIL-P-15011J, Pallets, Material Handling, Wood, Post Construction, 4-Way Entry, September 16, 1985

NN P-71C, Pallet, Material Handling, Wood, Stringer Construction, 2-Way and 4-Way (Partial), September 10, 1973

Publisher: Superintendent of Documents, United States Government Printing Office, Washington, DC 20402

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NONMANDATORY APPENDIX A9-C
CROSS REFERENCE LIST, OLD SPECIFICATIONS TO NEW MH1, PART 9 SPECIFICATIONS

(This Appendix is not part of Part 9 of ASME MH1-1997, and is included for information purposes only.)

Part No., ASME [See Note (1)]	U.S. Government National Stock No.		Old Specification	Old Specification				No. of	No. of	Species Class	Strapping	See
	FSC	NIIN	No.	Class	Type	Style	Size	Stringers	Blocks	(See Part 3)	Slots	Figure
MH1/9-01SW3240	3990	00-542-3294	NN-P-71	1	V	A	1	3	0	1, 3, 4, 21	Yes	10
MH1/9-02SW4048	3990	00-935-7960	NN-P-71	1	IV	A	2	3	0	1, 3, 11, 12, 29	Yes	3
MH1/9-03SW4048	3990	00-599-5326	NN-P-71	1	V	A	2	4	0	1, 3, 4, 21	Yes	3
MH1/9-04SF4048	3990	00-555-0458	NN-P-71	1	III	A	2	3	0	3, 11, 12	No	1
MH1/9-05SW4048	3990	01-041-8803	NN-P-71	1	VIII	A	2	3	0	1, 3, 4, 21	Yes	3
MH1/9-06SW4048	3990	01-320-1436	NN-P-71	1	V	A	2	4	0	11, 12, 13	Yes	3
MH1/9-07SW4848	3990	00-959-0743	NN-P-71	1	II	A	3	3	0	1, 3, 4, 21	Yes	12
MH1/9-08SF4860	3990	00-222-1044	NN-P-71	1	I	A	4	5	0	1, 3, 4, 21	No	14
MH1/9-09SF4444	3990	01-025-1568	NN-P-71	1	VII	A	...	3	0	11, 12, 13	No	2
MH1/9-10BW4048	3990	00-141-7261	MIL-P-15011	1	I	1	A	0	9	1, 3, 4, 21	Yes	4, 5
MH1/9-11BW4048P	3990	00-935-7826	MIL-P-15011	1	I	1	A	0	9	1, 4, 21	Yes	4, 5
MH1/9-12BW3545P	3990	01-090-0611	MIL-P-15011	1	I	1A	B	0	9	1, 4, 21	Yes	6, 7
MH1/9-13BW4253P	3990	01-093-6848	MIL-P-15011	1	I	1B	C	0	9	1, 4, 21	Yes	8, 9
MH1/9-14SW4048R	3990	01-448-4254	None	...	...	...	...	3	0	1, 3, 11, 12, 29	No	15
MH1/9-15SF4840	3990	01-105-9584	MIL-P-52999	...	...	...	...	3	0	1, 3, 4, 21	No	13

NOTES:

(1) ASME Part No. codes are shown in Table 4 of Part 9.

(2) All data shown (Class, Type, Style, Size) are extracted from the "old specifications."

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STD·ASME MH1-ENGL 0759670 0588237 TT9

ASME MH1-1997

PALLETS, SLIP SHEETS, AND OTHER BASES FOR UNIT LOADS

AN AMERICAN NATIONAL STANDARD



The American Society of
Mechanical Engineers

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STD.ASME MH1-ENGL 0759670 0588238 935



The American Society of Mechanical Engineers

AN AMERICAN NATIONAL STANDARD

PALLETS, SLIP SHEETS, AND OTHER BASES FOR UNIT LOADS

ASME MH1-1997

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FOREWORD

(This Foreword is not part of ASME MH1-1997.)

Hundreds of millions of wood pallets were manufactured in the United States of America during each of the past 30 years, considerably more than the 37 million pallets produced during 1953 when the ASME Standards Committee MH1 was established. It is estimated that approximately 20% of the total annual production of lumber in the United States was required for the assembly of these pallets. One pallet size of the approximately 100 sizes used, the 48 × 40 in. and 40 × 48 in. (1219 × 1016 mm and 1016 × 1219 mm) size, accounts for more than one-third of all the pallets produced; while ten additional sizes account for more than 1% of all pallets produced. Pallets made of metal and plastics are also manufactured in the United States. However, their production is limited and no production statistics are available.

The need for standardization of pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products, originated from the interconnecting nature of pallet usage. The great variety of pallet sizes and constructions restricted their movement through manufacturing and distributing channels. This variety was the result of each user treating pallet design as a private problem. More intense application of the unit-load method of assembling, stacking, storing, handling, and transporting of commodities in the United States and in international trade fostered extensive use of pallets both as captive and exchange pallets. The latter pallets, especially, required maximum standardization for any exchange to be successful.

Some industries and military services developed, by evolution, certain pallet standards to solve specific problems which are also existent with other users. Consequently, their sizes and constructions of pallets established a pattern of value to all users.

The American National Standards Institute (formerly the American Standards Association) project on pallet standardization was initiated in October 1953. A Material Handling Standards Committee, MH1 (initially B69), was organized to coordinate information and prepare standards under the scope of standardization of nomenclature, types, sizes, materials, and components of pallets, including sampling, inspection, and test procedures. The standards pertain to pallets used in the unit-load method of assembling, stacking, storing, handling, and transporting materials and products. The standards were to accomplish the following:

(a) define terminology associated with pallets;
(b) apply to pallets irrespective of components used in their fabrication;
(c) provide a series of recommended pallet dimensions;
(d) describe procedures for pallet testing; and
(e) indicate procedures for designating pallet requirements.

During 1967, the MH1 Committee was reorganized. A Nominating Committee was established in compliance with the procedures of ANSI. The Nominating Committee selected officers for the MH1 Committee during 1968 and, in turn, became the nucleus for the new MH1 Executive Committee to guide the continuing revision activities and organize the task groups to be formed.

The name of the MH1 Committee was changed in 1979 to Standardization of Pallets, Slip Sheets, and Other Bases for Unit Loads by action of ANSI's Physical Distribution

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Standards Management Board in light of the establishment of the MH1 Subcommittee on Standardization of Slip Sheets in March 1979. The following scope of the Committee was established: standardization of nomenclature, types, sizes, materials, and components of pallets, slip sheets, and other unit-load bases, including sampling, inspection, and test procedures.

The MH1 Committee, consisting of individual members and representatives of trade associations, engineering societies, and government agencies, organized a Technical Committee to perform its work. During July 1981, this Technical Committee was reorganized as an ASME Standards Committee operating under the ANSI accredited organization procedures.

The following MH1 Committee standards were issued:

MH1.1.2	Definitions and Terminology Covering Pallets and Related Structures
MH1.2.2M	Pallet Sizes
MH1.4.1M	Procedures for Testing Pallets
MH1.5M	Slip Sheets
MH1.6	Standard Procedures for Determination of Durability of Wooden Pallets and Related Structures
MH1.7M	Driven Fasteners for Assembly of Pallets and Related Structures
MH1.8M	Wood Pallets
MH1.9	Export Pallets

The MH1 Committee has published the above eight separate standards which are being consolidated into a single publication, MH1 Pallets, Slip Sheets, and Other Bases for Unit Loads. This 1997 Edition contains the consolidation of the revised MH1.1.2, MH1.4M (formerly MH1.4.1M), MH1.6, and MH1.7M standards. All of the documents contained in this Edition of the Standard were approved by ANSI as American National Standards on July 16, 1996. The remaining four documents, MH1.2.2M, MH1.5M, MH1.8M, and MH1.9 will be added through the addenda process.

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ASME STANDARDS COMMITTEE MH1
Standardization of Pallets, Slip Sheets, and Other Bases for Units Loads

(The following is the roster of the Committee at the time of approval of this Standard.)

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PREFACE

(This Preface is not part of ASME MH1-1997.)

ORGANIZATION OF THIS DOCUMENT

This Standard is arranged in Parts, and these Parts incorporate the requirements of previously published standards identified below:

ASME MH1-1997	Previous Designator	Title
Part 1	ASME MH1.1.2-1996 (Revision of ASME MH1.1.2-1989)	Definitions and Terminology Covering Pallets and Related Structures
Part 2	ASME MH1.2.2M-1989	Pallet Sizes (to be provided in addenda)
Part 3	ASME MH1.8M-1996	Wood Pallets (to be provided in addenda)
Part 4	ASME MH1.9-1993	Export Pallets (to be provided in addenda)
Part 5	ASME MH1.7M-1996 (Revision of ASME/ANSI MH1.7M-1988)	Driven Fasteners for Assembly of Pallets and Related Structures
Part 6	ASME MH1.6-1996 (Revision of ASME/ANSI MH1.6-1987)	Determination of Durability of Wood Pallets and Related Structures
Part 7	ASME MH1.4M-1996 (Revision of ASME MH1.4.1M-1989)	Testing Procedures for Pallets and Related Structures
Part 8	ASME MH1.5M-1993	Slip Sheets (to be provided in addenda)

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This Edition of ASME MH1-1997 includes an automatic addenda subscription service up to the publication of the next edition. The addenda subscription service will include the additional MH1 documents not already contained in the initial publication and approved revisions to the existing Parts.

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PALLETS, SLIP SHEETS, AND OTHER BASES FOR UNIT LOADS

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Part 1
Definitions and Terminology Covering Pallets and Related Structures

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PART 1
DEFINITIONS AND TERMINOLOGY COVERING PALLETS AND RELATED STRUCTURES

1 SCOPE

Part 1 provides definitions and terminology associated with the construction and use of pallets and related structures, such as skids and pallet containers.

2 PURPOSE

The purpose of Part 1 is to provide generally accepted definitions and terminology that serve as the basis for common understanding when describing pallets and related structures and their use.

3 REFERENCED STANDARDS

The following standards were reviewed during the preparation of Part 1:

ASME MH1.1.2-1989, Definitions and Terminology Covering Pallets and Related Structures
ASME MH1.4.1-1989, Procedures for Testing Pallets
ASME/ANSI MH1.6-1987, Standard Procedures for Determination of Durability of Wooden Pallets and Related Structures
ASME/ANSI MH1.7M-1988, Driven Fasteners for Assembly of Pallets and Related Structures
ASME MH1.8M-1996, Wood Pallets
ASME MH1.9-1993, Export Pallets

Publisher: The American Society of Mechanical Engineers (ASME), 345 East 47th Street, New York, NY 10017-2392

ASTM D 1185-1994, Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping
ASTM F 680-1980 (1993), Test Methods for Nails
ASTM F 1575-1995, Test Method for Determining Bending Yield Moment of Nails
ASTM F 1667-1995, Specifications for Driven Fasteners: Nails, Spikes, and Staples
ASTM E 380-1993, International System of Nails, The Modern Metric System

Publisher: American Society for Testing and Materials (ASTM), 100 Bar Harbor Drive, Conshohocken, PA 19428-2959

ISO 445-1996, Pallets for Materials Handling — Vocabulary
ISO 6780-1988 (1994), General-Purpose Flat Pallets for Through Transit of Goods — Principal Dimensions and Tolerances
ISO 8611-1995, General-Purpose Flat Pallets for Through Transit of Goods — Test Methods. Performance Requirements, Design Rating, and Maximum Working Load. Determination of Joint Strength
ISO/DIS 12777-1-1994, Methods of Test for Pallet Joints With Mechanical Fasteners — Pallet Nails, Other Dowel-Type Fasteners, and Staples — Determination of Bending Resistance, Testing for Shank Withdrawal and Head Pull-Through Resistance

Publisher: Informational Standards Organization (ISO), C.P. 56, CH-1211, Geneva 20, Switzerland

NWPCA-1994, Uniform Voluntary Standard for Wood Pallets

Publisher: National Wooden Pallet and Container Association (NWPCA), 1800 North Kent Street, Arlington, VA 22209-2104

Fiber Box Handbook-1987

Publisher: Fiber Box Association, 8725 Higgins Road, Chicago, IL 60631

4 DEFINITIONS AND TERMINOLOGY

accuracy: degree of agreement between specified value and that actually obtained.

adhesive: material capable of adhering one surface to another, such as plies of solid fiberboard, facings of corrugating medium in combined corrugated board, overlapping sides of container, and flaps in closing container as well as unit load to pallet deckboards or deck.

all-way entry pallet: see *pallet, all-way entry.*

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aluminum pallet: see *pallet, aluminum.*

analysis: determination of level of performance.

annularly threaded nail or *annular nail:* see *nail, annularly threaded* or *nail, annular.*

assembled pallet: see *pallet, assembled.*

assembly: process of connecting components to form an integral structure.

banding notch: see *strap slot.*

base: structural assembly designed to support unit load.

base pallet: see *pallet, base.*

basis weight, containerboard: see *containerboard, basis weight.*

bearer: see *stringer*; bearer (the preferential term in some British Commonwealth countries).

bearing surface: interface between pallet elements and components, such as deckboard and stringer or stringerboard or cross stringer of corrugated pallet. Also, interface between pallet top deck and unit load supported by pallet, such as complete top deck for uniformly distributed unit load or partial top deck for concentrated unit load. Also, interface between pallet bottom deck and pallet-supporting area. Also, interface between bottom deck of stacked pallet and palletized unit load supporting stacked pallet.

bevel: see *chamfer.*

bevel, sawn: missing edge along wood component, resulting from sawing or planing.

beveled deckboard: see *deckboard, chamfered.*

bias: systematic error in test results; contributing to difference between population mean of test results.

bin: multi-sided superstructure to be mounted on pallet base, with or without cover; also known as box or container.

bin pallet: see *pallet, bin.*

biodegradable: material property resulting in deterioration due to such environmental factors as exposure to moisture, oxygen, and bacterial action.

block: rectangular, square, multisided, or cylindrical deck or deck-mat spacer between top and bottom decks or beneath top deck of single-deck pallets, often identified by its location within pallet as corner block, end block, edge block, inner block, center or middle block; post.

block dimensions: length measured in direction of pallet length; width measured in direction of pallet width; height measured in direction of pallet height; not related to grain direction of block.

block pallet: see *pallet, block.*

block size: stated in terms of width followed by height and length.

blow molding: see *molding, blow.*

board: wood member sawn and dressed on its four sides, less than 50 mm (2 in.) in nominal thickness.

board, corrugated: see corrugated board.

board, water-resistant: sized board, treated with water-repellant material, to have a degree of resistance to damage or deterioration by water.

bolt: fastener with coarse thread along shank at end opposite square or hexagonal head, provided with washers and nut; to be inserted in oversize predrilled hole.

bolted pallet: see *pallet, bolted.*

bottom deck: assembly of elements comprising lower face of pallet; bearing surface of pallet; with construction being unidirectional, overlap (two-directional), and of perimeter or cruciform design (see pallet classification).

bottom deckboard: see *deckboard, bottom.*

box: see *bin*; also, container with solid or closely fitted sides, ends, bottoms, and top made of wood, metal, plastic, fiberboard, paperboard, or foamed or cellular plastic, completely and securely enclosing box contents.

box pallet: see *pallet, bin.*

bracket: angle-shaped support or connection fastened to components to be tied together.

bursting strength: material strength, in lbf/in.^{2}, as measured with Cady or Mullen tester.

butted deckboard: see *deckboard, butted.*

CAD: computer-assisted design.

CAD pallet software: tool to design pallet for specified use conditions.

cage pallet: see *pallet, cage.*

caliper: sheet thickness, in thousandths of inch, with 0.001 in. often called "point."

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cantilever pallet: see *pallet, cantilever.*

cap: see *mat.*

capacity, shock-absorbing: capability of sustaining impact load without failure.

capacity, shock-damping: capability of lessening effect of impacted load.

captive pallet: see *pallet, captive.*

carriage bolt: bolt with square or other shaped oversize element next to head to prevent head from turning during nut tightening or loosening; coach bolt.

center cluster deckboards: center bottom deckboards located below stringer foot between stringer notches.

center stringer: see *stringer, center.*

chamfer: machined or molded inclined surface along part or full length of edges of deckboards between stringers or blocks to facilitate passage of fork-arm wheels of pallet trucks and to guide tines of fork lift truck during entry into pallet; bevel.

chamfered deckboard: see *deckboard, chamfered.*

chipboard: paperboard usually made from reclaimed paper stock, with center ply or plies of solid fiberboard.

chord: see *stringer chord.*

class: denoting stringer or block pallet (see *pallet classification).*

classification: arrangement according to systematic division into groupings (see *pallet classification).*

clenched nail: see *nail, clenched.*

clinched nail: see *nail, clinched.*

closed distribution system: shipping system restricted to moving goods between specified plants and facilities.

coach bolt: see *carriage bolt.*

coefficient of friction: ratio of friction force between two bodies to normal force pressing these bodies together.

coefficient of friction, kinetic: coefficient of friction under conditions of macroscopic relative motion between two touching bodies.

coefficient of friction, static: coefficient of friction corresponding to maximum friction force that must be overcome to initiate macroscopic motion between two touching bodies.

coefficient of variation: measure of dispersion of observed values; standard deviation of observed values divided by value average.

collapsible bin, box, or container: superstructure that may be folded or separated into its component elements.

collar: fixed, hinged, removable, or collapsible horizontal solid, slatted, or mesh, framing members to tie together vertical elements of pallet superstructure; also, element on top of pallet deck to contain unit load placed on pallet; rail.

column: fixed or detachable vertical member forming part of superstructure to facilitate stacking with or without side superstructure components; post.

combined board: fabricated panel assembled from several components such as solid or corrugated fiberboard.

combo pallet: see *pallet, combo.*

companion stringer: see *stringer, companion.*

compliance: measurement of conformance with established requirements and criteria.

component: element of pallet such as deckboard, stringer, stringerboard, and block, and cross stringer of corrugated pallet.

concentrated load: see *load, concentrated.*

conditioning: exposure to specific environment, often until approximate equilibrium is reached with that environment.

connection: structural junction of two or more members, components, or assemblies, designed to be assembled with mechanical fasteners, adhesives, welds, or interlocks, or a combination of them, to transmit structural forces safely; often identified by location within pallet as end connection, center connection, corner connection. Colloquially, the term "joint" is used in place of the term "connection."

connector: see *fastener.*

container: see *bin.*

containerboard: corrugated and solid fiberboard manufactured from linerboard, corrugating material, and filler.

containerboard, basis weight: weight of linerboard or corrugating medium, in lbf/1000 ft^2 (MSF).

container pallet: see *pallet, bin.*

continuous chamfer: beveled edge along full length of deckboard between outer stringers or blocks.

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continuous deck pallet: see *pallet, solid-deck.*

converter: superstructure placed on flat pallet to change it to post pallet.

corner bracket: angle-shaped connector fastened to both pallet components to be tied together.

corner chamfer: bevel on pallet corner, that is, along outer vertical corner of outer pallet stringer or block.

corner drop test: impact test to determine pallet rigidity.

corrugated board

single face: board consisting of one corrugated element glued to one flat facing.

single wall, double face: one corrugated inner element glued to two flat facings.

double wall: two corrugated inner elements glued to two outer and one inner flat facings.

triple wall: three corrugated inner elements glued to two outer and two inner flat facings.

corrugating facing: see *facing, corrugated board.*

corrugated paper pallet: see pallet, corrugated paper.

corrugation: flute in corrugated board.

corrugating material, corrugating medium: paper used in forming fluted element of corrugated board.

cost per trip: average cost of pallet use for single one-way trip consisting of four to six handlings.

countersunk fastener: see *fastener, countersunk.*

crack: lengthwise separation of parts of wood member through part of cross section (for purposes of ASME MH1.8M-1996 standard, cracks exceeding one-half of depth, width, or thickness of member shall be treated as splits).

crane: lifting device for moving heavy objects by means of movable overhead equipment.

creep deflection: gradual change in flexural deformation over time.

criterion: standard of measurement.

critical defect: see *defect.*

cross stringer: see *stringer, cross.*

cruciform bottom-deck construction: butted or mitered bottom deckboards arranged in same plane and located along pallet perimeter in both directions of pallet length and width, with center and connector boards perpendicular to each other.

cruciform perimeter-base pallet: see *pallet, cruciform perimeter-base.*

cup: conical, square, or rectangular spacer, designed to facilitate pallet nesting.

cycle of use: complete repeatable series of sequential handlings.

damage: physical deterioration of pallet or container due to rupture of members, components, or connections.

damage coefficient: economic factor relating damage severity to cost of pallet repair, based on economic indicators for prices, cost of materials, and labor.

damage cost: measure of economic deterioration resulting from single occurrence of damage to pallet.

damage frequency: number of occurrences of damage to pallet.

damage rate: ratio of damage frequency to number of pallet trips.

damage severity: measure of extent of pallet damage per damage occurrence.

datum load: see *load, datum.*

decayed wood: wood of insignificant strength as compared to that of sound wood of same species and origin

deck: top or bottom surface of pallet, consisting of one or more elements, that is, slatted, close-boarded, or solid; (see pallet classification).

deck, cantilevered: deck extending beyond stringers or blocks, or both, resulting in deck overhang.

deck, racked across: pallet deck spanning between pallet supports.

deck, solid: singular, continuous sheet.

deck dimensions: length of top or bottom surface of pallet measured in its length direction; width of top or bottom surface of pallet measured in its width direction; thickness of deck components measured from spacer to top or bottom surface of pallet.

deck mat: assembly of deckboards and stringerboards or solid sheet of material, forming deck of block pallet.

deck opening: aperture provided in bottom deck to allow pallet-truck wheels to bear on floor; deck window.

deck spacer: see *spacer.*

deck spacing: see *deckboard spacing.*

deck span: distance between deck supports.

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deck window: see *deck opening.*

deckboard: element or component of pallet deck, oriented perpendicular to stringer or stringerboard.

deckboard, beveled: see *deckboard, chamfered.*

deckboard, bottom: any of deckboards located in pallet bottom deck.

deckboard, butted: inner deckboard placed tightly against adjacent deckboard during pallet assembly.

deckboard, chamfered: deckboard with edges of one face beveled, either along full or specified length of board or between stringers or blocks, with bevel facilitating entry of pallet-jack wheels and tines of forklift trucks.

deckboard, end: deckboard located at pallet end; leadboard; leading-edge deckboard; outer deckboard.

deckboard, inner: any deckboard located between end deckboards; interior deckboard.

deckboard, outer: see *deckboard, end.*

deckboard, racked across (RAS): pallet deckboard spanning between pallet supports (an output of PDS evaluation of wood pallets, providing information on load-carrying capacity and deformation of pallet and its decks where rack frame supports pallet at deckboard ends).

deckboard, top: any of deckboards located in pallet top deck.

deckboard dimensions: length of deck component measured in direction of pallet width; width of deck component measured in direction of pallet length; thickness of deck components measured vertically from top to bottom of deckboard.

deckboard projection: overhang extending from outer face of outer stringer to deckboard end (see *lip, wing*).

deckboard size: stated in terms of thickness followed by width and length.

deckboard spacing: distance between adjacent deckboards; deck spacing.

deckboard span: distance between deckboard supports.

defect: an irregularity or imperfection that reduces strength, durability, or value.

definition: explicit statement of meaning of words and phrases.

deflection: amount of flexural deformation due to imposed load; sag.

delamination: visible separation in the plane of a panel or panel component.

design: see *pallet design.*

design load: see *load, design.*

detachable-frame pallet: see pallet, detachable-frame.

device: mechanical contrivance.

diagonal: line connecting two non-adjacent, opposite pallet corners measured across pallet deck.

dimension: bulk piece of lumber to be remanufactured into pallet component; measured extent or distance; see *pallet dimension.*

dimensional lumber: see *lumber, dimension.*

direction: line of movement.

disposable pallet: see *pallet, expendable*; *pallet, limited use.*

distribution system: system of shipping goods among plants and facilities.

double-deck pallet: see *pallet, double-deck.*

double-face pallet: see *pallet, double-deck.*

double-wing pallet: see *pallet, double-wing.*

drive screw: helically threaded or fluted pallet nail; occasionally, helically threaded pallet nail with small thread angle.

driven fastener: see *fastener, driven.*

drop-bottom box pallet: see *pallet, drop-bottom box.*

drop height: distance of free-fall.

dummy load: see *load, dummy.*

dummy product: see *load, dummy.*

durability: life expectancy and cost per trip, in terms of number of one-way trips.

durability index: measure of estimated economic life of wood and wood-based stringer and block pallets relative to that of high-quality base pallet, as may be computed using Pallet Design System (PDS).

dwell time: time required or specified at each resonant frequency until damage occurs or unit load becomes unstable.

dynamic load: see *load, dynamic.*

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economic life: number of trips pallet will make, provided it is properly repaired, with maximum return on investment (an output of PDS evaluation).

edge deckboard: see *deckboard, end.*

edge of pallet: see *pallet side.*

edge stringer: see *stringer, edge.*

effectiveness: result of producing desired happening; degree of conformance to design.

emptying device: contrivance for moving or removing contents of container.

end of pallet: see *pallet, end of.*

enhanced-wood pallet: see *pallet, enhanced-wood.*

entry: opening between decks or beneath deck to permit passage of lifting devices of handling equipment between stringers or blocks.

exchange pallet: see *pallet, exchange.*

expendable pallet: see *pallet, expendable.*

export pallet: see *pallet, export.*

exposed pallet surface: see *pallet surface, exposed.*

facing, corrugated board: linerboard used as flat members bonded to corrugating medium to form corrugated board.

facing weight: weight of all facings of 90 m^2 (1000 ft^2) of corrugated board, excluding that of coatings, impregnants, and adhesive.

failure: breakdown of functioning, when pallet is no longer suitable for specified, subsequent, sequential testing or intended service; rupture of test specimen, component, or connection.

fastener: device for connecting pallet components to form integral structure; such as nail, staple, screw, bolt, lag bolt, adhesive, and weld.

fastener, countersunk: fastener with top of head flush with, or no more than 3 mm ($\frac{1}{8}$ in.) below, surface of fastened member.

fastener, driven: round-wire plain-shank, helically threaded, annularly threaded, fluted, or twisted square-wire nail and staple with the round- and squared-wire legs of same length.

fastener shear index (FSI): measure of estimated shear resistance of a given pallet fastener relative to shear resistance of high-quality "base" pallet nail.

fastener shear resistance (FSR): computed force required to cause connections to fail in shear (see *load, fastener withdrawal* or *load, fastener pull-through*).

fastener withdrawal index (FWI): measure of the estimated withdrawal resistance of a given fastener, based on lesser of shank or leg withdrawal or head or crown pull-through resistance, relative to that of high-quality "base" pallet nail.

fastener withdrawal resistance (FWR) or *fastener pull-through resistance (HPR):* see *load, fastener withdrawal* or *load, fastener pull-through.*

fiberboard: in container industry, solid or corrugated fabricated paperboard used in container manufacture.

fiberboard, solid: solid board made by laminating two or more plies of containerboard.

fiberboard pallet: see *pallet, fiberboard.*

filler: center ply or plies of solid fiberboard.

fillet: concave transition from one part to another part of a product, designed to reduce internal stress.

finger: see *tine.*

fixed side: vertical wall of superstructure attached permanently to pallet base.

flakeboard pallet: see *pallet, flakeboard.*

flat pallet surface: see *pallet surface, flat.*

flush pallet: see *pallet, flush.*

flute: see *corrugation.*

flute corrugation direction: normal direction parallel to box depth (in end-opening containers, flute direction may be parallel to length and width).

foam: multicellular form of plastic, usually of low density, 300 to 1200 N/m^3 (2 to 8 lbf/ft^3), created by action of blowing agent on plastic in molten condition.

foam pallet: see *pallet, foam.*

foot: see *stringer foot.*

fork: pronged device projecting from fork truck.

fork entry: opening between decks, beneath top deck and ground, or beneath stringer boards; to admit forks of lifting device.

forklift truck: movable, motorized, load-carrying device for handling palletized unit load by inserting forks in pallet.

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four-way block pallet: see *pallet, four-way block.*

four-way entry pallet: see *pallet, four-way block* or *pallet, four-way stringer.*

four-way stringer pallet: see *pallet, four-way stringer.*

frame: mat-assembled superstructure or superstructure accessory.

free entry: entry for passage of fork-arm wheels of pallet truck without leaving ground support.

free-entry pallet: see *pallet, free-entry.*

free span: distance between spacers within pallet; distance between external pallet supports.

full-perimeter pallet: see *pallet, full-perimeter base.*

functionality: effective performance under specified conditions.

general-purpose pallet: see *pallet, general purpose.*

glue: see *adhesive.*

glued pallet: see *pallet, glued.*

goods: movable product or merchandise forming unit load.

hand jack: see *pallet jack.*

hand-jack opening: see *pallet-jack opening.*

handling: movement as a result of picking up, transporting, and setting down of empty or loaded pallet.

hardwood: wood from broad-leaved tree species, containing vessel elements (not necessarily hard in texture or dense).

heavy-duty pallet: see *pallet, heavy duty.*

height: measure of vertical distance.

helix: single thread crest along tangent parallel to shank of helically threaded fastener; see *nail-thread helixes.*

identical measurements: observed readings within specified tolerance limits.

injection molding: see *molding, injection.*

inner deckboard: see *deckboard, inner.*

interior deckboard: see *deckboard, inner.*

intermediate bulk container: see *pallet, silo.*

jack: see *pallet jack.*

joint: see *connection.*

knockdown pallet: see *pallet, knockdown.*

lag bolt: wood screw with bolt head provided with washer under head.

lateral collapse: failure of pallet connections caused by excessive lateral force in direction perpendicular to stringer axis or parallel or perpendicular to stringerboard axis.

leading-end deckboard: see *deckboard, end.*

leadboard: see *deckboard, end.*

leg: for wood pallets, use *block* (leg is the preferential term in some British Commonwealth countries); for plastic pallets, use *leg*, a spacer between top and bottom decks or beneath top deck of single-deck pallet.

lid: movable cover for superstructure.

life to first repair: number of one-way trips of pallet prior to requiring repair (a generally used term and an output of PDS evaluation).

light-weight pallet: see *pallet, light-weight.*

limited-use pallet: see *pallet, limited-use.*

line load: see *load, line.*

liner: creased fiberboard sheet covering all side walls of container.

linerboard: paperboard used for flat facings in corrugated fiberboard; also, facings of solid fiberboard.

linerboard, wet strength: chemically treated flat facings of containerboard to impart improved rupture resistance when water-saturated.

lip: small [less than 65 mm ($2\frac{1}{2}$ in.)] top-deckboard overhang for load support by wood pallets and wrapping anchorage (not intended for enabling lifting; lip is a common term in some British Commonwealth countries); also, an element of plastic pallets, perpendicular to deckboard length on top of deckboards, to keep unit load from sliding off pallet.

load: imposed stationary force, constant in magnitude, sense, and direction; static load; monotonic load.

load, concentrated: load imposed over restricted area of pallet deck.

load, datum: load level at fraction of estimated or safe working load, tentatively established during pretesting, serving as base load during subsequent testing, at observed test deflection, and serving as base for subsequent deflection measurements.

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load, design: safe load based on probability of failure; ultimate load modified by factor of safety; working load.

load, dummy: test load simulating actual load in size and mass; dummy product.

load, dynamic: programmed, singular or repetitive (sequential, cyclic), unidirectional or two-directional (reversing), load-rate influenced, impact or vibrational force applied to structure sufficiently fast for the inertial response of the structure to be of significant influence; to simulate natural and man-made forces to which structure is likely to be exposed, including those generated while loaded pallet is supported by tines of lifting device during pallet handling; used in testing to provide data on estimated physical durability and functionality of multiple-use and limited-use pallets in specified material handling and shipping environments; safe load supported by pallet during its handing.

load, fastener pull-through or *load, fastener withdrawal:* computed force required to cause connections to fail due to force parallel to axis of fastener.

load, fastener shear: computed force required to cause connection to fail due to force perpendicular to axis of fastener.

load, line: weight of unit load acting along narrow area across full length or width of pallet.

load, palletized: unit load supported by pallet.

load, patch: uniformly or partially uniformly distributed load, restricted to portion of pallet deck.

load, point: concentrated load at point location of deck.

load, prerated: fixed percentage of average ultimate load obtained during prerating tests.

load, rated: uniformly distributed load supported by pallet, with safety factor determined during prerating tests and confirmed during mandatory tests.

load, shock: impacted force.

load, static: one-directional load applied gradually to structure in such a manner that forces created by changes in momentum of load can be neglected in data evaluation; used in testing to provide data on the estimated stiffness, strength, and safe working load for multiple-use and limited-use pallets of different designs and constructions in specified material handling and shipping environments as well as under specified load and support conditions; monotonic load; safe load supported by pallet when at rest.

load, test: consisting of mass of all unattached load applicators, including that of load-containing box, if used, and of applied load.

load, ultimate: load resulting in destruction of test specimen or when displacement, deformation, or deflection becomes excessive.

load, uniformly distributed: load imposed in a uniform manner over total, or major part of, pallet-deck area.

load-bearing pallet surface: see *bearing surface.*

load-carrying capacity: capability to support given test load consistent with performance criteria (not design load).

load-carrying pallet surface: top deck of pallet.

load duration: period of time supporting given load.

load span: free span less twice width of supporting member.

loading cycle: comprising incremental load increase from datum load to ultimate test load, required period of load application, and reduction to datum load.

lumber, dimension: sawn piece of wood dressed on its four sides, smaller than 100 mm (4 in.) in its least dimension.

lumber-deck pallet: see *pallet, lumber-deck.*

lumber pallet: see *pallet, lumber.*

mandatory test: required evaluation procedure.

mat: panel to be placed on top of unit load to allow tight strapping without damaging unit load; cap; see *deck mat.*

medium, wet-strength: see *wet-strength medium.*

mesh: panel or fabric with multitude of adjacent openings or pores.

meshed side: superstructure with wall constructed of mesh or framed mesh, self-supporting or framed panels with multiple openings next to each other.

metal pallet: see *pallet, metal.*

metal plating: see *stringer plating.*

MIBANT device: Morgan Impact Bend Angle Nail Tester.

MIBANT angle: angular deformation of fastener shank when subjected to MIBANT test, providing indication of impact bending resistance and toughness of fastener.

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MIBANT test: standard impact force applied to fastener head, with fastener shank clamped in vice in such a manner that impacted portion, extending fixed distance from vice, is impacted by standard mass dropped from standard height, to determine impact bending resistance and toughness of fastener, such as nail or staple.

modulus, flexural: in packaging, denoting degree to which film or sheet resists stretching or bending prior to reaching elastic limit during application of external force; sometimes used to denote degree of stiffness.

molded pallet: see *pallet, molded.*

molding, blow: process of forming semi-rigid plastic element, that involves use of gas pressure inside of almost molten plastic tube to expand it until it fills mold cavity and solidifies along mold walls.

molding, injection: process of forming plastic element by extruding molten plastic into cavity.

molding, thermoformed: process of forming plastic element by applying heat and pressure.

monotonic load: see *load, static.*

multiple-trip pallet: see *pallet, multiple-trip.*

multiple-use pallet: see *pallet, multiple-use.*

multitine forktruck: forktruck equipped with more than two forks to allow handling of unit load on pallet or without pallet.

nail: straight, slender, wire fastener, usually pointed and headed, designed to be driven, to hold two or more pieces together; made from endless wire by cutting point and forming head at shank end opposite point end; see *threaded nail.*

nail, annularly threaded or *nail, annular:* pallet nail with annular threads rolled onto shank: ring nail; ring-shank nail; ring-threaded nail.

nail, clenched: driven nail with point end bent back into wood of fastening member (common term in some British Commonwealth countries).

nail, clinched: driven nail with point end bent parallel and in tight contact with, or back into, wood of fastening member (see *nail, clenched).*

nail, hardened-steel: heat-treated and tempered stiff-stock steel pallet nail, with MIBANT angle between 8 and 28 deg, inclusive.

nail, helically threaded or *nail, helical:* threaded or fluted pallet nail with continuous helical thread; sometimes incorrectly referred to as spiral or spirally threaded nail; drive-screw nail; screw nail.

nail, interrupted thread: nail with non-threaded zone between threaded shank portions, to facilitate collating with welded wire or plastic strip.

nail, pallet: bright, stiff-stock or hardened-steel, helically threaded (with medium lead angle) or annularly threaded nail, up to 102 × 4.5 mm (4 × 0.177 in.) size with smooth or checkered, flat head up to 11 mm ($^{7}/_{16}$ in.) diameter and medium or blunt diamond or blunt chisel point or pointless.

nail, soft: pallet nail made of low-carbon steel, with MIBANT angle of 47 deg and higher.

nail, stiff-stock steel: pallet nail made of medium-high carbon steel without heat treatment and tempering, with MIBANT angle between 29 and 46 deg, inclusive.

nail diameter or *nail-wire diameter:* average diameter of nondeformed portion of nail shank.

nail-head diameter: average diameter of head.

nail length: distance measured parallel to shank axis from maximum diameter of head-bearing surface to point end.

nail length, effective: distance measured parallel to shank axis from maximum diameter of head-bearing surface to two-thirds of point length.

nail thread: continuous helical or annular deformations of nail shank.

nail-thread angle: angle of thread helix with plane perpendicular to nail axis.

nail-thread crest diameter: maximum diameter of deformed portion of shank.

nail-thread flute: continuous helical deformation along nail shank.

nail-thread helixes: number of helical thread crests along threaded length of shank.

nail-thread length: length of deformed portion of shank measured parallel to nail axis.

nail type: classification of nail with plain, helically threaded, helically fluted, or annularly threaded shank.

nail-wire diameter or *nail diameter:* average diameter of nondeformed portion of nail shank.

nailed pallet: see *pallet, nailed.*

nestable pallet: see *pallet, nestable.*

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net wrap: flexible, plastic netting for wrapping palletized goods, including pallet, for stability, often allowing ventilation and refrigeration of heat-producing load, such as fresh fruits and vegetables.

nominal dimension: customary description of component or element of standard size, uninfluenced by permissible tolerance.

nonreturnable pallet: see *pallet, expendable.*

nonreversible pallet: see *pallet, nonreversible.*

normative test: see *mandatory test.*

notch: filleted cutout in lower portion of stringer to allow entry for fork tine, usually 230 mm (9 in.) long and 32 to 38 mm ($1\frac{1}{4}$ to $1\frac{1}{2}$ in.) high.

notch area: region around stringer notches with special defect limitations.

notch depth: see *notch height.*

notch fillet: concave transition at notch corner.

notch height: vertical distance measured from bottom of stringer to top of notch.

notch length: distance measured in direction of stringer length between two notch ends.

notch location: distance measured from end of stringer nearest notch to start of notch.

notched stringer: stringer with two or more notches spaced for fork-tine entry.

notched stringer pallet: see *pallet, notched stringer.*

one-trip pallet: see *pallet, limited use.*

one-way pallet: see *pallet, limited use.*

one-way trip: movement of unit load from shipper to receiver, on the average including five handlings.

opening: aperture provided in pallet bottom deck to allow forkarm wheels of pallet truck to bear on ground; window.

opening height: vertical dimension measured between decks, from floor to underside of top deck, or from floor to top of stringer notch or cross stringer of corrugated pallet.

outer deckboard: see *deckboard, end.*

outer stringer: see *stringer, outer.*

out of square: non-conformance to rectangular configuration; pallet of same length or width with unequal diagonals.

overall height: vertical dimension measured from pallet bottom to pallet top.

overhang: distance of deck or deckboard extending from outer face of outer pallet stringer, stringerboard, or block; wing; lip; cantilever; distance unit load extending beyond deck.

overlap pallet: see *pallet, overlap-deck.*

pallet: portable, horizontal, rigid, composite platform used as base for assembling, storing, stacking, handling, and transporting goods as unit load; often equipped with superstructure (see Part 1, Fig. 1); described by providing the following information in the sequence listed: class, use, type, style, bottom deck, size, and design.

pallet, all-way entry: pallet with openings for fork entry that allow insertion of fork through pallet sides and ends (see *pallet, partial four-way entry* or *pallet, full four-way entry).*

pallet, aluminum: pallet constructed with aluminum-alloy components.

pallet, assembled: pallet consisting of premanufactured components, ready for use.

pallet, base: flat pallet forming base for superstructure; stringer pallet selected as arbitrary basis for measurement of durability during PDS pallet-performance evaluation.

pallet, bin: base pallet with permanently fixed, removable, or collapsible, mounted, bin superstructure; box pallet; container pallet.

pallet, block: pallet with blocks between decks or beneath top deck.

pallet, bolted: pallet assembled with bolts and nuts.

pallet, box: see *pallet, bin.*

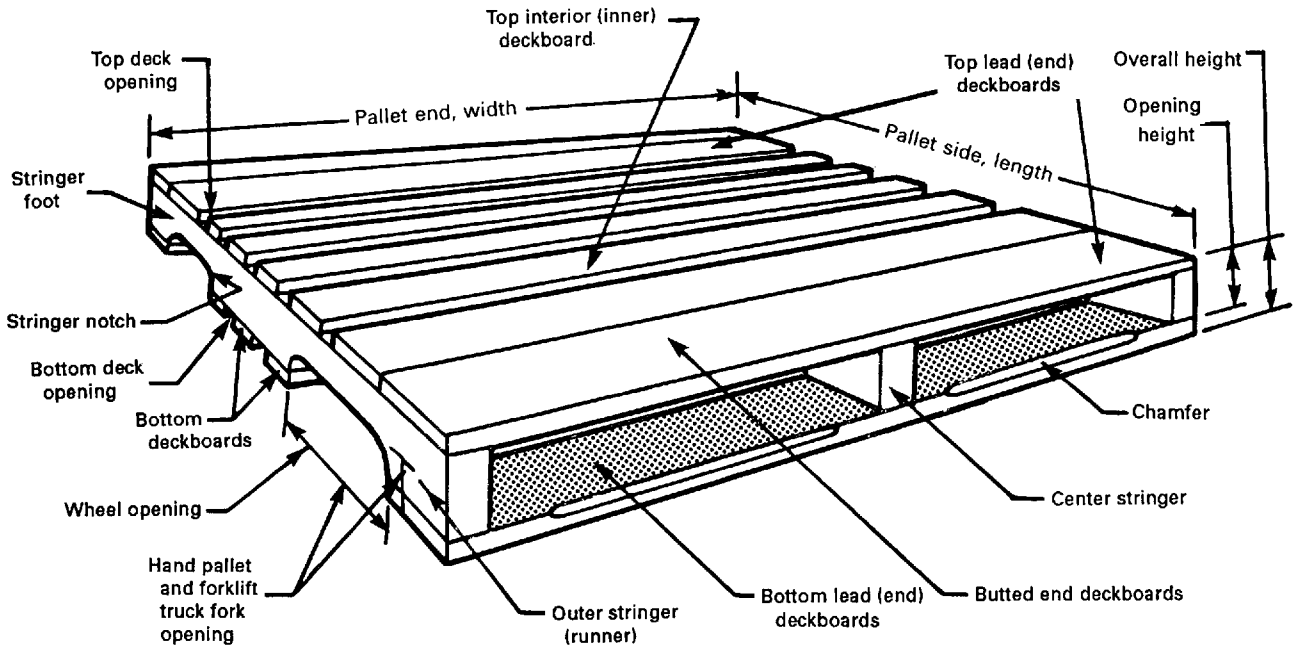
pallet, cage: pallet with permanently fixed, hinged, removable, or collapsible mesh, rodded, or barred-side superstructure.

pallet, cantilever: pallet with stringers or top or bottom stringerboards extending beyond pallet footprint.

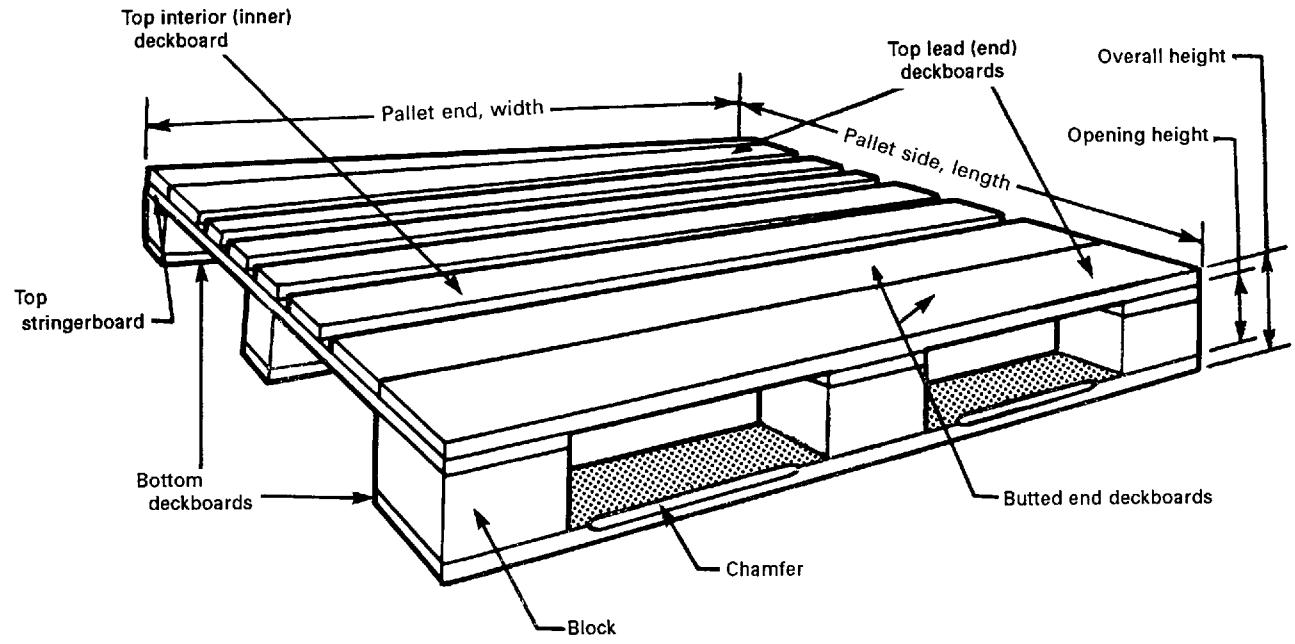
pallet, captive: pallet intended for use within confines of single facility, system, or ownership (not to be exchanged).

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(a) Stringer Design – Partial Four-Way Entry, Double Face, Nonreversible, Flush



(b) Block Design – Full Four-Way Entry, Double Face, Nonreversible, Flush

FIG. 1 PRINCIPAL PARTS OF WOOD STRINGER AND BLOCK PALLETS

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pallet, combo: pallet made of new and recycled (reclaimed) components.

pallet, corrugated board: pallet constructed of corrugated paper, paperboard, or fiberboard.

pallet, cruciform perimeter-base: perimeter-base pallet with center and connector boards perpendicular to each other in single plane.

pallet, detachable-frame: pallet with removable superstructure.

pallet, disposable: see *pallet, limited-use.*

pallet, double cantilever: pallet with top and bottom stringerboards extending beyond pallet footprint.

pallet, double-deck: pallet with top and bottom decks.

pallet, double-wing: pallet with top and bottom deckboards or decks extending beyond outer edges of stringers or stringerboards.

pallet, drop-bottom box: bin pallet with hinged base to permit discharge of contents.

pallet, edge of: see *pallet side.*

pallet, end of: portion of pallet at end of stringers or stringerboards.

pallet, enhanced wood: pallet constructed of components consisting of wood effectively treated to resist exposure under adverse conditions (trademarked by National Wooden Pallet and Container Association of Arlington, VA).

pallet, exchange: multiple-use pallet intended for use among designated group of shippers and receivers where possession of pallet is transferred with ownership of unit load; pool pallet.

pallet, expendable: pallet intended for limited series of handlings during single trip from shipper to receiver; (see *pallet, limited-use*).

pallet, export: wood-based pallet used in handling, storage, and transporting of goods and commodities between nations, meeting requirements of ASME MH1.9-1993.

pallet, fiberboard: pallet constructed with fiberboard components.

pallet, flakeboard: pallet constructed with flakeboard components.

pallet, flat: general-purpose pallet with even top and bottom decks and without superstructure.

pallet, flush: pallet without wings or cantilevers; deckboards or decks not extending beyond spacers along ends and sides of pallet.

pallet, foam: pallet constructed with foamed plastic components.

pallet, free-entry: block pallet having two entries through which fork-arm wheels of pallet truck can pass without leaving ground support.

pallet, full four-way entry: pallet with openings at both opposite ends and sides, with accessibility of all openings not limited to common handling equipment; block pallets with unidirectional perimeter boards or without bottom deck (see *pallet, partial four-way entry; pallet, all-way entry*).

pallet, full-perimeter base: block pallet with bottom deckboards arranged in same plane, with butted or mitered connections, forming complete frame along pallet ends and sides; window pallet.

pallet, general-purpose: double-deck, flat, returnable pallet intended for a wide variety of uses; multiple-use pallet.

pallet, glued: pallet assembled with adhesive.

pallet, heavy-duty: pallet designed to support heavy unit loads during multiple uses prior to first repair.

pallet, knockdown: unassembled pallet components, with or without fasteners, ready for assembly.

pallet, lightweight: pallet made of lumber having dimensions smaller than standard lumber dimensions; pallet made of lightweight materials, such as corrugated board; intended to support light unit loads.

pallet, limited-use: pallet designed for an average of up to nine trips, with an average of five handlings per trip in an average handling environment; single-trip pallet; one-trip pallet; one-way pallet; expendable pallet; shipping pallet; general service pallet.

pallet, lumber: pallet constructed with components cut from hardwood or softwood lumber or a combination of both.

pallet, lumber-deck: pallet constructed with wood deckboards with or without space between them.

pallet, metal: pallet fabricated using metal or metal components.

pallet, molded: pallet formed in mold, made of either plastic or wood particles, flakes, or strands bonded together with adhesive.

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pallet, multiple-trip: pallet intended for repeated use; multiple-use pallet.

pallet, multiple-use: pallet designed for repeated uses for more than one unit load with an average minimum life-to-first repair of ten trips, or more, with an average of five handlings per trip in an average handling environment; multiple-trip pallet; returnable pallet; reusable pallet; permanent pallet; general-purpose pallet; special service pallet; through-transit pallet.

pallet, nailed: pallet assembled with nails.

pallet, nestable: skid having hollow cups or other suitable spacers allowing those of adjacent empty skids to fit into each other for stacking; also, applicable to nestable wood pallets.

pallet, noncaptive: pallet designed for reuse within and outside of confines of single enterprise or system.

pallet, nonreturnable: see *pallet, limited-use.*

pallet, nonreversible: pallet with dissimilar top and bottom decks or without bottom deck.

pallet, notched stringer: pallet with all stringers provided with two or more notches.

pallet, one-trip: see *pallet, limited-use.*

pallet, one-way: see *pallet, limited-use.*

pallet, overlap-deck: block pallet with top and bottom decks, deckboards, or stringerboards above and below deck spacers.

pallet, panel-deck: pallet whose deck or decks consist of such board materials as plywood, particleboard, flakeboard, strandboard, fiberboard, corrugated paper, plastic, and metal.

pallet, paper: see *pallet, corrugated board.*

pallet, partial four-way entry: pallet with openings at both ends and sides, with limiting accessibility of openings to common handling equipment; notched stringer pallet and block pallet with overlapping bottom stringerboards and deckboards (see *pallet, full four-way entry; pallet, all-way entry*).

pallet, particleboard: pallet constructed with particleboard components.

pallet, perimeter-base: see *pallet, full-perimeter base.*

pallet, permanent: pallet intended for repeated use; multiple-use pallet.

pallet, phytosanitary: pallet meeting minimum requirements for wood and wood-base pallets destined for export or used in exporting unit loads, as described in ASME MH1.9-1993 Standard.

pallet, plastic: pallet formed with synthetically produced, polymerized chemical compounds or components thereof.

pallet, plywood: pallet whose deck or decks and possibly its deck spacers consist of plywood (that is, veneers adhesively bonded together, with the grain of adjacent layers at right angles).

pallet, pool: exchange pallet for use in open circuit.

pallet, post: pallet fitted with fixed or detachable columns or posts as part of its superstructure.

pallet, reassembled: pallet assembled with used components.

pallet, reclaimed: see *pallet, recycled.*

pallet, recycled: pallet made reusable by repairing, sorting, or rebuilding pallet, using reclaimed components or parts from damaged pallets.

pallet, remanufactured, reassembled: pallet made entirely of recycled components or parts from damaged pallets.

pallet, rental: pallet owned by other than user and rented by user.

pallet, repaired: pallet with damaged components replaced with new or used components.

pallet, required: pallet manufactured according to applicable specifications.

pallet, returnable: see *pallet, multiple-use.*

pallet, reusable: see *pallet, multiple-use.*

pallet, reversible: pallet with identical or similar top and bottom decks to allow either one to support unit load.

pallet, screwed: pallet assembled with screws.

pallet, sealed bin: tightly closing bin pallet.

pallet, seaport: use *stevedore pallet* (seaport pallet, the preferential term in some British Commonwealth countries).

pallet, shipping: see *pallet, limited-use.*

pallet, side of: see *pallet side.*

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pallet, silo: pallet container usually having liquid-tight walls and bottom provided with emptying device, for storage of liquids or particulate goods; Intermediate Bulk Container (IBC).

pallet, single-cantilever: pallet with stringer or top or bottom stringerboard extending beyond pallet footprint.

pallet, single-deck: see *skid.*

pallet, single-trip: see *pallet, limited-use.*

pallet, single-wing: pallet with top deckboards or deck extending beyond outer edges of stringers or stringerboards and with bottom deckboards or deck flush with outer edges of stringers or stringerboards.

pallet, slatted-deck: see *pallet, spaced-deckboard.*

pallet, slatted-side bin: base pallet with mounted bin superstructure, with bin walls having spaces between adjacent narrow-board wall members.

pallet, slave: rigid pallet or platform; single, thick panel used as support base for palletized load in rack-storage facilities or production system.

pallet, solid-deck: pallet with deck constructed of single or multiple elements without space between individual deck elements during pallet assembly.

pallet, solid-side: pallet with superstructure having sides consisting of tightly placed boards or panels.

pallet, spaced-deckboard: pallet with more or less uniform spaces between adjacent deckboards or deck sections.

pallet, special-purpose: pallet designed to accommodate specific product or use.

pallet, stacking: pallet with superstructure that allows palletized unit load to be placed on top of loaded pallet without bearing on lower unit load, to minimize, if not eliminate, damage to lower unit load.

pallet, standard: pallet design and size accepted by consensus approval of standard-developing body.

pallet, stapled: pallet assembled with staples.

pallet, steel: pallet fabricated using steel or steel components.

pallet, stevedore: pallet designed for use on seaport shipping docks; normally large pallet of heavy-duty, double-wing construction.

pallet, strandboard: pallet constructed with strandboard components.

pallet, stringer: double-deck pallet with stringer spacers between decks.

pallet, surface of: outer face of top or bottom deck.

pallet, take-it-or-leave-it: pallet fitted with fixed, spaced, solid or notched cleats on top deck to permit tines of multi-tine fork trucks to pass beneath unit load and remove it from pallet.

pallet, tank: pallet fitted with tank as superstructure provided with emptying device, for storage of liquids, particulate goods, or gases.

pallet, thermoplastic: pallet constructed with components made of synthetically produced, polymerized thermoplastic components.

pallet, through-transit: pallet designed for multiple use.

pallet, timber: see *pallet, wooden or wood.*

pallet, top-deck of: assembly of components comprising upper load-carrying pallet face.

pallet, two-way: see *pallet, two-way entry.*

pallet, two-way entry: pallet with openings, accepting handling equipment, only at two opposite ends; pallet without notches in stringers.

pallet, unassembled: see *pallet, knockdown.*

pallet, warehouse: double-deck, flat, multiple-use pallet intended for general warehouse use.

pallet, wing: pallet with top deckboards, bottom deckboards, or top and bottom deckboards or decks extending beyond outer edges of stringers or stringerboards.

pallet, wood or *wooden:* pallet constructed with wood or wood-based components or a combination of both.

pallet cap: see *mat.*

pallet classification (for wood pallets)

bottom deck: unidirectional, overlap (two-directional), perimeter, and cruciform constructions.

class: stringer and block pallets.

size: in terms of length, width, and height of pallet.

style: single-deck, double-deck reversible, and double-deck nonreversible, flush, single-wing, and double-wing, single-cantilever, and double-cantilever.

type: two-way, partial four-way, and full four-way entry pallets.

use: multiple- and limited-use pallets.

pallet container: bin superstructure mounted on pallet base.

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pallet converter: superstructure, with or without infill, which is applied to pallet to change it to post or bin pallet.

pallet design: selection of pallet size, class, style, type, bottom-deck layout, and applicable use category, as well as materials, components, and fasteners, resulting in description of construction and performance in terms of load-carrying capacity and durability of wood pallet, as may be computed using Pallet Design System (PDS).

pallet designations: terms included in any order or specification of pallets, such as design, classification, constituent materials, components, and fasteners.

Pallet Design System (PDS): for wood pallets, reliability-based, computer-assisted design (CAD) program for determination of safe load-carrying capacity, performance, and economic life of wood and wood-based stringer, block, and panel-deck pallets.

pallet dimension

length: measured between extreme pallet ends, parallel to stringers, stringerboards, or oblong blocks, parallel to strong panel axis, that is, to face grain of plywood top deck, parallel to production-flow direction of flakeboard and oriented strandboard top deck, or parallel to corrugations of corrugated-board top deck for pallet without stringers, stringerboards, or oblong blocks; for all other rectangular pallets with isotropic decks, length being the longest footprint dimension.

width: measured between extreme pallet sides perpendicular to pallet length.

height: measured vertically from bottom surface or floor to top surface of pallet.

pallet edge: see *pallet side.*

pallet end: portion of pallet at ends of stringers or stringerboards and along outer edge of end deckboards.

pallet footprint: net or actual pallet top-deck area or floor area occupied by pallet, whichever is larger, expressed in terms of length and width.

pallet handling: single pick up, movement, and set-down of empty or loaded pallet.

pallet handling environment: condition consisting of characteristics influencing pallet damage, including equipment, facilities, handling practices, and pallet repair and maintenance practices.

pallet height: see *pallet dimension*; refers to third dimension when describing pallet size.

pallet jack: hand-propelled, wheeled platform contrivance equipped with lifting device for moving palletized unit load.

pallet-jack opening: entry way between pallet blocks or stringers for pallet jack, reaching from floor to underside of stringerboard or top deck or deckboard.

pallet length: see pallet dimension; refers to first dimension when describing pallet size.

pallet life: period during which pallet remains useful under given maintenance conditions, expressed in units of time or in number of one-way trips.

pallet map: see *mat.*

pallet nail: see *nail, pallet.*

pallet opening: see *opening height.*

pallet performance: measurement of stiffness, flexural strength, lateral stability, and durability of pallet.

pallet price: delivered cost of pallet.

pallet side: portion of pallet at ends of flush deckboards or deck along stringers or stringerboards.

pallet size: overall dimensions of pallet, stated in terms of length, followed by width and height (see *pallet dimension, pallet classification*).

pallet spacer: vertical pallet member between top and bottom decks or deck assemblies, such as pallet stringer and pallet block.

pallet span: distance between pallet supports (see *load span*).

pallet specification requirements: see *pallet.*

pallet style: denotes single-deck, double-deck reversible, and double-deck nonreversible, flush, single-wing, double-wing, single-cantilever, and double-cantilever pallets (see pallet classification).

pallet support: for pallet testing, placement of pallet on rigid, square, semi-circular, or circular support beams serving as simulated ground support, superstructure support, rack support, fork-tine support, and sling support.

ground support: being uniformly distributed across bottom deck of double-deck pallet or stringers, blocks, or spacers of single-deck pallet.

superstructure support: being uniformly or non-uniformly, patch, or line-distributed across pallet-bottom deck depending on type of superstructure involved.

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rack support: being line-distributed along edge of pallet-bottom deck along narrow area across full pallet length (racked across deckboards) or width (racked across stringers).

fork-tine support: being line-distributed along narrow area across bottom of pallet-top deck or stringer-notch chords.

sling support: being line-distributed along bottom of pallet-top deck along narrow area outside of deck spacers of wing pallet across full pallet length.

pallet surface, exposed: all pallet planes exposed to potential contact by goods and individuals handling pallets properly.

pallet surface, flat: flatness of pallet surface measured by its deviation from corner-to-corner straight line across pallet.

pallet top: load-supporting surface of top-face components or deck of pallet.

pallet trip: pallet use including an average of five handlings.

pallet truck: see *pallet jack.*

pallet type: denotes two-way, partial four-way, and full four-way entry pallets (see pallet classification).

pallet use: denotes multiple-use (M) and limited-use (L) pallets (see *pallet classification*).

pallet weight: under static conditions, mass of pallet.

pallet width: see *pallet dimension*; refers to second dimension when describing pallet size.

palletized goods: see *unit load.*

panel: flat, normally square or rectangular, thin, structural component.

panel-deck pallet: see *pallet, panel-deck.*

paperboard: board made of cellulosic fibers on board machine, encompassing fiberboard; used for linerboard, corrugating medium, and plies of solid fiberboard.

paper pallet: see *pallet, corrugated board.*

partial four-way entry pallet: see *pallet, partial four-way entry.*

partially uniformly distributed load: load placed onto portion of pallet deck.

particleboard pallet: see *pallet, particleboard.*

patch load: see *load, patch.*

payload: unit load on pallet, with amount of load being above, identical with, or below rating load.

PDS: see *Pallet Design System.*

performance standard: specification describing functionality of standardized product as determined by physical testing or computer models, or both.

perimeter-base pallet: see *pallet, full perimeter-base.*

perimeter bottom-deck construction: butted or mitered bottom deckboards arranged in same plane and located along pallet perimeter in both directions of pallet length and width, including side, center, and end boards.

permanent pallet: see *pallet, multiple-use.*

permanent set: deformation or deflection remaining after reduction of test load to datum load.

phytosanitary pallet: see *pallet, phytosanitary.*

plan dimension, overall: see *pallet dimension.*

plastic, recycled: normally, consisting of polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), and/or polystyrene (PS) post-consumer and post-industrial plastics.

plastic pallet: see *pallet, plastic.*

platform: raised, horizontal, structural element, such as a pallet.

plating: see *stringer plating.*

plug: see *stringer plug.*

ply: any of several layers of plywood or solid fiberboard.

plywood pallet: see *pallet, plywood.*

point: one-thousandth of an inch (see *caliper).*

pool pallet: see *pallet, exchange.*

post: see *column, block.*

post pallet: see *pallet, post.*

power spectral density: quantification of intensity of random vibration in terms of mean square acceleration per unit of frequency; means of simulating transport or material handling system.

precision: degree of agreement between set of specified tolerances.

precycling: selecting product on basis of its potential reuse and recycling.

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prerated load: see *load, prerated.*

prescriptive standard: specification describing standardized product in such detail to allow its manufacture within specified limitations.

prototype design: typical, representative model produced for evaluating suitability of object.

pull-through load or *withdrawal load:* see *load, fastener pull-through* or *load, fastener withdrawal.*

puncture test: test method to determine strength of material, in inch ounces per in. of shear, as measured by Beach puncture tester.

quality: relative measure of performance characteristics of pallet or pallet components, normally represented in terms of conformance to predetermined agreed standards, including quality classes or grades.

quality control: system of maintaining desired standard in production with reference to materials, dimensions, and workmanship.

quality assurance: certification, based on inspection and testing by qualified personnel, whether product conforms with relevant prescriptive and performance standards.

quality index: measure of effectiveness of nails and staples during pallet use and of their influence on useful pallet life, representative of fastener withdrawal (FWI) and fastener shear (FSI) resistance (an input for PDS pallet evaluation).

rack span: distance between rack supports.

rack storage: warehousing palletized unit loads on specially designed shelves or racks.

racked across deck: see *deck, racked across.*

racked across deckboards (RAD): see *deckboard, racked across.*

racked across stringers (RAS): see *stringer, racked across.*

rail: see *collar.*

rated load: see *load, rated.*

rating: ranking; classifying; specifying performance as load-deformation or durability rating of object.

rating load: designated, uniformly distributed, unit load placed onto pallet, designed to be supported by pallet as verified by testing.

reassembled pallet: see *pallet, reassembled.*

reclaimed component: recycled part of damaged pallet or other structure.

reclaimed pallet: see *pallet, recycled.*

reconditioned pallet: see *pallet, repaired.*

recycled pallet: see pallet, *recycled.*

regrind: recovered, ground up, scrap polymer, often added to virgin polymer and often coextruded into plastic sheets, films, and objects.

rejection: refusal to accept, normally as result of nonconformance to agreed criteria.

remanufactured pallet: see *pallet, remanufactured*; *pallet, combo.*

removable side: detachable side component of pallet superstructure.

removable wall: detachable wall component of pallet superstructure.

rental pallet: see *pallet, rental.*

repaired pallet: see *pallet, repaired.*

reproducibility: capability of duplication.

resonance: reinforced vibration of body exposed to vibration of another body at its frequency.

resonance frequency: frequency at which resonance exists.

returnable pallet: see *pallet, multiple-use.*

reusable pallet: see *pallet, multiple-use.*

reversible pallet: see *pallet, reversible.*

rigidity: resistance to deformation within plane of object as determined by pallet corner drop test.

ring nail: see *nail, annularly threaded.*

ring-threaded nail: see *nail, annularly threaded.*

rivet: tube with large heads which are pressure-peened after insertion into predrilled hole.

roller: rotating cylinder or wheel to facilitate horizontal pallet movement.

round-robin test: identical experiment performed by several investigators in different laboratories.

runner, bearer: use *stringer; runner, bearer* (the preferential terms in some British Commonwealth countries); in plastic pallet, a partial bottom deck.

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sacrificial board: deckboard located at ends of panel-deck pallet to facilitate deck-end repair without replacement of panel deck.

safe load, safe working load: see *load, design.*

sag: see *deflection.*

sample: representative specimen or group of specimens from population.

screw, wood: wire fastener, pointed and headed, designed to be turned with screwdriver or other device during insertion into wood member; having in its simplest form one or two continuous helical threads along portion of shank nearest point; to hold two or more pieces together.

screwed pallet: see *pallet, screwed.*

sealable lid: movable, tightly closing cover of bin pallet.

sealed bin pallet: see *pallet, sealed bin.*

seaport pallet: see *pallet, seaport.*

shear strength: resistance to deformation in plane perpendicular to axis of specimen.

sheet: rectangular, untrimmed or trimmed, single or multiple-wall, combined board possibly scored one way across corrugations.

shelf life: period of time during which packaged material can be sold or used.

shiner: fastener shank or leg protruding from side of fastening member.

shipping container: container sufficiently strong for use in commerce for packing, storing, and transporting commodities.

shipping pallet: see *pallet, limited-use.*

shock-absorbing capacity: see *capacity, shock-absorbing.*

shock-damping capacity: see *capacity, shock-damping.*

shock load: see *load, shock.*

shook: cut-to-size lumber pallet component, such as deckboard, stringer, stringerboard, or block.

shook grade: classification of quality of lumber pallet component relative to its performance characteristics based on size and distribution of defects (independent of wood species).

short block: see *stringer plug.*

shrink wrap: tightly fitting, heat-shrunk, plastic film around loose or palletized goods including pallet, fabricated of polyethylene, polypropylene, polystyrene, saran, or vinyl.

SI unit: measure based on International System of Units (SI) developed to serve as basis for worldwide standardization of measurement units, the "Modern Metric System," using, e.g., millimeters for dimensions, newtons for forces and loads, and pascals for stresses and pressures.

side of pallet: see *pallet, side of.*

silo pallet: see *pallet, silo.*

single-deck pallet: see *skid.*

single-trip pallet: see *pallet, limited-use.*

single-wing pallet: see *pallet, single-wing.*

size: see *pallet size.*

skid: pallet without bottom deckboards or deck.

skip chamfer: machined, inclined surface along part of edges of deckboards between stringers or blocks (see *chamfer*).

slatted-deck pallet: see *pallet, spaced-deckboard.*

slatted-side bin pallet: see *pallet, slatted-side bin.*

slave pallet: see *pallet, slave.*

sling: system of cables, ropes, nets, spreader bars, or combination of them, used for lifting and depositing palletized unit-load or bulk goods.

softwood: wood from coniferous or needle-bearing tree species, not containing vessel elements (not necessarily soft in texture or of low density).

solid-deck pallet: see *pallet, solid-deck.*

solid fiberboard: see *fiberboard, solid.*

solid-side pallet: see *pallet, solid-side.*

spaced-deckboard pallet: see *pallet, spaced-deckboard.*

spacer: rectangular, square, cylindrical, or conical pallet component located between top and bottom deckboards or decks or beneath top deckboard or deck.

spacer bar: rigid element of sling, placed under wing of top deck to maintain cable or rope spacing.

span: distance between supports.

special-purpose pallet: see *pallet, special-purpose.*

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split: lengthwise separation of parts of wood member all the way through cross-section; see *crack.*

squareness: conformance to rectangular configuration, as measured by difference in length of two principal diagonals of square portion of pallet.

stack height: measure of height, in mm (in.), or number of unloaded or loaded pallets in stack, including pallet in contact with support.

stacked loads: palletized unit loads placed on top of one another to form a vertical column.

stacking of palletized loads: process of storing palletized unit loads in vertical columns without use of intermediate shelving or racking.

stacking pallet: see *pallet, stacking.*

standard deviation: square root of variance; measure of variability of set of values; basis of precision statement.

standard lumber dimensions: lumber size offficially listed by lumber grading organization.

standard pallet: see *pallet, standard.*

standard test condition: atmosphere of 23°C ± 1°C (73°F ± 2°F) temperatures and 50% ± 2% relative humidity.

staple: wire fastener formed by bending wire to form two legs of equal length and a crown connecting both legs at ends opposite leg points.

staple-crown length: distance measured parallel to crown between staple legs; length of bearing surface of staple crown.

staple-crown width: see *staple width.*

staple length: distance measured parallel to leg axis from bottom of crown to extreme end of staple leg.

staple length, effective: distance measured parallel to leg axis from bottom of crown to two-thirds of point length.

staple width: overall dimension parallel to staple crown from outside to outside of staple legs.

staple-wire diameter: diameter of round-wire staple leg.

staple-wire thickness: dimension of flattened-wire staple leg measured parallel to crown axis.

staple-wire width: dimension of flattened-wire staple leg measured perpendicular to crown axis.

stapled pallet: see *pallet, stapled.*

static load: see *load, static.*

steel pallet: see *pallet, steel.*

step: surface unevenness of wood component, resulting from sawing or planing.

stevedore pallet: see *pallet, stevedore.*

stiffness: resistance to flexural deformation in direction of applied force.

stiff-stock steel nail: see *nail, stiff-stock steel.*

stillage: skid with two unnotched stringers or four blocks (preferential term in some British Commonwealth countries).

stitch: staple-type fastener formed from coiled continuous wire at point of pallet or component assembly.

stopped chamfer: intermittent bevel along edges of one deckboard face; stop chamfer.

storage: placement of goods in holding area.

storage life: see *shelf life.*

strap notch: see *strap slot.*

strap slot: recess or cutout in top or bottom deck of pallet designed to allow tie-down of unit load to pallet deck; strap notch; banding notch.

strapping: thin, flat band used to secure unit load to pallet.

strength: resistance to external force, load, or generation of internal strain; expressed in terms of units of force, N, newtons (lbf, pound force); resistance to tensile, compressive, or shear force, or a combination of these, as compared to stress that is expressed in terms of force per unit area; load-carrying capacity indicated by ultimate value obtained during destructive test.

stress: internal force developed by application of external force, load, or generation of internal strain; expressed in terms of units of force per unit area, MPa, megapascals (psi, pounds/mass per square in.).

stretch wrap: tightly fitting, stretched, extensible, plastic film around loose or palletized goods often including pallet, held under tension by heat-sealing or frictional device.

stringer: continuous, longitudinal, solid, built-up, or notched beam component of pallet, supporting and spacing deck components, often identified by location

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as outer, interior, or center stringer; bearer, runner (the preferential terms in some British Commonwealth countries).

stringer, center: stringer placed centric between outer stringers.

stringer, companion: full or half-length supplementary stringer placed next to damaged stringer during pallet repair.

stringer, cross: combination of stringer and top-deck component, perpendicular to stringer of corrugated pallet.

stringer, edge: see *stringer, outer.*

stringer, interior: stringer placed between outer stringers.

stringer, outer: stringer located at deckboard ends; outside stringer.

stringer, racked across (RAS): pallet stringer or stringerboard spanning between pallet supports (an output of PDS pallet evaluation, providing information on load-carrying capacity and deflection of pallet and its decks where rack frame supports pallet at stringer or stringerboard ends).

stringer chord: continuous top portion above notch of notched stringer connecting stringer feet.

stringer-chord height: dimension of stringer chord measured from top of stringer to top of notch.

stringer dimensions: length of stringer measured along its axis in direction of pallet length; thickness of stringer measured in direction of pallet width; height of stringer measured in direction of pallet height.

stringer end: portion of stringer supporting pallet-end deckboard.

stringer foot: lower portions of notched stringer between stringer ends and notch and between notches.

stringer notch: see *notch.*

stringer pallet: see *pallet, stringer.*

stringer plating: reinforcement or repair of damaged stringer by applying metal plate connector over weak or damaged surface.

stringer plug: lumber block of length shorter than one half stringer, used for stringer repair.

stringer projection: extension from outer edge of end deckboard to stringer end.

stringer size: stated in terms of width, followed by height and length.

stringer span: distance between pallet supports when stringers are racked.

stringer top: top surface of stringer.

stringerboard: continuous, solid board member extending for full length of pallet, perpendicular to deckboard members, and placed between deckboards and blocks, to serve as support of deckboards or deck.

stringerboard, cantilevered: stringerboard extending beyond blocks, resulting in stringerboard overhang.

stringerboard dimensions: length measured along length axis of stringerboard; width measured perpendicular to length; thickness measured vertically from top to bottom of stringerboard.

stringerboard size: stated in terms of thickness, followed by width and length.

style: see *pallet style.*

superstructure: permanently fixed, hinged, removable, or collapsible assembly attached to supporting base pallet.

surface of pallet: see *pallet, surface of.*

take-it-or-leave-it pallet: see *pallet, take-it-or-leave-it.*

tank pallet: see *pallet, tank.*

target dimension: specified measure, at time of component manufacture, giving consideration to allowable tolerance deviations.

teenut: threaded metal bushing with base, serving as nut and washer; often provided with long or short prongs for retention in wood and other materials and to provide resistance to rotation; if specified, provided with self-locking barrel (trademarked by Carr Fastener Company, Division of United-Carr Fastener Corporation of Cambridge, MA).

terminology: terms characteristic of particular field.

test load: see *load, test.*

test method: procedure for evaluating performance.

thermoforming: process of forming plastic sheet into desired shape by using heat and pressure to force softened plastic into mold.

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thermoplastic: material produced synthetically from polymerized plastic which melts during application of heat without decomposing.

thermoplastic pallet: see *pallet, thermoplastic.*

thermoset: plastic which hardens during application of heat and will thereafter not melt without decomposing.

threaded nail: pallet nail with thread rolled onto shank.

through-transit pallet: see *pallet, multiple-use.*

tie-down: system of securing unit load to pallet base.

timber: sawn wood member with its least nominal dimension 125 mm (5 in.) or more.

timber pallet: see *pallet, wooden or wood.*

tine: horizontal load-lifting portion of fork of forklift truck; finger (the preferential term in some British Commonwealth countries).

tolerance: permitted amount of deviation from average specified dimension.

top cap: panel placed on top of palletized unit load to facilitate stacking and to allow tight strapping without damaging unit load.

top deckboard: see *deckboard, top.*

top-deck of pallet: see *pallet, top-deck of.*

toughness: material property which indicates resistance to energy absorption.

transporting: moving from one place to another.

trip: series of four to six handlings required to move palletized unit load from shipping point to receiving point.

two-directional bottom deck construction: bottom boards oriented in both directions of pallet length and width, with bottom deckboards overlapping bottom stringerboards.

two-way pallet: see *pallet, two-way.*

two-way entry pallet: see *pallet, two-way entry.*

type: see *pallet type.*

ultimate load: see *load, ultimate.*

ultimate strength: maximum resistance to external force, load, or generation of internal strain of material, member, connection, component, or assembly of given size, at which failure occurs; expressed in terms of units of force, N, newtons (lbf, pound force); sometimes referred to as maximum load, ultimate load, or maximum strength; and incorrectly referred to as ultimate stress.

unassembled pallet: see *pallet, knockdown.*

unidirectional bottom-deck construction: bottom deckboards oriented in direction of pallet length or width.

uniformly distributed load: see *load, uniformly distributed.*

unit load: assembly of goods or single item on pallet for handling, moving, storing, and stacking, as single entity; also, unit load, as defined, including supporting pallet.

units of measurements: see *SI units* and *U.S. customary units.*

use: see *pallet use.*

U.S. customary units: measures based on Imperial units, such as inches for dimensions, pound force for forces and loads, and pounds/mass for stresses and pressures.

warehouse pallet: see *pallet, warehouse.*

water-resistant board: see *board, water-resistant.*

weight of facing: see *facing weight.*

wet-strength linerboard: see *linerboard, wet strength.*

wet-strength medium: chemically treated containerboard to impart improved rupture resistance when water-saturated.

wheel-jack opening: clear space provided in bottom deck panel to allow pallet-jack wheels to bear on floor.

window: see *opening.*

window pallet: see *pallet, full-perimeter base.*

wing: deckboard or deck overhang, not less than 65 mm ($2\frac{1}{2}$ in.), along pallet side, to increase unit-load area, to add pallet load-bearing capacity, to reduce deckboard-end splitting by fasteners, and to facilitate lifting with bar slings hanging from crane (see *lip*).

wing pallet: see *pallet, wing.*

wood pallet or *wooden pallet:* see *pallet, wood or wooden.*

wood screw: see *screw, wood.*

wood species: botanical classification of tree species.

working load: see *load, design.*

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workmanship: characteristic quality of producing goods.

wrap: see *net wrap; shrink wrap; stretch wrap.*

yield stress: limit to internal stress developed by application of external force, load, or generation of internal strain to material, member, connection, component, or assembly beyond which marked increase in deformation occurs without appreciable increase in load; expressed in terms of units of mass per unit area, MPa, megapascals, (psi, pounds force per square in.); in the case of nonlinear initial rate of force, agreed-on convention is applied; sometimes incorrectly referred to as yield strength and as ultimate strength.

5 SPECIAL PALLETS

A number of special pallets constructed of a variety of materials, as defined in para. 4, are pictured in Appendix A1-A (previously included in Appendix E of ASME MH1.4.1M-1989) to provide a visual description of these pallets.

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NONMANDATORY APPENDIX A1-A
SPECIAL PALLETS CONSTRUCTED OF A VARIETY OF MATERIALS

(This Appendix is not part of Part 1 of ASME MH1-1997, and is included for information purposes only.)

NOTE: A number of wooden pallets are shown in the illustrations of the main part of this document.

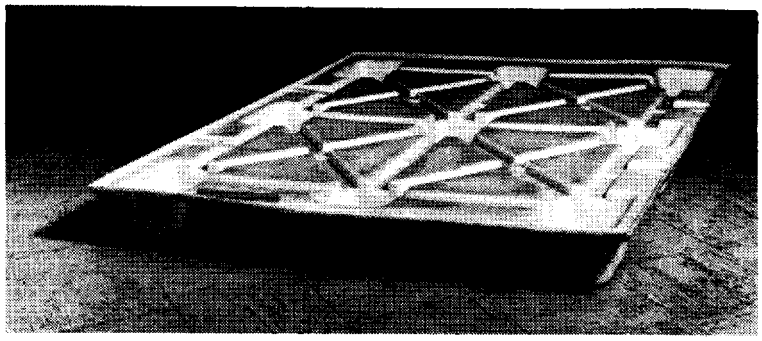


FIG. A1 MOLDED PLASTIC PALLET

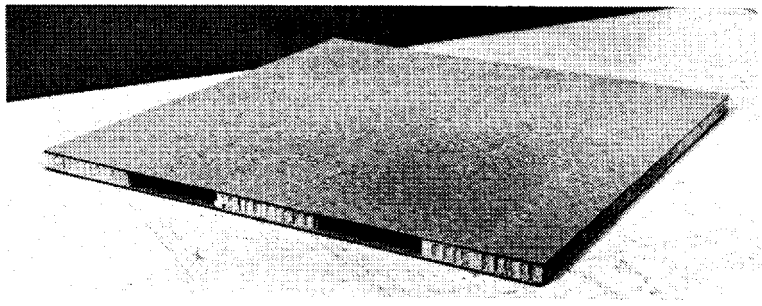


FIG. A2 COMBINATION PALLET WITH CORRUGATED DECK AND HONEYCOMB STRINGERS

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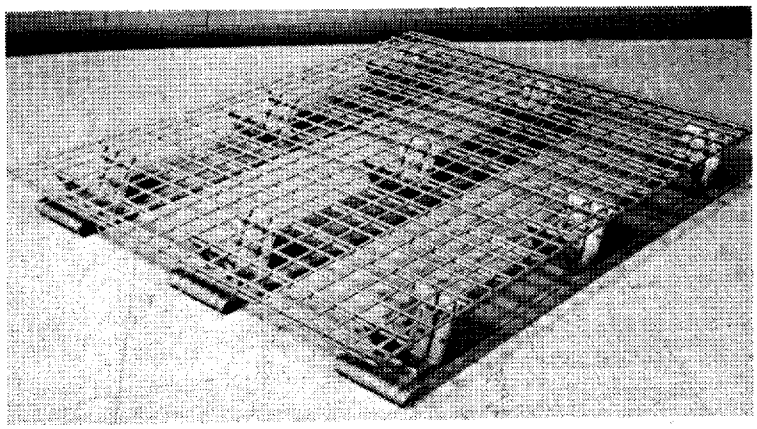


FIG. A3 STEEL PALLET

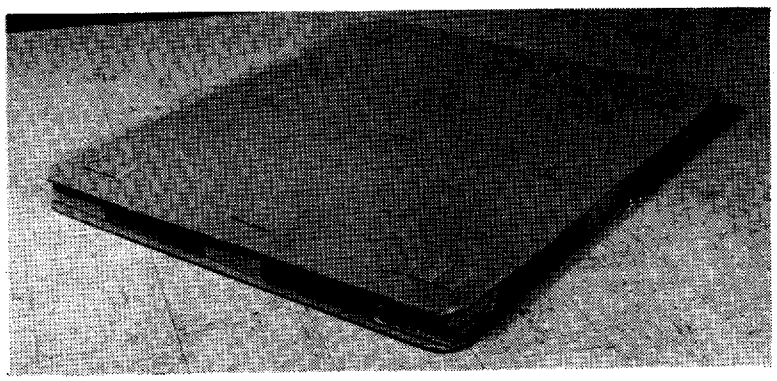


FIG. A4 CORRUGATED FIBERBOARD PALLET

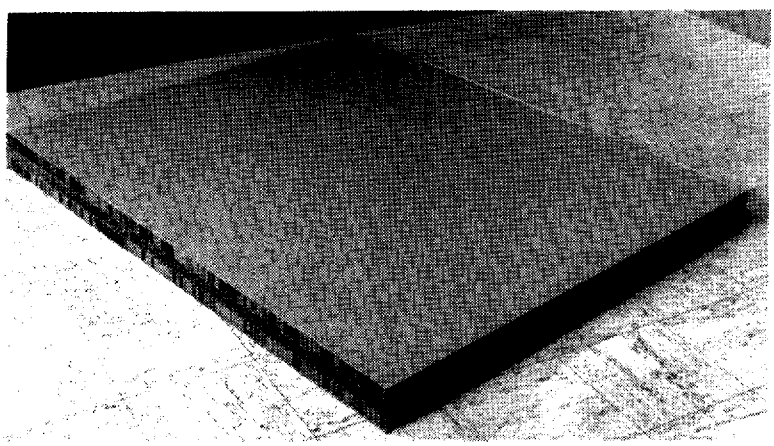


FIG. A5 HONEYCOMB PALLET

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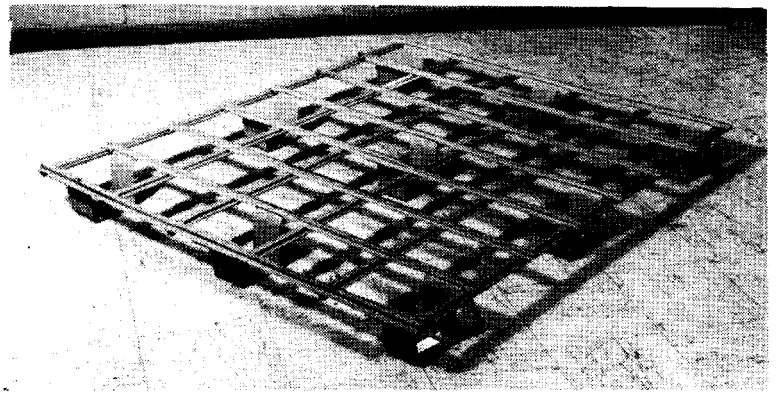


FIG. A6 STEEL PALLET

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Part 2
Pallet Sizes

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Part 3
Wood Pallets

Refer to ASME MH1.8M-1996 Wood Pallets.

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Part 4
Export Pallets

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Part 5
Driven Fasteners for Assembly of Pallets and Related Structures

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3 Standard, Bright and Coated, Plain-Shank, Regular-Stock Steel, Nails and Staples for Pallet-Mat Assembly: Nails With Filleted, Flat Heads and Short, Blunt, Chisel Points; and Staples With Two, Equal-Length, Flattened Legs Connected by Staple Crown and Short, Blunt, Chisel Points With ½ in. Wide Crown (Imperial Units) 51

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PART 5
DRIVEN FASTENERS FOR ASSEMBLY OF PALLETS AND RELATED STRUCTURES

1 SCOPE

(a) Part 5 is based on technological developments in the pallet and pallet-fastener fields and emphasizes the benefits of use of the fastener withdrawal and shear indexed as means of rating fastener performance.

(b) Part 5 provides manufacturers and users of pallet nails and staples with a detailed description of common, regular-stock, stiff-stock and hardened stiff-stock steel nails as well as common regular-stock steel staples used for the assembly of limited-use and multiple-use wood pallets and related structures employed in materials handling and shipping.

(c) Such pallet fasteners that do not conform to Part 5 shall be considered special fasteners. These specials include such standardized fasteners having features different from those described in Part 5, such as heads, points, and threads of different designs.

(d) Inspection and MIBANT (Morgan Impact Bend Angle Nail Tester) Testing [see Appendix A5-A, para. A2(c)] of the pallet fasteners described in Part 5 shall be considered a routine procedure. All other required testing shall be covered specifically in the purchase order.

(e) The standard fasteners are coded for easy reference by all involved, i.e., pallet-fastener manufacturers and specification writers as well as for ordering by pallet manufacturers. The performance indexes estimated and presented for each standard fastener should be helpful in fastener selection as the optimum one for a given end product.

(f) The listing, coding, and indexing of the standard pallet fasteners in Part 5 should result in the preferred use and reduce proliferation of special fasteners.

(g) The fastener information presented includes the input required for fasteners used in the *Pallet Design System* [see Appendix A5-A, paras. A5(g) and (h)].

(h) Part 5 may be incorporated in related documents by reference. Any required deviation from Part 5 shall be noted prominently in order to reduce any possible misinterpretations to a minimum.

(i) Part 5 may involve hazardous materials, operations, and equipment. Part 5 does not purport to address all the safety problems associated with its use. It is the user's responsibility to consult and establish appropriate safety practices and determine the applicability of regulatory limitations.

2 PURPOSE

This descriptive and performance Part 5 covers nails and staples used for the assembly of pallets and related structures made of wood and wood-base materials.

3 DEFINITIONS AND TERMINOLOGY

The terminology used in Part 5 is in accordance with Part 1 and Appendix A5-A, paras. A2(a) and (b) and A5(f). The following specific definitions are basic to Part 5:

fastener shear index (FSI): measure of estimated shear resistance of given pallet fastener relative to shear resistance of high-quality "base" pallet nail.

fastener withdrawal index (FWI): measure of estimated withdrawal resistance of given pallet fastener, based on lesser of shank or leg withdrawal or head or crown pull-through resistance relative to that of high-quality "base" pallet nail.

helix: single thread crossing along shank of helically threaded fastener.

MIBANT angle: angular deformation of fastener shank or legs when subject to MIBANT test, providing indication of impact bending resistance and toughness of fastener, with device and method described in ASTM F 680 [see Appendix A5-A, para. A2(c)].

staple-crown length: distance measured parallel to crown between staple legs; length of bearing surface of staple crown.

staple-crown width or staple width: overall dimension parallel to staple crown from outside to outside of staple legs.

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staple-wire thickness: dimension of flattened-wire staple leg measured parallel to crown axis.

staple-wire width: dimension of flattened-wire staple leg measured perpendicular to crown axis.

4 SYMBOLS USED

C = number of the fastener couples (single staple is one fastener):

Fasteners per joint	2	3	4	5	6
Fastener couples per joint	1	3	4	5	6

Example: For 4-nail joint, use four couples as shown in Part 5, Fig. 1.

CL = staple-crown length, mm (in.)

FSI = fastener shear index, %

FSR = fastener shear resistance, N (lb), of all fasteners in assembly

FWI = fastener withdrawal index, %

$FWRF$ = fastener withdrawal resistance, N (lb), of single fastener

GD = oven-dry specific gravity of deckboard components

GS = oven-dry specific gravity of stringer components

H = number of helixes along thread length

HD = nail-head diameter, mm (in.)

$HPRF$ = fastener head-pull-through resistance, N (lb), of single fastener

M = MIBANT angle of fastener, deg, according to test using 15.6 N ($3\frac{1}{2}$ lb) weight and 392 mm ($15\frac{7}{16}$ in.) drop height or equivalent computed for other weight or drop height

MC = moisture content during assembly, % of dry weight (maximum: 28% for green wood; minimum: 12% for dry wood)

P = penetration of threaded shank portion of fastener in fastening member, mm (in.)

T = thickness of fastening member, mm (in.), limited to maximum of 19 mm ($\frac{3}{4}$ in.) in computation of head-pull-through resistance

TA = thread angle, deg

TD = thread-crest diameter, mm (in.)

TL = thread length, mm (in.)

WD = wire diameter of fastener, mm (in.)

WT = width of flattened round wire mm (in.), measured parallel to crown axis; wire thickness

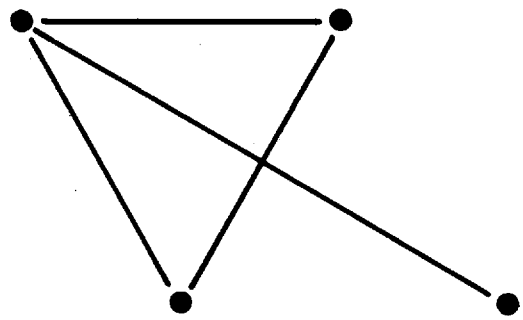


FIG. 1 NUMBER OF FASTENER COUPLES (Example shown: Four fastener joint uses four couples)

WW = width of flattened round wire, mm (in.), measured perpendicular to crown axis; wire width

5 FASTENERS COVERED

5.1 Standard Pallet-Assembly Nails

The standard, helically threaded, stiff-stock and hardened steel, pallet-assembly nails are described in Part 5, Table 1. They have filleted flat heads, are pointless or provided with short, blunt or medium-long diamond or chisel points (not wider than the wire diameter), have four thread flutes with 60 to 68(±2) deg thread angles [see Part 5, para. 10(e)]. Their fastener withdrawal index FWI and fastener shear index FSI with respect to their withdrawal resistance $FWRF$ and shear resistance $FSRF$, respectively, are based on the following relationships (see Part 6):

Using SI units:

$$FWI = 8.7WD\,[1 + 27.15\,(TD - WD)\,(H/TL)] \quad (1a)$$

Using Imperial units:

$$FWI = 221WD\,[1 + 27.15\,(TD - WD)\,(H/TL)] \quad (1b)$$

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Using SI units:

$$FSI = 2056WD^{1.5}/(3M + 40) \quad (2a)$$

Using Imperial units:

$$FSI = 263{,}260WD^{1.5}/(3M + 40) \quad (2b)$$

5.2 Standard Pallet-Assembly Staples

(a) The standard, bright or coated, plain-shank, regular-stock steel, 13 mm (½ in.) wide, pallet-assembly staples are described in Part 5, Table 2. They have two, equal-length, flattened legs connected by the flattened staple crown. The legs are provided with short, blunt, chisel points. Their fastener-quality indexes *FWI* and *FSI* with respect to their withdrawal resistance *FWRF* and shear resistance *FSRF*, respectively, are based on the following relationships (see Part 6):

Using SI units:

$$FWI = 8.7\ (1.273)\ (WW + WT) \quad (3a)$$

Using Imperial units:

$$FWI = 221\ (1.273)\ (WW + WT) \quad (3b)$$

Using SI units:

$$FSI = 2056\ [0.8476\ (WW + WT)]^{1.5}/(3M + 40) \quad (4a)$$

Using Imperial units:

$$FSI = 263{,}260\ [0.8476\ (WW + WT)]^{1.5}/(3M + 40) \quad (4b)$$

(b) For any coating to be given consideration in determining connection effectiveness, the increase in delayed withdrawal resistance of coated staples, driven into green wood and tested after its seasoning to 12% moisture content, shall be at least 33% beyond that of identical bright staples. If the coating is more effective, its benefit can be prorated in determining the fastener's *FWI*.

5.3 Standard Pallet-Mat Assembly Nails and Staples

Standard, bright and coated, plain-shank, regular-stock steel nails and staple for pallet-mat assembly are described in Part 5, Table 3. The nails have filleted flat heads and short, blunt, diamond or chisel points. The staples have two equal-length, flattened legs, connected by the flattened staple crown, and short, blunt, chisel points. To allow for at least 6 mm (¼ in.) clinching, the fastener length shall be at least equal to the thicknesses of the fastened and fastening members plus 6 mm (¼ in.) less the depth of countersinking.

6 PERFORMANCE CRITERIA

The performance criteria, in newtons (N) or pounds (lb), as applicable, are based on the 5% exclusion level and are determined as follows (see Part 6).

(a) Fastener Withdrawal Resistance Values (FWRF)

Using SI units:

$$FWRF = 38.9FWI(GS^{2.25})(P)/(MC - 3) \quad (5a)$$

Using Imperial units:

$$FWRF = 222.2FWI(GS^{2.25})(P)/(MC - 3) \quad (5b)$$

(b) Fastener Head-Pull-Through Resistance Values (HPRF)

Using SI units:

$$HPRF \text{ for nails} = 339T(GD^{2.25}) \times (HD^2 - WD^2)/(MC - 3) \quad (6a)$$

Using Imperial units:

$$HPRF \text{ for nails} = 1{,}250{,}000T(GD^{2.25}) \times (HD^2 - WD^2)/(MC - 3) \quad (6b)$$

Using SI units:

$$HPRF \text{ for staples} = 432T(GD^{2.25})(CL) \times (WW)/(MC - 3) \quad (7a)$$

Using Imperial units:

$$HPRF \text{ for staples} = 1{,}591{,}550T(GD^{2.25}) \times (CL)(WW)/(MC - 3) \quad (7b)$$

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(c) Fastener Shear Resistance Values (FSR)

Using SI units:

$$FSR = 10.84FSI(GD)(T)(C)/(MC - 3) \quad (8a)$$

Using Imperial units:

$$FSR = 61.93FSI(GD)(T)(C)/(MC - 3) \quad (8b)$$

7 ORDERING INFORMATION

(a) Orders for the pallet-assembly fasteners listed in Part 5 shall include the following information:

	Example
Quantity (weight or number of packaged fasteners)	50 lb bulk
Type and Size	Pallet nail: 2½ × 0.120 in.
Material, grade, and finish	Steel, hardened, bright
Shank-thread description	Helical, 1¾*TL*, 0.142*TD*, 60*TA*
Head (crown) and point description	0.28 in., flat, pointless
MIBANT angle	16 deg
FWI and *FSI* performance indexes	108*FWI*; 124*FSI*, %
Code number	250 × 120AA
Special information	...

(b) Standard pallet-assembly fastener-package labels shall provide the required label information in a uniform manner and sequence, as indicated in Appendix A5-B.

8 MATERIALS AND MANUFACTURING

(a) The steel used for making the fasteners shall be made by any suitable means and the method of fastener manufacture shall be at the manufacturer's discretion to provide a uniform product of specified properties. Part 5 covers the following three steel grades.

(1) Regular-Stock Steel. This grade is customary if no special mechanical properties are specified.

(2) Stiff-Stock Steel. This grade is stiffer than regular stock and results in higher resistance to buckling and bending and lesser MIBANT angles than regular-stock steel.

(3) Hardened Steel. This grade denotes heat-treated and tempered fasteners (see Warning below), which provide higher resistance to buckling and bending and lesser MIBANT angles than regular-stock and stiff-stock fasteners.

WARNING: The driving of hardened-steel fasteners into certain materials is potentially hazardous because of the possibility of fastener breakage and flying particles. Hardened-steel fasteners shall not be driven without appropriate precautions. Wearing approved safety glasses and/or other equivalent protection is mandatory.

(b) Coating and finishes shall be applied to the fasteners as specified. The fastener dimensions shall apply to the fasteners prior to any coating or finishing.

(c) Galvanized coating shall meet the requirements of weight and adherence given in ASTM A 153, Class D [see Appendix A5-A, para. A2(f)]. The coating may be applied by the hot-dip, tumbling or mechanical galvanization process, if not specified otherwise. Galvanized wire for steel staples shall be coated in accordance with ASTM A 641 (A 641M), Class 1 [see Appendix A5-A, para. A2(g)]. Supplementary chromate or dichromate treatment may be used to enhance the corrosion resistance of the fasteners, subject to prior agreement between vendor and purchaser.

(d) Coated fasteners shall be uniformly coated with a natural resin (cement) or conversion coating (thermoplastic or thermosetting polymer). Other coatings may be used subject to prior agreement between vendor and purchaser. If test verification of the effectiveness of the coating is required, it shall provide a minimum increase of 33% in delayed withdrawal resistance of the fastener when driven into green wood and tested after its seasoning to 12% moisture content in accordance with ASTM D 1761 [see Appendix A5-A, para. A2(h)]. None of the coatings shall be tacky or gummy under ambient conditions normally encountered.

(e) Helical shank deformations of the fasteners listed in this Part shall be applied by threading, in line with ASTM F 547 [see Appendix A5-A, para. A2(a)]. However, other methods of applying shank deformations may be used where they are shown to be suitable for the fastener application, subject to prior agreement between vendor and purchaser.

(f) The helical threads shall extend from the nail point to at least two-thirds of the nail length. The thread flanks on the nail-head side shall be almost pendicular to the nail axis, and the thread flanks on the point side shall be tapered toward the point. Both flat-bottom and round-bottom threads are suitable.

9 PHYSICAL REQUIREMENTS

(a) The nails described in Part 5 shall be sufficiently ductile and tough to provide an average MIBANT angle, in line with ASTM F 680 [see Appendix A5-A, para. A2(c)], for 25 random samples of the lot

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under test, ranging from 8 to 28 deg for hardened steel nails, 29 to 46 deg for stiff-stock steel nails, and 47 deg and beyond for regular-stock steel nails which may be clinched, provided that not more than 8% of the nail heads or shanks fail partially or completely during impacting. In borderline cases, retesting is permitted. Because of the different wear conditions of different MIBANT devices, correction factors may have to be applied which relate to the condition of the device in use.

(b) The mechanical properties of the wire may be used in guiding its selection. Thus, stiff-stock steel wire may have a minimum tensile strength of 827 MPa (120,000 psi).

(c) When MIBANT or equivalent data cannot be made available, stiff-stock steel nails shall have a minimum hardness of HRC 24, as determined by conversion of tensile strength to hardness in accordance with SAE J 417b [see Appendix A5-A, para. A6]; while hardened steel nails shall have a minimum hardness of HRC 37 unless specified otherwise.

10 DIMENSIONS AND TOLERANCES

(a) The nominal fastener dimensions are given in Part 5, Tables 1 to 3. The tolerances provided for in Part 5 are applicable to hammer-driven and machine-driven nails and tool-driven staples. The tolerances for tool-driven nails shall be mated to the requirements of the driving equipment, subject to prior agreement between vendor and purchaser.

(b) The nail length shall be measured from the underside of the head to the tip of the point. The nail-length tolerances shall be ±2 mm (±0.078 in.) for lengths from 25 mm (1.00 in.) up to and including 64 mm (2.50 in.) and ±3 mm (±0.118 in.) for lengths over 64 mm (2.50 in.). The length of tool-driven staples shall be measured from the top of the staple crown to the tip of the staple point. The staple-length tolerance shall be +0.5 mm and −1.6 mm (+0.016 in. and −0.062 in.).

(c) The wire diameter of nails shall be measured away from the gripper marks and prior to the application of any coatings and finishes. The diameter tolerances shall be ±0.05 mm (±0.002 in.). The leg width and thickness of tool-driven staples shall be measured prior to the application of any coating or along the leg portion which is not coated. The tolerances of the leg thicknesses and widths of tool-driven staples shall be as indicated in the following tabulation:

Nominal Wire Diameter		Thickness Range		Width Range	
mm	in.	mm	in.	mm	in.
1.6	0.062	1.4 to 1.5	0.054 to 0.058	1.6 to 1.7	0.062 to 0.066
1.8	0.072	1.6 to 1.7	0.064 to 0.068	1.8 to 1.9	0.072 to 0.076
2.0	0.080	1.8 to 2.0	0.070 to 0.078	2.1 to 2.3	0.082 to 0.090

(d) The thread-crest diameters of threaded nails shall be the mean diametral dimension along the deformed portion of the shank. The tolerance shall be +0.10 mm and −00.0 mm (+0.004 in. and −0.000 in.).

(e) The thread-angle tolerance of helically threaded nails shall be ±2 deg with the plane perpendicular to the nail axis.

(f) The nominal head diameters shall be based on the mean of the major and minor head diameters. The tolerance shall be ±10% of the nominal head diameter in individual measurements, and the differences in major and minor head diameters shall not exceed 10% of the nominal head diameters. The shape of the heads may deviate from the round to permit tight collating, provided the bearing area of the head is not decreased by this change.

11 WORKMANSHIP

The fasteners covered in Part 5 shall be substantially clean and free of foreign material, corrosion products, and fine metal slivers. Cohered fasteners shall be properly aligned in their assembled form. Machine-quality fasteners shall be substantially free of foreign matter which could clog tools and machines.

12 TESTING

(a) When required in the purchase order that tests be conducted on the performance of randomly selected fasteners of the lot involved, the test methods to be used shall be in accordance with ASMT F 680 [see Appendix A5-A, para. A2(c)] and ASTM F 1575 [see Appendix A5-A, para. A2(j)], except that the MIBANT test shall be the governing test in preference of the conventional bend test and the Rockwell hardness test.

(b) When required in the purchase order, the manufacturer shall furnish a certified test report which covers the fasteners in the lot involved (see Note below).

NOTE: A lot shall consist of fasteners of a single shipment of the same type, grade, and finish, taken from the same manufacturing lot.

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13 REJECTION AND REHEARING

(a) Fasteners that fail to conform to the requirements of Part 5 may be rejected. Rejection shall be reported promptly to the vendor in writing. In the case of dissatisfaction, the vendor may make a claim for a rehearing. Under these rehearing procedures, the lot shall be reinspected in the presence of both vendor and purchaser, unless special arrangements were negotiated at the time of ordering.

(b) A random sample shall be obtained from the lot for examination as indicated below:

Test Type	Sample Size	Acceptance Number for Each Test [Note (1)]
Nondestructive test	100	8
Destructive test	30	2
Functionally defective [Note (2)]	100	2

NOTES:

(1) Acceptance number is the maximum number of defectives that may occur for acceptance of the lot.

(2) A functionally defective lot includes defects such as duds, lack of coating, incorrect coating, or wrong grade. If the acceptance number is exceeded for any of the characteristics subject to rehearing, the lot represented by the sample shall be rejected.

(c) The responsibility for the performances of the required inspection and testing in line with this Specification is that of the fastener manufacturer, unless specified otherwise in the purchase order. The fastener manufacturer may use his own or any other suitable facilities for the performance of inspection and testing, unless specified otherwise in the purchase order. The purchaser shall have the right to perform any of the inspections and test, where such inspections and tests are considered necessary to ensure that the fasteners conform to the specified requirements.

14 PACKAGING

The fasteners shall be packaged in accordance with the supplier's standard practice which is acceptable to the carrier at the lowest rate, unless specified otherwise in the purchase order. Containers and packaging shall comply with the Uniform Freight Classification Rules [see Appendix A5-A, para. A7(a)] or National Motor Classification Rules [see Appendix A5-A, para. A7(b)]. Marking of the containers for shipment of the fasteners shall be in accordance with Appendix A5-B, unless specified otherwise in the purchase order.

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Table 1 begins on next page.

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Table 1 Standard, Helically Threaded, Stiff-Stock and Hardened-Steel, Pallet-Assembly Nails With Filleted, Flat Head, Pointless or Short, Blunt, or Medium (< 5/32 in.) Diamond or Chisel Point (Not Wider Than Wire Diameter), Four Thread Flutes, and 60 to 68 (±2) deg Thread Angle (Imperial Units)

			Crest Diam.		Thread Angle		
Code	Length, in.	Wire Diam., in.	Stand., in. *A*	Min., in. *B*	Stand., deg *A*	Max., deg *B*	Head Diam., in.
150x105AA	1½	0.105	0.124	...	60	...	0.25
AB			0.124	...	...	67	0.25
BA			...	0.120	60	...	0.25
BB			...	0.120	...	67	0.25
175x105AA	1¾	0.105	0.124	...	60	...	0.25
AB			0.124	...	...	67	0.25
BA			...	0.120	60	...	0.25
BB			...	0.120	...	67	0.25
175x112AA	1¾	0.112	0.132	...	60	...	0.28
AB			0.132	...	...	67	0.28
BA			...	0.128	60	...	0.28
BB			...	0.128	...	67	0.28
200x105AA	2	0.105	0.124	...	60	...	0.25
AB			0.124	...	...	67	0.25
BA			...	0.120	60	...	0.25
BB			...	0.120	...	67	0.25
200x112AA	2	0.112	0.132	...	60	...	0.28
AB			0.132	...	...	67	0.28
BA			...	0.128	60	...	0.28
BB			...	0.128	...	67	0.28
200x120AA	2	0.120	0.142	...	60	...	0.28
AB			0.142	...	...	67	0.28
BA			...	0.137	60	...	0.28
BB			...	0.137	...	67	0.28
225x112AA	2¼	0.112	0.132	...	60	...	0.28
AB			0.132	...	...	67	0.28
BA			...	0.128	60	...	0.28
BB			...	0.128	...	67	0.28
225x120AA	2¼	0.120	0.142	...	60	...	0.28
AB			0.142	...	...	67	0.28
BA			...	0.137	60	...	0.28
BB			...	0.137	...	67	0.28
250x112AA	2½	0.112	0.132	...	60	...	0.28
AB			0.132	...	...	67	0.28
BA			...	0.128	60	...	0.28
BB			...	0.128	...	67	0.28
250x120AA	2½	0.120	0.142	...	60	...	0.28
AB			0.142	...	...	67	0.28
BA			...	0.137	60	...	0.28
BB			...	0.137	...	67	0.28

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Table 1 Standard, Helically Threaded, Stiff-Stock and Hardened-Steel, Pallet-Assembly Nails With Filleted, Flat Head, Pointless or Short, Blunt, or Medium (< $^5/_{32}$ in.) Diamond or Chisel Point (Not Wider Than Wire Diameter), Four Thread Flutes, and 60 to 68 (±2) deg Thread Angle (Imperial Units)

Quality Index *FWI* With Respect to Withdrawal Resistance	Quality Index *FSI* With Respect to Shear Resistance For Given MIBANT Angle, deg										
	Stiff-Stock Steel Nails				Hardened Steel Nails						
	29	34	40	46	8	12	16	20	24	28	Code
94	70	63	56	50	140	118	102	90	80	72	150x105AA
76	70	63	56	50	140	118	102	90	80	72	AB
81	70	63	56	50	140	118	102	90	80	72	BA
66	70	63	56	50	140	118	102	90	80	72	BB
94	70	63	56	50	140	118	102	90	80	72	175x105AA
76	70	63	56	50	140	118	102	90	80	72	AB
81	70	63	56	50	140	118	102	90	80	72	BA
66	70	63	56	50	140	118	102	90	80	72	BB
100 (1)	78	70	62	55	154	130	112	99	88	80	175x112AA
80	78	70	62	55	154	130	112	99	88	80	AB
87	78	70	62	55	154	130	112	99	88	80	BA
70	78	70	62	55	154	130	112	99	88	80	BB
94	70	63	56	50	140	118	102	90	80	72	200x105AA
76	70	63	56	50	140	118	102	90	80	72	AB
81	70	63	56	50	140	118	102	90	80	72	BA
66	70	63	56	50	140	118	102	90	80	72	BB
100 (1)	78	70	62	55	154	130	112	99	88	80	200x112AA
80	78	70	62	55	154	130	112	99	88	80	AB
87	78	70	62	55	154	130	112	99	88	80	BA
70	78	70	62	55	154	130	112	99	88	80	BB
108	86	77	68	62	171	144	124	109	98	88	200x120AA
87	86	77	68	62	171	144	124	109	98	88	AB
92	86	77	68	62	171	144	124	109	98	88	BA
75	86	77	68	62	171	144	124	109	98	88	BB
100 (1)	78	70	62	55	154	130	112	99	88	80	225x112AA
80	78	70	62	55	154	130	112	99	88	80	AB
87	78	70	62	55	154	130	112	99	88	80	BA
70	78	70	62	55	154	130	112	99	88	80	BB
108	86	77	68	62	171	144	124	109	98	88	225x120AA
87	86	77	68	62	171	144	124	109	98	88	AB
92	86	77	68	62	171	144	124	109	98	88	BA
75	86	77	68	62	171	144	124	109	98	88	BB
100 (1)	78	70	62	55	154	130	112	99	88	80	250x112AA
80	78	70	62	55	154	130	112	99	88	80	AB
87	78	70	62	55	154	130	112	99	88	80	BA
70	78	70	62	55	154	130	112	99	88	80	BB
108	86	77	68	62	171	144	124	109	98	88	250X120AA
87	86	77	68	62	171	144	124	109	98	88	AB
92	86	77	68	62	171	144	124	109	98	88	BA
75	86	77	68	62	171	144	124	109	98	88	BB

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TABLE 1 Standard, Helically Threaded, Stiff-Stock and Hardened-Steel, Pallet-Assembly Nails With Filleted, Flat Head, Pointless or Short, Blunt, or Medium (< 5/32 in.) Diamond or Chisel Point (Not Wider Than Wire Diameter), Four Thread Flutes, and 60 to 68 (±2) deg Thread Angle (Imperial Units) (Cont'd)

			Crest Diam.		Thread Angle		
Code	Length, in.	Wire Diam., in.	Stand., in. *A*	Min., in. *B*	Stand., deg *A*	Max., deg *B*	Head Diam., in.
250x135AA	2 1/2	0.135	0.159	...	60	...	0.30
AB			0.159	...	...	67	0.30
BA			...	0.154	60	...	0.30
BB			...	0.154	...	67	0.30
275x120AA	2 3/4	0.120	0.142	...	60	...	0.28
AB			0.142	...	...	67	0.28
BA			...	0.137	60	...	0.28
BB			...	0.137	...	67	0.28
275x135AA	2 3/4	0.135	0.159	...	60	...	0.30
AB			0.159	...	...	67	0.30
BA			...	0.154	60	...	0.30
BB			...	0.154	...	67	0.30
300x120AA	3	0.120	0.142	...	60	...	0.28
AB			0.142	...	...	67	0.28
BA			...	0.137	60	...	0.28
BB			...	0.137	...	67	0.28
300x135AA	3	0.135	0.159	...	60	...	0.30
AB			0.159	...	...	67	0.30
BA			...	0.154	60	...	0.30
BB			...	0.154	...	67	0.30
350x135AA	3 1/2	0.135	0.159	...	60	...	0.30
AB			0.159	...	...	67	0.30
BA			...	0.154	60	...	0.30
BB			...	0.154	...	67	0.30

NOTE:
(1) Basis of comparison.

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Table 1 Standard, Helically Threaded, Stiff-Stock and Hardened-Steel, Pallet-Assembly Nails With Filleted, Flat Head, Pointless or Short, Blunt, or Medium (< $^{5}/_{32}$ in.) Diamond or Chisel Point (Not Wider Than Wire Diameter), Four Thread Flutes, and 60 to 68 (±2) deg Thread Angle (Imperial Units) (Cont'd)

Quality Index *FWI* With Respect to Withdrawal Resistance	Quality Index *FSI* With Respect to Shear Resistance For Given MIBANT Angle, deg										
	Stiff-Stock Steel Nails				Hardened Steel Nails						
	29	34	40	46	8	12	16	20	24	28	Code
120	103	92	82	73	204	172	148	130	117	105	250x135AA
96	103	92	82	73	204	172	148	130	117	105	AB
103	103	92	82	73	204	172	148	130	117	105	BA
84	103	92	82	73	204	172	148	130	117	105	BB
108	86	77	68	62	171	144	124	109	98	88	275x120AA
87	86	77	68	62	171	144	124	109	98	88	AB
92	86	77	68	62	171	144	124	109	98	88	BA
75	86	77	68	62	171	144	124	109	98	88	BB
120	103	92	82	73	204	172	148	130	117	105	275x135AA
96	103	92	82	73	204	172	148	130	117	105	AB
103	103	92	82	73	204	172	148	130	117	105	BA
84	103	92	82	73	204	172	148	130	117	105	BB
108	86	77	68	62	171	144	124	109	98	88	300x120AA
87	86	77	68	62	171	144	124	109	98	88	AB
92	86	77	68	62	171	144	124	109	98	88	BA
75	86	77	68	62	171	144	124	109	98	88	BB
120	103	92	82	73	204	172	148	130	117	105	300x135AA
96	103	92	82	73	204	172	148	130	117	105	AB
103	103	92	82	73	204	172	148	130	117	105	BA
84	103	92	82	73	204	172	148	130	117	105	BB
120	103	92	82	73	204	172	148	130	117	105	350x135AA
96	103	92	82	73	204	172	148	130	117	105	AB
103	103	92	82	73	204	172	148	130	117	105	BA
84	103	92	82	73	204	172	148	130	117	105	BB

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Table 2 Standard, Bright and Coated, Plain-Shank, Regular Stock Steel, ½ in. Wide, Pallet-Assembly Staples With Two, Equal-Length, Flattened Legs and Short, Blunt, Chisel Points (Imperial Units)

Code	Length, in.	Nominal Wire Diameter, in.	Cross Section		Finish		Quality Index *FWI* With Respect to Withdrawal Resistance		Quality Index *FSI* With Respect to Shear Resistance for Given Computed MIBANT Angle, deg, for Bright or Coated Fasteners		
			Thickn., in.	Width, in.	Bright *A*	Coated *B*	Bright	Coated	85	115	150
200x062A	2	0.062	0.055	0.061	x	...	33	...	...	...	17
B					...	x	...	50	...	...	17
200x072A	2	0.072	0.067	0.073	x	...	39		...	28	...
B					...	x	...	59	...	28	...
200X080A	2	0.080	0.075	0.080	x	...	44	...	42	...	...
B					...	x	...	65	42	...	...
225x062A	2¼	0.062	0.055	0.061	x	...	33	...	...	...	17
B					...	x	...	50	...	...	17
225x072A	2¼	0.072	0.067	0.073	x	...	39	...	...	28	...
B					...	x	...	59	...	28	...
225x080A	2¼	0.080	0.075	0.080	x	...	44	...	42	...	...
B					...	x	...	65	42	...	...
250x072A	2½	0.072	0.067	0.073	x	...	39		...	28	...
B					...	x	...	59	...	28	...
250x080A	2½	0.080	0.075	0.080	x	...	44	...	42	...	...
B					...	x	...	65	42	...	...
300x072A	3	0.072	0.067	0.073	x	...	39	...	...	28	...
B					...	x	...	59	...	28	...
300x080A	3	0.080	0.075	0.080	x	...	44	...	42	...	...
B					...	x	...	65	42	...	...
375x072A	3¾	0.072	0.067	0.073	x	...	39	...	...	28	...
B					...	x	...	59	...	28	...
375x080A	3¾	0.080	0.075	0.080	x	...	44	...	42	...	...
B					...	x	...	65	42	...	...

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Table 3 Standard, Bright and Coated, Plain-Shank, Regular-Stock Steel, Nails and Staples for Pallet-Mat Assembly: Nails with Filleted, Flat Heads and Short, Blunt, Chisel Points; and Staples With Two, Equal-Length, Flattened Legs Connected by Staple Crown and Short, Blunt, Chisel Points With $\frac{1}{2}$ in. Wide Crown (Imperial Units)

Nails				Staples		
Code	Length, in.	Wire Diameter, in.	Head Diameter, in.	Code	Length, in.	Nominal Wire Diameter, in.
100x086	1	0.086	0.19	100x062	1	0.062
100x091	1	0.091	0.22	100x072	1	0.072
100x099	1	0.099	0.25	100x080	1	0.080
100x105	1	0.105	0.25			
				125x062	$1\frac{1}{4}$	0.062
125x086	$1\frac{1}{4}$	0.086	0.19	125x072	$1\frac{1}{4}$	0.072
125x091	$1\frac{1}{4}$	0.091	0.22	125x080	$1\frac{1}{4}$	0.080
125x099	$1\frac{1}{4}$	0.099	0.25			
125x105	$1\frac{1}{4}$	0.105	0.25	150x062	$1\frac{1}{2}$	0.062
				150x072	$1\frac{1}{2}$	0.072
150x086	$1\frac{1}{2}$	0.086	0.19	150x080	$1\frac{1}{2}$	0.080
150x091	$1\frac{1}{2}$	0.091	0.22			
150x099	$1\frac{1}{2}$	0.099	0.25	175x062	$1\frac{3}{4}$	0.062
150x105	$1\frac{1}{2}$	0.105	0.25	175x072	$1\frac{3}{4}$	0.072
				175x080	$1\frac{3}{4}$	0.080
175x086	$1\frac{3}{4}$	0.086	0.19			
175x091	$1\frac{3}{4}$	0.091	0.22	200x062	2	0.062
175x099	$1\frac{3}{4}$	0.099	0.25	200x072	2	0.072
175x105	$1\frac{3}{4}$	0.105	0.25	200x080	2	0.080
200x086	2	0.086	0.19			
200x091	2	0.091	0.22			
200x099	2	0.099	0.25			
200x105	2	0.105	0.25			

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NONMANDATORY APPENDIX A5-A
APPLICABLE DOCUMENTS

(This Appendix is not part of Part 5 of ASME MH1-1997 and is included for information only.)

A1 NWPCA SPECIFICATIONS AND STANDARDS

NWPCA, 1800 North Kent Street, Arlington, VA 22209

(a) Pallet Design System, 1990.

(b) Uniform Standard for Wood Pallets, 1996.

A2 ASTM STANDARDS

ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

(a) ASTM F 547-95, Definitions of Terms Relating to Nails for Use With Wood and Wood-Base Materials.

(b) ASTM F 592-95, Definitions of Terms Relating to Collated and Cohered Fasteners and Their Application Tools.

(c) ASTM F 680-93, Methods of Testing Nails.

(d) ASTM F 1667-95, Specification for Driven Fasteners: Nails, Spikes, and Staples.

(e) ASTM D 1185-94, Methods for Testing Pallets and Related Structures Employed Materials Handling and Shipping.

(f) ASTM A 153-95, Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.

(g) ASTM A 641-92, Specification for Zinc Coated (Galvanized) Carbon Steel Wire.

(h) ASTM D 1761-95, Methods of Testing Metal Fasteners in Wood.

(i) ASTM E 18-94, Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.

(j) ASTM F 1575-95, Test Methods for Determining Bending Yield Moment of Nails.

A3 ASME STANDARDS

ASME, 345 East 47th Street, New York, NY 10017

(a) ASME MH1.2.2M-1989 (R1996), Pallet Sizes.

A4 U.S. GOVERNMENT PUBLICATIONS

Publications: General Services Administration, Washington, DC 20405

Reports: U.S. Forestry Sciences Laboratory, P.O. Box 152, Princeton, WV 24740

(a) Federal Specification FF-N-105B-71, Nails, Brads, Staples, and Spikes: Wire, Cut and Wrought; Amendments: December 1972 and October 1974.

(b) Wallin, W. B., and Whitenack, K. R., "Life Expectancy and Cost per Use Analysis of Wooden Pallets, Skids, Etc.," Forestry Sciences Laboratory, January 1981. Also, "Life Expectancy and Cost per Trip Analysis for Wooden Pallets and Related Structures," Ibidem, December 1981. Also, "Durability Analysis for Wooden Pallets and Related Structures," Ibidem, August 1982.

(c) Wallin, W. B., and Whitenack, K. R., "Pallet Joint Shear Resistance, the F(2) Factor," Pallet Enterprise 1(4): 20-21, May/June 1982. Also, "Application of Joint Performance Criteria to Pallet Design," Ibidem, 1(5): 24–27, July/August 1982. Also, "Fastener Equivalence Guides for Wooden Pallets," Ibidem, 1(6): 25, 27–29, September/October 1982.

A5 VPI&SU BULLETIN AND REPORTS

VPI&SU William H. Sardo Jr. Pallet and Container Research Laboratory, Blacksburg, VA 24061

(a) Stern, E. G., Nails – "Definitions and Sizes, A Handbook for Nail Users," Bulletin No. 61, September 1967.

(b) Stern, E. G., "MIBANT Test Criteria for Pallet Nails," Bulletin No. 115, December 1972.

(c) Stern, E. G., "MIBANT Tests for Pallet Staples," Bulletin No. 149, April 1977.

(d) Stern, E. G., Wallin, W. B., and Whitenack, K. R., "Pallet Rigidity, A Major Indicator for Pallet Durability," Bulletin No. 4, January 1985. Also, *Proceedings of Symposium on Forest Products Research International,* Pretoria, South Africa, April 22-26, 1985, Vol. 4(3-20: 1–23). Also, Forest Products Journal 35(11/

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12): 83–86, November/December 1985. Also, "Evidence Shows Pallet Rigidity to Be a Major Indicator of Pallet Durability," Pallet Enterprise 6(1): 42–45, January/February 1986.

(e) Stern, E. G., and Wallin, W. B., "Model Specification for Driven Fasteners for Assembly of Pallets and Related Structures," *Proceedings of Meeting of International Council for Building Research Studies and Documentation (CIB) Committee on Timber Structures (W 18)* in Beit Oren, Haifa, Israel, June 3–7, 1985. Revised paper presented at Pallet Workshop International 1985 on Fédération Européenne de Fabricants de Palettes et Emballages en Bois, Hamburg, Federal Republic of Germany, October 14, 1985.

(f) Stern, E. G., "Glossary of Test in Pallet Field," *Proceedings of '85 International Physical Distribution Conference,* Tokyo, Japan, May 13–15, 1985, Vol. II(A3-1: 1–24). Also, Virginia Polytechnic Institute and State University's William H. Sardo, Jr. Pallet and Container Research Laboratory, 1985.

(g) McLain, T. E., Wallin, W. B., and White, M. S., *Pallet Design Short Course Manual,* June 1985.

(h) White, M. S., *Pallet Design System (PDS),* Fédération Européenne de Fabricants de Palettes et Emballages en Bois, Pallet Workshop International 1985, Hamburg, Federal Republic of Germany, October 1985.

(i) Loferski, J. R., and Gamalath, S., "Predicting Rotational Stiffness of Nail Joints," Bulletin No. 13, January 1990. Also, Forest Products Journal 39(7/8): 8–16, July/August 1989.

(j) White, M. S., "Effect of Mat Fastener Stiffness on the Diagonal Rigidity of Wooden Block Pallets," Bulletin No. 14, February 1991. Also, Forest Products Journal 41(1): 57–60, January 1991.

(k) White, M. S., and Gales, T. L., "Quality Variations in Helically Threaded Nails," Bulletin No. 15, February 1991. Also, Forest Products Journal 40(11/12): 64–66, November/December 1990.

(l) White, M. S., McLain, T. E., and Padla, D., "Relationships Between the Results of Nail Impact Bend Tests and Selected Material Properties," Bulletin No. 17, February 1991. Also, Journal of Testing and Evaluation 18(3): 219–226, May 1990.

(m) White, M. S., McLain, T. E., Padla, D., and Kasal, B., "Hardness Gradients Within Roll-Threaded Steel Nails," Bulletin No. 16, February 1991. Also, Journal of Testing and Evaluation 18(2): 128–130, March 1990.

(n) Loferski, J. R., and Stern, E. G., "Understanding Impact Testing of Pallet Nails and Staples," Bulletin No. 18, April 1992. Also, Journal of Testing and Evaluation 19(5): 379–384, September 1991.

(o) Stern, E. G., "Assembly of Dense Hardwood Pallets with Superior Nails," *Proceedings of CIB/W18B International Conference of Tropical and Hardwood Timber Structures,* Kuala Lumpur, Malaysia, September 1992.

(p) Stern, E. G., and White, M. S., "Protocol for Measuring Quality of Pallet Nails and Staples," Bulletin No. 23, December 1996.

A6 SAE STANDARD

SAE, 400 Commonwealth Drive, Warrendale, PA 15096

SAE J 417b-1983, Hardness Test and Hardness Number Conversions

A7 TRANSPORTATION STANDARDS

UCC, 202 Union Station, Chicago, IL 60606

NMFTA, 1616 P Street, N.W., Washington, DC 20036

(a) UCC: Uniform Freight Classification Rules.

(b) NMFTA: National Motor Classification Rules.

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NONMANDATORY APPENDIX A5-B
STANDARD PALLET-FASTENER PACKAGE LABELS
(IMPERIAL UNITS)

(This Appendix is not part of Part 5 of ASME MH1-1997 and is included for information only.)

(1) NAILS Quantity _____ lb

Manufacturer _____
Manufacturer's code _____ Lot _____

Type: Pallet nail _____
Length _____ in. Wire diameter _____ in.

Metal: Regular-stock steel _____ Stiff-stock steel _____ Hardened steel _____
Finish: Bright _____ Galvanized _____ Coated (type) _____

Shank deformation: Helically threaded _____ None _____
Thread type:

Length _____ in. Crest diameter _____ in.
Number of flutes _____
Angle _____ deg Helixes/in. _____

Head type _____ Head diameter _____ in.
Point type _____

MIBANT angle _____ deg Performance index *FWI* _____
Performance index *FSI* _____

Code _____

(2) STAPLES Quantity _____ lb

Manufacturer _____
Manufacturer's code _____ Lot _____

Type: Pallet staple _____
Length _____ in. Width _____ in.
Nominal wire diameter _____ in. Leg cross section _____ × _____ in.

Metal: Regular-stock steel _____ Finish: Bright _____ Galvanized _____ Coated (type) _____

Crown type: Flattened
Point type: Chisel

MIBANT angle _____ deg Performance index *FWI* _____
Performance index *FSI* _____

Code _____

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Part 6
Determination of Durability of Wood Pallets and Related Structures

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PART 6
DETERMINATION OF DURABILITY OF WOOD PALLETS AND RELATED STRUCTURES

1 SCOPE

(a) Part 6 is applicable to wood pallets and related structures constructed of lumber and other wood-base products and assembled with nails or staples. Durability is measured in terms of the number of one-way trips.

(b) The determination of pallet durability is important in establishing the economic performance characteristics of a pallet. The flexural strength and stiffness are measures of the physical performance characteristics of a pallet, which are not covered in Part 6.

(c) Pallet design considerations are based on pallet strength, stiffness, stability, and durability. These properties are the foundation for the pallet design system (PDS), adopted by the National Wooden Pallet and Container Association of Arlington, VA, for stringer and block pallets with lumber or panel decks.

2 PURPOSE

The main objective of Part 6 is to provide a procedure for the determination of the anticipated durability, that is, the life and cost of use of wood pallets and related structures.

3 DEFINITIONS AND TERMINOLOGY

The terminology used in Part 6 is in accordance with Part 1. The following specific definitions are basic to Part 6:

damage: any physical deterioration of the pallet or container due to any cause. Discussion: Pallet damage may refer to any single failure or to the accumulation of a series of single failures. Pallet damage is measured in terms of the frequency and the severity, or extent, of damage. Pallet damage accumulates at a compound rate relative to the amount of use, that is, one-way trips of the pallet.

damage cost: the measure of economic deterioration resulting from single occurrence of damage to pallet or container. Discussion: Damage cost is the cost of repairing a pallet during its economic life. Damage cost is computed as the product of damage frequency and cost per damage.

damage, cost per: the cost to repair a characteristic damage. Discussion: Cost per damage is computed as a regression relating the repair cost represented by an economic coefficient c to the severity of damage S [see Appendix A6-A, para. A7.4(g), where cost per damage is computed as $C = c \times 1.5^S$].

damage factors: measures of the proportionate damage to a pallet due to its specific structural characteristics or specific characteristics of the materials handling operations. Discussion: Nine damage factors have been defined from empirical studies [see Appendix A6-A, para. A7.4(g)].

damage frequency: number of occurrences of damage to a pallet during its economic life [see Appendix A6-A, para. A7.4(g)].

damage rate: percentage ratio of damage frequency per trip to total number of damages. Discussion: A measure of the overall damage frequency that a pallet will incur during use, where 1 plus the number of damages that a pallet sustains is equal to 1 plus the damage rate raised to the power of the number of uses [see Appendix A6-A, para. A7.4(g)].

damage severity: measure of the extent of pallet damage per damage occurrence. Discussion: Damage severity describes the extent of a characteristic damage to a pallet each time it is damaged. Severity of damage is dependent on the number and type of fasteners used in the pallet, the quality of the wood components, and the dimensions and density of the wood components [see Appendix A6-A, para. A7.4(g)].

durability: measure of life expectancy and cost per trip, in terms of number of one-way trips. Discussion: Durability is representative of the physical life expectancy of a pallet to the point in its life where the average cost of use is minimum. Use of the pallet beyond this point results in a marginal cost of use

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greater than the average cost of use. At this point, it is less costly to replace the pallet than to continue to repair it.

economic coefficient: a weighted index of pallet repair costs based on economic indicators obtained from publications of the Council Economic Advisors [see Appendix A6-A, para. A7.4(b)]. Discussion: The economic coefficient is computed as follows:

$$c = 0.0395\ (0.60LP + 0.15CP + 0.25PP)$$

where

CP = consumer price index for all items less food, energy, and shelter/100
LP = average gross weekly earnings in manufacturing/consumer price index for all items
PP = producer price index for other intermediate materials/100

NOTE: The regression equation for cost per damage was initially derived from data collected during the course of the study conducted from 1968 to 1971. The economic coefficient for that period was 0.0395. The adjustment to this coefficient is based on sample repair cost data collected annually from 1972 to 1984 and compared to costs predicted by the above regression. Adjustment is made annually based on the October data. The coefficients beginning in 1976 to 1984 were as follows: 0.0573, 0.0599, 0.0622, 0.0648, 0.0679, 0.0718, 0.0728, 0.0747, 0.0765, respectively.

economic life: number of trips pallet will make provided it is properly repaired, with maximum return on the investment. Discussion: Economic life is the period during which the pallet remains useful, terminated when it becomes uneconomic to continue pallet repair, expressed in number of one-way trips U.

fastener, base: the helically threaded, hardened-steel, $2\frac{1}{2} \times 120$AA nail used for assembly of the base pallet [see Part 5 and Appendix A6-A, para. A7.4(g)]. Discussion: The base fastener serves as the basis of measurement of the relative withdrawal resistance and the relative shear resistance. The base fastener is assigned a relative withdrawal-resistance value of 100% and a relative shear-resistance value of 100%.

fastener, specific: the particular fastener, nail or staple, under consideration for use in the specific pallet.

handling: a single physical movement as a result of picking up, transporting, and setting down of an empty or loaded pallet.

life expectancy: the number of one-way trips that a pallet will provide.

pallet, base: a stringer pallet selected as arbitrary basis for measurement of durability. Discussion: A high-quality pallet has performance characteristics in agreement with those selected to function as an arbitrary basis of comparison for measurement of pallet performance [see Appendix A6-A, para. A7.4(g)].

pallet, specific: the particular pallet design under consideration that is to be evaluated relative to the base pallet.

physical life: the number of uses that can be obtained before the pallet is sufficiently damaged to make it unusable. Discussion: At the end of the physical life of a pallet, it may be repaired at a cost to extend its life or replaced by a new pallet.

trip, average cost per: the minimum average cost of use per one-way trip A is the total cost to the pallet user T divided by the number of trips U. Discussion: The total cost T is comprised of the amortization of the initial price of the pallet P plus the total cost of damage D.

trip, one-way: the movement of the unit load from the shipper to the receiver, on the average including five handlings. Discussion: A one-way trip is comprised of four to six handlings. It is a single increment of use that a pallet user derives from a pallet in transferring an empty or loaded pallet, e.g., from a shipper to a receiver.

4 FACTOR FOR FASTENER WITHDRAWAL-RESISTANCE DAMAGE *F*(1)

Fastener withdrawal resistance FWR is computed using the fastener withdrawal index FWI in conjunction with the specific gravity GS and moisture content MC of the wood components. $F(1)$ is based on the ratio of the FWR of the base pallet to that of the specific pallet.

4.1 Symbols for Fastener Withdrawal Resistance

CL = length of staple crown measured between the staple legs, mm (in.)
FL = fastener length, mm (in.)
FWI = fastener-withdrawal index, %, the relative withdrawal resistance of the fastener used in the base pallet to that of the fastener use in the specific pallet

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FWR = fastener-withdrawal resistance, N (lb); the computed total withdrawal resistance of all fasteners in the pallet

$FWRF$ = fastener-withdrawal resistance for a single fastener, N (lb)

GD = oven-dry specific gravity of deckboard components

GS = oven-dry specific gravity of stringer or block components

H = number of helixes along the shank for helically threaded or fluted nails

HD = nail-head diameter, mm (in.)

HPR = head pull through resistance for a single fastener, N (lb)

MC = moisture content of wood at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)

N = number of fasteners driven into stringers or blocks

P = penetration of fastener shank into stringers or blocks, mm (in.), where P is the lesser value of TL or $(FL - T)$

T = thickness of deckboards, mm (in.)

TD = thread-crest diameter for threaded or fluted nails, mm (in.)

TL = thread length, mm (in.), e.g., length of threaded portion of shank

WD = round-wire diameter or the equivalent for square-wire nails and staples, mm (in.)

WT = thickness of flattened staple wire measured parallel to the staple-crown axis, mm (in.)

WW = width of flattened staple wire measured perpendicular to the staple-crown axis, mm (in.)

4.2 Fastener Withdrawal-Resistance Formulas

U-shaped staples formed from flattened wire:

$$WD = 1.27324\ (WW + WT)$$

U-shaped staples formed from round wire:

$$WD = 2WT$$

Twisted square-wire or helically fluted nails:

$$WD = 0.9TD$$

$$FWI = 8.7WD\ [1 + 27.15\ (TD - WD)\ (H/TL)]$$

$$(221.24)^1$$

$$FWRF = 38.9FWI\ GS^{2.25}\ P/(MC - 3)$$

$$(222.2)^1$$

$$HPR \text{ for nails} = 339T\ GD^{2.25}\ (HD^2 - WD^2)/(MC - 3)$$

$$(1{,}250{,}000)^1$$

$$HPR \text{ for staples} = 432T\ GD^{2.25}\ CL\ WW/[WW/(MC - 3)]$$

$$(1{,}591{,}550)^1$$

$$FWR = N \text{ (lesser value of } FWRF \text{ or } HPR)$$

Where more than one type or size of fastener is used in a pallet, the weighted average FWR is computed as follows:

$$F(1) = (243\ 394.56/FWR - 1)/10$$

$$(54{,}720)^1$$

5 FACTOR FOR FASTENER SHEAR-RESISTANCE DAMAGE $F(2)$

Fastener shear resistance FSR is computed using the fastener shear index FSI in conjunction with the specific gravity GD and the moisture content MC of the deck components. $F(2)$ is based on the ratio of FSR for the base pallet to that of the specific pallet.

5.1 Symbols for Fastener-Shear Resistance

C = number of fastener couples in all pallet connections where one staple is considered one fastener

Number fasteners per connection	2	3	4	5
Number couples per connection	1	3	4	5

FSI = fastener-shear index, %, the relative shear resistance of the nail used in the base pallet to the shear resistance of the specific fastener

FSR = fastener-shear resistance, N (lb), the computed total shear resistance of all fastener couples in the pallet

GD = oven-dry specific gravity of deckboard components

M = average MIBANT bend angle of fastener determined from test, using 15.6 N ($3\frac{1}{2}$ lb) weight and 392 mm ($15\frac{7}{16}$ in.) drop height or the equivalent computed for smaller weights and/or smaller drop heights

[1] Coefficient for Imperial units in lieu of coefficient for SI units.

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MC = moisture content of wood at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)
T = thickness of deckboards, mm (in.)
TD = thread-crest diameter, mm (in.)
WD = round-wire diameter or the equivalent for square-wire nails and staples, mm (in.)
WT = thickness of flattened staple wire measured parallel to the staple-crown axis, mm (in.)
WW = width of flattened staple wire measured perpendicular to the staple-crown axis, mm (in.)

5.2 Fastener Shear-Resistance Formulas

U-shaped staples formed from flattened wire:

$$WD = 0.84755\ (WW + WT)$$

U-shaped staples formed from round wire:

$$WD = 2^{0.5}\ WT$$

Twisted square-wire or helically fluted nails:

$$WD = 0.9TD \text{ [mm (in.)]}$$

$$FSI = 2056.5\ WD^{1.5}/(3M + 40)$$

$$(263{,}260)^{1}$$

$$FSR = 10.844\ FSI\ GD\ T\ C/(MC - 3)$$

$$(61.926)^{1}$$

$$F(2) = (53\,376/FSR)^{0.5} - 1$$

$$(12{,}000)^{1}$$

6 FACTOR FOR CONNECTION-SPLITTING RESISTANCE *F*(3)

This factor is computed using the fastener size WD for nails or WW for staples, and location, that is, width of edge stringers E in conjunction with the thickness T and specific gravity GD of the deckboards. It relates the splitting resistance of the deckboards of the base pallet to that of the specific pallet.

6.1 Symbols for Connection-Splitting Resistance

E = width of edge stringers, mm (in.)
GD = oven-dry specific gravity of deckboard components
T = thickness of deckboards, mm (in.)
TD = thread-crest diameter for threaded or fluted nails, mm (in.)
WD = round-wire diameter or the equivalent for square-wire nails, mm (in.)

6.2 Connection Splitting-Resistance Formulas

Twisted square-wire or helically fluted nails:

$$WD = 0.9\ TD$$

$$F(3) = (26.575WD/0.004526397GD^{2}\ E^{2}\ T^{0.5} - 1)/10$$

$$(675)^{1} \qquad (74.17436)^{1}$$

$$= 7.66229\ WD^{0.5}/(GD\ E\ T^{0.5}) - 0.1$$

$$(0.301665)^{1}$$

For pallets with $E \geq 47.625$ mm ($1\frac{7}{8}$ in.), and for wing-type or block-type pallets, $F(3) = 0.0$.

7 FACTOR FOR PALLET SHOOK QUALITY *F*(4)

This factor is a measure of the relative quality of the shook used for the base pallet to that used for the specific pallet. Shook quality is defined in terms of PEP grades given in Appendix A6-A, Table A1.1.

7.1 Terms for Pallet Shook Quality

minimum PEP grade (min. grade): the minimum quality of wood components permitted in the pallet, where PEP Grade 1 represents the highest quality and PEP Grade 5 represents the lowest quality.

average PEP grade (ave. grade): the weighted average grade of the mix used in the pallet.

7.2 Pallet Shook-Quality Formulas

For pallets constructed of shook consisting of a minimum grade and better, e.g., PEP Grade 3 & Better, $F(4) = 0.08\ (\text{min. grade})^{0.75}$.

For pallets constructed of shook consisting of specified grades, e.g., a mix of PEP Grade 3 and PEP Grade 4, $F(4) = 0.12$ (ave. grade).

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8 FACTOR FOR SELECTIVE PLACEMENT *F*(5)

This factor is a measure of the effect of selectively placing high-quality pallet components at the exposed ends and edges of the pallet.

When PEP Grade 1 boards are used for endboards and stringerboards, and PEP Grade 2 & Better stringers are used in edge-stringer locations, $F(5) = 0.0$.

When the above practice is not followed, $F(5) = 0.10$.

9 FACTOR FOR FLEXURAL STRENGTH OF STRINGER *R*(1)

The bending strength of the stringers in a specific pallet is computed relative to the strength of the stringers in the base pallet to provide a measure of the relative damage resistance.

9.1 Symbols for Stringer Strength

a = length of stringer notch, mm (in.)
b = total cumulative actual width of all stringers, mm (in.)
f = weighted average working stress in bending by species classes of green wood, computed as 0.3 times modulus of rupture, N/mm^2 (psi) (see Appendix A6-A, Tables A2.1 and A2.2)
g = factor for shook-grade adjustment applied to f value
h = height of stringers, mm (in.)
h' = depth of stringer notch, mm (in.)
l = location of notch measured from stringer end to start of notch, mm (in.)
C = $a + l$
K = moment factor of $^4/_3$ for simple beam with 2-point loading at third point
L = length of stringer, mm (in.)
MC = moisture content of wood at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)
MF = factor for moisture content based on moisture content at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)
P = safe load-carrying capacity of stringers, N (lb)
S = load span, mm (in.)
= $L - 50.8 - 2h(L - 2 - 2h)$
Y = factor for strength reduction due to notches

9.2 Stringer-Strength Formulas

$$Y = [(1 - h'/h)L]^2/[4C(L - C)]$$

$$g = 1 - 0.08 \text{ (min. grade)}^{0.75}$$

or

$$g = 1 - 0.12 \text{ (ave. grade)}$$

$$MF = (3 - MC/28)/2$$

$$P = KYbh^2fgLMF/S^2$$

$$R(1) = 13\,344/P - 1$$

$$(3000)^1$$

10 FACTOR FOR FLEXURAL STRENGTH OF DECKS *R*(2)

The combined strength of the top and bottom decks is computed as a composite beam and is related to the strength of the decks of the base pallet to provide a relative measure of damage resistance.

10.1 Symbols for Deck Strength

b = total cumulative actual width of bottom deckboard, mm (in.)
b' = total cumulative actual width of top deckboard, mm (in.)
f = working stress in bending (0.3 × *MOR*), N/mm^2 (psi)
g = factor for shook-grade adjustment applied to f value
h = thickness of bottom deckboard, mm (in.)
h' = thickness of top deckboard, mm (in.)
E = weighted average modulus of elasticity by species classes for green wood, N/mm^2 (psi) (see Appendix A6-A, Tables A2.1 and A2.2)
K = moment factor for different pallet designs and fasteners

	Number of Stringers			
Moment Factor K	2	3	4	5
Helically threaded nails with *FWI* and *FSI* of 100 or more	1.333	2.666	3.333	3.533
Other nails and staples	1.333	2.133	2.667	2.826

L = length of deckboard, mm (in.)

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MC = moisture content of wood at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)
MF = factor for moisture content based on moisture content at time of pallet assembly, % (maximum for green wood = 28%, minimum for dry wood = 12%)
MOR = modulus of rupture
P = safe load-carrying capacity of decks, N (lb)
S = load span, mm (in.)
= $L - 50.8$ ($L - 2$)
Y = factor for strength reduction due to notches

10.2 Deck-Strength Formulas

$$Y = (E'b'h'^3/Ebh^3) + 1$$

For pallets with same materials in top and bottom decks, $Y = (b'/b) + 1$

$$MF = (3 - MC/28)/2$$

$$P = KYbh^2fgL\,MF/S^2$$

$$R(2) = (17\,792/P)^{0.5} - 1$$

$$(4000)^1$$

11 FACTOR FOR DECK CONSTRUCTION *R*(3)

This factor is a measure of the effect of improving the deck to reduce pallet damage. The first two boards at each pallet end may be tightly butted together or the pallet may be constructed with a solid deck. In the case of a solid deck, the effect on damage is the same as when each of the two butted boards have three nails per connection. The deck may be improved also by using higher density boards for endboards than for centerboards.

11.1 Symbols of Deck Construction

BF = factor for effectiveness of butted deck endboards
G_1 = oven-dry specific gravity of endboards
G_2 = oven-dry specific gravity of centerboards
S = number of pallet stringers
W_1 = cumulative width of four endboards, mm (in.)
W_2 = cumulative width of the four endboards plus the butted centerboards, mm(in.)
W_3 = cumulative width of all centerboards, mm (in.)

11.2 Deck-Construction Formulas

Butting of endboards:

$$BF = 1.6 - W_2S/4572$$

$$(180)^1$$

Density of endboards equal to or less than that of centerboards:

$$R(3) = 1.6 - W_2S/4572 - 1$$

$$(180)^1$$

Density of endboards higher than that of centerboards:

$$R(3) = 1.6 - W_2S/4572\,(G_1W_1 + G_2W_3)$$

$$/G_1\,(W_1 + W_3) - 1$$

12 FACTOR FOR MATERIALS-HANDLING ENVIRONMENT *R*(4)

The materials-handling environment has a highly significant effect on pallet durability. This factor is a measure of the influence of 17 characteristics of the handling environment on pallet damage. These characteristics include equipment, facilities, handling practices, and pallet repair and maintenance practices. This factor may be determined by evaluating each of the 17 characteristics (as shown in Appendix A6-A, Form A3) or by employing the environment rating scale.

12.1 Environment Rating Scale Based on Analysis of Warehouse Operations

	Environment Rating Scale						
	Very Poor	Poor	Fair	Average	Good	Very Good	Excellent
R(4) factor	0.6	0.5	0.4	0.35	0.3	0.2	0.1

13 LIMITATIONS

The estimates of pallet life and cost per trip are average values for given pallet designs and are based on a large, although limited, number of observations in the laboratory and field. These estimates are considered to be the best available at this state of the art. When additional information becomes available, improved factors may be introduced. When applying the computed estimates to actual field conditions, particular

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emphasis may have to be given to variability in materials, workmanship, environment, and other factors.

Under certain conditions of use, actual tests of the pallet must be conducted before their field performance can be guaranteed.

14 DETERMINATION OF PALLET DURABILITY

The anticipated pallet durability is determined by means of a computer program. It is based on the use of factors $F(1)$ to $F(5)$ and $R(1)$ to $R(4)$. This computer program is available from the National Wooden Pallet and Container Association, 1800 North Kent Street, Arlington, VA 22209-2104.

The required information is listed in Appendix A6-A, para. A4.

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MANDATORY APPENDIX A6-A

(This Appendix is an integral part of Part 6 of ASME MH1-1997, and is included after the main text for the user's convenience.)

Appendix A6-A begins on next page.

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TABLE A1.1 PALLET SHOOK GRADES

Hardwoods and Southern Pine			
PDS Input	PEP Grades [1]	NWPCA Hardwood Pallet Standards [2]	NWPCA Southern Pine Pallet Specifications [3]
1	2 & Better	Precision & Better	SP-1 & Better
2	3 & Better	Premium/AA & Better	SP-2 & Better
3	4 & Better	A & Better	SP-3 & Better
4	5 & Better	All lumber	All lumber

Softwoods		
PDS Input	PEP Grades [1]	NWPCA West Coast [4] and White Woods [5] Pallet Standards
11	3 & Better	Premium & Better
12	4 & Better	Standard & Better
13	5 & Better	Shipping & Better

REFERENCES:
[1] Sardo, W.H., and W.B. Wallin, eds., *The Performance of Wooden Pallets in Pallet Exchange Programs,* 1974
[2] NWPCA Logo-Mark Hardwood Pallet Standards, March 1982
[3] NWPCA Specifications for Warehouse, Permanent, and Returnable Pallets of Southern Pine, NWPCA, 1962
[4] NWPCA Logo-Mark West Coast Pallet Standards, March 1982
[5] NWPCA Logo-Mark White Woods Pallet Standards, March 1983

TABLE A1.2 GROWTH-RELATED DEFECTS AFFECTING THE QUALITY OF PALLET COMPONENTS

Definitions	Defect Classifications
sound knots: a knot that is tight, solid, without voids, and at least as hard as the surrounding wood in at least one face, exhibiting structural strength. *unsound knots:* a knot that is loose and/or, due to decay, has no structural strength. *wane:* bark or lack of wood from any cause, except eased edges, on the edges or corners of the pallet component. *decay:* a disintegration of the wood substance due to actions of wood-destroying fungi, also known as dote, rot, and unsound wood. *splits or shake:* separation within a wood member not confined to the wood surface, usually intersecting two surfaces. For the purposes of this Standard, a crack intersecting only one face of the pallet part will be treated as a split only when it exceeds ½ the depth, width, or thickness of the piece.	**Critical Defects** Broken components Protruding nails on edge or end stringers, stringerboards, blocks, or deckboards Nonconforming pallets due to size, flatness, or squareness Missing wood exceeding allowable limits Notch area defects (splits, decay, excess knot) **Other Defects** Checks Component placing Compression wood Crook Decay Decayed knot Fastener in decay Fastener in max. wane Holes Honeycomb Inside shiner Knots Missing nail Moisture content Overhang Pitch Sawcut Shake Slope of grain Splits Step Underhang Wane Wane above notch Wane on edge of leading deckboard or exposed stringer

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TABLE A2.1 PALLET-COMPONENT WOOD-SPECIES CLASSES

North American Species [Note (1)]

Class 1 (0.67)

Hickory
Birch:
- Yellow
- Sweet

Maple:
- Sugar
- Black
- Red

Ash:
- Green
- White

Elm:
- Rock
- Slippery

American beech
Black locust
Black cherry
Tanoak
Dogwood
Persimmon
Eucalyptus

Class 2 (0.55)

Bigleaf maple
Oregon ash

Class 3 (0.54)

Sweetgum
Tupelo
Paper birch
Ash:
- Black
- Pumpkin

Hackberry
Sycamore
Maple:
- Silver
- Striped

Magnolia

Class 4 (0.61)

Oregon white oak
California black oak
Cascara
Chinquapin
Myrtle
Pacific Madrone

Class 6 (0.45)

Red alder

North American Species [Note (1)] (Cont'd)

Class 7 (0.40)

Aspen:
- Bigtooth
- Quaking

Catalpa
Buckeye
Butternut
American basswood
Cottonwood:
- Black
- Balsam poplar
- Eastern

Class 11 (0.51)

Douglas fir:
- Coast
- Interior west
- Interior north
- Interior south
- Western larch

Southern pine:
- Loblolly
- Longleaf
- Shortleaf
- Slash

Class 12 (0.42)

Hemlock:
- Western
- Mountain

Fir:
- California red
- Grand
- Noble
- Pacific silver
- White

Class 13 (0.42)

Spruce:
- White
- Black
- Red
- Engelmann
- Sitka

Pine:
- Sugar
- Western white
- Lodgepole
- Ponderosa
- Monterey
- Jack
- Norway
- Eastern white

North American Species [Note (1)] (Cont'd)

Southern pine:
- Pitch
- Pond
- Spruce
- Virginia

Fir:
- Subalpine
- Balsam

Baldcypress
Eastern hemlock
Western red cedar
Redwood

Class 14 (0.36)

Cedar:
- Alaska
- Incense
- Port Orford
- Atlantic white
- Northern white
- Eastern red

Class 21 (0.58)

Eastern red and white oaks

Class 29 (0.48)

Yellow poplar

Southern Asian Species

Class 31 (0.62)

Mengkulang
Kapur
Keruing

European Species

Class 32 (0.63)

Ash
Beech
Oak
Sycamore (plane)

European Species (Cont'd)

Class 33 (0.54)

Douglas fir
Larch
Pine:
- Maritime
- Scots
- Jack

Class 34 (0.43)

Poplar:
- Grey
- Black Italian

Elm:
- Dutch
- Redwood

Larch:
- Hybrid

Pine:
- Lodgepole
- Corsican

Fir:
- Silver

Class 35 (0.42)

Elm:
- English

Spruce:
- Silka

Whitewood

Class 36 (0.39)

Pine:
- Radiata

Spruce:
- Black
- Norway

Willow:
- White

Spruce:
- White
- Silka (UK, Eire)

Class 37 (0.36)

Poplar:
- Hybrid

(General Note and Note follow on next page)

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TABLE A2.1 (CONT'D)

GENERAL NOTE: Oven-dry specific gravity shown in parentheses.

NOTE:
(1) North American wood-species classes ranked according to relative strength and stiffness:

Strongest	21
	1
	2
	11
	29
	4
	6
	3
	12
	7
	13
Weakest	14

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TABLE A2.2 FLEXURAL PROPERTIES OF PALLET-COMPONENT WOOD-SPECIES CLASSES

	Stringer Component					Deckboard Component					According to		Grade Factor to Be Applied			
													Stringer		Deckboard	
Species Class	Grade No.	MOR, psi	C.V., %	MOE, ksi	C.V., %	Grade No.	MOR, psi	C.V., %	MOE, ksi	C.V., %	In-Grade Tests	Small Clear Spec.	MOR	MOE	MOR	MOE
1	1	7072	21.2	1487	25.2	1	7,028	23.2	1633	23.9	x	...	...	...	...	...
	2	6608	23.4	1401	24.8	2	6,717	24.3	1572	24.2	x	...	...	...	...	...
	3	6354	24.9	1353	25.1	3	6,624	25.1	1547	24.5	x	...	...	...	...	...
	4	6196	27.5	1328	26.3	4	6,574	25.8	1537	25.1	x	...	...	...	...	...
	5	6099	23.4	1308	21.9	5	6,229	27.3	1476	23.1	x	...	...	...	...	...
	6	5491	25.4	1191	21.6	6	6,008	28.7	1382	23.6	x	...	...	...	...	...
	7	4491	44.6	1050	30.3	7	5,819	34.4	1375	33.2	x	...	...	...	...	...
2	...	7050	20.0 [Note (1)]	1220	25.7 [Note (1)]	...	7,500	20.7 [Note (1)]	1220	23.3 [Note (1)]	...	x	0.792	0.856	0.759	0.965
3	1	5682	14.9	1159	16.7	1	5,727	21.4	1362	27.6	x	...	...	...	...	...
	2	5423	19.1	1137	24.7	2	5,362	23.5	1270	26.9	x	...	...	...	...	...
	3	5227	22.1	1111	23.7	3	5,252	24.5	1248	27.7	x	...	...	...	...	...
	4	5126	22.2	1092	24.3	4	5,231	25.8	1239	28.9	x	...	...	...	...	...
	5	5107	22.7	1111	32.5	5	5,091	24.0	1202	24.7	x	...	...	...	...	...
	6	4479	29.1	1011	14.8	6	4,776	27.4	1154	30.4	x	...	...	...	...	...
	7	3897	29.0	925	46.6	7	5,035	36.5	1150	39.2	x	...	...	...	...	...
4	...	6392	21.8	760	25.6	...	6,800	22.1	760	24.3	...	x	0.759	0.822	0.739	0.933
6	1	5112	17.6	1163	11.6	1	5,738	20.8	1341	20.3	x	...	...	...	...	...
	2	4797	20.1	1095	13.4	2	5,384	22.0	1250	20.7	x	...	...	...	...	...
	3	4676	21.3	1080	13.6	3	5,293	22.7	1228	20.2	x	...	...	...	...	...
	4	4501	24.0	1048	15.8	4	5,164	23.3	1197	20.6	x	...	...	...	...	...
	5	4625	20.6	1058	13.2	5	5,190	21.9	1199	19.8	x	...	...	...	...	...
	6	4371	23.1	1041	13.6	6	5,113	23.6	1187	18.4	x	...	...	...	...	...
	7	3899	29.3	939	18.9	7	4,840	23.8	1118	20.3	x	...	...	...	...	...
7	1	4859	12.6	1174	15.5	1	5,268	23.6	1453	26.1	x	...	...	...	...	...
	2	4501	19.6	1066	23.3	2	5,050	24.7	1390	27.7	x	...	...	...	...	...
	3	4283	22.6	1026	24.4	3	4,862	28.4	1351	30.1	x	...	...	...	...	...
	4	4128	26.1	1006	24.7	4	4,727	30.0	1323	30.3	x	...	...	...	...	...
	5	3606	23.1	910	22.1	5	4,825	25.5	1324	29.1	x	...	...	...	...	...
	6	3396	23.7	863	21.6	6	4,178	39.4	1210	37.9	x	...	...	...	...	...
	7	3397	38.2	795	24.8	7	3,756	35.6	1119	26.3	x	...	...	...	...	...
11	...	7003	20.0 [Note (2)]	1250	25.7 [Note (2)]	...	7,450	20.7 [Note (2)]	1250	23.3 [Note (2)]	...	x	0.792	0.856	0.759	0.965
12	...	5875	20.7 [Note (3)]	1250	25.3 [Note (3)]	...	6,250	21.3 [Note (3)]	1250	23.7 [Note (3)]	...	x	0.774	0.836	0.747	0.947

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TABLE A2.2 FLEXURAL PROPERTIES OF PALLET-COMPONENT WOOD-SPECIES CLASSES (CONT'D)

	Stringer Component					Deckboard Component					According to		Grade Factor to Be Applied			
													Stringer		Deckboard	
Species Class	Grade No.	MOR, psi	C.V., %	MOE, ksi	C.V., %	Grade No.	MOR, psi	C.V., %	MOE, ksi	C.V., %	In-Grade Tests	Small Clear Spec.	MOR	MOE	MOR	MOE
13	...	4841	21.8 [Note (4)]	1130	25.6 [Note (4)]	...	5,150	22.1 [Note (4)]	1130	24.3 [Note (4)]	...	x	0.759	0.822	0.739	0.933
14	...	4371	24.6 [Note (5)]	780	23.1 [Note (5)]	...	4,650	25.4 [Note (5)]	780	26.1 [Note (5)]	...	x	0.669	0.720	0.679	0.841
21	1	7880	20.2	1285	25.0	1	7,427	18.9	1397	25.1	x	...	...	...	...	...
	2	7413	22.2	1224	24.3	2	7,113	19.9	1343	24.7	x	...	...	...	...	...
	3	7059	24.4	1179	25.0	3	6,944	21.2	1311	25.6	x	...	...	...	...	...
	4	6648	28.2	1129	26.9	4	6,638	24.3	1261	27.4	x	...	...	...	...	...
	5	6955	22.8	1164	22.2	5	6,839	20.0	1296	23.6	x	...	...	...	...	...
	6	6328	25.1	1083	24.5	6	6,440	23.5	1216	27.2	x	...	...	...	...	...
	7	5406	33.5	978	28.6	7	5,764	29.3	1117	29.7	x	...	...	...	...	...
29	1	5605	17.6	1374	36.1	1	5,492	14.8	1338	22.7	x	...	...	...	...	...
	2	5428	19.6	1333	36.6	2	5,621	21.4	1314	25.0	x	...	...	...	...	...
	3	5305	21.0	1280	36.9	3	5,529	23.5	1296	25.9	x	...	...	...	...	...
	4	5182	23.1	1245	37.8	4	5,494	23.6	1287	25.8	x	...	...	...	...	...
	5	5169	21.7	1272	37.0	5	5,731	25.4	1294	27.0	x	...	...	...	...	...
	6	4711	25.2	1024	26.6	6	4,907	35.0	1166	31.4	x	...	...	...	...	...
	7	4111	33.2	953	36.5	7	4,640	43.6	1069	34.3	x	...	...	...	...	...
31	...	9776	...	1870	...	...	10,400	...	1870	...	...	x	...	...	...	...
32	...	7877	...	1320	...	...	8,380	...	1320	...	...	x	...	...	...	...
33	...	6260	...	1175	...	...	6,660	...	1175	...	...	x	...	...	...	...
34	...	5494	...	1060	...	...	5,845	...	1060	...	...	x	...	...	...	...
35	...	5100	...	1100	...	...	5,425	...	1100	...	...	x	...	...	...	...
36	...	4756	...	1000	...	...	5,060	...	1000	...	...	x	...	...	...	...
37	...	4362	...	610	...	...	4,690	...	610	...	...	x	...	...	...	...

GENERAL NOTE: MOR for stringers, derived from small clear specimens, adjusted by size factor of 0.94.

NOTES:
(1) Limited to Grade 3 & BTR.
(2) Limited to Grade Premium.
(3) Limited to Grade Standard & BTR.
(4) Limited to Grade Shipping & BTR.
(5) Limited to Grade Standard.

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FORM A3 PALLET PERFORMANCE TALLY FORM FOR MEASUREMENT OF THE HANDLING ENVIRONMENT CONDITIONS

	Sample		Completed	
	Characteristic	Damage Factor	Example Rate	Damage Factor
1	[(% of trucks with no side shifters)/400] + 1	_____	25%	1.0625
2	[(% of pallets handled with clamp platens)/200] + 1	_____	50%	1.025
3	[(% of pallets mishandled with hand jacks)/2000] + 1	_____	2%	1.001
4	[(% of pallets transported on roller conveyors)/1000 + 1	_____	0%	1.000
5	Warehouse layout orderly to congested: [(0 to 10)/1000] + 1	_____	10%	1.01
6	Housekeeping clean to dirty: [(0 to 10)/1000] + 1	_____	0%	1.00
7	Dock conditions clean and 10 + ft wide to clogged and under 10 ft wide: [(0 to 10)/1000] + 1	_____	2%	1.002
8	Deck height level with vehicle ± 6 in. to ± 12 in.: [(0 to 10)/1000] + 1	_____	0%	1.00
9	[(% of pallets entered with tines not level)/2000] + 1	_____	5%	1.0025
10	[(% of pallets entered at speeds over 2 mph)/2000] + 1	_____	0%	1.000
11	[(% of pallets skewed in process of handling)/1000] + 1	_____	10%	1.01
12	[(% of pallets pushed with tines during handling)/400] + 1	_____	15%	1.0375
13	[(% of pallets handled by hand)/2000] + 1	_____	5%	1.0025
14	[(% of pallets misused in handling system)/2000] + 1	_____	2.5%	1.00125
15	[(% of pallets stored outside when not in use)/4000] + 1	_____	50%	1.0125
16	[(% of pallets in use and needing repair)/2000 + 1	_____	10%	1.005
17	[(% of pallets repaired with inferior materials)/2000] + 1	_____	0%	1.000

Compute the product of all damage factors: damage rate r = (computed product − 1)100

(1.184 − 1)100 = 18.4% 1.184

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A4 DERIVATION OF ECONOMICS OF PALLET USE

(a) This model, as described in Appendix A6-A, para. A7.4(g), is based on the performance of a 1219 × 1016 mm (48 × 40 in.) base pallet constructed of green dense hardwood-lumber components having a modulus of elasticity in bending of 9653 MPa (1,400,000 psi), a modulus of rupture of 55 160 kPa (8000 psi), and an oven-dry specific gravity of 0.60. There are three equally spaced stringers: 48 mm ($1\frac{7}{8}$ in.) in width, 95 mm ($3\frac{3}{4}$ in.) in height with notches 35 mm ($1\frac{3}{8}$ in.) in depth, 229 mm (9 in.) in length, and located 152 mm (6 in.) from the stringer ends. The top deck of the pallet has nine boards 21 mm ($\frac{13}{16}$ in.) thick and 1016 mm (40 in.) in length; four of the boards are 140 mm ($5\frac{1}{2}$ in.) in width and five are 89 mm ($3\frac{1}{2}$ in.) in width; and two of the 140 mm ($5\frac{1}{2}$ in.) boards are butted together at each end of the pallet, while the rest of the boards are equally spaced. The bottom deck of the pallet has two 140 mm ($5\frac{1}{2}$ in.) boards at the pallet ends with two 140 mm ($5\frac{1}{2}$ in.) boards and one 89 mm ($3\frac{1}{2}$ in.) board equally spaced in the center. The pallet is of flush construction with four nails per connection in the bottom endboards, three nails per connection in the other 140 mm ($5\frac{1}{2}$ in.) boards, and two nails per connection in the 89 mm ($3\frac{1}{2}$ in.) boards. The nails are helically threaded, hardened-steel nails with head diameter of 7 mm (0.281 in.), wire diameter of 2.9 mm (0.113 in.), thread-crest diameter of 3.4 mm (0.133 in.), length of 57 mm ($2\frac{1}{4}$ in.) with thread length of 38 mm ($1\frac{1}{2}$ in.), four thread flutes, and thread angle of 60 deg with nail heads countersunk 1.6 mm ($\frac{1}{16}$ in.).

(b) This model is based on the analysis of empirical data obtained during the PEP studies [see Appendix A6-A, para. A7.4(g)]. It requires that a given pallet design be repaired and used until the average cost of use is at a minimum. Beyond this point, the cost of use is greater than the cost of use of a new pallet.

A4.1 Model Symbols

a = overall damage-rate factor for pallet
= $1 + r$
b = regression coefficient for wood pallet
= 1.5
c = economic regression coefficient based on economic indicators of cost of repair of pallets
ln = logarithm to the base e
r = overall damage rate for pallet
A = minimum average cost of use per one-way trip
= T/U
C = cost per damage to pallet
= cb^S
D = total damage cost to pallet during economic life
= CF
F = number of damages incurred during economic life
= $a^U - 1$
M = marginal cost per trip
= Ca^U (ln a)
P = price of pallet delivered, U.S. dollars
S = overall severity of damage to pallet
T = total cost of use of pallet during economic life
= $D + P$
U = economic life of pallet in number of one-way trips

A4.2 Pallet Damage Factors

$F(1)$ = factor for fastener-withdrawal resistance
$F(2)$ = factor for fastener-shear resistance
$F(3)$ = factor for connection-splitting resistance
$F(4)$ = factor for shook quality
$F(5)$ = factor for selective shook-quality placement
$R(1)$ = factor for flexural strength of stringers
$R(2)$ = factor for flexural strength of decks
$R(3)$ = factor for deck construction
$R(4)$ = factor for materials-handling environment

A4.3 Overall Pallet-Damage Rate *r*

The overall pallet damage rate r is computed as the summation of the influences of the F and R factors. It is a measure of the damage frequency of any specific pallet design. It is employed to determine the economic life and cost per one-way trip:

$$r = [1 + F(1)]\,[1 + F(2)]\,[1 + F(3)]\,[1 + F(4)]\,[1 + F(5)] \times [1 + R(1)]\,[1 + R(2)]\,[1 + R(3)]\,[1 + R(4)]\,[0.01]$$

A4.4 Overall Pallet-Damage Severity *S*

The overall pallet-damage severity S is computed as a summation of the influences of the F factors and the $R(4)$ factor. It is a measure of the severity, or extent, of damage for any specific pallet design. It is employed in combination with the overall pallet-damage rate to determine the economic life and cost per one-way trip:

$$S = [1 + F(1)]\,[1 + F(2)]\,[1 + F(3)]\,[1 + F(4)]\,[1 + F(5)] \times [1 + R(4)/2]\,[2.0]$$

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A4.5 Economic Life *U* and Cost of Use per One-Way Trip *A*

The minimum average cost per one-way trip A occurs at the point where the slope of the average cost curve is zero, and where the marginal cost M equals the average cost. Then the economic life of a pallet is determined by finding the U value at the minimum average cost A.

A4.5.1 Derivation of Formulas for Pallet Life and Cost per Trip *A*

$$A = (P + D)/U = [P + C(a^U - 1)]/U$$

Then, setting the derivative of A with respect to U equal to zero and solving for U

$$dA/dU = \left[[C - P + (CU \ln a a^U)] - Ca^U \right] /U$$

and

$$a^U (U - 1) - (P - C)/C = 0$$

Since this equation cannot be solved directly, Newton's method of successive approximation is used as follows:

$$gx_{k+1} = gx_k - (fgx/f'gx)$$

Solution for optimum life

$$fU = a^U (\ln a^U) - a^U - (P - C)/C$$

$$f'U = a^U \ln a^U \ln a = U(a^U) (\ln a)^2$$

Then,

$$U_{i+1} = U_i - fU/f'U$$

and, simplifying,

$$U_{i+1} = U_i - \left(\frac{a^U (\ln a^U) - a^U (P - C)/C}{a^U (\ln a^U) \ln a} \right)$$

Solution for frequency of damage:

$$fa^U = a^U (\ln a^U - 1) - (P - C)/C$$

$$f'a^U = \ln a^U$$

Then,

$$a^U_{i+1} = a^U{}_i - \left(\frac{a^U (\ln a^U - 1) - (P - C)/C}{\ln a} \right)$$

A5 REMARKS

Life expectancy and cost per use estimates were initially derived from empirical data collected on 20 different designs of pallets with 50 pallets of each design. Number of damages and extent, or severity, of each damage was recorded relative to number of trips of the pallets. These data were employed to compute an expected damage rate and severity for each design. The principal factor variables were identified based on comparisons of the different designs. The equations relating these variables to the properties of the pallet components were derived from historical research records and tested against the durability data for each design. The system was then computerized and tested for a year against the designs of pallets producted by ten large manufacturing firms to substantiate the differentiation among designs by the system.

The purpose of the system, therefore, is to provide a consistent relative measure of durability to differentiate designs. This was done consciously to fulfill a specific need. From this base, it has been possible to refine the system to reflect durability for individual pallets and assess the variance within a design, although at the present time, information on the distribution of some individual variables as well as on composites of these variables is limited.

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FORM A6 STRINGER-PALLET ANALYSIS DATA FORM

Purpose of Form

When completed, this Form contains the information needed to analyze a pallet design using the Pallet Design System—a computer-assisted design program. This is also the basic information Form on which recommendations of alternative, more efficient pallet designs can be based. Fill out this Form to the best of your ability. All pallet component dimensions must be actual at time of manufacture. Pallets must also be symmetrical across their length and width.

Date: _____

Customer Information

Requested by: _____

Company: _____

Address: _____

City, St, Zip: _____

Telephone: _____

FAX No.: _____

General Pallet Information

Pallet name _____ Single-use (S) or multiple-use (M) _____

Pallet length _____ Pallet width _____

Pallet style: Flush _____ Single wing _____ Double wing _____

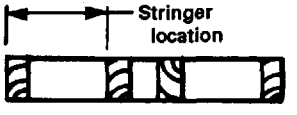
Single face _____ Double face _____

Two-way _____ Four-way (notched stringers) _____

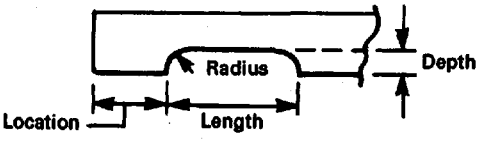
Stringer Data

Height _____ Length _____ Total no. of stringers _____

Below, show placement of stringer widths from left to right across the end of the pallet. (Example: A three-stringer pallet with 1.5 in. outside stringers and a 2-in. inside stringer would be written as: 1.5 - 2.0 - 1.5)

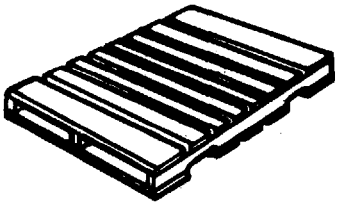


Notch data (4-way pallets): Depth _____ Location _____ Length _____ Fillet radius _____



Wood Species Used	Grade	Percentage (%)

Moisture Content (%) _____



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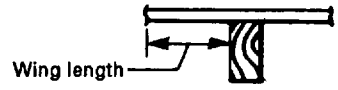
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Top Deckboard Data

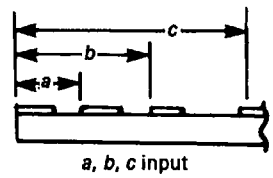
Thickness _____ Length _____ Wing length (winged pallets) _____ Total no. deckboards _____

Below, show placement of top deckboard widths from left to right across the edge of the pallet. (Example: A pallet with two 5.5 in. lead boards and five 3.5 in. internal deckboards would be written as: 5.5 - 3.5 - 3.5 - 3.5 - 3.5 - 3.5 - 5.5.)

Endboard placement: Flush _____ Butted _____

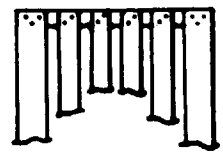


Deckboard spacing: Equally spaced _____ Unequally spaced _____
(NOTE: If deckboards are unequally spaced, indicate distance from stringer ends to deckboard lead edges.)



a, b, c input

Wood Species Used	Grade	Percentage (%)	Moisture Content (%) _____



Number of connections per stringer with: Two fasteners _____ Three fasteners _____ Four fasteners _____

Bottom Deckboard Data

Thickness _____ Length _____ Wing length (winged pallets) _____ Total no. deckboards _____

Below, show placement of bottom deckboard widths from left to right across the edge of the pallet. (Example: A pallet with two 5.5 in. lead boards and three 3.5 in. internal deckboards would be written as: 5.5 - 3.5 - 3.5 - 3.5 - 5.5.)

Endboard placement: Flush _____ Butted _____

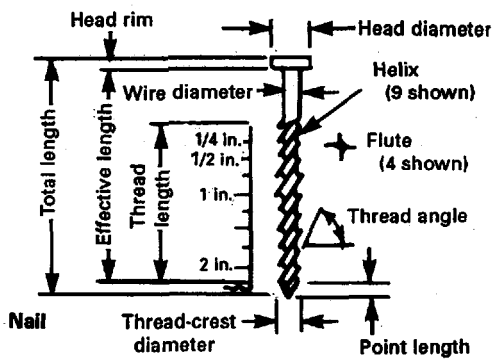
Deckboard spacing: Equally spaced _____ Unequally spaced _____
(NOTE: If deckboards are unequally spaced, indicate distance from stringer ends to deckboard lead edges.)

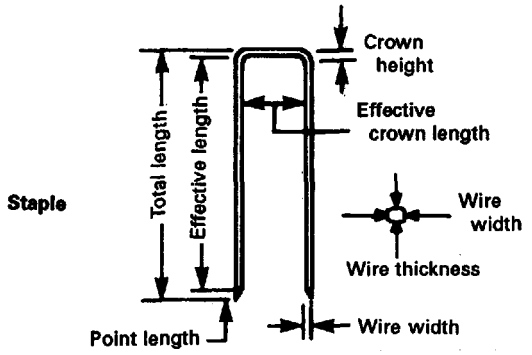
Wood Species Used	Grade	Percentage (%)	Moisture Content (%) _____

Number of connections per stringer with: Two fasteners _____ Three fasteners _____ Four fasteners _____

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	Fastener Data	
	Top Deck	Bottom Deck
Fastener type [Note (1)]		
Fastener length		
Thread length		
Thread diameter (*TD*)		
Wire diameter (*WD*)		
No. of flutes (screw nails)		
No. of helices (screw nails)		
No. of rings (ring-shank nails)		
Nail head diameter (*DH*)		
MIBANT bend angle		
Crown length (staples)		
Leg thickness (staples)		



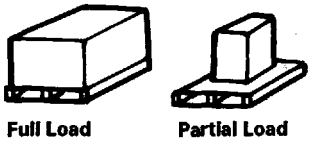


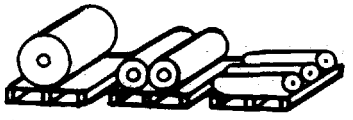
NOTE:
(1) Fastener types may include helically threaded nails (screw nails), annularly threaded nails (rink-shank nails), square wire nails, plain-shank nails, round wire staples, and rectangular wire staples.

Load Information

Load Type:

- Full uniform load _____
- Partial uniform load _____
- One-line load _____
- Two-line load _____
- Three-line load _____





GENERAL NOTE: For partial uniform loads, indicate where the load starts from both the stringer and deckboard ends. For line loads, indicate if the line loads are parallel or perpendicular to the stringers and note the distance from pallet edge/end to placement of the line loads.

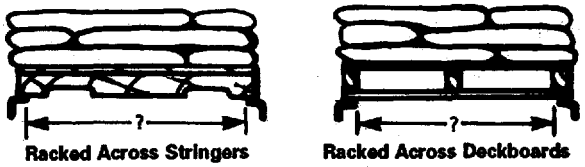
Load Weight: Load variability: Low _____ Medium _____ High _____

Total weight (lb) Max. _____ Min. _____ Avg. _____

Coefficient of variation (C.V.) (%) _____ (C.V. = standard deviation/average x 100)

Load support conditions:

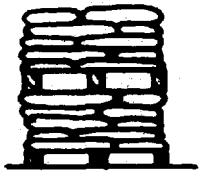
If pallets are placed in rack storage, the ***exact*** span between supports is critical for determining safe pallet load-bearing capacities!



Racked across stringer span _____

Racked across deckboard span _____

How high are pallet loads stacked (max.)? _____



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Durability Analysis Data

The Pallet Design System-Stringer Version (PDS-Stringer) offers two durability analyses options: an economic durability analysis and a durability index analysis. The economic durability analysis provides a predicted economic life, life to first repair, cost per one-way trip, and average cost per trip before repair. The durability index is a relative scale used to compare the durability between different pallet designs. To perform an economic durability analysis, both a rating of the handling environment and the delivered price of the pallet is required. The durability index procedure does not require information about the handling environment or the pallet price.

Durability analysis requested: Economic _____ Index _____

GENERAL NOTE: To perform an economic durability analysis, the delivered pallet price is due to the economic design of the durability model.

Material handling environment rating (see below) _____

Very poor	= 1
Poor	= 2
Fair	= 3
Average	= 4
Good	= 5
Very good	= 6
Excellent	= 7

Delivered price of pallet (U.S. $) _____

Other Pertinent Information

To provide the best service for our customers, the Pallet & Container Research Laboratory needs all the information about your pallet design that is possible for you to provide. It is important that you fill this information sheet out to the best of your ability. Include other information, such as pallet drawings, pallet specification sheets, fastener specifications, information about the product to be shipped on the pallets, and sketches of load and support conditions. This will help us solve your pallet design problems. It is our goal to provide you with the best, safest, most economical pallet design for a given materials handling requirement.

Whom to Contact to Perform Analyses

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A7 APPLICABLE DOCUMENTS

A7.1 ASME Standards

ASME, 345 East 47th Street, New York, NY 10017

(a) ASME MH1.8M-1996, Wood Pallets

A7.2 ASTM Standards

ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

(a) ASTM F 680-93(87), Standard Methods of Testing Nails

(b) ASTM D 1185-94 Methods for Testing Pallets and Related Structures Employed in Materials Handling and Shipping

A7.3 NWPCA Specifications and Standards

NWPCA, 1800 North Kent Street, Arlington, VA 22209

(a) Pallet Design System, 1990

(b) Uniform Standard for Wood Pallets, 1996

A7.4 U.S. Government Publications

(a) Abramowitz, M., and I. A. Stequn, *Handbook of Mathematical Functions,* U.S. Department of Commerce, Washington, DC, 1964

(b) Council of Economic Advisors, *Economic Indicators,* Joint Economics Committee of U.S. Congress, Washington, DC

(c) Markwardt, L. J., and T. R. C. Wilson, *Strength and Related Properties of Woods Grown in the United States,* Technical Bulletin No. 479, U.S. Department of Agriculture, Washington, DC, 1935

(d) Sardo, W. H., Jr., and W. B. Wallin, *The Performance of Wooden Pallets in Pallet Exchange Programs,* National Wooden Pallet and Container Association, Arlington, VA, 1974

(e) U.S. Forest Products Laboratory, *Wood Handbook,* Agriculture Handbook No. 72, U.S. Department of Agriculture, Washington, DC, 1987

(f) U.S. Forest Service, *An Analysis of the Timber Situation in the United States 1952–2030,* Forest Resources Report No. 23, U.S. Department of Agriculture, Washington, DC, 1982

(g) Wallin, W. B., and K. R. Whitenack, "Durability Analysis for Wooden Pallets and Related Structures," Forestry Sciences Laboratory, unpublished report, August 1982 (revised January 1984)

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Part 7
Testing Procedures for Pallets and Related Structures

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PART 7
TESTING PROCEDURES FOR PALLETS AND RELATED STRUCTURES

1 SCOPE

(a) Part 7 describes laboratory test procedures for evaluating the anticipated performance of expendable and reusable pallets.

(b) Numerous techniques of testing pallets have been proposed and published. Few of them are actually used. In the light of technological developments during the past decade, some of the described procedures have met with approval. Laboratory evaluation of pallet performance and design has been based on them. Yet, appropriate in-service testing under actual-use conditions may be required for final evaluation of laboratory-tested pallets.

(c) Because only limited experience exists concerning the merit of some of these test procedures, they should be considered tentative until such time as their merits will have been fully established. Therefore, the proposed procedures should be looked at as alternate ways of evaluating pallet performance.

(d) Only those procedures should be used that are considered appropriate in a given instance to throw light on the aspects to be investigated. In many instances, only two or three types of tests may have to be performed, whereas, in other instances, more tests need to be given consideration. For potential uses of these described test procedures, refer to Appendix A7-A.

(e) The performance of pallets under anticipated field conditions should be the sole criterion for the selection of the test procedures to used. Each procedure described simulates exposures during which certain stresses imposed by given external forces are applied. These forces result from proper use, abuse, handling, transportation, storage, and other hazards to which pallets are subjected. A given test procedure may simulate only one, or at best, a few of such hazards that contribute to the forces to be withstood by pallets without excessive deterioration.

(f) The testing of a single pallet per test does not provide satisfactory qualitative information for most use conditions encountered. The required number of test replications varies with the use under consideration. However, a minimum of three pallets should be subjected to each type of test to be performed to assure some degree of confidence in the test results.

(g) For uniformity of evaluation, it is suggested that the detailed procedures be followed in the testing of pallets as long as there is no urgent reason to deviate from them. If such a reason should exist, the reasoning should be included in the report in which the findings are presented.

(h) It is difficult to determine how much or how little deterioration can be allowed before a pallet should be repaired or discarded. Such criteria have to be established by the pallet user. No consideration is given to these criteria in the test procedures described.

2 PURPOSE

(a) The main objective of Part 7 is to provide pallet manufacturers and users with test procedures to determine anticipated performance of pallets when used in industry, transport, and service.

(b) Performance criteria are not included, since they should be established by the pallet users to meet their particular requirements.

(c) One or more of the test procedures presented in Part 7 may be used to measure expected performance against selected criteria.

3 PALLET CONDITIONING

(a) Special conditioning is not always required. However, the physical characteristics and performance of pallets can vary greatly depending not only on ambient temperature and relative humidity at time of test, but also on the conditions at time of manufacture as well as on interim storage conditions and length of time in storage. These influencing factors can be particularly important if the materials of which the pallets are made are hygroscopic in nature as well as in the instance of lumber which may have been green or partially or fully seasoned during assembly. In addition, most pallets are placed into service shortly after being manufactured and, thus, are subjected to loading, vibration, shock, and hazards of use while at or close to the initial

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moisture content of the components prevailing at the time of manufacture.

Consequently, it may be preferable to evaluate pallets shortly after manufacture, foregoing conditioning to simulate potential actual field conditions. On the other hand, conditioning prior to testing may be necessary to simulate effects resulting from exposure to high or low or both levels of temperature as well as high or low or both levels of humidity during actual use.

(b) Where pallet reuse is a factor and, especially, where longlife expectancy is anticipated, it may be advisable to expose pallets to prescribed conditions for periods of time up to several weeks prior to testing. In the instance of pallets incorporating materials highly susceptible to moisture conditions and changes in moisture content, proper conditioning prior to testing as well as during testing in a controlled atmosphere may be a mandatory requirement. For wooden pallets, 5 to 8 week storage of the pallets in 50% relative humidity and 70°F (57°C) temperature may be sufficient to result in such conditions as are often encountered in warehouses.

(c) Lack of any preconditioning, chosen preconditioning, or exposure to given cyclic laboratory preconditioning should be reported on in detail in the test report.

4 DROP TESTS

The drop tests simulate stresses and strains imposed by dropping pallets during handling. Such dropping may occur during unsticking of pallets and during removal of pallets with handling and lifting equipment. This dropping may occur with both loaded and unloaded pallets.

(a) Three basic types of tests fall in this category:

(1) corner drop of vertically suspended pallet;

(2) edge drop of slightly inclined suspended pallet; and

(3) corner drop of more or less horizontally suspended loaded pallet.

(b) The pallet is dropped from a given height. Therefore, the pallet weight is of significant influence on the test data. To eliminate such a test parameter, a given weight could be dropped on a pallet from a given height. No standard procedures of testing complete pallets, based on the latter principle, have been advanced to date. On the other hand, procedures for testing pallet sections, based on the dropping of a given weight onto the pallet section from predetermined heights, have been developed. These procedures are covered in Appendix A7-B.

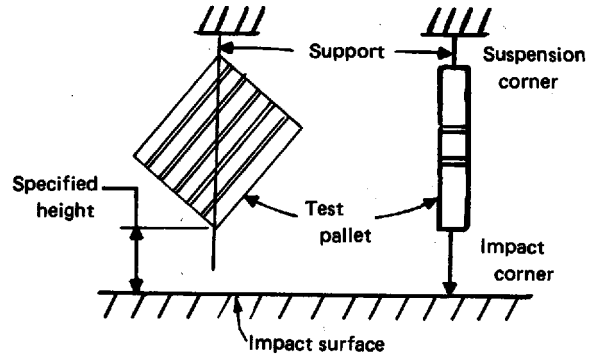


FIG. 1 CORNER DROP OF VERTICALLY SUSPENDED PALLET

4.1 Corner Drop of Vertically Suspended Pallet (See Part 7, Fig. 1)

(a) This free-fall drop test on one of the pallet corners is performed to determine the rigidity of the unloaded pallet and its resistance to cornerwise impact and racking forces in the plane of the pallet.

(b) The unloaded pallet is suspended at one corner in such a manner that the diagonal across the pallet face from the suspended corner to the impact corner is vertical. The lowest corner of the pallet is located at a specified height, usually 40 in. (1016 mm) above the level, smooth, and hard surface of a rigid, massive block of metal or concrete or both materials. The pallet is allowed to fall freely from this position onto the impact surface. After the impact has occurred, the pallet is restrained so as to prevent a secondary fall. This procedure is repeated, always dropping the pallet on the same corner from the specified height between the lowest pallet corner and the impact surface.

(c) The following test equipment is required:

(1) a suitable suspension device, such as a hoist or forklift truck allowing accurate positioning of the suspended pallet;

(2) a release mechanism, such as a solenoid release;

(3) a rigid, massive block of metal or concrete or of both materials, having a level, smooth, and hard surface;

(4) a graduated scale of sufficient length or a calibrated rod with attached scale for measuring the lengths of the pallet diagonals, allowing observations as small as 0.06 in. (1.5 mm).[1]

(d) Prior to the first drop and after each drop, the

[1] If it is desired to plot curves requiring greater accuracy, this measurment may be made in 0.01 in. (0.25 mm) increments.

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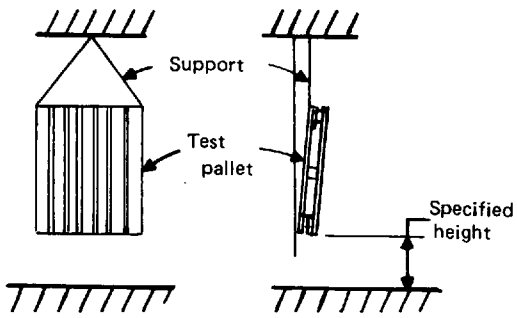


FIG. 2 EDGE DROP OF SLIGHTLY INCLINED SUSPENDED PALLET

lengths of each of the two top-deck and two bottom-deck pallet diagonals are measured and recorded. The measurements are taken between reference marks (or pins) near the four corners of both the top and bottom of the pallet, with the marks spaced 0.5 in. (12.7 mm) or 1.0 in. (25 mm) from both edges leading to each corner. At the impact corner of the pallet, it may be advisable to place a second mark spaced 1.0 in. (25 mm) from the first mark along the diagonal, in the instance any damage of the corner should extend to and beyond the first mark.

If it is desired to plot curves requiring greater accuracy, this measurement may be made in 0.01 in. (0.25 mm) increments.

(e) In evaluating the test data, the following steps are required. First, the changes in lengths of the four diagonals after each drop are averaged. The average distortions of the pallets are plotted against the number of free falls to provide a visual record of the test values. Second, the percentages of the distortion based on the original dimensions of the four pallet diagonals are averaged and tabulated. Third, the sum of the average changes in lengths of the four diagonals after each drop is determined and recorded.

(f) The test is terminated when the pallet will no longer function properly during its intended use.

(g) Any major and minor defects and damages of deckboards, decks, stringer, blocks, and fasteners, observed immediately prior to, during, and after testing, are recorded for given drops.

(h) To allow satisfactory interpretation of the test findings, supplementary information is collected and recorded covering:

(1) the design and construction of the pallet;

(2) the materials used, including the specific gravity based on oven-dry weight and volume at time of test in the instance of a wooden pallet;

(3) the overall dimensions of the pallet; and

(4) its weight after assembly and immediately prior to the performance of the test.

NOTE: An alternate test procedure requires the dropping of the pallet in such a way that, during four successive drops, the pallet is impacted consecutively on each of the four pallet corners, with, for instance, drops on the two diagonally opposite corners followed by drops on the other set of diagonally opposite corners. This test cycle is repeated as often as necessary for failure to occur.

4.2 Edge Drop of Slightly Inclined Suspended Pallet (See Part 7, Fig. 2)

(a) This free-fall drop test is performed to determine the resistance of the unloaded pallet to edge-wise impact.

(b) The unloaded pallet is suspended from the two highest adjacent corners of the slightly inclined top deck in such a manner that the lowest edge of the deck is horizontal and at a specific height above the level, smooth, and hard surface of a rigid massive block of metal or concrete or both materials. The pallet is allowed to fall freely from this position onto the impact surface. After the impact has occurred, the pallet is restrained so as to prevent a secondary fall.

(c) This procedure is repeated in such a way that, during four successive drops, the pallet is impacted consecutively on each of the two pallet sides and two pallet ends, with, for instance, drops on two opposite sides followed by drops on two opposite ends. This test cycle is repeated as often as necessary for failure to occur. Failure is considered to have occurred when the pallet will no longer function properly during its intended use. A drop height is selected to allow completion of at least one test cycle prior to failure.

(d) The following test equipment is required:

(1) a suitable suspension device, such as a hoist or forklift truck;

(2) a release mechanism such as a solenoid release;

(3) a rigid, massive block of metal or concrete or blocks of both, having a level, smooth, and hard surface; and

(4) a graduated scale of sufficient length.

(e) See para. 4.1(g).

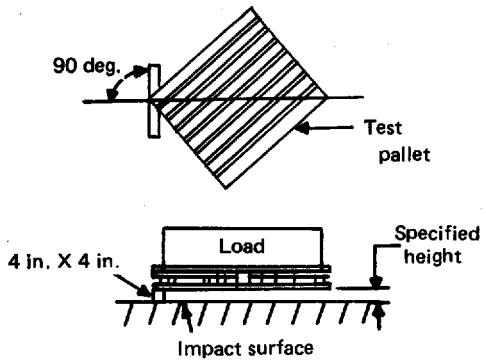
(f) See para. 4.1(h).

4.3 Corner Drop of More or Less Horizontally Supported Loaded Pallet (See Part 7, Fig. 3)

(a) This free-fall test is performed to determine the capacity of a loaded pallet to support a given load and to absorb a given amount of shock.

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FIG. 3 CORNER DROP OF MORE OR LESS HORIZONTALLY SUPPORTED LOADED PALLET

(b) The pallet is placed in more or less horizontal position, supported by:

(1) a 4.0 in. (102 mm) high, 4.0 in. (102 mm) wide, and 12.0 in. (305 mm) long block placed under one pallet corner at an angle of 90 deg to a pallet diagonal and flush with the outer corner of the pallet bottom; and

(2) a 4.0 in. (102 mm) square block of specified height, placed under the diagonally opposite pallet corner and flush with the outer corner of the pallet bottom. The pallet is loaded with a specified load, or a load which simulates that expected in service, and the load is secured to the pallet as required. Then the 4.0 in. (102 mm) square block of specified height is pulled with a rope from under the pallet to allow the pallet corner to fall freely and impact onto the level, smooth, and hard surface of a rigid, massive block of metal or concrete or both materials.

(c) Instead of placing one corner of the pallet on the 4.0 in. (102 mm) square block of specified height, the pallet corner may be suspended from a hoist of sufficient capacity, allowing accurate positioning of the suspended pallet corner. Then, by activating a release mechanism, such as a solenoid release, the suspended pallet corner is allowed to drop freely onto the impact surface.

(d) This procedure is repeated in such a way that during four consecutive drops, the pallet is impacted consecutively on each of the four pallet corners, with, for instance, drops on two diagonally opposite corners followed by drops on the two other diagonally opposite corners. This test cycle is repeated as often as necessary for failure to occur. The test is terminated when the pallet will no longer function properly during its intended use. A drop height is selected to allow completion of at least one test cycle prior to test termination.

NOTE: An alternate test procedure requires the introduction of a twisting force by placing one pallet corner on a nominal 6 in. (152 mm) high block and an adjacent corner at the same pallet end on a nominal 12 in. (305 mm) high block. The test is conducted by raising the opposite pallet end until the lower corner is at the prescribed drop height and by dropping each of the four bottom pallet corners from 6.0, 12.0, 18.0, and 24.0 in. (152, 305, 457, and 610 mm). After these series of 16 falls, four additional drops are made, one on each pallet bottom side and end, from a height of 24.0 in. (610 mm) while the opposite pallet side or end is supported on a single 6.0 in. (152 mm) high block.

5 INCLINE-IMPACT TESTS

The purpose of these tests is to simulate the stresses imposed by lateral forces applied to various parts of the pallet. These stresses occur at certain stages of the pallet handling cycle such as:

(a) sudden acceleration and deceleration of transportation vehicles (switching rail cars);

(b) fork heel impact when forklift truck fork heels strike the leading-edge deckboard upon termination of fork entry;

(c) fork impact when misaligned forks strike the corner posts or stringers upon pallet entry;

(d) fork toe pressure when the pallet is turned on its axis by a fork pushing against the pallet corners (sluing).

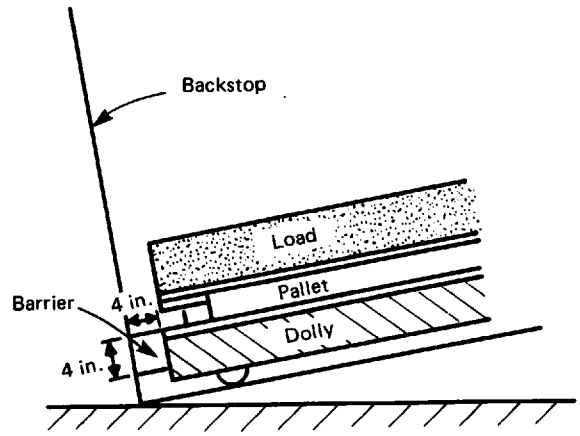
5.1 Incline-Impact Test for Pallet-Bottom Car-Switching Resistance (See Part 7, Fig. 4)

(a) A test pallet shall be loaded with the specified goods or a simulated load of the same density as the material that is customarily placed on the pallet. The same form of packaging (if the goods are ordinarily packed in bags, cartons, cases, or other containers, they shall be used in the test) as well as the same load pattern arrangement on the pallet shall be followed.

(b) Load the test pallet uniformly with a suitable load which does not overhang the pallet and is secured to the pallet. Place the loaded pallet on the dolly of the testing machine, as described in ASTM Standard D 880, with the leading edge of the bottom-end deckboard of the pallet flush with the forward edge of the dolly. When there are no bottom deckboards, place the between-deck supports flush with the forward edge of the dolly.

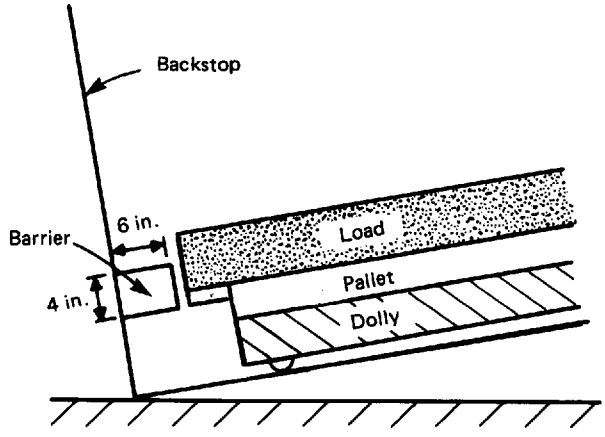
(c) The dolly with the loaded pallet shall be brought to a predetermined position, approximately 8 in. (203

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FIG. 4 INCLINE-IMPACT TEST FOR PALLET-BOTTOM CAR-SWITCHING RESISTANCE



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FIG. 5 INCLINE-IMPACT TEST FOR TOP-DECK LEADING-EDGE FORK-HEEL IMPACT RESISTANCE

mm) up the incline, and released. Each impact shall be considered a cycle. If more than one cycle is specified or desired, the point on the incline from which the dolly is released for each cycle shall be the same.

(d) Load a second test pallet, as described in (a) and (b) above, however, with the pallet on the dolly so that the impact is directed against the pallet along a line 90 deg to the axis of the pallet from that used in the previous test.

(e) Test as described in (c) above.

(f) Secure a solid, high-density hardwood (of 0.60 or higher oven-dry specific gravity) hazard, at least as long as the width of the pallet, to the face of the backstop. The upper edge of the barrier shall be level with the top edge of the bottom deckboard of the pallet when the dolly is in its lowest position. If the pallet has no bottom deckboard, the barrier shall extend 0.25 in. (6.4 mm) above the level of the top edge of the dolly. The barrier shall project outward from the face of the backstop such a distance that there shall remain at least 4 in. (102 mm) between the backstop and the nearest edge of the pallet when the forward edge of the dolly is resting against the barrier.

(g) The test is terminated when the pallet will no longer function with the particular type or size of handling devices intended for use, or when the pallet will no longer support the load.

5.2 Incline-Impact Test for Top-Deck Leading-Edge Fork-Heel Impact Resistance (See Part 7, Fig. 5)

(a) The provisions of para. 5.1(a) through para. 5.1 (c) are applicable.

(b) To simulate fork heel impact stresses, two high-density hardwood hazards [see para. 5.1(f)], 4.0 in. (102 mm) long, 6.0 in. (152 mm) wide, and 4.0 in. (102 mm) thick (high) shall be used (see Fig. 5). The hazards shall be positioned so as to meet squarely the leading edge of the top deck, equidistant between the outside stringers or blocks and center stringer(s) or block(s).

5.3 Incline-Impact Test for Fork Toe and Slue Resistance of Stringer or Block (See Part 7, Fig. 6)

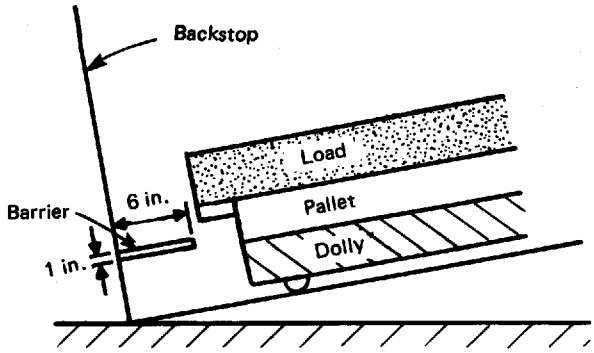
(a) The provisions of para. 5.1(a) through para. 5.1 (c) are applicable.

(b) To simulate fork toe impact of sluing stresses, a slightly different hazard (and hazard position) shall be firmly attached to the backstop (see Part 7, Fig. 6). This high-density hardwood [see Part 7, para. 5.1(f)] or steel hazard shall be 6.0 in. (152 mm) long, 6.0 in. (152 mm) wide, 1.0 in. (25.4 mm) thick (high) and gently rounded at the protruding end. The barrier shall be level with the middle of the block or stringer and positioned so as to meet one of the outside corners of the pallet.

5.4 Incline-Impact Pallet Distortion Test (See Part 7, Fig. 7)

(a) The incline-impact distortion test is performed

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FIG. 6 INCLINE-IMPACT TEST FOR FORK TOE AND SLUE RESISTANCE OF STRINGER OR BLOCK

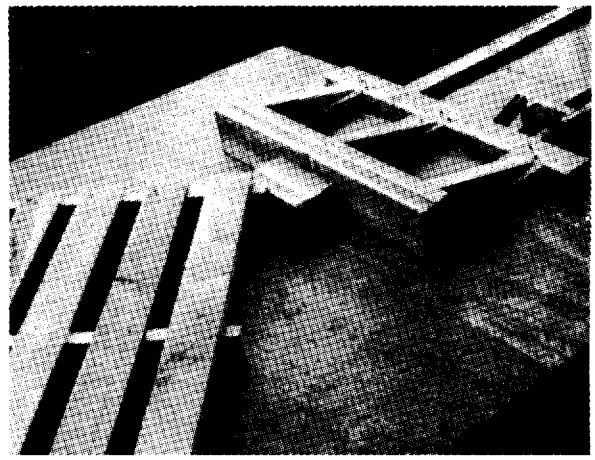


FIG. 8 INCLINE-IMPACT PALLET DISTORTION TEST WITH BARRIER AFFIXED TO DOLLY

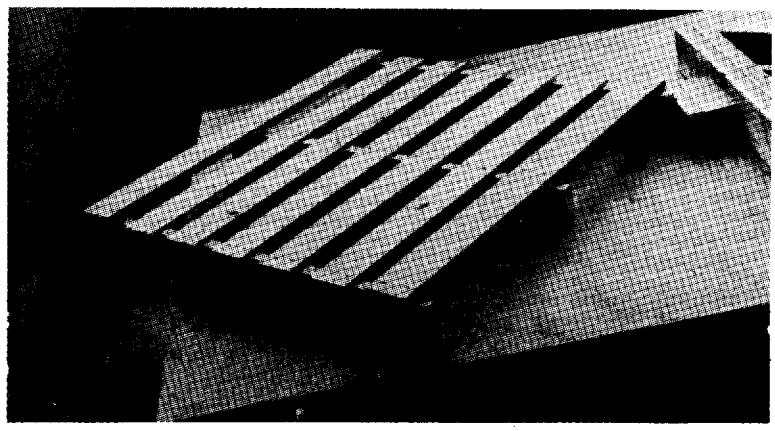


FIG. 7 INCLINE-SUPPORT PALLET DISTORTION TEST WITH PALLET OVERHANGING DOLLY

to determine the rigidity of the unloaded pallet and its resistance to cornerwise impact and racking forces in the plane of the pallet.

(b) The incline-impact tester, a standard package testing apparatus, as described in ASTM Standard D 880, is modified by:

(1) affixing a barrier to the dolly, positioned so that test pallets will overhang the front of the dolly by 9.0 in. (229 mm) when braced against the backstop (see Part 7, Figs. 7 and 8); and

(2) addition of a stop to prevent secondary impacts (see Part 7, Fig. 9).

(c) The dolly of the incline-impact tester is raised up to incline so as to provide clearance for the overhang of the pallet. The pallet is placed on the dolly in contact with the barrier on the dolly. The corner of the pallet touching the backstop and the diagonally opposite corner of the pallet shall be on a line perpendicular to the backstop. Prior to the first impact and after each additional impact, the distance between the two pallet corners forming the diagonal parallel to the backstop is accurately measured to 0.06 in. (1.5 mm).

(d) The dolly is then raised to a distance of 8.0 in. (203 mm) up the incline to provide an impact to the extended pallet corner. After release of the dolly and primary contact with the backstop of the impact tester, a block is dropped in between the dolly and backstop to prevent secondary impacts. The procedure is repeated, always, impacting the pallet on the same corner from the original distance up the incline.

(e) The test data are evaluated in a manner similar

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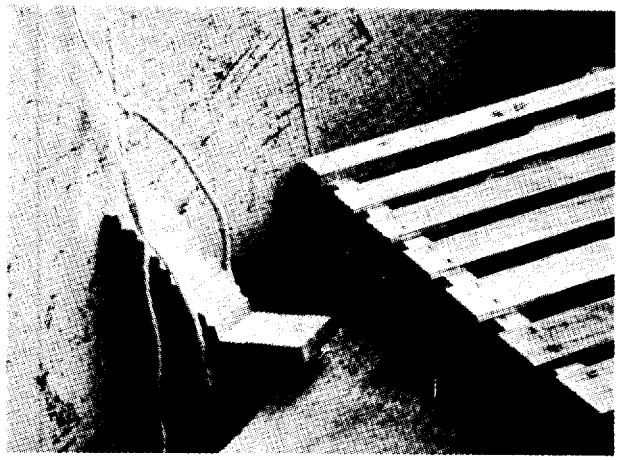


FIG. 9 BLOCK TO PREVENT SECONDARY IMPACTS AFTER PERFORMANCE OF INCLINE-IMPACT PALLET DISTORTION TEST

to that described for the corner drop of vertically suspended pallet (see Part 7, para. 4.1).

NOTE 1: The test procedure described above is intended as an alternate to the corner drop of vertically suspended pallet test procedure (see Part 7, para. 4.1).

The incline-impact test has the advantage of better control of the test sample during and after the test, e.g., there is no need to prevent the pallet from falling after the drop. Furthermore, substantial variation in all drop test results is attributable to the weight of the pallet. Although weight is a consideration, it is less of a factor in the incline-impact test, as is shown in the following presentation.

For the drop test:

$$V = \sqrt{2gh}$$

For a drop height of 40 in. (1016 mm):

$$V = \sqrt{(2)(32.2 \text{ ft/sec}^2)(3.3 \text{ ft})}$$

$$= 14.58 \text{ ft/sec}$$

For an incline-impact test from 8.0 in. (208 mm):

$$V = \sqrt{(2)(g \sin 10 \text{ deg})(8/12 \text{ ft})}$$

$$= 2.73 \text{ ft/sec}$$

The kinetic energy ($\frac{1}{2}MV^2$) for various pallet weights including the dolly weight of 395 lb (179 kg) would be for the two test procedures as shown in Part 7, Table 1.

NOTE 2: In order to eliminate variations in the mass of the moving parts, supplementary weights can be added to or removed from the dolly, for the total gross weight of pallet, dolly, and supplementary weights to be constant for all tests to be performed on a comparative basis.

5.5 Incline-Impact Deckboard-Stringer Separation Test (See Part 7, Figs. 10 Through 10C)

(a) This incline-impact test is performed to determine the resistance of the pallet's leading edge to damage as well as to the deck's separation from the stringer as a result of forces exerted by forklift truck forks (see Part 7, Fig. 10A).

(b) The incline-impact tester, a standard package testing apparatus, described in ASTM Standard D 880, shall be modified by affixing two forks, each 1.5 in. × 4.0 in. × 36 in. (38 mm × 102 mm × 914 mm) in size, having a 4 deg taper, 0.50 in. (12.7 mm) inside radius of the fork heel (Part 7, Fig. 10B), and often used with forklift trucks of 3000 lb (1360 kg) or greater capacity. The two forks shall be securely fastened, spaced 20 in. (504 mm) on centers, to the rigid backstop

TABLE 1 KINETIC ENERGY VALUES, ft-lb (J)

Pallet Weight		40 in. Vertical Drop		8 in. Incline Impact	
lb	kg	ft-lb	J	ft-lb	J
20	9.1	67	91	48.1	65.2
30	13.6	100	136	49.3	66.8
40	18.1	133	180	50.5	68.5
50	22.7	167	226	51.6	70.0
60	27.7	200	271	52.8	71.6
70	31.8	233	316	53.9	73.1
80	36.3	267	362	55.1	74.7
90	40.0	300	407	56.3	76.3
100	45.4	333	451	57.4	77.8

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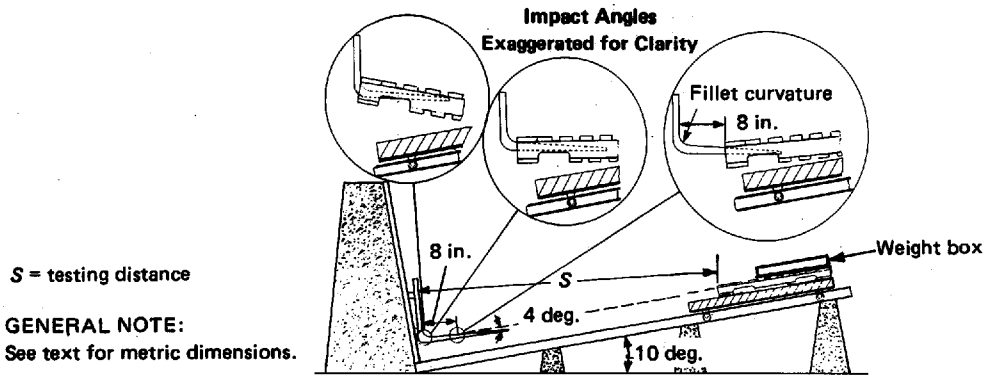


FIG. 10 SCHEMATIC INCLINE-IMPACT TEST ON SEPARATION RESISTANCE OF TOP LEADING-EDGE DECKBOARD FROM STRINGERS BY MEANS OF ENTRY OF FORKLIFT TRUCK FORKS

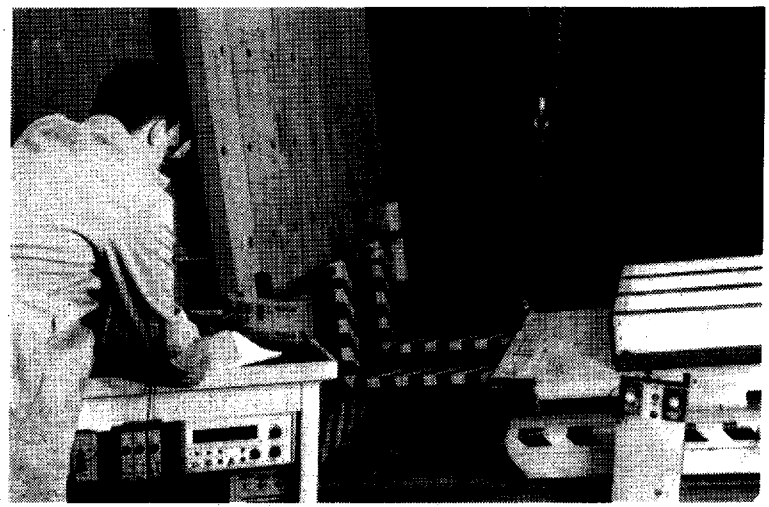


FIG. 10A INCLINE-IMPACT DECKBOARD-STRINGER SEPARATION TEST ON PALLET WITH TOP LEADING-EDGE LUMBER DECKBOARD BUTTED AGAINST PLYWOOD DECK

of the tester in such a manner that the upper flat surface of the forks is angled 4 deg downward from the direction of travel of the dolly. Furthermore, the fork height shall be adjusted in such a manner that the pallet, which is securely fastened to the dolly, strikes and rides up the forklift truck forks during its last 8.0 in. (203 mm) of travel (Part 7, Fig. 10). As the upper leading edge of pallet strikes the radius of curvature of the fork heel, an exacting push-and-pry action is developed.

(c) The dolly of the tester shall be raised up the incline to result in a 14.0 in. (356 mm) clearance between dolly front and fork back.

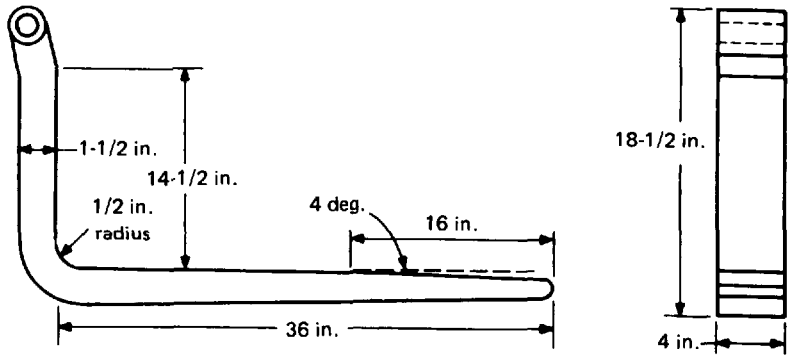
(d) The pallet shall be placed on the dolly in such a manner that the forward-leading edge of the pallet is parallel to, and overhangs by 2.0 in. (51 mm), the forward-leading edge of the dolly [see Note (1)]. A weight box, which shall be as wide as the pallet, however, 16 in. (406 mm) shorter than the pallet, shall be fastened to the pallet in such a manner that:

(1) the trailing upper edge of the box is flush with the trailing upper edge of the pallet; and

(2) the kinetic inertia of the box is transferred at impact directly to the pallet stringers or blocks.

This shall be accomplished by angling the trailing edge of the box over the upper trailing edge of the pallet in such a manner that the steel angle rests on the stringer or blocks. Alternatively, the box shall be

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FIG. 10B FORK OF TOP LEADING-EDGE, DECKBOARD-STRINGER SEPARATION-RESISTANCE, INCLINE-IMPACT TEST APPARATUS

bolted directly to the stringers or blocks. The box shall be weighted uniformly over its area with a number of suitable weights.

(e) Failure shall be considered to have occurred when the forks have destroyed the leading edge in such a way that the pallet will no longer function with the particular type or size of handling devices intended for use, have torn the leading edge off the top deckboard or deck from the stringers or blocks, or when the pallet will no longer support the load.

(f) If the pallet or pallet top deck bends and rides beyond the tines up the forks during impact, two nominal 1 × 4 in. (25 × 102 mm) stiffener boards of the full length of the pallet shall be placed along the pallet top deck, between it and the weight box, as close as possible near the pallet sides without causing interference with the forks during impact. These stiffener boards shall be rigidly fastened to the top deck.

(g) As in any severe impact test, caution shall be exercised and strict adherence to safety requirements shall be mandatory, especially since the heavy weights used can result in severe impact forces. Possible premature triggering of the release mechanism shall be avoided under all circumstances by the use of safety devices.

(h) Any major and minor defects and damages of deckboards, decks, stringers, blocks, and fasteners, observed immediately prior to, during, and after testing, shall be recorded for given test cycles.

NOTES:

(1) Three variations in placing the test pallet on the dolly have been used despite the fact that they influence the test data. These variations are shown in Part 7, Fig. 10C.

(2) Many variations of the described test, which simulates satisfactory and unsatisfactory entry of the handling devices can be performed by repositioning or angling or both repositioning and angling the forks in such a manner that the forks simulate such entries into the pallet as may be encountered in the operation of a forklift truck.

6 REVOLVING DRUM TEST

The revolving drum test is performed to determine the adequacy of the unloaded flat pallet to resist severe rough handling impacts as simulated by falls in the 14 ft (4.27 m) diameter revolving drum (see Part 7, Fig. 11). This test may simulate shocks resulting from handling and stacking of individual unloaded pallets.

(a) The test is used to give an indication of the ability of a pallet to withstand a variety of shocks and impact stresses, thereby permitting a comparison of different designs and constructions of pallets of the same size, materials, and identical fasteners if applicable. The test allows observation of the progressive destruction or failure of the pallet, by which ways of improving the design may be determined.

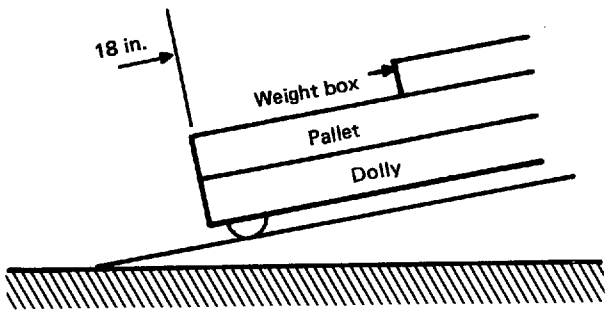
(b) The drum test subjects a pallet to a series of random falls onto the inner faces or against the baffles arranged on the inner periphery of a drum. The baffles cause the pallet to fall on different faces, edges, and corners, and present various impact hazards to the pallet. The series of falls is unpredictable, and probably no two pallets tested will receive exactly the same cycle of abuse. For this reason, drum test results may be expected to vary more than results of a test that does not contain this random characteristic. The test is used primarily when it is desired to simulate an unpredictable and uncontrolled type of rough handling.

(c) The test procedure does not necessarily simulate a particular pallet exposure in the field. Hence, the results cannot be considered conclusive and should have limited application especially in the instance of pallets made of a number of synthetic materials.

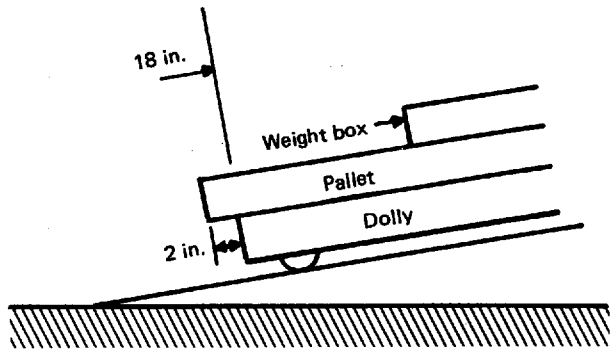
(d) The apparatus used is fully described in ASTM Standard D 782, which covers the 14 ft (4.27 m) drum.

(e) The test shall be started by positioning the pallet

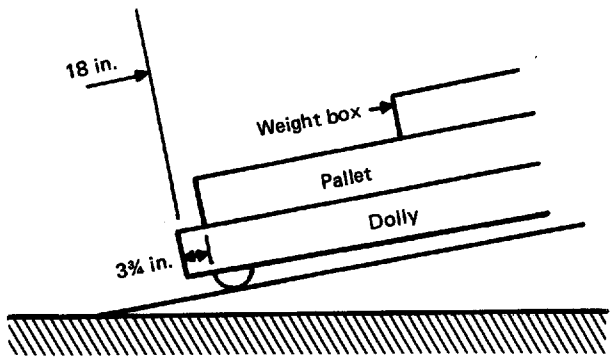
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(a) Pallet and Dolly Flush [Note (1)]



(b) Pallet Overhanging Dolly 2 in. [Note (2)]



(c) Pallet Set Back from Dolly Front 3¾ in. [Note (3)]

GENERAL NOTE:
James R. Reeves, in his May 1973, VPI&SU M. S. Thesis on "The Effect of Stringer and Leading-Edge Design on Strength and Stiffness of Reusable Wooden Pallets," and Franco Nielson, in his June 1978, VPI&SU M. S. Thesis on "Evaluation of Improved Stevedore Pallet," VPI & SU Wood Research and Wood Construction Laboratory Bulletin No. 157 (p.27, top), used the ASME MH1, Part 7, para. 5.5(d) and ASTM D 1185-40 test setup.

NOTES:
(1) ASME MH1, Part 7, para. 5.1(b).
(2) ASME MH1, Part 7, para. 5.5(d), ASTM D 1185-40, and VPI&SU.
(3) VPI&SU Sardo Pallet Research Laboratory, J.R. Reeves, May 1973 (40, 43).

FIG. 10C VARIATIONS IN TEST SETUP FOR PERFORMANCE OF INCLINE-IMPACT TESTS ON LEADING-EDGE IMPACT RESISTANCE OF WOOD PALLETS

in the crotch of the hazard on face No. 1 and with the top deck up. When the drum is started in motion, the pallet is caused to slide, tumble, and fall from face to face. Under given conditions, the pallet skips the faces without hazards (every other one). If the pallet catches on a face without a hazard, it shall be moved forward to the next face with a hazard.

(f) As the test continues, a record shall be made on a data sheet of the development of damage to the pallet such as racking, splits or tears, broken components, blocks or stringers, and failure of fastenings and reinforcements. The drum may be stopped at intervals during the test to permit close inspection of the pallet. Movement of the pallet from one face, past a face, and to the next face with a hazard shall be counted as one fall. One revolution shall be counted as three falls.

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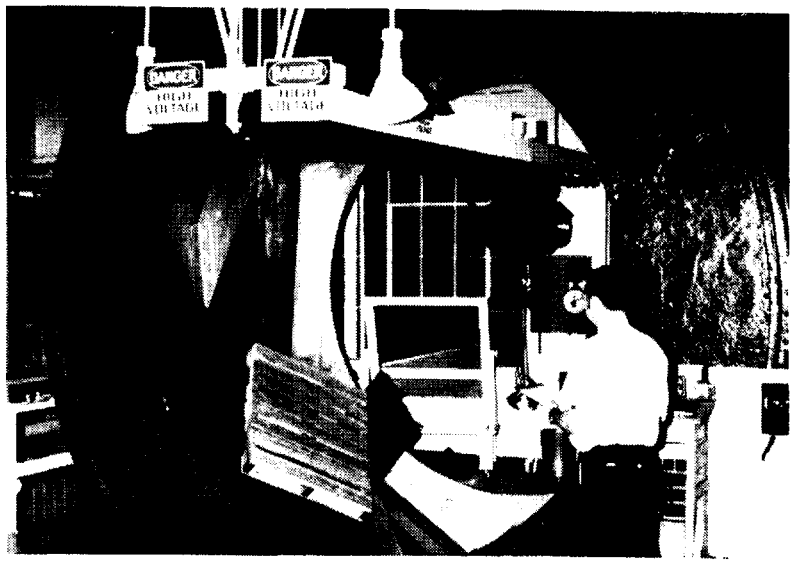


FIG. 11 REVOLVING DRUM TEST, USING 14 ft (4.27 m) DRUM

(g) The number of falls sustained by the pallet up to the time of each occurrence of damage shall be recorded with the description of the damage. The test is terminated when the pallet will no longer function properly during its intended use.

7 VIBRATION TEST

(a) The vibration test simulates stresses imposed by vertical and lateral vibratory motions to which the loaded pallet may be exposed. These motions can occur during handling and transportation of the loaded pallet.

(b) The test pallet is loaded with a specified load or a simulated load of the same or approximately the same density as that normally placed on the pallet.

(c) The load is secured to the top deck of the pallet. The loaded pallet is placed on the table of the vibration machine without being fastened thereto. Gates are used to prevent excessive lateral movement of the loaded pallet on the table. The pallet is tested in two positions. First, the pallet is placed on the table of the vibration machine so that the horizontal component of the vibratory motion is parallel to the fore-and-aft axis of the pallet when it is in its normal position in the type of vehicle in which it would normally be transported (see Part 7, Fig. 12). Second, the pallet is turned 90 deg with respect to the direction of horizontal motion of the table of the vibration machine (see Part 7, Fig. 13).

(d) The frequency and amplitude of the vibrations and the duration of the tests shall be as prescribed in the users' criteria for the test pallet, except that the tests shall be terminated if pallet failure occurs prior to the specified time. Testing at resonant frequency can accelerate failure of the pallet.

(e) The test is terminated:

(1) when the pallet will no longer function properly with the particular type or size of handling device intended to move the pallet; or

(2) when the pallet will no longer support the specified load.

8 STATIC TESTS

Static tests simulate stresses and strains imposed by vertical line loads(s) or patch load, or a uniformly distributed load placed on the pallets. These loads occur during use of the loaded pallets, in stacking, lifting, and handling operations.

Four basic tests fall under this category:

(a) stiffness and flexural strength test;

(b) deckboard stiffness and flexural strength test;

(c) combined deckboard, stringer, and pallet stiffness and flexural strength test; and

(d) pallet compression test.

A fifth test is applicable only to loaded wing pallets designed to be handled with sling bars placed under the top deckboard wings. A supplementary test is the lateral collapse test which determines the resistance of the loaded pallet to forces applied perpendicular to the deckboard ends.

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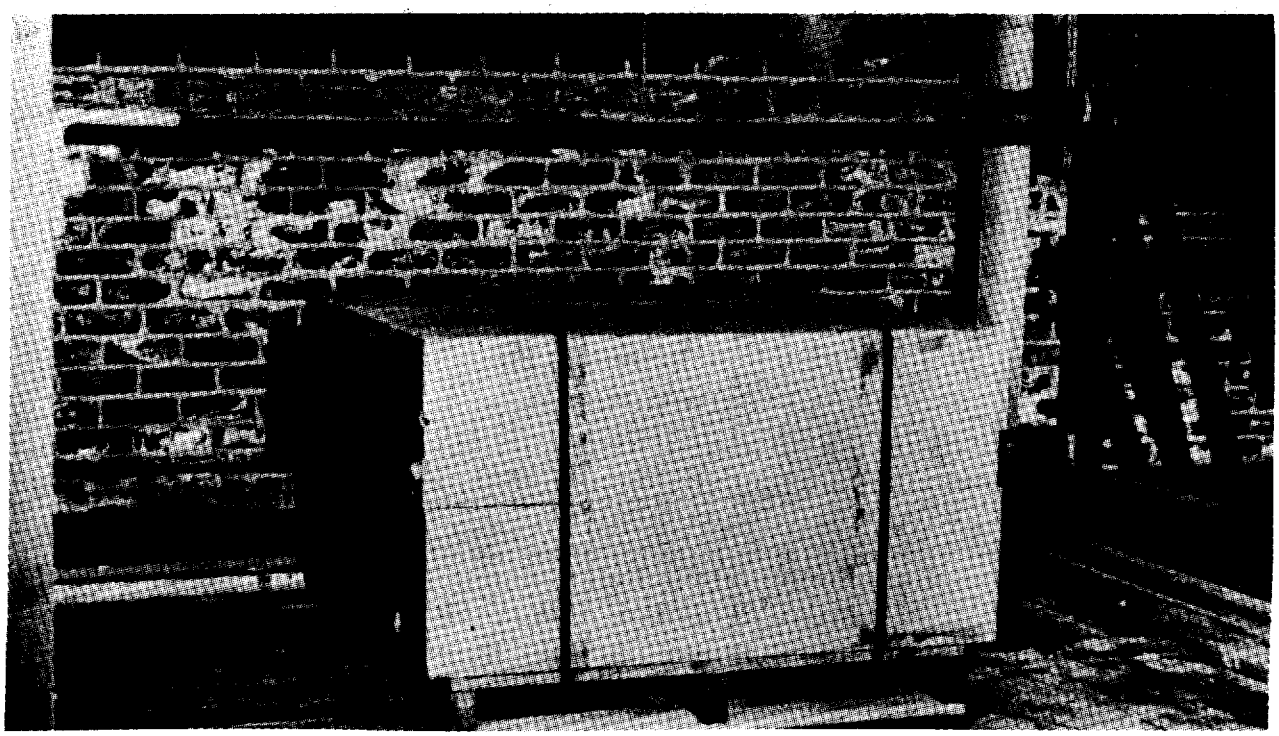


FIG. 12 VIBRATION TEST ON LOADED PALLET ORIENTED PARALLEL TO PLANE OF MOTION

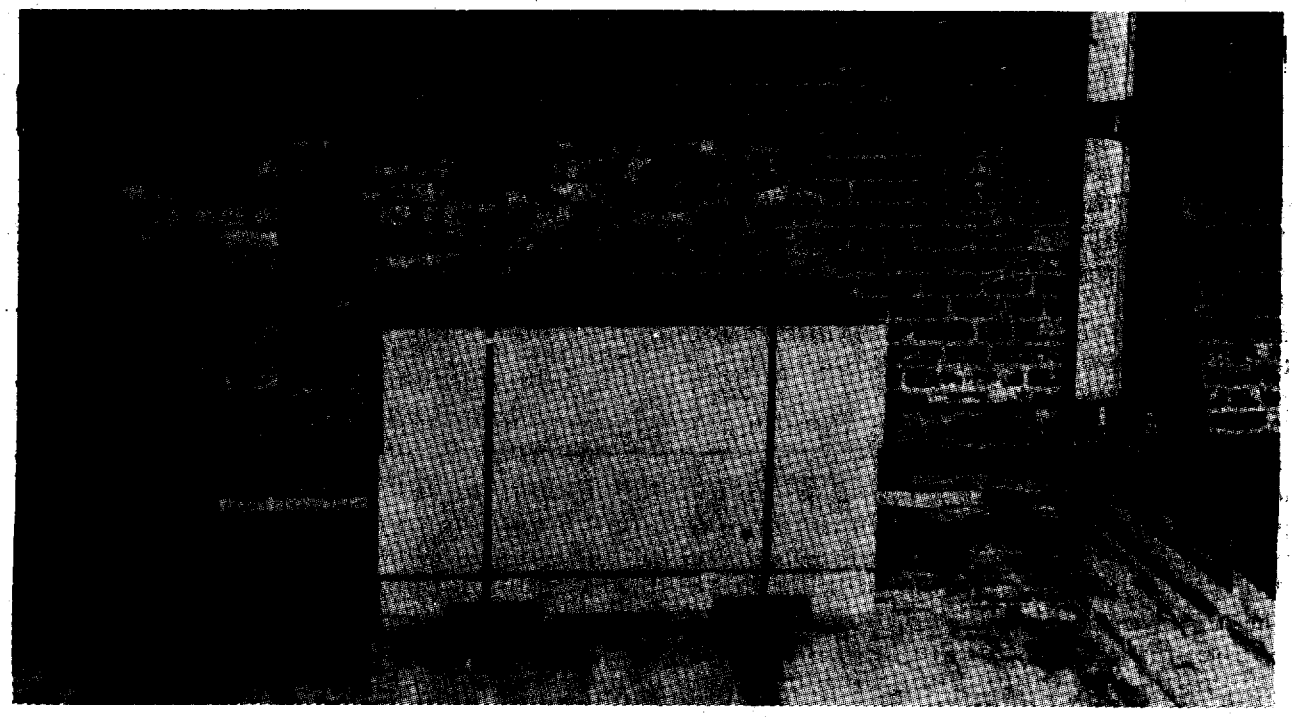
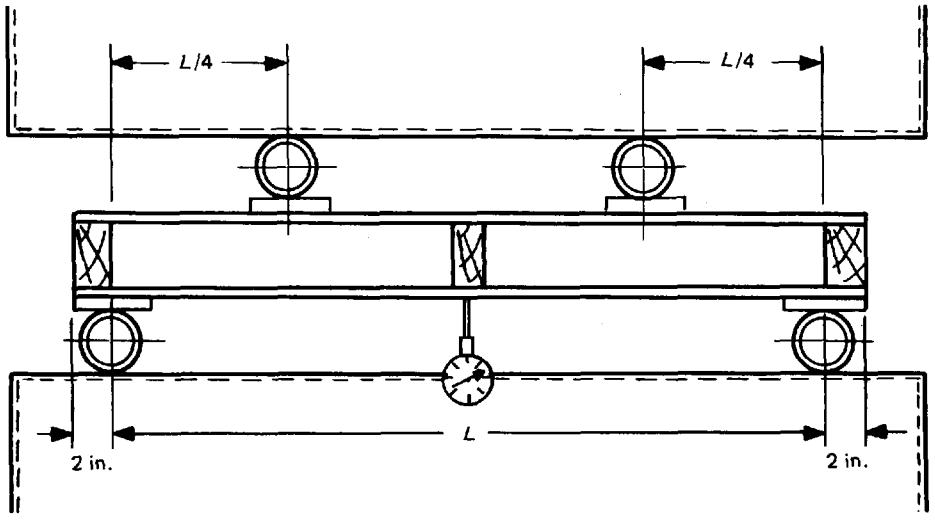


FIG. 13 VIBRATION TEST ON LOADED PALLET ORIENTED 90 deg TO PLANE OF MOTION

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FIG. 14 STIFFNESS AND FLEXURAL STRENGTH TEST, USING TESTING MACHINE WITH LARGE PLATENS

8.1 Stiffness and Flexural Strength Test (See Part 7, Figs. 14 Through 14D)

(a) This test procedure is applicable to determining the relative stiffness and flexural strength of a pallet when loaded as a beam at the one one-quarter points of the span.

(b) The use of the following test equipment is required:

(1) a universal testing machine with large platens, a suitable test rack, as shown in Part 7, Figs. 14A and 14B, or a dead-weight loading setup;

(2) four 3.0 in. (76 mm) diameter steel pipes for support and loading;

(3) four bearing plates, each a 0.5 in. (12.7 mm) by 4.0 in. (102 mm) plywood piece; and

(4) two dial micrometer gages, allowing deflection readings of 0.001 in. (0.025 mm), with suitable mounting stands. The pipes and bearing plates shall be at least as long as the pallets.

(c) Each pallet shall be tested consecutively four times:

(1) with the pallet spanning 4.0 in. (102 mm) less than the width and with the top deck up;

(2) with the pallet spanning 4.0 in. (102 mm) less than the length and with the top deck up;

(3) with the pallet spanning 4.0 in. (102 mm) less than the width and with the top deck down;

(4) with the pallet spanning 4.0 in. (102 mm) less than the length and with the top deck down.

The supports shall be 3.0 in (76 mm) diameter pipes, placed crosswise to the span and 2.0 in. (51 mm) from each end. The loads shall be applied through 3.0 in. (76 mm) diameter pipes, placed crosswise to the span at the one-quarter points of the span.

(d) All pipes shall be separated from the pallets with plywood load-bearing plates centered on and oriented along the axis of the pipes. The specimen shall be loaded to its rated load at a uniform rate of crosshead or piston movement of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min]. A load deflection record shall be maintained in a suitable manner.

(e) Another procedure is applicable when a uniformly distributed load is to be applied to the whole pallet surface (see Part 7, Fig. 14D). The pallet is installed above the pallet supports and below an inflatable air bag. The load can be measured with strategically located load cells and the deflection can be measured with satisfactorily located potentiometers, as is indicated in Part 7, Fig. 14D.

8.2 Deckboard Stiffness Test (See Part 7, Figs. 15 Through 15B)

(a) This test procedure is applicable to determining the adequacy of decks of pallets to resist bending stresses resulting from superimposed loads such as stacks of similarly loaded pallets in storage.

(b) In conducting the deckboard stiffness and flexural strength test, any convenient procedure may be used

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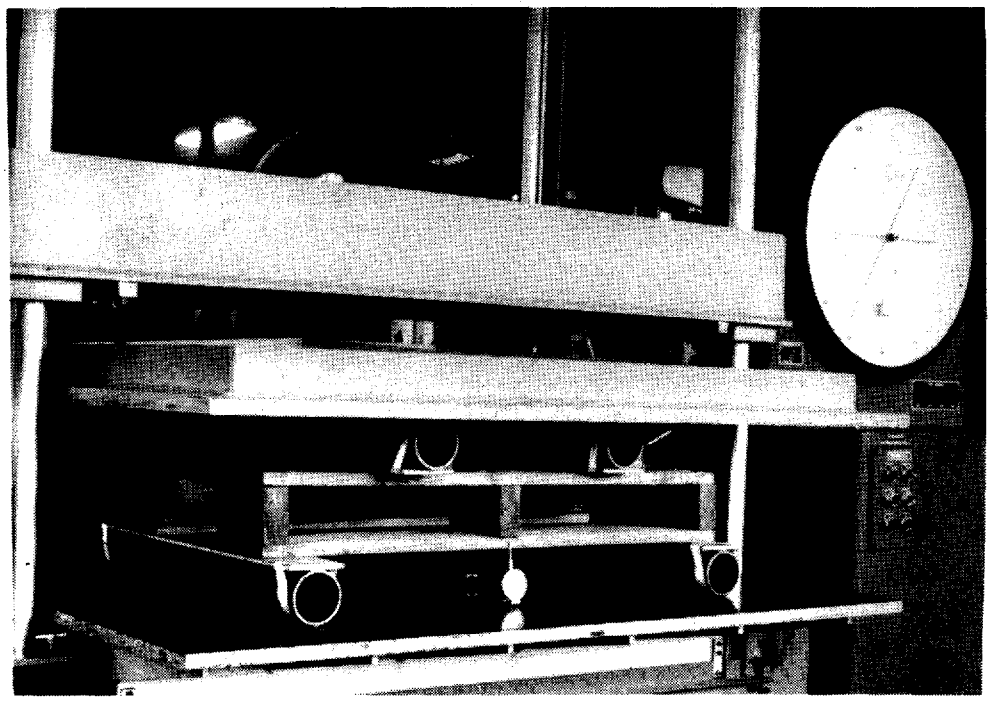


FIG. 14A STIFFNESS AND FLEXURAL STRENGTH TEST, USING TESTING MACHINE WITH LARGE PLATENS

for placing the load on the pallet, such as with a hoist, a block and tackle, a forklift truck, or manually. The load may also be applied and maintained by means of a suitable testing machine. Use of the following additional test equipment is required:

(1) two 30 in. (76 mm) diameter pipes for loading:

(2) two load-bearing plates, each a 0.5 × 4.0 in. (12.7 × 102 mm) plywood piece; and

(3) two dial micrometer gages, allowing deflection readings of 0.001 in. (0.025 mm), with suitable stands.

The pipes and bearing plates shall be at least as long as the pallets.

(c) The pallet shall be placed with its bottom on a flat, level, rigid floor or testing machine bed. The pipes and bearing plates shall be positioned at the one-third points of the span, as shown in Part 7, Fig. 15. A load, twice the rated load capacity of the pallet, shall be placed evenly. If a testing machine is used, the rate of loading shall be uniform at 0.100 (±0.050) in./min [2.54 (±1.27) mm/min]. The maximum deflection of the deckboards and any damage shall be recorded. The load shall be removed and any residual deformation shall be measured. The same load shall be reapplied in a like manner and the maximum deckboard deflection shall be recorded. Any abnormalities or residual deformations shall be recorded on a suitable data sheet. For evaluating the bottom deck, the pallet shall be turned upside down and the test conducted in a similar manner with a load equal to one and one-half times the rated load capacity of the pallet.

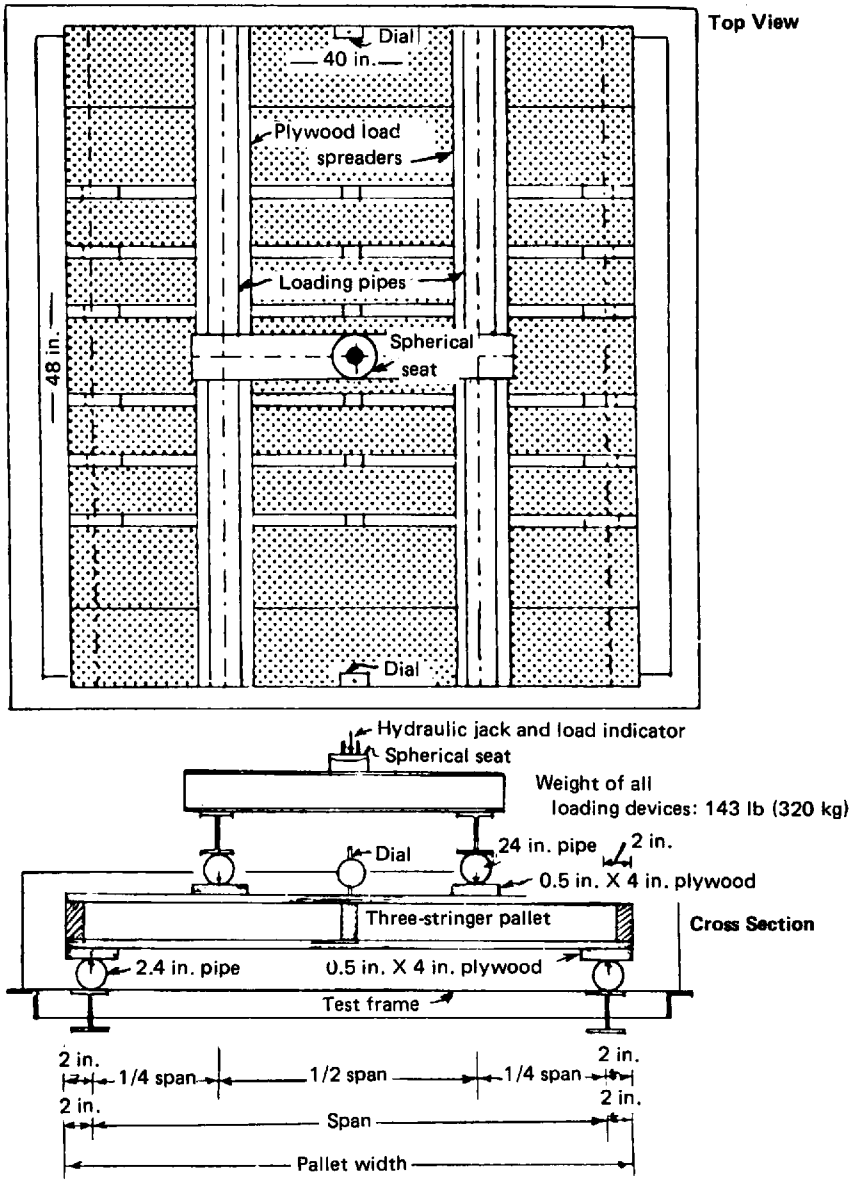
(d) Another procedure of loading the deckboards or deck in a uniform manner is by using vacuum loading (see Part 7, Fig. 15B). The pallet is installed in an enclosure with a plastic membrane taped over the deckboards or deck to attain a vacuum-tight enclosure. A satisfactory clearance between the pallet deckboards or deck and the enclosure is provided. A certain amount of slack in the plastic membrane shall ensure uniform load application. Deflection measurements shall be taken of the surface of the deck structure relative to points directly above the pallet supports.

8.3 Combined Deckboard, Stringer, and Pallet Stiffness and Flexural Strength Test (See Part 7, Figs. 16 and 16A)(VPI & SU Pallet and Container Research Laboratory Bulletins, Nos. 123 and 131)

(a) This test procedure is applicable to determination of the relative stiffness and flexural strength of the deckboards, the stringers, and the whole pallet under load. It may serve as an alternative or supplementary

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FIG. 14B STIFFNESS AND FLEXURAL STRENGTH TEST, USING SPECIAL TEST RACK WITH PALLET SIDES SUPPORTED

test procedure to those described in Part 7, paras. 8.1 and 8.2.

(b) The use of the following test equipment is required:

(1) a universal testing machine with large platens, a suitable test rack, as shown in Part 7, Figs. 16 and 16A, or a dead-weight loading setup;

(2) four 2.0 × 2.0 in. (50.8 × 50.8 mm) bearing plates supporting the four pallet corners, a steel loading plate with a spherical loading device; and

(3) five dial micrometer gages, allowing deflection reading of 0.001 in. (0.025 mm) and having a range of at least 1 in. (25.4 mm) with suitable mounting stands or devices.

(c) The steel leading plate shall be 0.56 × 12.0 × 14.0 in. (14.3 × 305 × 356 mm) when testing a 40 ×

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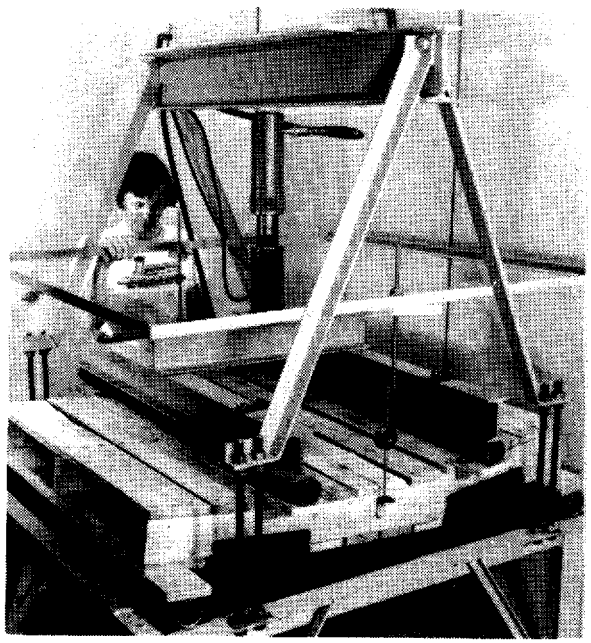


FIG. 14C STIFFNESS AND FLEXURAL STRENGTH TEST, USING SPECIAL TEST RACK WITH PALLET ENDS SUPPORTED

48 in. (1016 × 1219 mm) pallet and of proportionate length and width dimensions when testing pallets of other dimensions.

(d) One dial micrometer shall be located at each of the two pallet sides and ends at the midpoints of the span as well as below the pallet center.

(e) The pallet shall be loaded to its rated load at a uniform rate of cross-head or piston movement of 0.100 (±0.050) in./mm [2.54 (±1.27) mm/min]. In the instance the available equipment does not permit such a rate of load application and in the instance of dead-weight loading, an appropriate load-time record shall be maintained. In order to observe creep, if any, the test load, instead of being applied at a uniform rate, shall be applied in increments of 200 lbf (890 N), with each test load maintained for a period of 2 min. If determination of the pallet stiffness is the sole purpose of testing, the load application shall be discontinued at a suitable load level. If the pallet's ultimate flexural load is to be observed, in addition to the pallet stiffness, the test shall be terminated only after the ultimate load has been reached. Load deflection records shall be maintained in a suitable manner.

(f) Other procedures of loading the pallet in a uniform manner are the air bag and the vacuum method [see Part 7, paras. 8.1(e) and 8.2(d)]. In these instances, the support of the pallet within the enclosure shall be modified to achieve testing of the overall stiffness and flexural strength of the whole pallet.

8.4 Pallet Compression Test

(a) This procedure is applicable to determining the ability of pallets to resist compressive loads such as are imposed on the bottom pallet of a stack of similarly loaded pallets in storage. Using this procedure does not result in data on the load-carrying capacity of the deckboards or deck.

(b) In conducting the compression test, any convenient method may be used for placing the load on the pallet, such as a hoist, a block and tackle, and forklift truck, or manually. The load may also be applied and maintained by means of a suitable testing machine or air or vacuum bags.

(c) The test pallet shall be placed with its bottom on a flat, level, rigid floor or testing machine bed. A load of five times the rated capacity of the pallet or 200 psf (9.58 kPa), whichever is greater, shall be applied to the pallet top through a stiff, flat plate in such a manner that no bending stress is applied to the top deck. The load shall be allowed to remain in place for a period of 1 hr. If the test is being conducted in a testing machine, the load shall be checked frequently and adjusted so that it is relatively constant throughout the 1-hr period. A record shall be made of changes in the deformation and recovery or damage to the pallet.

(d) Another procedure is to apply the appropriate test load only to a single pallet corner at a time, that is, above a corner block or above one end of a stringer. The test can be repeated in an identical manner at another corner of the pallet.

8.5 Stiffness and Flexural Strength of Wing Pallets

(a) This test procedure is applicable to the determination of the relative stiffness and flexural strength of loaded wing pallets supported by sling bars (not rope slings) placed under the top-deckboard or deck wings and hanging from the slings.

(b) In conducting this test, place the sling bars beneath the wings of the top deckboards or deck in such a way that the bars are placed directly adjacent to the vertical outer face of the outer stringers or blocks. The test load supported by the pallet shall simulate that expected in service. In the case of a

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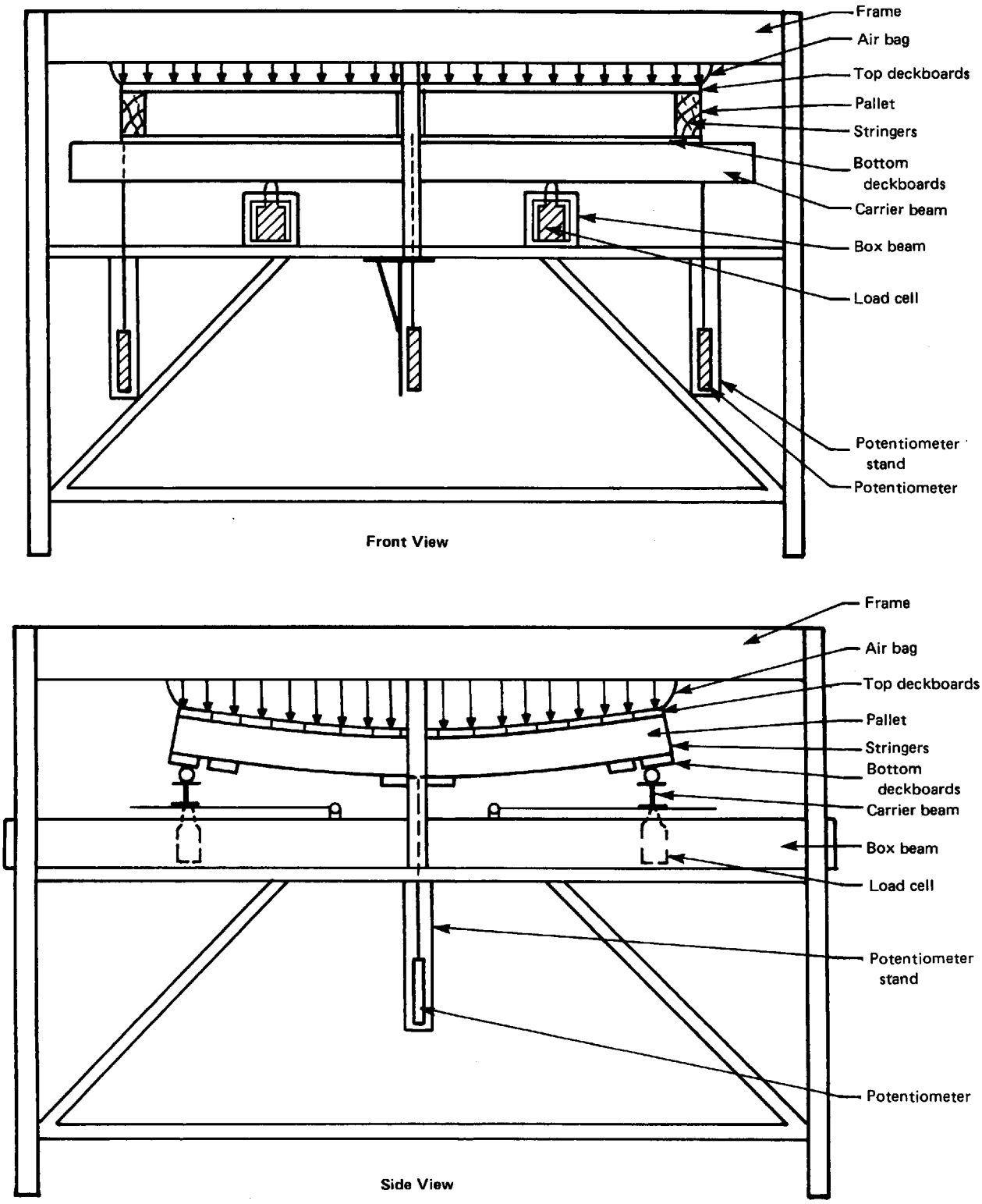


FIG. 14D SCHEMATICS OF PALLET STIFFNESS AND FLEXURAL STRENGTH TESTER, USING AIR BAG IN SPECIAL TEST RACK, PROVIDING UNIFORM LOAD DISTRIBUTION OVER WHOLE PALLET DECK

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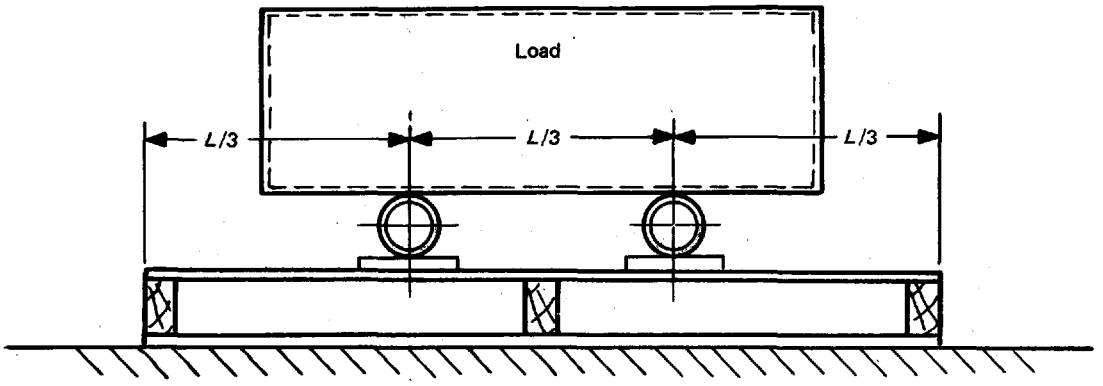


FIG. 15 DECKBOARD STIFFNESS AND FLEXURAL STRENGTH TEST, USING DEAD WEIGHT

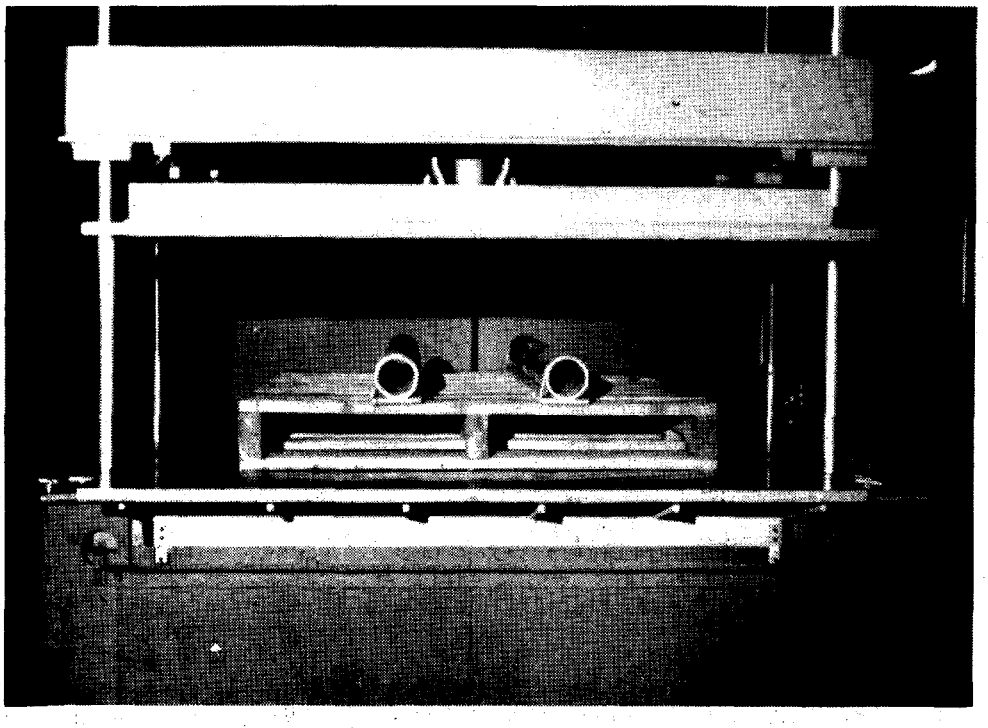


FIG. 15A DECKBOARD STIFFNESS TEST, USING TESTING MACHINE WITH LARGE PLATENS

uniformly distributed load, it shall be placed from wing end to wing end.

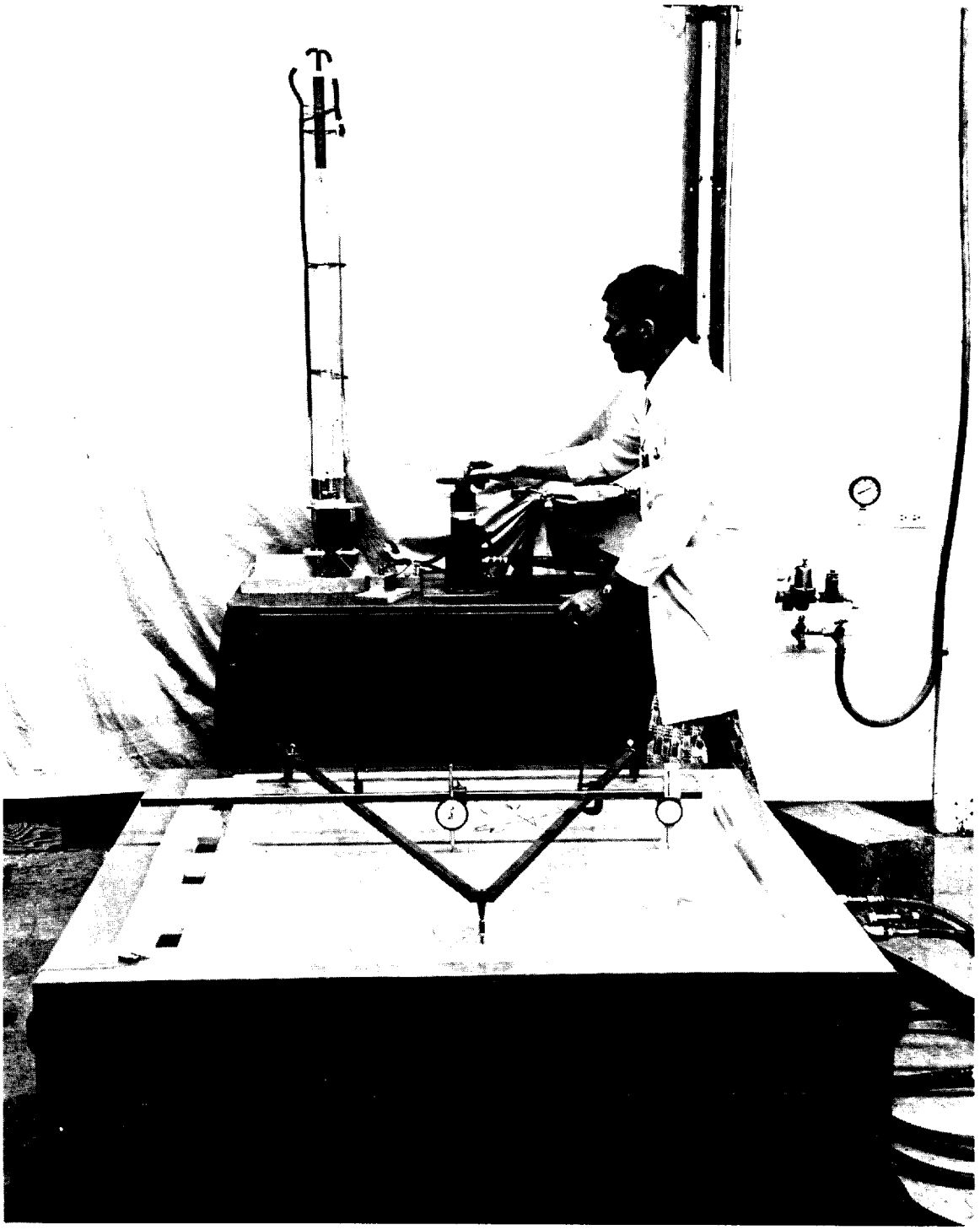
(c) Determine (a) the pallet deflection at the pallet center and ends along both major pallet axes, as measured relative to the upper surface of the top deckboards or deck prior to load application and (b) the maximum load supported by the wing pallet.

8.6 Lateral Collapse Test

(a) This procedure is applicable when determining the resistance of stringer-type, single and double-deck pallets to such lateral forces which could cause the lateral collapse of these pallets, that is overturn all stringers of the loaded pallet as a result of inplane, lateral, static, impact, or vibrational forces applied perpendicular to the deckboard ends. The resistance to these forces is influenced by the pallet size and shape, the size and distribution for the unit load placed on the pallet, and the moment-resistance characteristics of the pallet connections. The schematics of resistance to lateral collapse are shown in Part 7, Fig. 17 and the

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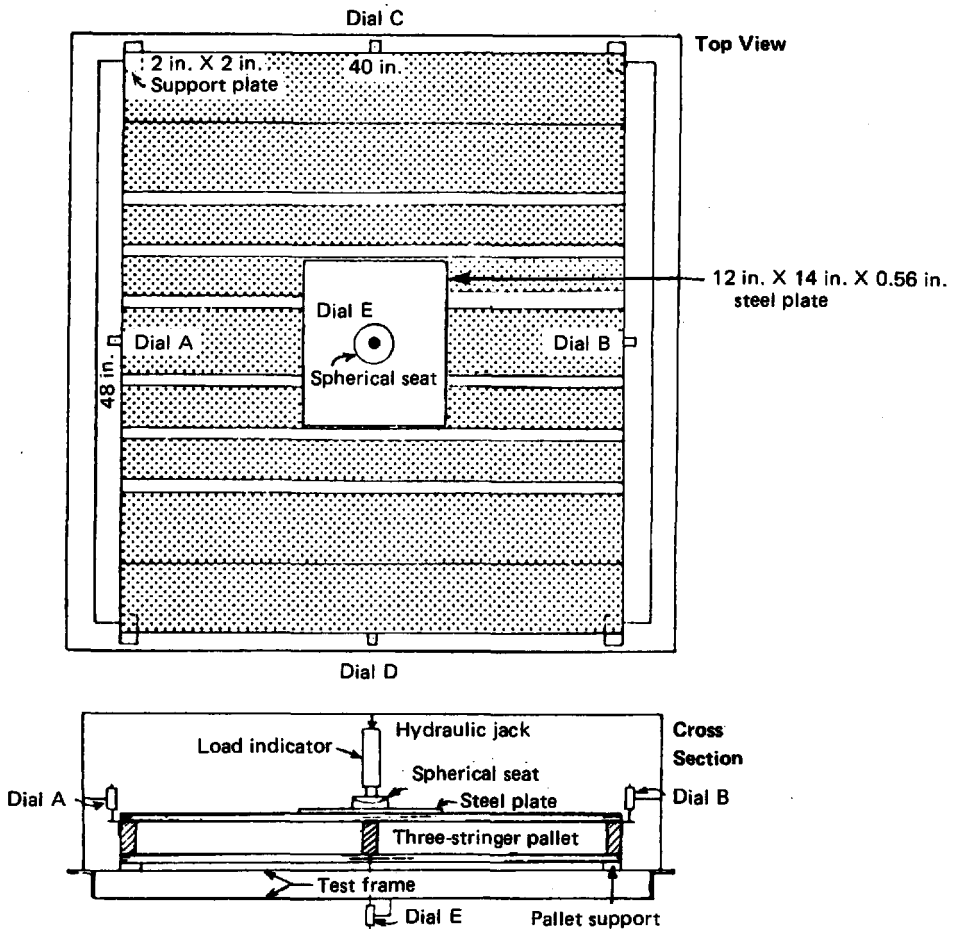


GENERAL NOTE:
Mirrors in viewing ports on left top of chamber allow observation of pallet underside, while deflection is measured from top.

FIG. 15B STIFFNESS AND FLEXURAL STRENGTH TEST, USING VACUUM TEST SETUP, PROVIDING UNIFORM LOAD DISTRIBUTION OVER WHOLE PALLET DECK, WITH LOAD REGULATION AND MEASURING DEVICES IN BACKGROUND

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GENERAL NOTE: See text for metric dimensions.

FIG. 16 COMBINED DECKBOARD, STRINGER, AND PALLET STIFFNESS AND FLEXURAL STRENGTH TEST, USING SPECIAL TEST RACK WITH PALLET SUPPORTED AT FOUR CORNERS

lateral collapse test apparatus is shown in Part 7, Fig. 17A.

(b) In conducting this test, any convenient method may be used for imposing the lateral force against the deckboard ends.

(c) The test pallet is placed on a level steel frame which functions as a test base. The specified unit load is placed on the pallet. The lateral load is applied, at a uniform rate of 4.0 in. (102 mm) per min, uniformly to all deckboard lead ends via a swivel head or other universal joint and a rigid steel loading beam, with a hydraulic cylinder attached to a steel I-beam fastened to the test base. The horizontal load is measured with a calibrated load cell placed near the end of the hydraulic ram. The loading beam travels on Teflon pads to minimize friction. The required lateral motion restraint is provided by adjustable stops to the far bottom-deckboard ends of double-faced pallets and to the bottom of the side of the far outside stringer of single-faced pallets (skids).

(d) The horizontal motion for the top-deckboard ends relative to the test base is measured by suitable means, such as linear variable deferential transducers attached to the top deckboards near the lead stringer. The force-deformation curve is recorded. It should indicate a clearly defined collapse force.

9 TEST REPORT

The test report shall include the following particulars:

(a) the number of replicate pallets tested;

(b) full description, including dimensions, structural,

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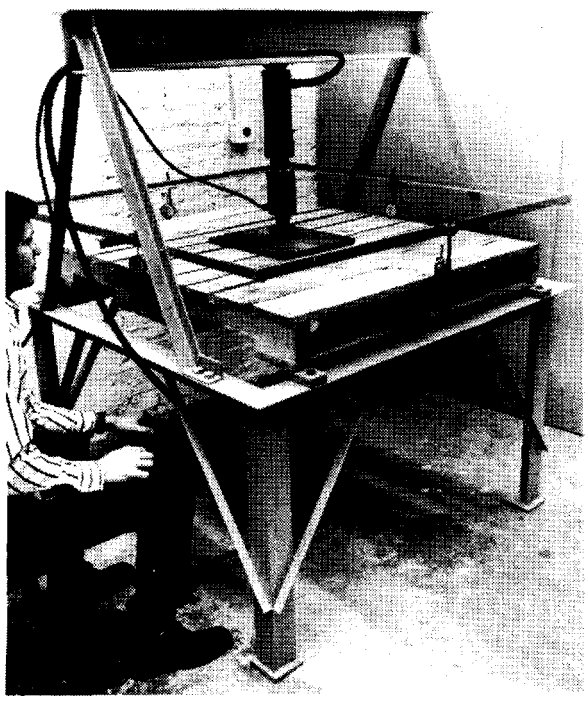


FIG. 16A COMBINED DECKBOARD, STRINGER, AND PALLET STIFFNESS AND FLEXURAL STRENGTH TEST, USING SPECIAL TEST RACK WITH PALLET SUPPORTED AT FOUR CORNERS

and material specifications of the pallet(s) and its fasteners;

(c) net weight of the pallet(s);

(d) relative moisture content (if any) of the pallet(s), its temperature, and time of conditioning (if any);

(e) temperature and relative humidity of the test area at time of test;

(f) test procedure or procedures used;

(g) drop heights, incline distances (if used), and number and frequency of each test or procedure;

(h) location of points on pallet and stage of test at which measurements were made;

(i) type of apparatus used;

(j) any deviations from the test procedures described in Part 7:

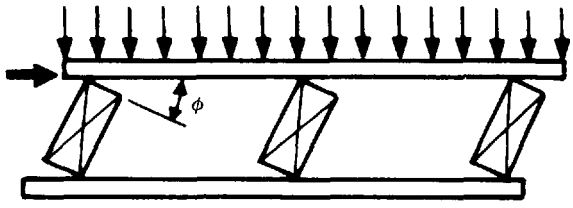
(k) a record of all load data on stiffness tests, with any observations that may assist in correct interpretation;

(l) weight and type of load when loaded pallets are tested;

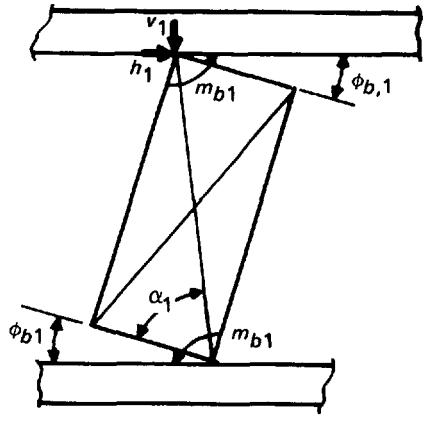
(m) frequency, amplitude, and duration of each type of vibration test used;

(n) date of test and date of report; and

(o) signature of tester.



(a) Lateral Collapsing Force is Applied as Shown



(b) Force is Resisted by Fasteners Connecting Deckboards to Stringers

GENERAL NOTE:
For details, see T. E. McLain and D. L. Arritt. "Lateral Collapse Potential of Wood Stringer-Type Pallets," *Journal of Testing and Evaluation* 16(2):222-228, March, 1988.

FIG. 17 SCHEMATICS OF RESISTANCE TO LATERAL COLLAPSE OF STRINGER-TYPE PALLETS

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FIG. 17A LATERAL COLLAPSE TEST FOR STRINGER-TYPE PALLETS, WITH IMPOSED UNIT LOAD DELETED TO CLEARLY DEMONSTRATE TEST SETUP

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NONMANDATORY APPENDIX A7-A
POTENTIAL USES OF DESCRIBED TESTS

(This Appendix is not part of Part 7 of ASME MH1-1997, and is included for information purposes only.)

This Table represents the Committee's suggested guide as to the applicability of the test procedures towards evaluating pallets constructed of different materials. For example, little valid data can be obtained by corner-dropping or tumbling a very lightweight pallet, since a lightweight pallet will tend to float. The user of Part 7 should be the ultimate judge of a given test's applicability to his own needs.

Test Procedures	Section	Wood Reusable	Wood Expendable	Ply-wood	Fiber-Board	Plastic	Metal
Drop Tests	4						
Corner drop (vertical)	4.1	1	1	2	2	1	1
Edge drop (almost vertical)	4.2	1	2	2	2	1	1
Corner drop (horizontal, loaded)	4.3	1	2	2	2	1	1
Incline-Impact Tests	5						
Pallet bottom (loaded)	5.1	1	2	1	1	1	1
Pallet top (loaded)	5.2	1	2	1	1	1	1
Stringer or block (loaded)	5.3	1	2	2	2	1	1
Pallet distortion	5.4	1	2	1	1	1	1
Deckboard-stringer separation	5.5	1	1	1	1	1	1
Revolving Drum Test	6	3	3	3	3	3	3
Vibration Test (Loaded)	7	2	2	1	1	1	1
Static Tests	8						
Pallet stiffness	8.1	1	2	1	1	1	1
Deckboard stiffness	8.2	2	2	2	1	1	1
Combined stiffness, strength	8.3	1	1	1	1	1	1
Compression	8.4	2	2	2	1	1	1
Impact Tests on Pallet Sections	B						
Separation	B2	1	1	1	3	3	3
Torsion	B3	1	1	3	3	3	3

Classification:
1 = meaningful, depending on intended use
2 = of questionable applicability, requiring careful interpretation of results
3 = of questionable value, if applicable

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NONMANDATORY APPENDIX A7-B
IMPACT TESTS ON PALLET SECTIONS
Forest Products Journal 5(6); 243-4; also VPI & SU William H. Sardo, Jr., Pallet and Container Research Laboratory Bulletins, Nos. 126 and 139

(This Appendix is not part of Part 7 of ASME MH1-1997, and is included for information purposes only.)

B1 GENERAL

In many instances, especially in developmental work as well as during the performance of control tests, the desired test data can be obtained by testing pallet sections instead of assembled pallets.

(a) Two basic types of tests have been advanced:

(1) deckboard-stringer separation test; and

(2) deckboard-stringer corrosion test.

(b) Whereas the testing of pallets calls for the dropping of the pallets, the testing of pallet sections requires the dropping of a given mass onto the pallet sections. The latter procedure has the advantage of making it possible to disregard the weight of the assembly under observation during the evaluation of the test data.

B2 DECKBOARD-STRINGER/BLOCK SEPARATION TEST (SEE APPENDIX A7-B, FIG. B1)

(a) The test is performed to determine the resistance to separation of pallet deckboard from pallet stringer or block during application of impact forces, in the direction perpendicular to the plane of the deckboard. The forces applied simulate the action of the forks of forklift trucks under given conditions. In most instances, this test indicates the head pull-through impact resistance of the fasteners in the deckboard or the shank withdrawl impact resistance of the fasteners from the stringer or block or both.

(b) The deckboard-stringer or block connection is placed into a testing device in such a way that given impact forces can be applied onto the tow ends of the deckboard extending beyond both sides of the stringer or block being firmly supported or vice versa. This is accomplished by dropping a given weight from given heights onto a hard maple or similar loading block straddling the stringer, block, or deckboard in such a way that friction cannot occur between loading block and stringer, block, or deckboard.

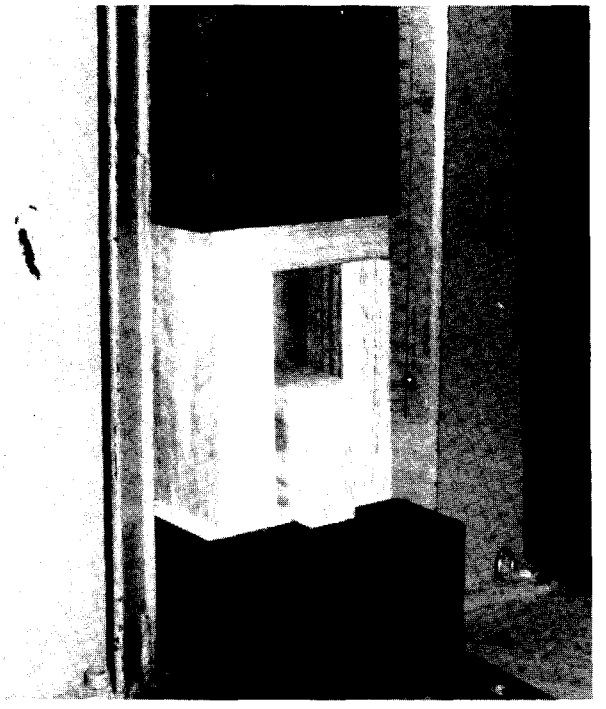


FIG. B1 DECKBOARD-STRINGER SEPARATION TEST

(c) The test is performed by dropping a steel weight, usually of 15.0 or 40.0 lb (6.8 or 18.1 kg) from a height of 4.0 in. (102 mm) between the bottom of the weight and the top of the loading block after release by hand or by a mechanism, such as a solenoid release. Subsequently, this same weight is dropped from heights of 8.0, 12.0, 16.0, 20.0, 24.0, 24.0, and 24.0 in. (203, 305, 406, 508, 610, 610, and 610 mm) above the

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loading block until failure occurs, that is, until the deckboard is separated completely from the stringer or block. In certain instances, it is advisable to apply a smaller or larger increment of energy input by using a smaller or larger weight or a smaller or larger drop height or by increasing or decreasing both weight and height. The selection of the energy-impact levels depends on the type of connection under scrutiny, in order to allow satisfactory evaluation of the test data.

(d) The total energy required to achieve failure and the types of failure observed are recorded. In addition, the actual separation of the deckboard from the stringer or block during progress of the test, that is, after the application of each impact, may be recorded and plotted in a drop height/separation diagram in order to allow a visual comparison of the test results.

NOTE: Under certain conditions, it may be desirable to perform a similar test under static loading conditions by pushing the deckboard from the stringer or block, in the direction perpendicular to that of the plane of the deckboard, using a suitable testing machine and applying the load at a constant rate of motion of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min] of the cross-head of this testing machine.

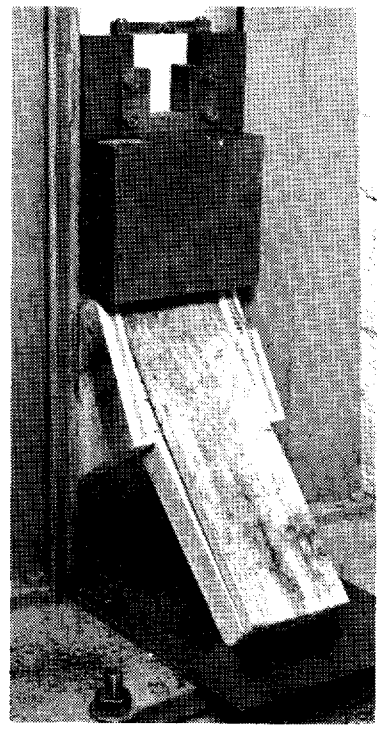


FIG. B2 DECKBOARD-STRINGER TORSION TEST

B3 DECKBOARD-STRINGER TORSION TEST (SEE APPENDIX A7-B, FIG. B2)

(a) This test is performed to determine the rigidity and torsional resistance of the pallet corner, deckboard-stringer connection during application of impact and racking forces in the direction of the pallet diagonal in the plane of the pallet.

(b) The deckboard-stringer connection is placed into the same testing device as used for the performance of the deckboard-stinger/block separation test to allow application of given impact forces onto the slightly rounded outer edge of the three-member connection, while the rounded far edges of both 10.75 in. (273 mm) long and 5.5 in. (140 mm) wide deckboards and the 12.0 in. (305 mm) long stringer are placed on the bed of the testing device without being restricted from spreading.

(c) The test is performed by dropping a steel weight, usually of 15.0 or 40.0 lb (6.8 or 18.1 kg) from a height of 4.0 in. (102 mm) between the bottom of the weight and the top of the loading block after release by hand or by a mechanism, such as a solenoid release. Subsequently, this same weight is dropped from heights of 8.0, 12.0, 16.0, 20.0, 24.0, 24.0, and 24.0 in. (203, 305, 406, 508, 610, 610, and 610 mm) above the connection edge until failure occurs. Failure is considered to have taken place after the angle between the deckboard and stringer has increased from the original angle of 90 to 120 deg. In certain instances, it is advisable to apply a smaller increment of energy input by using a smaller weight or a smaller drop height or by decreasing both weight and height. The selection of the energy-impact levels depends on the type of connection under scrutiny, in order to allow satisfactory evaluation of the test data.

(d) The total energy required to achieve failure and the types of failure observed are recorded. In addition, the actual angular distortion of the connection during progress of the test, that is, after the application of each impact, may be recorded and plotted in a drop height/distortion diagram in order to allow a visual comparison of the test results. A typical drop height/distortion diagram is presented in Appendix A7-B, Fig. B3.

NOTE: Under certain conditions, it may be desirable to perform a similar test under static loading conditions by pushing against the slightly rounded upper edge of the three-member connection, using a suitable testing machine and applying the load at a constant rate of motion of 0.100 (±0.050) in./min [2.54 (±1.27) mm/min] of the cross-head of the testing machine.

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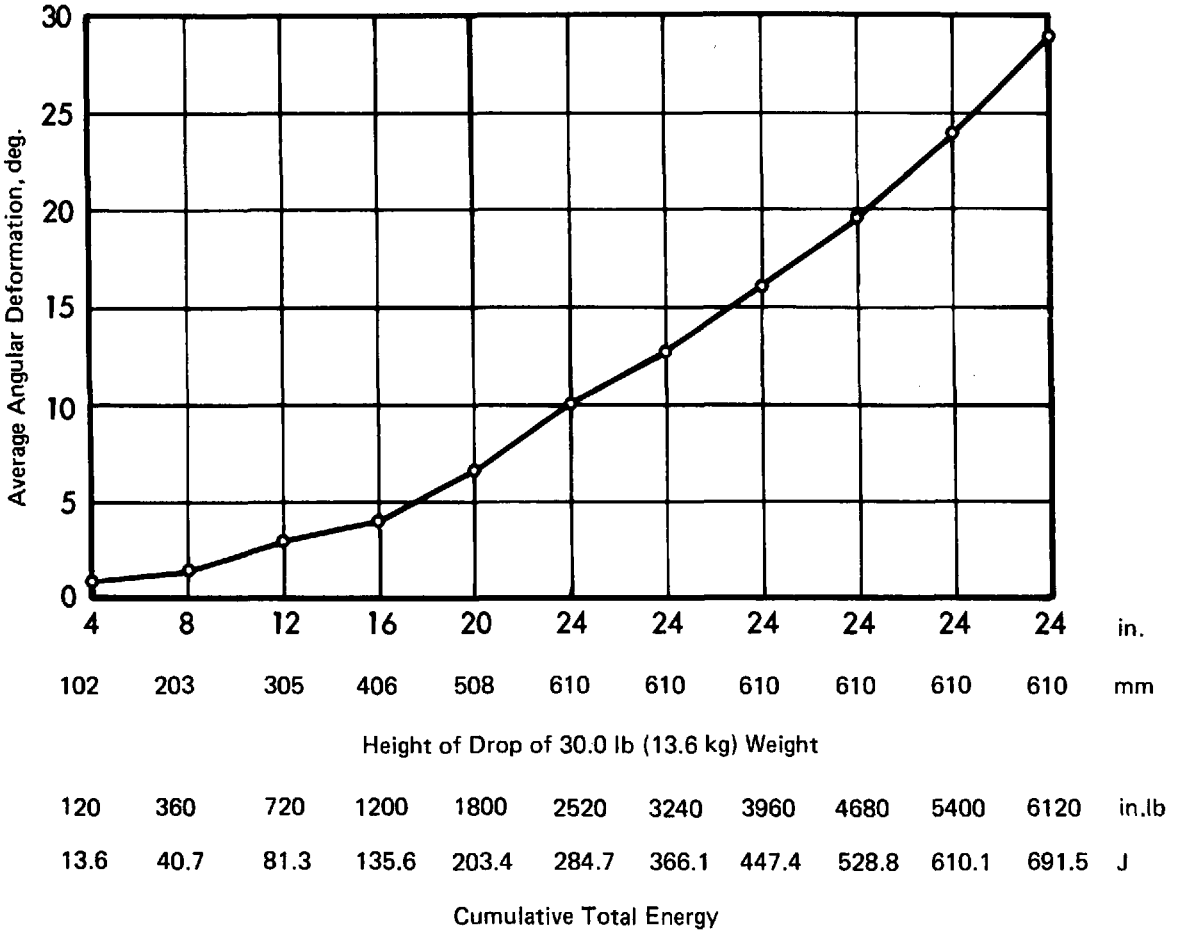


FIG. B3 TYPICAL TORSIONAL IMPACT RESISTANCE OF PALLET CORNER CONNECTION WITH 2 × 4 in. (50.8 × 102 mm) STRINGER BETWEEN 1 × 6 in. (25.4 × 152 mm) DECKBOARDS

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NONMANDATORY APPENDIX A7-C
PALLET HANDLING TEST PROCEDURES

(This Appendix is not part of Part 7 of ASME MH1-1997, and is included for information purposes only.)

C1 SLIDING TEST (FEDERAL TEST METHODS STANDARDS 101B-5011-6.5)

Place the loaded pallet on a horizontal, flat, smooth, concrete floor. Position a forklift truck with its mast vertical and its forks extended between pallet stringers or blocks in such a manner that the forks do not support the pallet. Operate the forklift truck to push the loaded pallet for a distance of 35 ft (10.7 m) in about 85 sec at constant speed. Observe damage. Subsequently, push the loaded pallet in the direction 90 deg to the first direction, repeat procedure, and observe damage.

C2 SLIDING-FRICTION TEST (SEE APPENDIX A7-C, FIG. C1) (NAVAL SUPPLY SYSTEMS COMMAND, INTERIM REPORT 73-B5-R2)

To determine a coefficient of friction, i.e., between a pallet and a concrete floor, place a loaded pallet on a horizontal, flat, smooth, clean concrete floor. Attach a suitable scale to a chain between the test pallet and a truck or winch. Operate the towing device to permit measuring the horizontal force F_1 required to initiate movement of the loaded pallet along the floor. Also observe the force F_2 required to maintain movement of the loaded pallet across the floor. Repeat the test with force applied and pallet being moved in a direction 90 deg to first test. Calculate either the startup Cf_1 or sliding Cf_2 coefficients of friction by the formula:

$$Cf_1 = \frac{F_1}{W} \quad \text{or} \quad Cf_2 = \frac{F_2}{W}$$

where

F_1 = average horizontal force to start movement of pallet

F_2 = average horizontal force to maintain movement of pallet

W = weight of loaded pallet

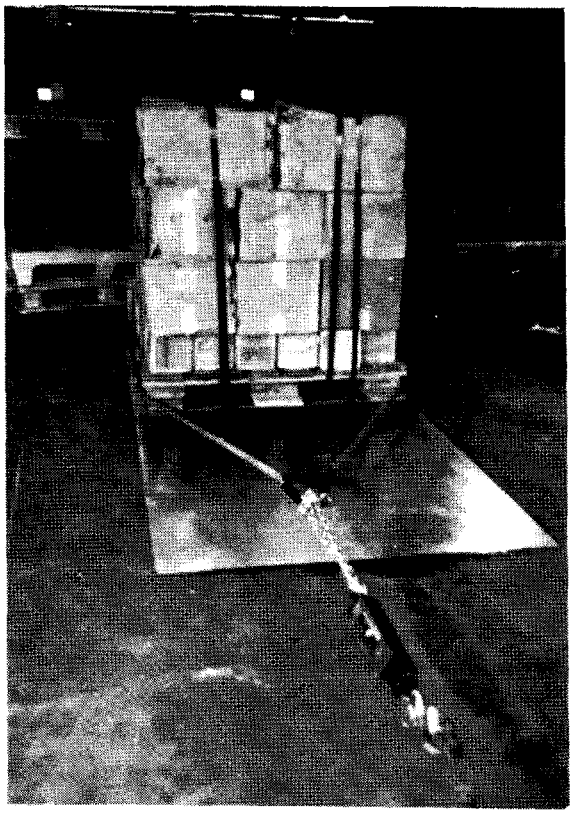


FIG. C1 SLIDING-FRICTION HANDLING TEST ON PLASTIC PALLET ON TOP OF STEEL PLATE

To determine a coefficient of friction across a simulated steel decking, use a flat and clean sheet of galvanized steel laid over a horizontal concrete surface.

C3 SLING-HOIST HANDLING TEST (SEE APPENDIX A7-C, FIG. C2) (FEDERAL TEST METHODS STANDARD 101B-5011-6.3)

Place two 0.75 in. (19 mm) nylon rope slings without spreaders under wings of loaded pallet and bring to common point at a distance at least equal to the height

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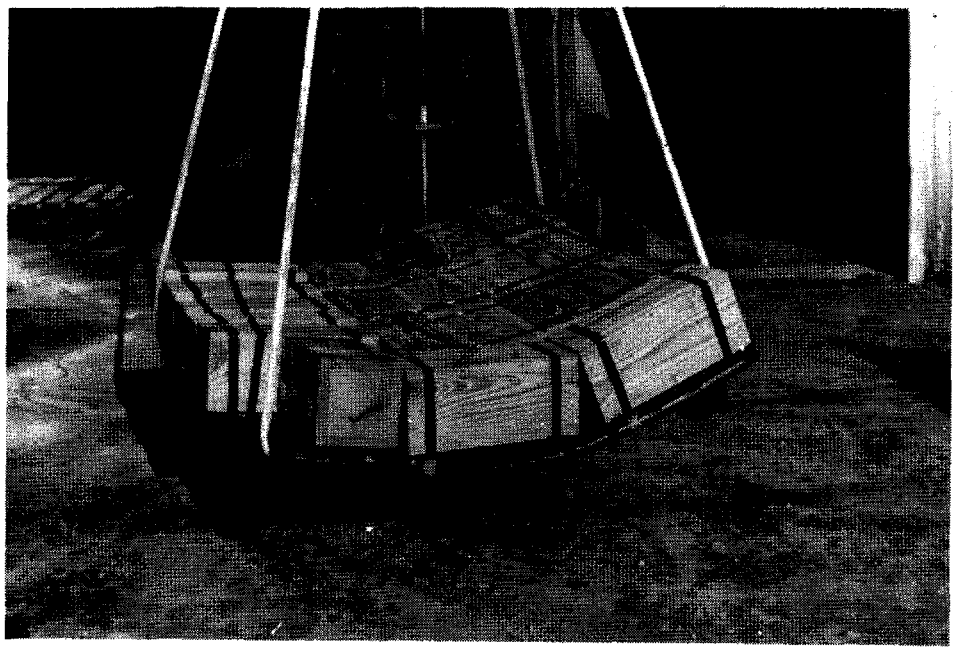


FIG. C2 SLING-HOIST HANDLING TEST ON PLASTIC PALLET, USING TWO SLINGS

of the unit load above center of balance for attachment of hoist. Lift loaded pallet clear off ground and hold it suspended for not less than 2 min. Observe inadequacies and damage. Measure deflection of lifted pallet sides and ends. Lower loaded pallet to come to rest.

NOTE: If pallet sides and ends are both provided with wings, repeat same procedure as directed above, with the slings placed under wings not previously tested.

C4 FORKLIFT TRUCK FORK IMPACT TEST (SEE APPENDIX A7-C, FIG. C3) (U.S.D.A. FOREST SERVICE, FOREST PRODUCTS LABORATORY, REPORT FPL 258)

(a) Place loaded pallet on a horizontal, flat, smooth concrete floor. Locate forklift truck with forks tilted forward 4 deg upward in such a manner that they can enter pallet between pallet stringers or blocks without hitting any pallet parts except bottom of top leading edge, which shall initially contact top surface of forks 8.0 in. (203 mm) away from fork heel. If required, install an electronic or other suitable device to measure speed of forklift truck immediately prior to impacting leading edge. Return pallet to original position on the floor and repeat procedure, with forklift truck traveling same distance at same speed as during initial testing. Terminate test after specified number of impacts or after a substantial part of pallet has separated or when pallet would no longer function properly during its intended use.

(b) If pallet load is simulated, locate this load in such a way that an area of the top deck adjacent to the points of impact is not restrained by any part of this load. In the instance of a pallet with leading-edge top deckboards, the leading edge and adjoining deckboards shall no be restrained by simulated load (see Appendix A7-C, Fig. C3).

(c) An alternate procedure is to place a heavy [1000 lb (454 kg)] loaded pallet behind the test pallet to increase the impact on the test pallet, in order to simulate such field situations where one pallet load is backed up by another one.

C5 FORKLIFT TRUCK FORK SLUING TEST (PACKAGE RESEARCH LABORATORY)

Place loaded pallet on horizontal, flat, smooth, concrete floor. Locate forklift truck fork in such a manner that one fork toe is in contact with side of stringer near its end or side or block. Manipulate forklift truck in such a manner that loaded pallet is slued 180 deg around pallet center. Observe inadequacies and damage.

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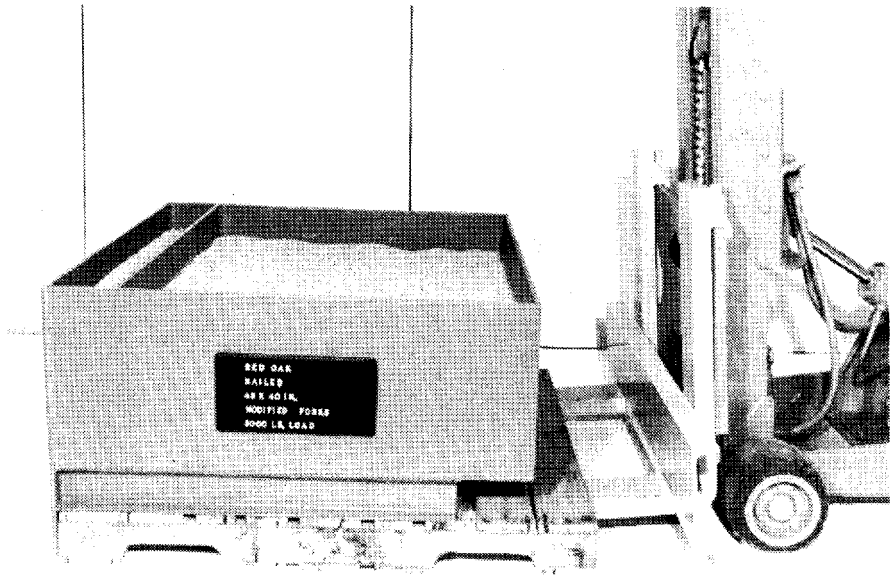


FIG. C3 FORKLIFT TRUCK HANDLING TEST WITH FORKS ENTERING BELOW LEADING-EDGE LUMBER DECKBOARD OF LOADED WOOD PALLET

Repeat procedures several times by contacting other stringers or blocks. Terminate test after specified number of sluings or when pallet would no longer function properly during its intended use.

C6 LOAD-SEPARATION OF TOPPLING TEST (PACKAGE RESEARCH LABORATORY)

Place three nominal 2 × 4s (38 × 89 mm) on a horizontal, flat, smooth, concrete floor, 4.0 ft (1.2 m) on centers and staggered in such a manner that front tire on the one side of forklift truck goes over first 2 × 4, front tire on opposite side of forklift truck goes over second 2 × 4, and first front tire goes over third 2 × 4, when forklift truck travels at speed of approximately 1.0 mph (1.6 km/h) over the three staggered 2 × 4s. Lift loaded pallet with forks of forklift truck and move it as prescribed, which will result in rocking, ripping, and flexing of loaded pallet, load separation, and disarrangement or toppling. Observe inadequacies and damage of pallet and movement of load. Repeat procedure and terminate test after specified number of repetitions, when pallet will no longer function properly during its intended use or when load is no longer arranged as required.

C7 FORKLIFT TRUCK FORK TILT TEST

(a) Place loaded pallet on horizontal, flat, smooth, concrete floor. Locate forklift truck with forks tilted backward 4 deg in such manner they can enter pallet between pallet stringers or blocks without hitting any pallet parts. Drive forklift truck forward, allowing its forks to enter the pallet until the tips (leading edges of the forks) are at the width center of the last top deckboard. Stop the forklift truck and raise the forks, allowing the fork tips to make the initial contact with the pallet on the bottom side of the last top deckboard. Raise loaded pallet off the floor, then lower to its original horizontal position. Repeat lifting and lowering of the load. Terminate test after specified lowering of the load. Terminate test after specified number of lift/lower cycles or after the top deckboard has separated or when pallet would no longer function properly during its intended use.

(b) Although this test procedure has not been specified by any laboratory or government agency, it simulates an incorrect procedure of inserting forklift truck forks into a pallet and lifting a loaded pallet as practiced by many forklift truck operators to save time (by eliminating time to tilt forks to horizontal, lifting, and then tilting backward for travel position) at the expense of potential pallet damage.

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NONMANDATORY APPENDIX A7-D
SELECTED STANDARDS, SPECIFICATIONS, ARTICLES, AND REPORTS REFERENCED IN TEXT

(This Appendix is not part of Part 7 of ASME MH1-1997 and is included for information purposes only.)

American Society of Mechanical Engineers

ASME MH1.2.2M-1989, Pallet Sizes

ASME MH1.8M-1996, Wood Pallets

American Society for Testing and Materials (Annual book of ASTM Standards, Section 15, Volume 15.09)

D 782-87, Methods of Testing Shipping Containers in Revolving Hexagonal Drum: 187–192

D 880-92, Method of Incline Impact Test for Shipping Containers: 205–210

D 1185-94, Methods for Testing Pallets and Related Structures Employed in Materials Handling and Shipping: 294–304

F 680-87, Test Methods for Nails

F 1575-95, Test Methods for Determining Bending Yield Moment of Nails

International Standards Organization

ISO 445-1984, Pallets for Materials Handling — Vocabulary

ISO 6780-1994, General-Purpose Flat Pallets for Through Transit of Goods — Principal Dimensions and Tolerances

ISO 8611-1994, General-Purpose Flat Pallets for Through Transit of Goods — Test Methods

ISO 12771-1994, Methods of Test for Pallet Joints, Part 1 — Determination of Bending Resistance of Pallet Nails, Staples, and Other Dowel-Type Fasteners

ISO/TR 10232-1992, General Purpose Flat Pallets for Through Transit of Goods — Design Rating and Maximum Working Load

ISO/TR 10233-1989, General-Purpose Flat Pallets for Through Transit of Goods — Performance Requirements

National Wooden Pallet and Container Association

Uniform Standard for Wood Pallets (May 1995)

Grocery Manufacturers of America

Recommended Hardwood Pallet Specifications for the Grocery Industry (May 1978)

American Forest and Paper Products Association (formerly National Forest Products Association)

National Design Specification for Wood Construction (1991)

Commentary on the National Design Specification for Wood Construction (1993)

U.S. Government Specifications

Federal Test Methods Standard No. 101b, Method 5005, Cornerwise-Drop (Rotational) Test (January 1969)

Federal Test Methods Standard No. 101b, Method 5008, Edgewise-Drop (Rotational) Test (January 1969)

Federal Test Methods Standard No. 101b, Method 5011, Mechanical Handling Test (January 1969)

Federal Test Methods Standard No. 101b, Method 5016, Superimposed-Load Test (Stackability with Dunnage) (January 1969)

Federal Test Methods Standard No. 101b, Method 5019, Vibration (Repetitive Shock) Test (January 1969)

NATO Document — STANAG NO. 2828, Standardization Agreement; Subject: Military Pallets, Packages, and Containers (August 1974)

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Loferski, J. R. and E. George Stern. "Understanding Impact Testing of Pallet Nails and Staples." *Journal of Testing and Evaluation* 19(5) (September 1991): 379–384.

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Nethercote, C. H. and J. R. Reeves. "A Modern Outlook on Pallet Research." *Materials Management and Distribution* 17(5) (May 1972): 35, 36, 66.

Stern, E. George. "Pallets Assembled With 10-Gauge Automatic Nails." *Forest Products Journal* 5(6) (June 1965): 242–246.

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Reports

"New Impact Test for Pallets." Canadian Department of Fisheries and Forests 13(5). Information Report OP-X-31. Canadian Forest Service's Eastern Forest Products Laboratory.

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———. "Interaction Between Pallets and 36 Packagers' Products and the Effect of These Interactions on Unit-

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Load Performance." MHI-PROMAT '91, Chicago, Illinois (1991).

———. "New Uniform Product Standard for Wood Pallets." National Wooden Pallet and Container Association Meeting, Phoenix, Arizona (1991).

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Part 8
Slip Sheets

Refer to ASME MH1.5M-1993 Slip Sheets.

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AMERICAN NATIONAL STANDARDS FOR MATERIAL HANDLING DEVICES

Safety Standard for Low Lift and High Lift Trucks B56.1-1993
Safety Standard for Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles B56.5-1993
Safety Standard for Rough Terrain Forklift Trucks B56.6-1992
Safety Standard for Industrial Crane Trucks B56.7-1987 (R1992)
Safety Standard for Personnel and Burden Carriers B56.8-1993
Safety Standard for Operator Controlled Industrial Tow Tractors B56.9-1992
Safety Standard for Manually Propelled High Lift Industrial Trucks .. B56.10-1992
Double Race or Bi-Level Swivel and Rigid Industrial Casters B56.11.1-1992
Load Handling Symbols for Powered Industrial Trucks B56.11.3-1992
Hook-Type Forks and Fork Carriers for Powered Industrial Forklift Trucks B56.11.4-1992
Measurement of Sound Emitted by Low Lift, High Lift, and Rough Terrain Powered Industrial Trucks B56.11.5-1992
Evaluation of Visibility From Powered Industrial Trucks B56.11.6-1992
Pallets, Slip Sheets, and Other Bases for Unit Loads MH1-1997
Pallet Sizes MH1.2.2M-1989
Slip Sheets MH1.5M-1993
Wood Pallets MH1.8M-1996
Export Pallets MH1.9-1993

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