

ASME MH1.8M

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WOOD PALLETS

AN AMERICAN NATIONAL STANDARD



The American Society of
Mechanical Engineers



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Mechanical Engineers

A N A M E R I C A N N A T I O N A L S T A N D A R D

WOOD PALLETS

ASME MH1.8M-1996

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FOREWORD

(This Foreword is not part of ASME MH1.8M-1996.)

The extensive use of wood pallets in the United States and many other countries created a need for the standardization of wood pallets. According to statistics gathered by the National Wooden Pallet and Container Association of Arlington, Virginia, hundreds of millions of wood pallets were manufactured in the United States during each of the past 30 years. In the light of this and to prevent serious problems in the handling, storing, and transporting unit loads within the U.S.A. as well as the international trade, it became imperative that prescriptive as well as performance standards for new and repaired, captive and exchange, wood pallets be established.

With this in mind, The Pallet Association prepared and published a ‘‘Uniform Voluntary Standard for Wood Pallets’’ during 1994, to establish minimum quality requirements for the most common classes, types, and styles of wood pallets made of lumber of any wood species commercially available and suitable for this purpose. That Standard served as a basis for this American National Standard for Wood Pallets.

To establish standard specifications and guidelines for pallets and other bases for unit loads, the American National Standards Institute (formerly, the American Standards Association) project on pallet standardization was initiated during October, 1953. A Materials 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 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. Five subcommittees were organized:

- (a) *Advisory Liaison* — to provide an effective two-way information flow between the MH1 Pallet Standards Committees, related ANSI standards committees, and other concerned organizations;
- (b) *Definitions* — to prepare definitions of pallet terms, as outlined in the Style Manual for American National Standards, and prepare for publication all standards developed under the procedures of ANSI by the ASME Standards Committee MH1;
- (c) *Sizes* — to define the minimum number of pallet sizes that provide the maximum of efficiency, economy, interchangeability, and adaptability when used in all types of rail, highway, and waterborne transports in the U.S.;
- (d) *Testing* — to assemble information on, submit recommendations for, and develop test procedures;

(e) *Materials* — to describe, specify, or otherwise stipulate the quality and/or nomenclature of materials suitable for use in the construction and fabrication of pallets.

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 Standardization of Slip Sheets in March of that year. 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 governmental agencies, organized a Technical Committee comprised of five subcommittees — Survey, Definitions, Materials, Testing, and Sizes — to perform its work. During July 1981, this Technical Committee was reorganized as an ASME Standards Committee operating under the ANSI accredited organization procedures. During December 1981, the Executive Committee was deactivated by unanimous vote of the MH1 Committee during its regular meeting.

The following MH1 Committee standards were issued:

MH1.1.2	Pallet Definition and Terminology
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
MH1.9-1993	Export Pallets

The preparation of this American National Standard on Wood Pallets was suggested by The Pallet Association and initiated during 1992. The first draft was submitted to the Secretariat of MH1 during June, 1992, and letter-balloted within MH1 from August 26th to September 16, 1992, resulting in 11-1-1 vote. A second draft was submitted to the Secretariat during January, 1993, and letter-balloted within MH1 from December 28, 1992, to January 28, 1993, resulting in two (four) negatives based on the terminology used in the proposed Standard. These negatives were resolved and withdrawn during the April, 1993 Annual MH1 Meeting, since the terminology used represents the terminology predominantly common in the industries involved.

Because of major developments in industry, which justified significant changes in the draft, The Pallet Association suggested, and the Committee Chairman instructed the Secretariat to withdraw that draft from further consideration by MH1. With the issuance of a revised "Uniform Voluntary Standard for Wood Pallets" by The Pallet Association, dated June 1, 1994, a new draft for an American National Standard on Wood Pallets was prepared and submitted to the MH1 Secretariat for letter-ballot within MH1 during November, 1994. It was letter-balloted during 1995 and the revised standard was again letter-balloted from January 16, 1996 to February 23, 1996, resulting in unanimous approval by the Committee membership.

The revised draft was submitted during January 16, 1996 to the ASME Board of Standardization and the American National Standards Institute (ANSI) for public review and approval. It was approved by ANSI as an American National Standard on July 16, 1996.

Suggestions for improvement of this Standard should be sent to the Secretary, MH1 Committee, the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

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

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

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WOOD PALLETS

1 PURPOSE

The purpose of this Uniform Voluntary Standard for Wood Pallets (hereinafter referred to as the 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.

2 SCOPE

This Uniform Voluntary Standard applies to all lumber-deck pallets, either new or repaired, as well as the lumber components and fasteners. Criteria contained in this Standard are applicable only at the completion of manufacture. This Standard does *not* cover panel-deck pallets.

This Standard is in three parts. Part I is the Prescriptive Standard which concerns the manufacture of the pallet. This includes pallet and pallet component descriptions, fastener descriptions, workmanship criteria, dimensional tolerances, markings, and moisture content levels. Part II is the Performance Standard which concerns the functionality of the pallet. This 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 Part I of the Prescriptive Standard. Part III covers the Quality Assurance Auditing Program.

This Standard 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 Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.

To assist the user of this Standard, other related standards are listed in Appendix B.

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

PART I. PRESCRIPTIVE STANDARD

3 CLASSIFICATIONS

3.1 Classes

- (a) *Class 1.* Stringer pallet (see Fig. 1).
- (b) *Class 2.* Block pallet (see Fig. 1).

3.2 Use Categories

(a) *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 Section 10.2); also known as a returnable pallet, reusable pallet, permanent pallet, general-purpose pallet, special-purpose pallet, special-service pallet, or through-transit pallet.

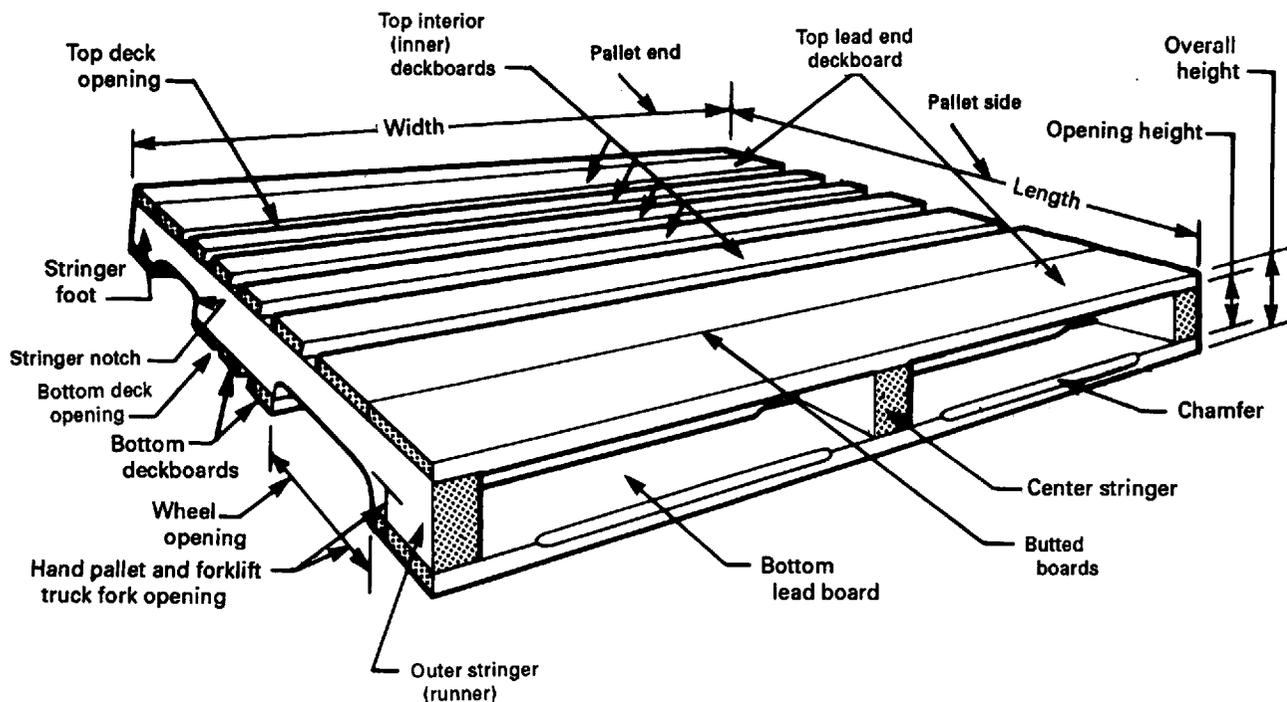
(b) *Category 2: Limited-Use (L)* — pallet designed for an average of up to nine trips, with an average of five handlings per trip and an average handling environment as defined in the Pallet Design System (PDS), before first repair, i.e., life to first repair (LFR) (see Sections 4, 9, and 10.2); also known as a single-trip pallet, one-trip pallet, one-way pallet, expendable pallet, shipping pallet, or general-service pallet.

3.3 Types

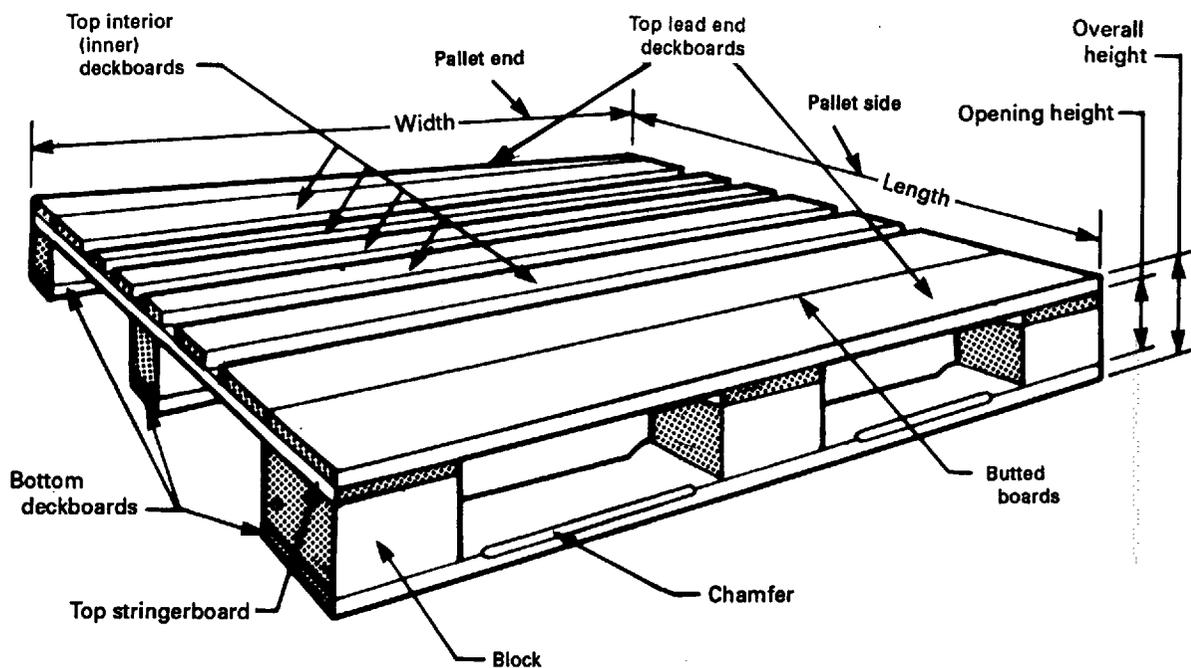
Type 1. Two-way entry pallet with openings accepting handling equipment only in two pallet ends, i.e., unnotched stringer pallet.

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

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, or without bottom deckboards.



(a)



(b)

FIG. 1 SCHEMATIC DIAGRAMS OF TYPICAL STRINGER AND BLOCK CLASS PALLETS WITH PRINCIPAL PARTS LABELED

3.4 Styles

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

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.

3.5 Bottom-Deck Constructions

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

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 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 Fig. 2).

¹Styles of block class pallets, in which stringerboards overhang end blocks.

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.

4 DEFINITIONS AND/OR TERMINOLOGY²

For definitions covering defects which affect the quality of pallet components, see Annex 3.

block — rectangular, square, multisided, or cylindrical deck or deck-mat spacer between top and bottom decks or beneath top deck of single-deck pallet, often identified by its location within pallet as corner block, end block, edge block, inner block, center, or middle block; *post block size* — stated in terms of width, followed by height and length

deckboard — element or component of pallet deck, oriented perpendicular to stringer or stringerboard

deckboard size — stated in terms of thickness, followed by width and length

Fastener Shear Index (FSI) — measure of estimated shear resistance of a given pallet fastener relative to the shear resistance of a high-quality “base” pallet nail

Fastener Withdrawal Index (FWI) — measure of estimated withdrawal resistance of a given pallet fastener, based on lesser of shank or leg withdrawal or head or crown pull-through resistance, relative to that of a high-quality “base” pallet nail

*MIBANT Angle*³ — angular deformation of fastener shank or leg, when subjected to MIBANT test, providing indication of fastener bending resistance and toughness

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 Section 10.2)

pallet length — pallet dimension between the extreme pallet ends, parallel to and corresponding to the length of the stringers or top stringerboards; refers to first dimension when describing pallet size

²For a complete listing of pallet definitions see “Definitions and Terminology Covering Pallets and Related Structures,” ASME MH1.1.2-1996, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

³MIBANT angles are measured according to procedures contained in ASTM F680-87, Standard Test Methods for Nails. Volume F16.06, American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2989.

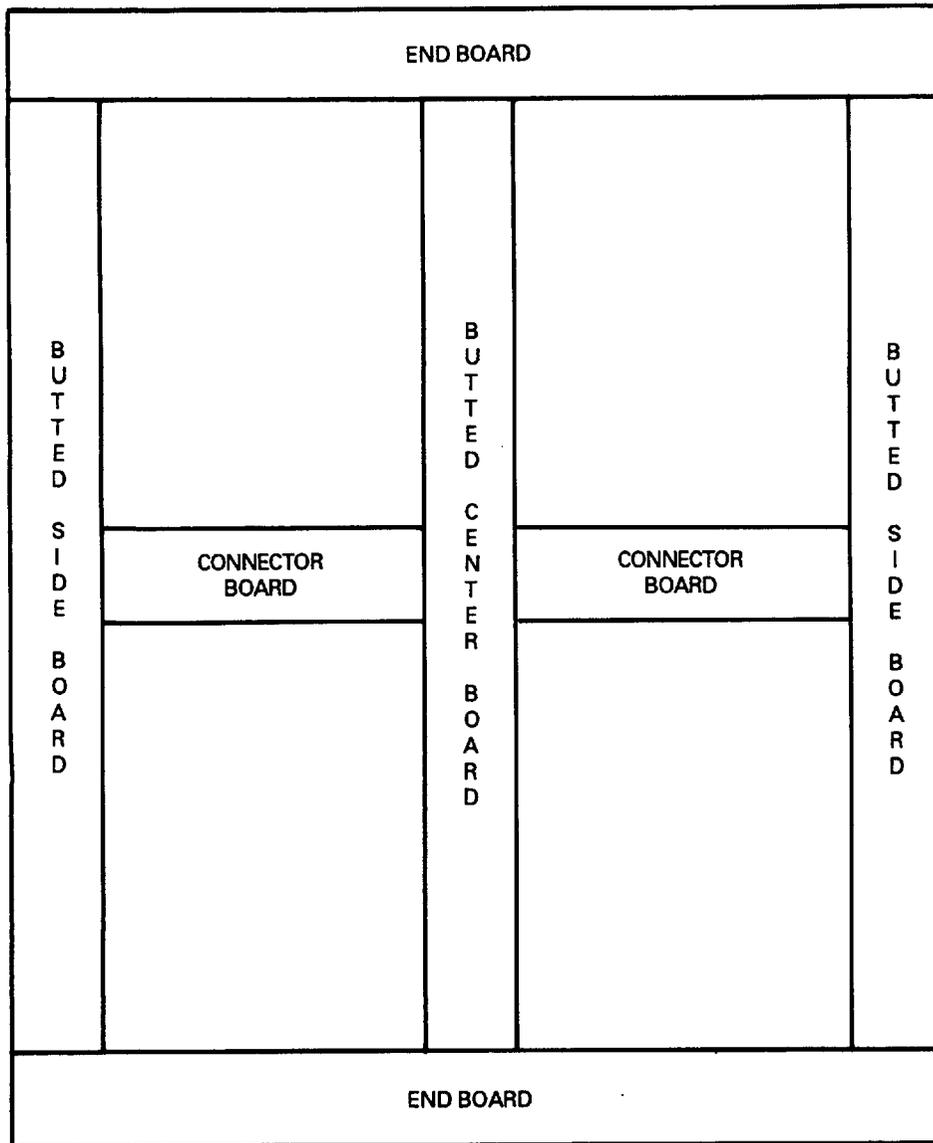


FIG. 2 COMPONENT NAMES FOR PERIMETER AND CRUCIFORM BOTTOM-DECK CONSTRUCTIONS, WITH ALL BOTTOM-DECK COMPONENTS LOCATED IN ONE PLANE

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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; refers to second dimension when describing pallet size

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 British Commonwealth countries)

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

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

5 MATERIALS

The materials used for pallet manufacture shall be in conformance with the requirements outlined in Part III, Section 11.2

5.1 Lumber Components

5.1.1 Species. The species of woods used in pallet manufacture are numerous. As an aid to the pallet designer, Annex A contains a classification of many commercially available woods listed according to similarities in mechanical properties, regional availability, and commercial use in pallets.⁴ When specifying wood pallets, the wood species permissible in the structure can be indicated by the species class numbers given in Annex A.

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 Table 1 and the manufactured defect limitations specified below. Descriptions and definitions of the defects in Table 1 can be found in Annex B.

⁴Details concerning the development of these wood-species classifications are found in McLeod, J.A., 1985, "Development of Flexural Values for Pallet Shook," M.S. Thesis, Department of Wood Science and Forest Products, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0503.

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 Section 6.1.2)

saw cuts — same as unsound knot (see Table 1 and Section 6.1.2)

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

5.1.4 Preparation of Pallet Components

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: + unlimited, $-1/4$ 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.

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 bot-

TABLE 1 MINIMUM PALLET COMPONENT QUALITY

Defect	Description	Defect Limitations	
		Multiple-Use (M) [Note (1)]	Limited-Use (L) [Notes (2), (3)]
Sound knots [Note (4)]	Maximum portion of the cross section affected	$\frac{1}{2}$	$\frac{1}{8}$
Frequency of knots	Number of maximum size knots per component	2 in 6 in. (153 mm) of length	1 in every $\frac{1}{2}$ length of component
Unsound knots and holes [Note (5)]	Maximum portion of the cross section affected [Note (6)]	$\frac{1}{4}$	$\frac{3}{8}$
Wane	Maximum portion of the actual deckboard or stringerboard width by thickness (full length) [Note (6)]	$\frac{1}{4} \times \frac{2}{3}$ (exposed) [Note (8)] $\frac{1}{3} \times \frac{2}{3}$ (non-exposed) [Note (8)]	$\frac{3}{8} \times$ full thickness (exposed) [Notes (7), (8)] $\frac{1}{2} \times$ full thickness (non-exposed) [Notes (7), (8)]
	Maximum portion of the actual stringer and block width and height (full length) [Note (6)]	$\frac{1}{3} \times \frac{1}{2}$ [Note (8)]	$\frac{3}{8} \times \frac{2}{3}$ [Note (8)]
Decay	Maximum portion of the cross section affected [Note (9)]	$\frac{1}{4}$	$\frac{1}{4}$
Splits/shakes [Note (10)]	Maximum portion of deckboards, stringerboards, stringers, and blocks length (L) or width (W)	Deckboards $\frac{1}{3}$ L Stringerboards $\frac{1}{2}$ L Stringers [Note (11)] Horizontal – Less than 4 in. or $2 \times W$ Vertical – Same Block $\frac{1}{2}$ L	Full length Less than full length Less than 4 in. or $2 \times W$ $\frac{1}{2}$ L $\frac{1}{2}$ 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 Section 10.2).
- (2) This minimum quality description corresponds to all PDS Grades (see Section 10.2).
- (3) This quality is limited to use for deckboards and stringerboards $\frac{5}{8}$ in. (17 mm) thick, or greater, and stringers or blocks $1\frac{1}{4}$ in. (38 mm) wide, or greater. Limited-use (L) pallets with deckboards and stringerboards less than $\frac{5}{8}$ in. (17 mm) thick or stringers or blocks less than $1\frac{1}{4}$ in. (38 mm) in width shall meet or exceed the multiple-use (M) quality level.
- (4) Sound knots are limited over or within 2 in. (51 mm) of the notch ends to $\frac{1}{2}$ of the net dimension above the notch.
- (5) Unsound knots (decay within knot) or holes are limited to $\frac{1}{2}$ in. (13 mm) over or within 2 in. (51 mm) of the ends of stringer notches.
- (6) Provided the average width of the wood is not less than $\frac{3}{4}$ 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 (see Section 6.1.3).
- (9) No decay (outside of unsound knot) is allowed over or within 2 in. (51 mm) of the ends of the stringer notches.
- (10) See definition of splits in Annex B.
- (11) Not allowed over or within 2 in. (51 mm) of the ends of the stringer notches.

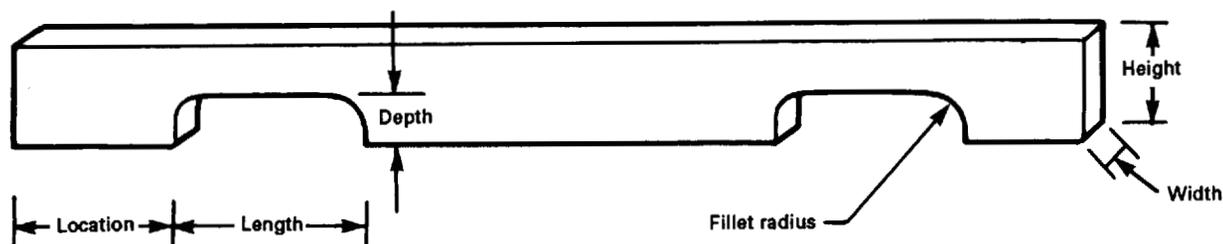


FIG. 3 SCHEMATIC DIAGRAM OF A PALLET STRINGER WITH NOTCH FEATURES INDICATED

tom 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.

5.1.4.3 Stringer Notches. Notches in stringers, if required, shall be specified by location (distance from stringer end), depth, and length (see Fig. 3). The recommended opening sizes to be provided by the notch and the bottom deck, if present, are 2 in. (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. (38 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.

5.2 Fasteners

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

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

- direct measurement of the physical and mechanical characteristics indicated in Table 2 and Fig. 4;
- the Fastener Shear and Fastener Withdrawal Indexes (FSI and FWI); and
- the Fastener Code.⁵

The fastener length shall be sufficient to provide a minimum penetration of $1\frac{1}{4}$ in. (32 mm) into the stringer or block for all deckboard thicknesses over $\frac{1}{2}$ in. (13 mm) and a minimum penetration of 1 in. (25 mm) for deckboard thicknesses of $\frac{1}{2}$ in. (13 mm) or less. Manufacturing tolerances shall conform to those specified in MH1.7M-1996.⁵ The minimum acceptable quality of driven fasteners is specified in Table 3. To assist the pallet designer, physical descriptions of fasteners meeting the performance criteria in Table 3 are contained in Appendix A, Tables A-1, A-2, and A-3.

5.2.2 Bolts. For bolted constructions, standard steel carriage bolts can be 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.⁶ When ordinary standard commercial carriage bolts are employed, washers 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 $\frac{1}{32}$ in. (0.75 mm) larger in diameter than the bolt diameter for

⁵Driven Fasteners for Assembly of Pallets and Related Structures, ASME/ANSI MH1.7M-1996, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

⁶Soled, J. 1957, Fastener Handbook. Reinhold Publishing Corporation, New York, NY, pp. 430.

TABLE 2 PHYSICAL AND MECHANICAL CHARACTERISTICS OF DRIVEN FASTENERS USED IN PALLETS¹

Nails [Note (2)]				Staples	
Plain Shank	Helically Threaded	Annularly Threaded	Fluted/Square Wire	Round Wire	Square 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 [Note (3)]	MIBANT angle	MIBANT angle	MIBANT angle	MIBANT angle	MIBANT angle

NOTES:

- (1) ASTM F680-89, Standard Test Methods for Nails, Volume F16.06. American Society of Testing and Materials, 100 Bar 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 $\frac{5}{32}$ in. (4 mm) in length. In 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.

bolts less than $\frac{1}{2}$ in. (13 mm) in diameter. For $\frac{1}{2}$ in. (13 mm) or larger diameter bolts, the hole shall be $\frac{1}{16}$ 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-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)	$\frac{1}{4}$ in. (6 mm)
2501 to 4000 lbf (11.2–17.8 kN)	$\frac{5}{16}$ in. (8 mm)
Over 4000 lbf (17.8 kN)	$\frac{3}{8}$ in. (9.5 mm)

5.2.3 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. Overdriving and overtightening 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 predrilling 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.

6 MANUFACTURE

The pallet manufacturing practices shall be in conformance to the requirements specified in Part III, Section 11.2.

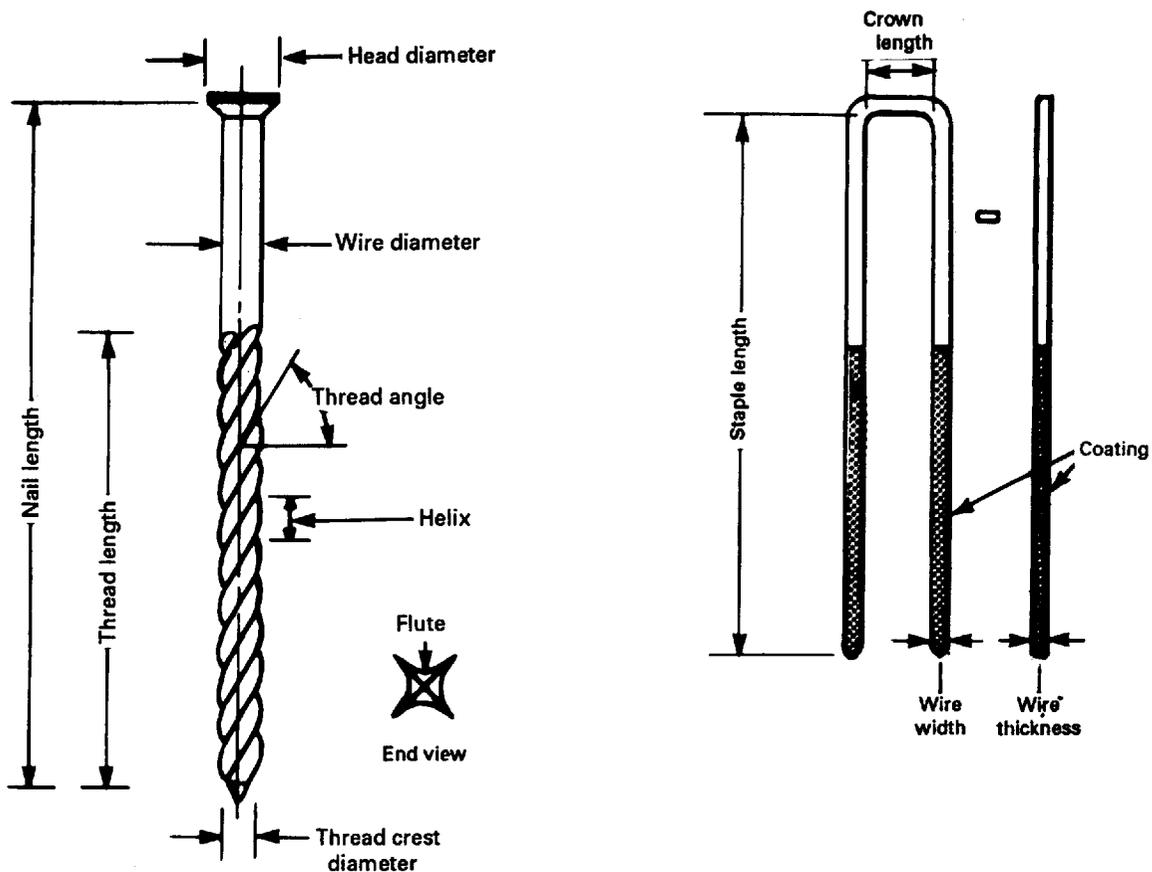


FIG. 4 SCHEMATIC DIAGRAM OF DRIVEN FASTENERS USED IN PALLET, INDICATING THE MEASUREMENTS OF THE PHYSICAL CHARACTERISTICS INCLUDED IN TABLE 2

6.1 Location of Defects

For definitions, see Annex B.

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

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, nor on the exposed ends of stringers or blocks.

6.1.3 Wane and Decay. Wane and decay are permitted on any component, provided they are not located on the outer edge of endboards, on the exposed sides of stringers or blocks, or in the notched area [over or within 2 in. (51 mm) of the ends of stringer notches)]. Wane may appear 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.

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.

6.2 Assembly

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

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

TABLE 3 MINIMUM QUALITY OF DRIVEN FASTENERS¹

	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), (5)]	65	50	55	40	2.25	2.00	0.375 in. (9.5 mm) [Note (3)]
Clinched mat fasteners [Note (4)]	Completely through the fastened and fastening members and clinched	25	20	25	20	2.00	2.00	0.375 in. (9.5 mm) [Note (3)]

NOTES:

- (1) Or 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 Section 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) Acceptable in both Multiple-Use (M) and Limited-Use (L) pallets.
- (4) 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).
- (5) For Limited-Use (L) pallets with 1/2 in. (12 mm) thick, or thinner, deckboards, the minimum penetration depth shall be 1 in. (25 mm).

(b) Other wood components shall be within $\pm 1/2$ 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 are to be flush with the stringer. All allowable deviations under Section 6.2.1 are subject to the overall pallet-size criteria in Section 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.

6.2.2 Pallet-Size Deviation. The pallet size shall be limited to $+1/4$ in. (+6 mm) and $-1/2$ in. (-13 mm) of the target dimension, as measured at specific points along the pallet length and width. The pallets must be flat on their top and bottom surfaces to within 1/4 in. (6 mm) maximum deviation from the corner-to-corner straight line.

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.

6.2.4 Fastenings (Mechanical Fasteners)

6.2.4.1 Fastening Schedules

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

(b) *Bolts, Wood Screws, and Lag Bolts.* 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. It is recommended that bolts be retightened at the time the connected components reach equilibrium moisture content (EMC) during the use of the pallet.

6.2.4.2 Fastener Placement. Fasteners shall be placed in such a way as to minimize splitting of the connected components. 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.

TABLE 4 MINIMUM NUMBER OF DRIVEN FASTENERS

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

NOTES:

- (1) No less than one nail or staple per 8 in.² (512 mm²) of block fastening surface.
 (2) Corner blocks with less than 16 in.² (1032 mm²) of block fastening surface shall be connected with at least two fasteners.

They shall not be placed in the same connection or different connections of an assembly.

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 crown or head.

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 ⅓ of the components per pallet shall contain open splits with visible fastener shanks or legs at the completion of manufacture.

6.2.4.5 Protruding Fasteners. Nail heads, staple crowns, bolt heads, nuts, and screw heads shall be flush 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.

6.2.5 Fastening With Chemical Adhesives and Glues. Adhesives and glues shall only be used in conjunction with mechanical fasteners conforming to Section 5.2.

7 PALLET REPAIR**7.1 Purpose and Scope**

Section 7 defines the general classifications for pallet repairs. Detailed repair requirements are fixed. Pallets needing repair are of two distinct requirement groups, therefore, each group receives different repair treatments.

Properly repairing and recycling wood pallets can yield increased efficiencies and result in long-range cost reductions to pallet users. The purpose of this standard 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.

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

Proper use of this repair standard requires compliance with the requirements which specify the markings of repaired pallets.

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.

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.

7.2 Sizes and Types of Pallets

This repair section is applicable to all lumber-deck stringer and block pallets as described in Section 3.

7.3 Repair Classifications

7.3.1 Repair of Multiple-Use (M) Pallets, M-R Repair. Repairs 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 Section 7.5.

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 Section 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 Section 7.6.

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 Section 11.3). 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 Section 7.5. The designations R-1, R-1P, R-2, and R-3 shall be used for pallets repaired according to Section 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 MH1.8M (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.

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.

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.

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 Sections 5 and 6. Any nonconforming components shall be removed and replaced.

(a) *Lumber.* Components shall meet or exceed the grade and species group (see Annex A) 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 Sections 5 and 6. Any nonconforming components shall be removed and replaced.

(b) *Fasteners.* The fasteners used for all M-R repair shall meet the minimum requirements for Multiple-Use pallets as described in Section 5.2. Examples of fasteners and corresponding schedules, meeting the minimum performance requirements in Section 5.2.1, Table 3, are given in Appendix A, Tables A-1 to A-3.

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 split components (see Fig. 5) and those with unacceptable damage shall be removed and replaced. All the exposed fasteners shall be clipped, re-

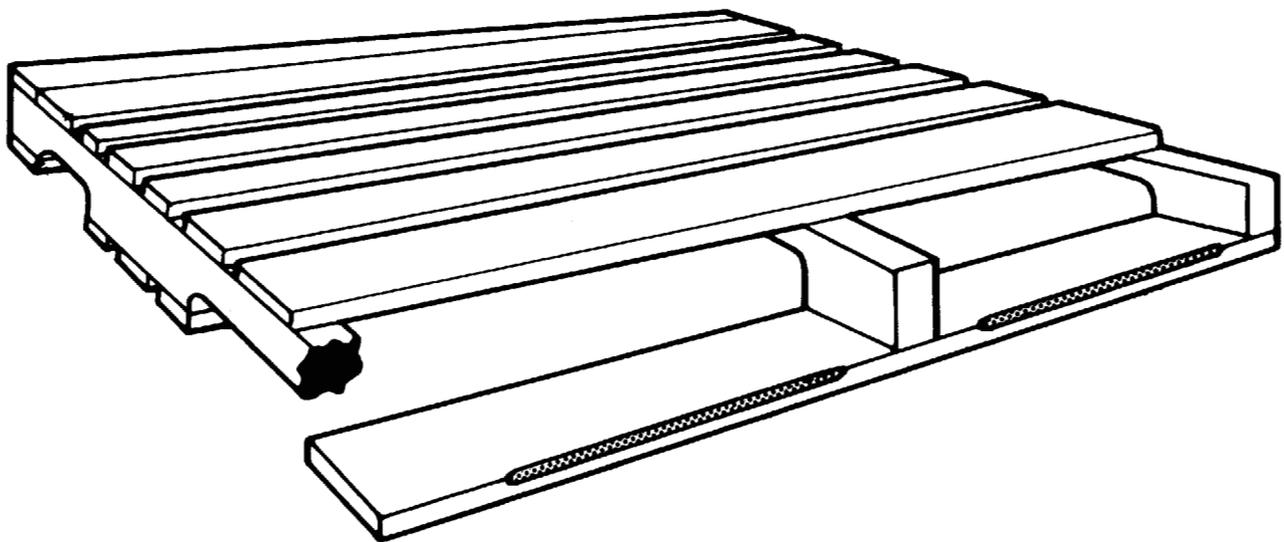
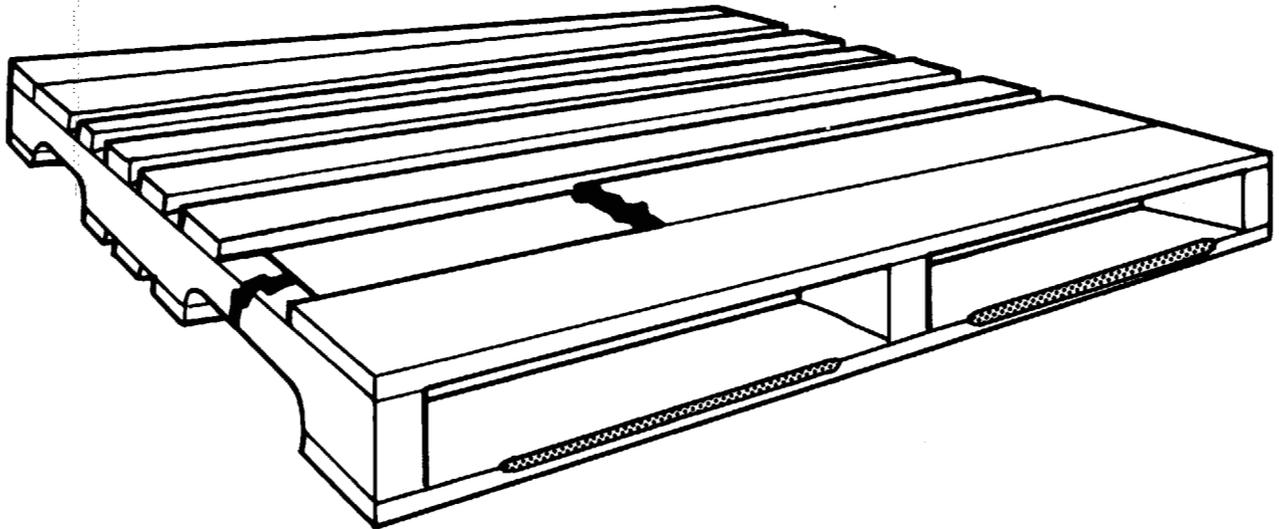


FIG. 5 ALL DECKBOARDS, STRINGERBOARDS, AND STRINGERS BROKEN ACROSS FULL WIDTH, THICKNESS, OR HEIGHT SHALL BE REPLACED

moved, 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 in. × 40 in. 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.

7.5.3.1 Splits (See Fig. 6). 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* — $\frac{1}{3}$ the length and $\frac{1}{8}$ in. (3 mm) wide, full thickness

(b) *Stringers*

(1) *Horizontal splits* — shall be less than 4 in. (102 mm) or $2 \times$ width in length and $\frac{1}{8}$ in. (3 mm) wide.

(2) *Vertical splits* — are defined as splits if the separation is deeper than $\frac{1}{2}$ of the height. In that case, the length is limited to less than 4 in. (102 mm). If the vertical separation is less than $\frac{1}{2}$ of the height, the length is unlimited (see definitions in Annex B).

(c) *Stringerboards* — $\frac{1}{3}$ of the length and $\frac{1}{8}$ in. (3 mm) wide, full thickness.

(d) *Blocks* — a split is defined when the separation is deeper than $\frac{1}{2}$ of the dimension. In that case, the split is limited to $\frac{1}{2}$ of the block length. If the separation is less than $\frac{1}{2}$ of the dimension, the split length is unlimited (see definitions in Annex B).

7.5.3.2 Missing Wood (See Fig. 7). Only one section of missing wood, up to the maximum size allowed, is permitted for any component. Missing wood which 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 $\frac{1}{2}$ 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 up to 1 in. (25 mm) deep and 10 in. (254 mm) long along the board edge.

(b) *Stringers* — more than $\frac{1}{4}$ of the width and $\frac{1}{4}$ 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 $\frac{1}{4}$ of the width and $\frac{1}{4}$ of the height for $\frac{1}{4}$ 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 Fig. 8).

7.5.4 Manufacturing Accuracy, M-R Repair

(a) The placement of all components and fasteners shall conform to Section 6.2.

(1) All leading deckboards shall be within $\pm \frac{1}{4}$ in. (± 6 mm) of their specified location.

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

(3) Unless otherwise specified, lead deckboards and ends of deckboards are assumed to be flush with the stringer.

(b) Maximum placement deviation shall be limited to $\frac{1}{3}$ of the components in any pallet. All similar components shall be placed parallel unless otherwise specified.

(1) The pallet sizes shall be limited to $+\frac{1}{4}$ in. (+6 mm) and $-\frac{1}{2}$ 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 $\pm \frac{1}{4}$ 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 the measured top-deck diagonals of the 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 Section 5. The fasteners shall meet the minimum requirement for multiple-use pallets (see Section 5.2).

(e) The fastening locations and their schedule per connection shall comply with the requirements in Section 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 below deck surfaces. Coun-

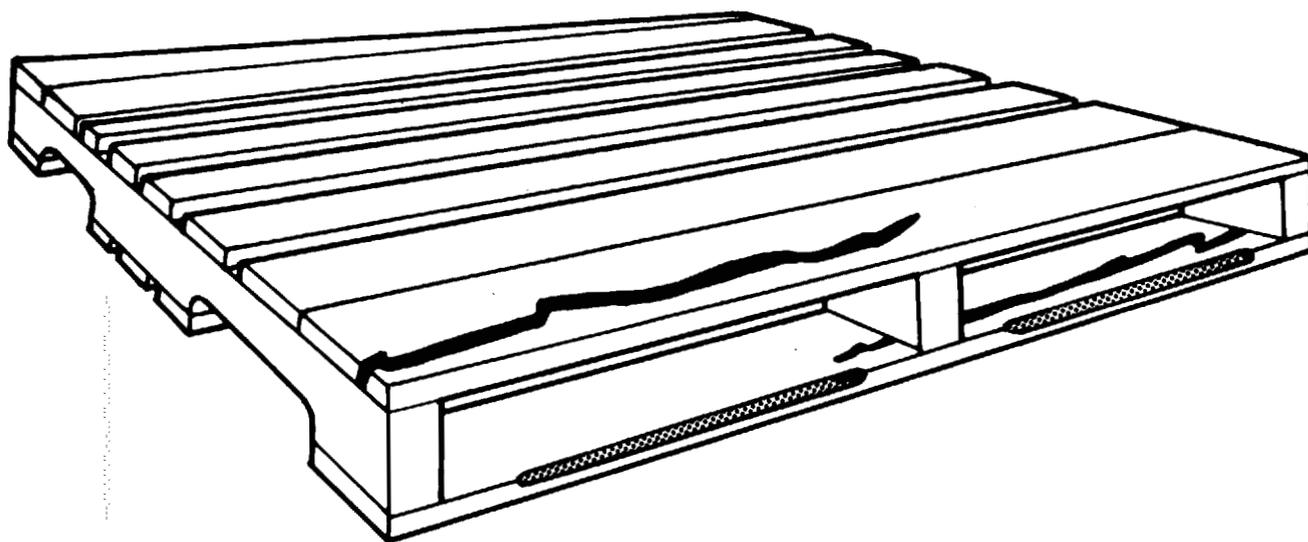
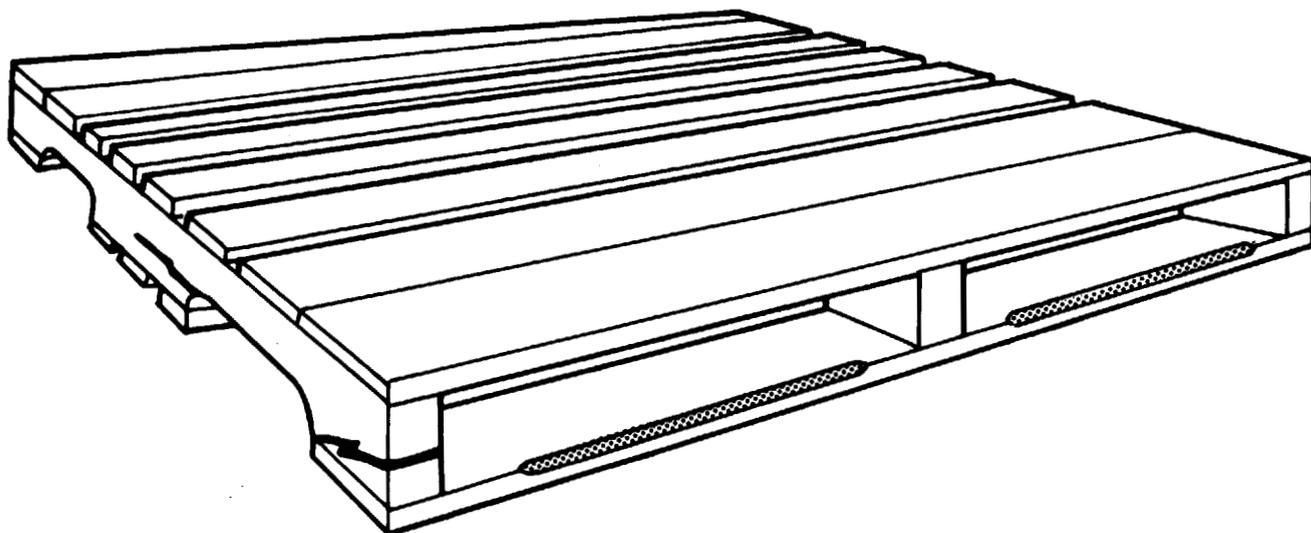
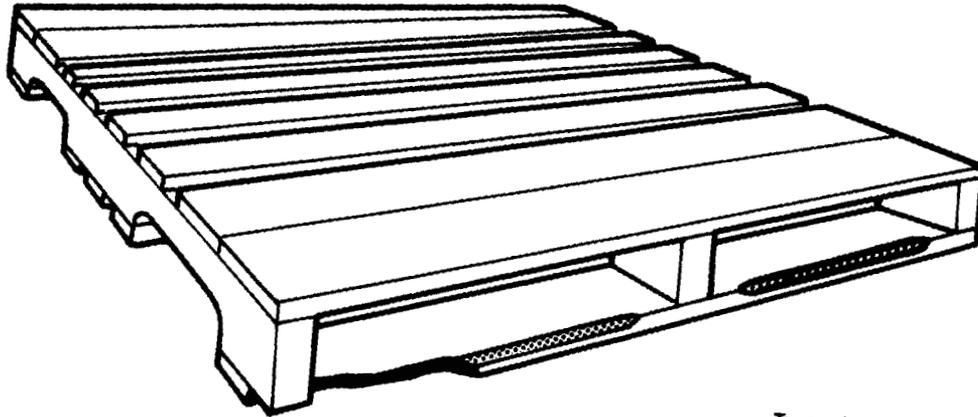
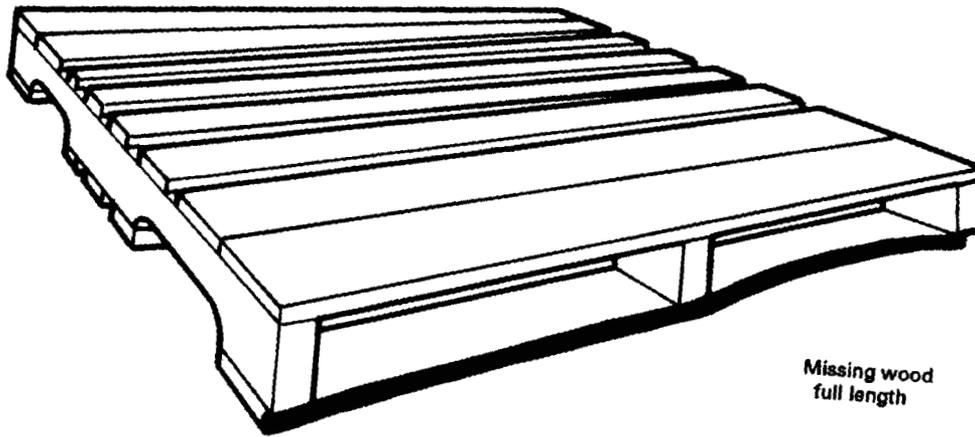


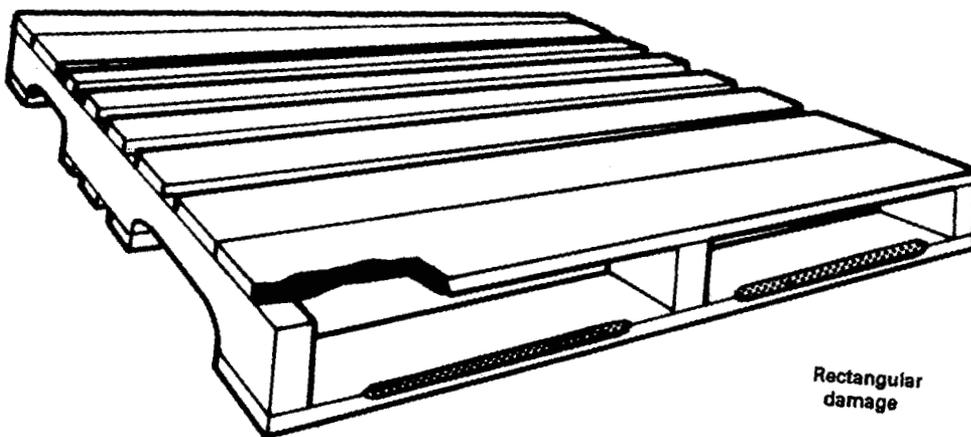
FIG. 6 ALL COMPONENTS WITH SPLITS EXCEEDING THE CRITERIA IN SECTIONS 7.5.3.1 AND 7.6.3.1 SHALL BE REPLACED OR REPAIRED



Tapered damage



Missing wood
full length



Rectangular
damage

**FIG. 7 SCHEMATIC DIAGRAMS SHOWING EXAMPLES OF MISSING WOOD DAMAGE DESCRIBED
IN SECTIONS 7.5.3 AND 7.6.3**

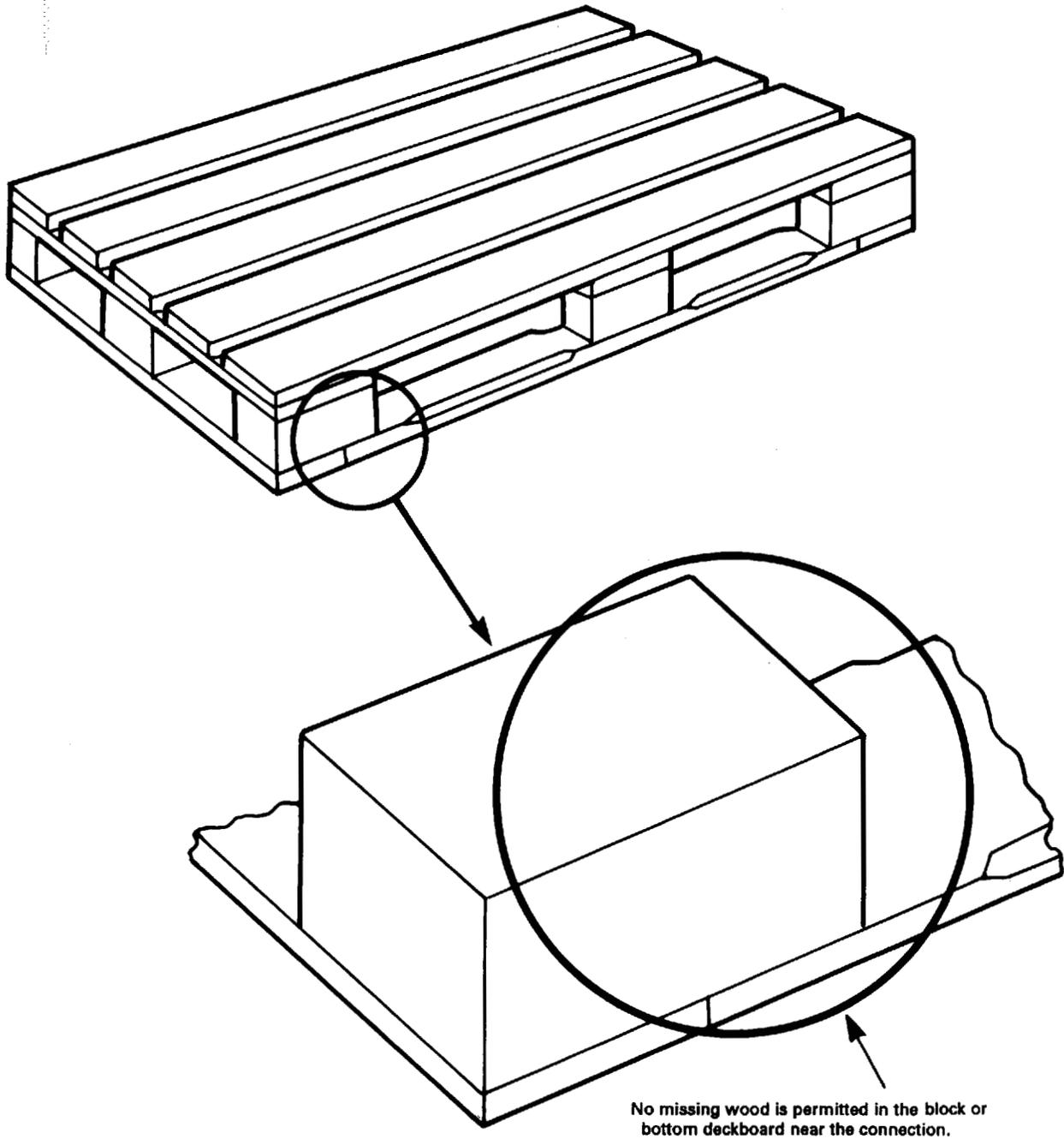
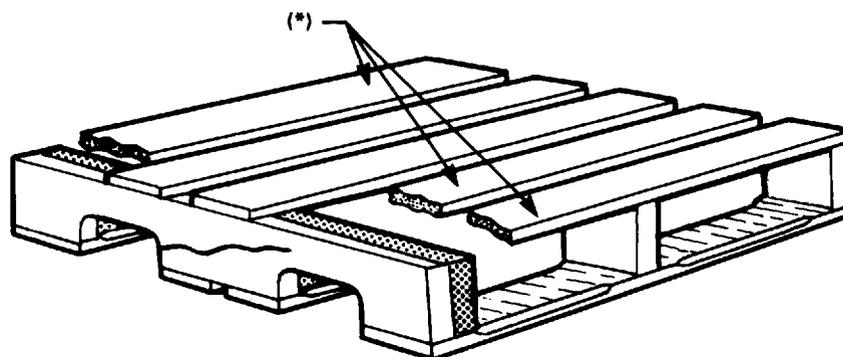


FIG. 8 SCHEMATIC DIAGRAM OF A BLOCK CLASS PALLET SHOWING THE BUTTED CONNECTION IN THE BOTTOM DECK OF A PERIMETER BASE DESIGN



*Deckboards shortened for illustrative purposes only.

FIG. 9 SCHEMATIC DIAGRAM OF AN R-2 FULL-LENGTH COMPANION STRINGER REPAIR

tersinking 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 Section 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 $\frac{1}{3}$ of the components per pallet shall contain open splits with visible fastener shanks at the completion of repair.

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

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.

7.6.1 Repair of Limited-Use (L) Pallets, R Repairs. No stringerboard or block companion repairs are allowed in block pallets for any type of general-service

repair. Repair types R-1P, R-2, and R-3 concern only stringer pallets.

(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.

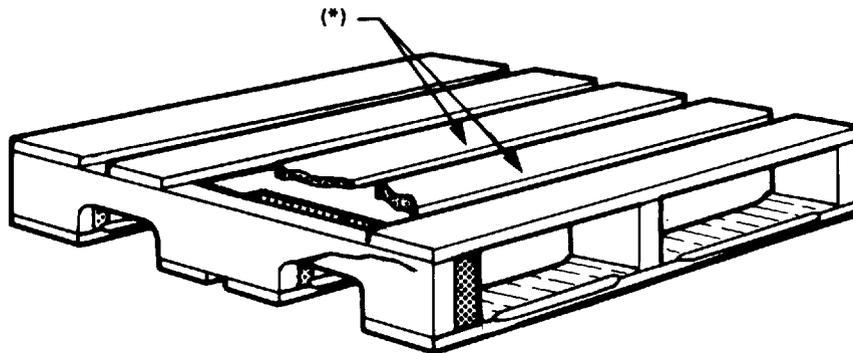
(4) Broken stringers or blocks shall be replaced for R-1 repairs. Plated or companion stringers shall not be used in R-1 repairs.

(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 Section 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 $\frac{1}{2}$ in. (13 mm)] and height and notched where applicable, and in accordance with Section 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 Section 7.6.4. Only one companion stringer per pallet is permitted (see Fig. 9).



*Deckboards shortened for illustrative purposes only.

FIG. 10 SCHEMATIC DIAGRAM OF AN R-2 HALF-COMPANION STRINGER REPAIR

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 notched where appropriate. The half companion stringer shall be properly fastened to all top and bottom deckboards as required in Section 7.6.4. Only a single half companion stringer per pallet is permitted (see Fig. 10).

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 Annex A). A maximum of two stringer feet per pallet shall be repaired and only one foot per stringer. Plating is described in Section 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 $\frac{1}{2}$ companion stringers shall be properly fastened to all top and bottom deckboards, as required in Section 7.6.4.

A maximum of two half stringer companions 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 Fig. 11). Three-wide stringer repairs are not allowed at any stringer end.

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 Section 7.7.

7.6.2 Replacement Component Quality and Sizing for R Repairs

(a) *Lumber Quality and Species.* For all R pallet repairs, the requirements in Section 5 for Limited-Use (L) pallets is the minimum requirement. Reclaimed lumber shall also comply with Section 5. (Note: Section 5.1.4.1 is *not* applicable to R repairs.)

The L classification in Section 5, Table 1 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 Annex 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 allow no overhang beyond the overall dimensions of the pallet.

Boards

Thickness: $\pm \frac{1}{8}$ in. (± 3 mm) maximum

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 Sec-

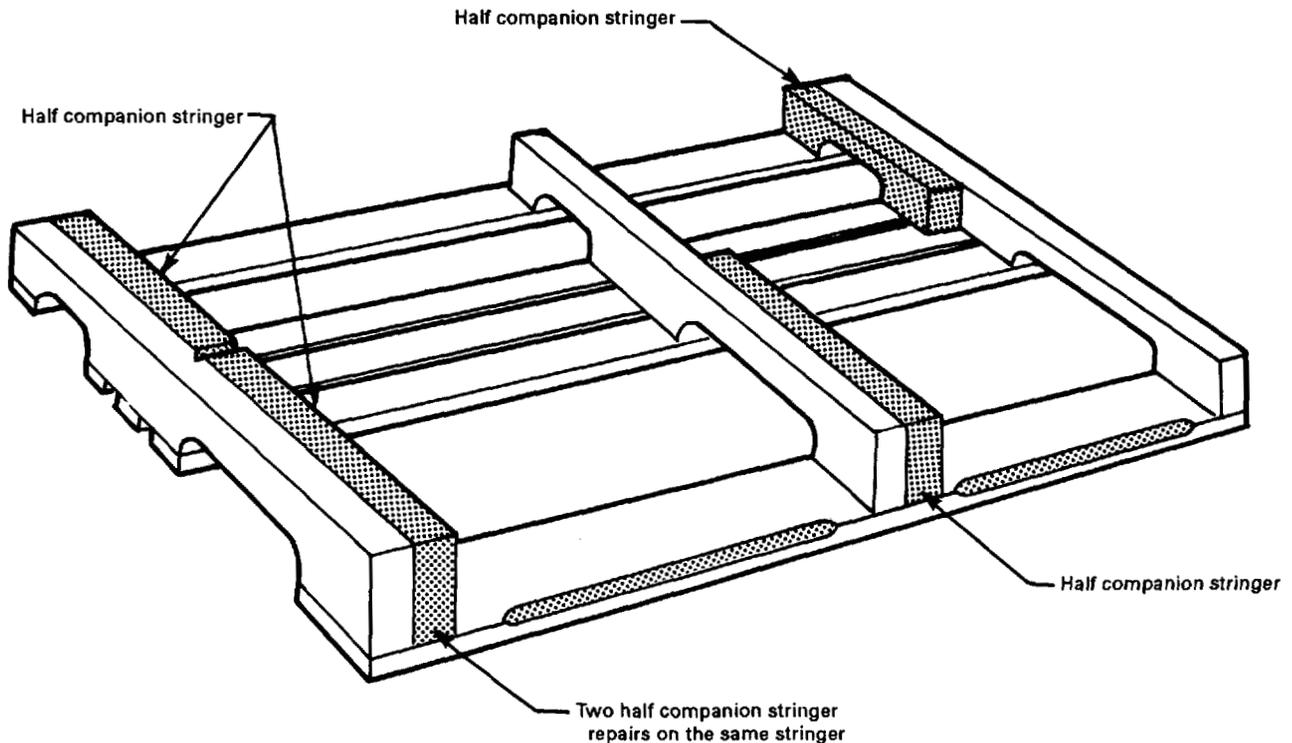


FIG. 11 SCHEMATIC DIAGRAM SHOWING THE MAXIMUM NUMBER OF HALF-STRINGER REPAIRS PERMISSIBLE IN AN R-3 REPAIR

tion 5.2. The minimum requirements for R-1 and R-1P type repair fasteners can be found in Appendix A, Table A-1.⁷

Examples of nail sizes and the minimum quantities of fasteners required per connection are given in Appendix A, Tables A-1, A-2, and A-3.

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 which differs substantially from the

rest of the components in grade or species, whether damaged or not, shall be replaced. Any existing component that substantially differs in size from the other components shall be replaced.

7.6.3.1 Splits (See Fig. 6). 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.

(b) *Stringers*

(1) *Horizontal splits* — shall be less than 4 in. (104 mm) or $2 \times$ width in length.

(2) *Vertical splits* — are defined as a split if the separation is deeper than $\frac{1}{2}$ of the component height. In that case, the length is limited to $\frac{1}{2}$ of the length of the stringer. If the vertical separation is less than $\frac{1}{2}$ of the height, the length is unlimited (see definitions in Annex B).

⁷The minimum requirements for R-2 and R-3 repair fasteners can be found in Appendix A, Table A-2.

(c) *Stringerboards* — less than full length.

(d) *Blocks* — limited to half length. A split is defined when the separation is deeper than $1/2$ dimension. In that case, the split is limited to $1/2$ the block length. If the separation less than $1/2$ the dimension, then the split length is unlimited (see definitions in Annex B).

7.6.3.2 Missing Wood (See Fig. 7). 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 Section 7.5.3.2.

7.6.4 Manufacturing Accuracy, R Repair

(a) The placement of all components and fasteners of R types of repair shall conform to Section 6.2.

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

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

(3) Unless otherwise specified, lead deckboards and ends of deckboards are assumed to 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 $\pm 1/4$ 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, 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 shall always be met.

(d) The quantities of the fasteners and their locations are given in Section 5. The fasteners shall meet the appropriate minimum requirements in Appendix A, Tables A-1, A-2, and A-3.

(e) The fastener locations and their schedule per connection shall comply with the requirements in Section 6.2.4; including those concerning countersinking and shiner limitations.

(1) Nailheads, staple crowns, bolt heads, nuts, and screwheads shall be flush or below deck surfaces. Coun-

tersinking 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 Section 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) No more than one open split with a visible fastener shank or leg per connection shall be permitted and not more than $1/3$ of the components per pallet shall contain open splits with visible fastener shanks or legs at the completion of repair.

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

7.7 Metal Plates for the Repair of Wood Stringers (See Fig. 12)

7.7.1 Minimum Plate Specifications⁸

(a) *Size.* Plates shall be a minimum of $2\frac{3}{4}$ in. (70 mm) in length and width and 11 in.² (7100 mm²) 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 in.² (645 mm²) 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.

⁸Plate as specified in Section 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.

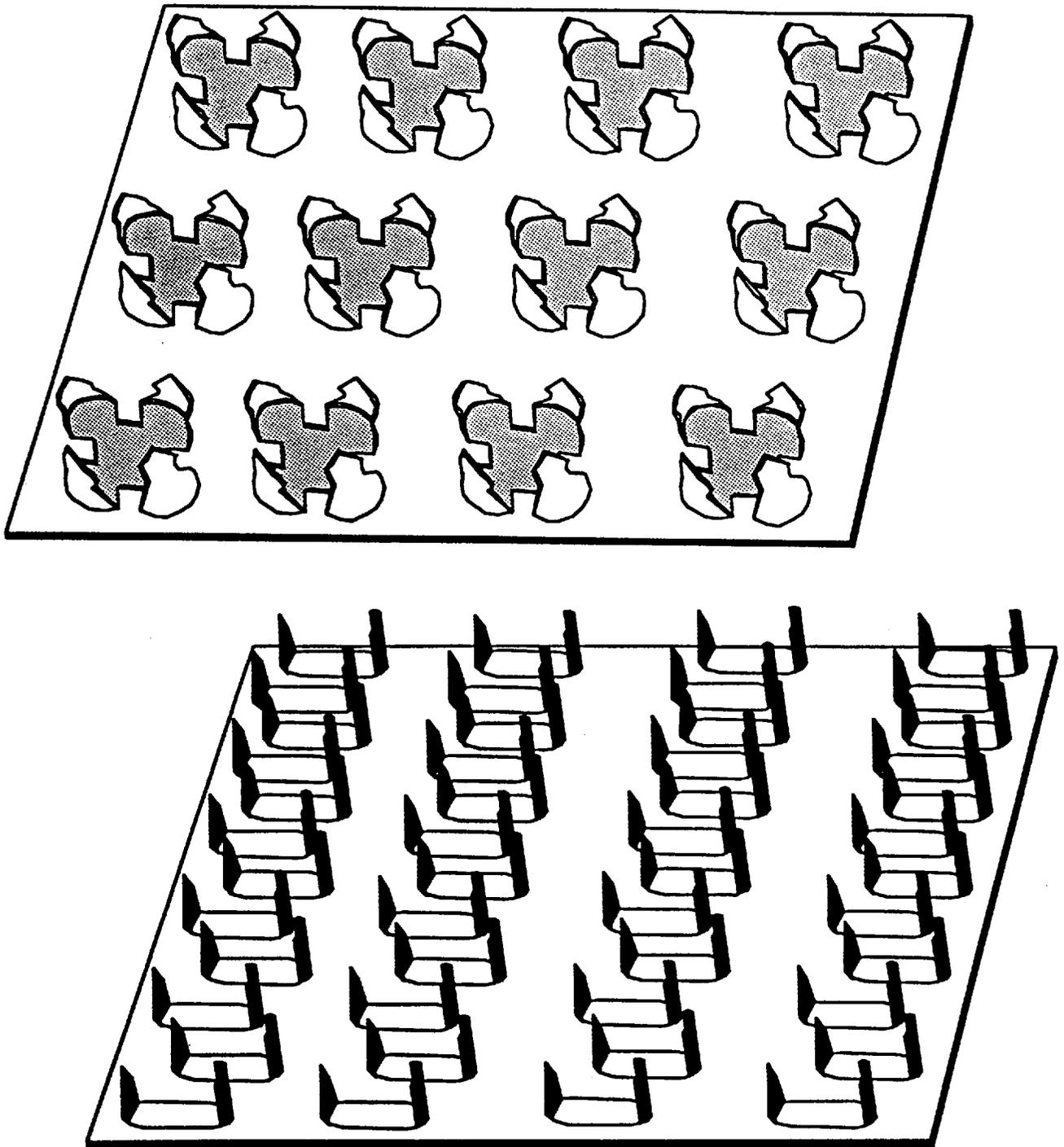


FIG. 12 SCHEMATIC DIAGRAMS OF TWO OF THE COMMON STYLES OF METAL CONNECTOR PLATES USED TO REPAIR WOOD STRINGERS

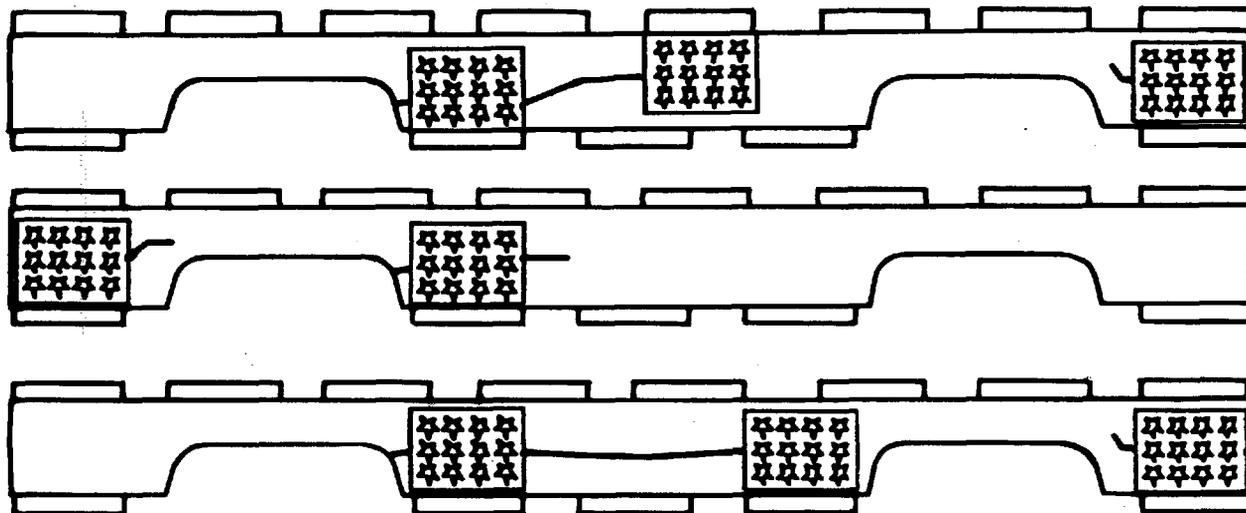


FIG. 13 SCHEMATIC DIAGRAM SHOWING PROPER PLACEMENT OF STRINGER METAL PLATES OVER SPLITS

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 Section 7.6.1). Repair of damage above the stringer notches is not permissible. Splits at large knots, 1 in. (25.4 mm) in diameter, or greater, shall not be repaired.

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 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 Fig. 13. 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 Fig. 13.

PART II. PERFORMANCE STANDARD

8 CONDITIONS OF PALLET USE

The use conditions which 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 which results in the highest stress levels shall be used as a basis for determining performance.

8.1 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.

8.2 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.

9 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 Section 3.2); Category Multiple-Use (M) (see Section 3.2)

(1) Limited-Use (L) pallets are intended for a series of handlings of up to nine trips (see Section 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)⁹ (see Section 10.2).

The criteria for the classification of pallets as L and M are given in the documentation of the test procedures provided in Section 10.

10 TEST PROCEDURES

10.1 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:

ISO-8611. "General Purpose Flat Pallets for Through Transit of Goods — Test Methods." International Standards Organization (ISO).C.P.56, CH 1211, Geneva 20, Switzerland.

ASME D-1185. "Standard Test Methods for Pallets and Related Structures Employed in Material Han-

dling and Shipping." Vol. 15.09. American Society for Testing and Materials (ASTM), 100 Bar Harbor Drive, West Conshohocken, PA 19428-2989.

10.2 Testing by Computer Models

A computer model of wood pallets for predicting pallet performance is the Pallet Design System (PDS).⁹

PART III. QUALITY ASSURANCE AUDITING PROGRAM

11 CERTIFICATION OF SHIPMENTS

In order to assure the purchaser that the pallet received is of the quality specified, each pallet shall be certified as being in conformance with this Standard and shall be identified with the quality assurance auditing program¹⁰ as provided for in Section 11.1. Each pallet shall be marked as specified in Section 11.3.

11.1 Qualified Auditing and Testing Agency

An authorized and designated inspection service shall act as auditing agency¹¹ 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.

11.2 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 com-

⁹The 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.

¹⁰The Pallet Association established a quality assurance auditing program which is in conformance with the provisions of this Standard.

¹¹Such an agency, having been found acceptable to The Pallet Association is Timber Products (TP) Inspection Service, P.O. Box 919, Conyers, GA 30207.

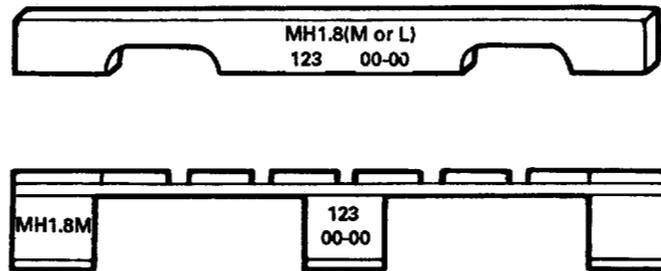


FIG. 14 EXAMPLES OF QUALITY AUDIT PALLET LABELS

combination of the two within the finished pallet immediately after its manufacture.

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

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

- (1) component size and quality (see Section 5);
- (2) fasteners (see Section 5); and
- (3) general fabrication (see Section 6).

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

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

11.3 Pallet Marking

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

(a) The mark M or L on new pallets indicates evaluation has been made according to Part II of this Stan-

dard. 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 Standard can be used to mark pallets covered in this Standard. 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 Section 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 Fig. 14). 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.

11.4 Voiding Marks

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

ANNEX A

PALLET-COMPONENT WOOD-SPECIES CLASSES*
(Oven-Dry Specific Gravity Shown in Parentheses)

(This Annex is an integral part of ASME MH1.8M-1996.)

NORTH AMERICAN
SPECIES**

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
Casara
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
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)

Source:
 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 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)

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

*These species classes and class numbers correspond to those used as Pallet Design System (PDS) inputs.

**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

ANNEX B

DESCRIPTION OF GROWTH-RELATED DEFECTS WHICH AFFECT THE QUALITY OF PALLET COMPONENTS

(This Annex is an integral part of ASME MH1.8M-1996.)

DEFINITIONS

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

unsound knot — 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

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 $\frac{1}{2}$ the depth, width, or thickness of the piece.

DEFECT CLASSIFICATIONS

(a) Critical Defects

- (1) Broken component
- (2) Protruding nail on edge or end 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 max. 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

**APPENDIX A — NONMANDATORY
PHYSICAL DESCRIPTION OF TYPICAL FASTENERS MEETING CRITERIA
IN TABLE 3, SECTION 5**

(This Appendix is not part of ASME MH1.8M-1996, and is included for information purposes only.)

TABLE A-1 EXAMPLES OF FASTENERS AND FASTENING SCHEDULES WHICH MEET THE MINIMUM PERFORMANCE REQUIREMENTS PROVIDED IN SECTION 5.2, TABLE 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 (Section 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	66	51
	FSI per nail	55	55	55
Helically threaded nail, 11½-gauge	Wire diameter (in.)	0.112	0.112 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		
	Rings per in.	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 Section 5.2, Table 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 Section 5.2, Table 3. These examples include both the four- and five-flute fasteners.
- (3) 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.

TABLE A-2 EXAMPLES OF FASTENERS AND FASTENING SCHEDULES WHICH MEET THE MINIMUM PERFORMANCE REQUIREMENTS PROVIDED IN SECTION 5.2, TABLE 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 (Section 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		
Adhesive-coated staple, 14-gauge	Wire width (in.)	0.080				
	Wire thicknesses (in.)	0.075				
	MIBANT angle (deg.)	55				
	FWI per staple	44				
	FSI per staple	61				
Adhesive-coated staple, 15-gauge	Wire width (in.)			0.073		
	Wire thicknesses (in.)			0.067		
	MIBANT angle (deg.)			85		
	FWI per staple			39		
	FSI per staple			36		
Adhesive-coated staple, 16-gauge	Wire width (in.)					0.062
	Wire thicknesses (in.)					0.055
	MIBANT angle (deg.)					100
	FWI per staple					33
	FSI per staple					24

NOTES:

- (1) When repairing connections to R-2 and R-3 categories, it is assumed the original fasteners in the connections which are still effective meet the minimum requirements in Section 5.2, Table 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 Section 5.2, Table 3. These examples include both the four- and five-flute fasteners.
- (3) Repairing connections, using an excessive number of fasteners which would degrade overall connection integrity, shall be avoided.

TABLE A-3 EXAMPLES OF FASTENERS AND FASTENING SCHEDULES WHICH MEET THE MINIMUM PERFORMANCE REQUIREMENTS PROVIDED IN SECTION 5.3, TABLE 3 FOR CLINCHED FASTENERS¹

Pallet Category	Fastener Type/Size	Fastener Physical Characteristics [Note (2)]	Minimum Fastener Schedule (Section 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	
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 Section 5.2, Table 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 Section 5.2, Table 3. These examples include both the four- and five-flute fasteners.
- (3) Repairing connections, using an excessive number of fasteners which would degrade overall connection integrity, shall be avoided.

**APPENDIX B — NONMANDATORY
SPECIFICATIONS AND STANDARDS RELATED TO WOOD PALLETS**

(This Appendix is not part of ASME MH1.8M-1996, and is included for information purposes only.)

**THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
(345 East 47th Street, New York, NY 10017-2392)**

ASME MH1.1.2-1989 (1996)	Definitions and Terminology Covering Pallets and Related Structures
ASME MH1.4.1M-1989 (1996)	Procedures for Testing Pallets
ASME MH1.6-1987 (1996)	Procedures for Determination of Durability of Wooden Pallets and Related Structures
ASME MH1.7M-1988 (1996)	Driven Fasteners for Assembly of Pallets and Related Structures
ASME MH1.9-1992	Export Pallets

**AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
(100 Bar Harbor Drive, West Conshohocken, PA 19428-2959)**

ASTM D1185-94	Test Methods for Pallets and Related Structures Employed in Material Handling and Shipping
ASTM F-680-80(87)	Test Methods for Nails
ASTM F1575-95	Test Method for Determining Bending Yield Moment of Nails

**INTERNATIONAL STANDARDS ORGANIZATION (ISO)
(C.P.56, CH-1211, Geneva 20, Switzerland)**

ISO 445-1984	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

**AUTOMOTIVE INDUSTRY ACTION GROUP (AIAG)
(26200 Lahser Road, Suite 200, Southfield, MI 48034)**

AIAG RC-8-1989	Expendable Containers and Expendable Container Systems
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**APA, THE ENGINEERING WOOD ASSOCIATION [FORMERLY, AMERICAN
PLYWOOD ASSOCIATION (APA)]
(P.O. Box 11700, Tacoma, WA 98411)**

PP-61-80	Specification for Softwood Plywood Pallets
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GROCERY MANUFACTURERS OF AMERICA (GMA)
(1010 Wisconsin Ave. NW, Suite 800, Washington, DC 20007)
 Recommended Hardwood Pallet Specifications for the Grocery Industry (1978)

WESTERN WOODEN BOX ASSOCIATION (WWBA)
(430 Sherman Ave., Suite 206, Palo Alto, CA 94306)
 Standard Grading Rules, Expendable Produce Pallets (1976)

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS (ASAE)
(2950 Niles Road, P.O. Box 410, St. Joseph, MO 49085)
 Standards for Agricultural Pallet Bins (1975)

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)
(400 Commonwealth Drive, Warrendale, PA 15096)
 Recommended Practices for Air-Land Demountable Cargo Pallets (1977)
 Pallet Sizes (1967)
 Minimum Requirements of Air Cargo Pallets (1967)

U.S. DEPARTMENT OF DEFENSE
(Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120)

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 Handling, Wood Stringer Construction, 4-Way Partial, 48 × 40 Inch
MIL-P-15011H-1981	Pallet, Material Handling, Wood, Post Construction, 4-Way Entry, 48 × 40 Inch
MIL-P-43465-1966	Pallet, Material Handling, Wood, Double Faced (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

NATIONAL WOODEN PALLET AND CONTAINER ASSOCIATION (NWPCA)
(1800 North Kent Street, Suite 911, Arlington, VA 22209-2104)

Uniform Voluntary Standard for Wood Pallets (1994)

TIMBER PRODUCTS (TP) INSPECTION SERVICE
(P.O. Box 919, Conyers, GA 30207-0919)

Rules and Regulations for Manufacturing SPEQTM Pallets (1992)