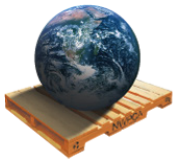
UNIFORM STANDARD
FOR WOOD PALLETS



National Wooden Pallet
& Container Association
Pallets Move the World®

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Wood pallets are manufactured, recycled, repaired or remanufactured for the sole purpose of storing and/or transporting material. Under no circumstances should a pallet be used for anything other than its intended purpose, such as a person standing, stepping, or leaning upon them or otherwise using them for support or as a structural construction component. The wood 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. All pallets should be removed from service if determined to be unsafe and dangerous to persons or goods.

UNIFORM STANDARD FOR WOOD PALLETS

Intent and Applicability

This standard was approved by the NWPCA Board of Directors on November 5, 2025. It was developed with the sole intention of providing information to parties engaged in the manufacture, recycling, marketing, purchase, or use of pallets for unit loads. This standard is advisory only, and acceptance is voluntary. The standard should be regarded as a guide that the user may or may not choose to adopt, modify, or reject. The information does not constitute a comprehensive safety program and should not be relied upon as such. Any safety program should be developed in consultation with a qualified, independent safety professional.

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Acknowledgement

The *Uniform Standard for Wood Pallets* was developed by the Standards Committee of NWPCA. This 2025 edition represents a revision to the 2014 standard of the same name. Technical drawings were prepared by Raymond Bartolotti. Certain illustrations have been modified for clarity; for example, some deckboards were shortened for illustrative purposes.

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CONTENTS

1 PURPOSE

The purpose of this Uniform 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, recyclers, distributors, and users of wood pallets.

2 SCOPE

This Standard applies to all lumber-deck and panel-deck pallets, either new, repaired or remanufactured as well as their lumber, panels, wood-based composites and engineered wood components and fasteners. Criteria contained in this Standard are applicable only at the completion of manufacture.

This Standard is in three parts:

1. **Part I** is the Prescriptive Standard which concerns the manufacture of the pallet. This includes pallet and pallet component descriptions, definitions, fastener descriptions, workmanship criteria, dimensional tolerances, markings, moisture content levels, and repair and remanufacture of pallets.

2. **Part II** is the Performance Standard which concerns the functionality of the pallet. This contains references to the testing of physical models or prototypes, and computer software to assist manufacturers, recyclers, distributors, and users to determine the performance level of a specified pallet. Use of the Performance Standard is required for new, repaired and remanufactured pallet constructions, along with conformance to Part I of the Prescriptive Standard.

3. **Part III** covers Phytosanitation of Wood Pallets. This Standard does not describe other established special requirements for export 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 ANNEX A.

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

PART I: PRESCRIPTIVE STANDARD

3 TERMINOLOGY AND DEFINITION[1]

block: rectangular, square, multisided, or cylindrical deck spacer, often identified by its location within the pallet as corner block, end block, edge block, inner block, or center or middle block.

block size: pallet member dimension, specified by width followed by height and length.

deckboard: element or component of pallet top and bottom, perpendicular to stringers or stringerboards.

deckboard size: specified by thickness followed by width and length.

delamination: a visible separation in the plane of a panel or panel component. This may occur in the panel manufacturing process, or in use due to rough handling. The latter may be caused by impacting panel edges with a tine tip, and may or may not result in material being removed from the panel component (see Figure 13).

MIBANT Angle[2]: fastener bend angle providing indication of (fastener) toughness and bending resistance (see Table 5).

notch area: a region around stringer notches with special defect limitations (see Figure 5).

Pallet Design System™ (PDS): a reliability-based computer-aided design (CAD) software for wood stringer and block pallets (see Section 11.2).

pallet length: pallet dimension between the extreme pallet ends, parallel to the stringers or top stringerboards. For panel-deck block pallets without stringerboards, it is the top deck pallet dimension parallel to the face grain for plywood (strong panel axis).

pallet width: pallet dimension between the extreme pallet sides, parallel to and corresponding to the length of the top deckboards. For panel deck block pallets without stringerboards, it is the top deck panel dimension perpendicular to the face grain for plywood (strong panel axis).

pallet size: pallet dimension specified by stringer or stringerboard length, followed by top deckboard length and overall pallet height. For panel deck block pallets, it is the length, width, and overall pallet height.

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[1] For a complete listing of pallet definitions, see "Part 3 Definitions," MH1 Pallets, Slip sheets, and Other Bases for Unit Loads, Material Handling Industry of America (MHIA), www.mhia.org

[2] MIBANT angles are measured according to procedures contained in ASTM F680 Standard Test Methods for Nails, ASTM International, www.astm.org

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

recycled pallet: pallet made reusable by sorting, repairing or remanufacturing, using new or reclaimed components from damaged pallets.

recycled wood pallet part: a pallet part that has been removed from a wood pallet after it has been in service.

remanufactured pallet: a pallet assembled entirely or in part with recycled wood pallet parts and manufactured by complete reassembly of all parts with new fasteners.

remanufactured combination "combo" pallet: a pallet assembled, specifically, with both new and recycled wood parts. Combo pallets are typically assembled with recycled top and bottom deckboards and new wood stringers.

repaired pallet: a pallet with damaged components replaced with new or used components.

shiner: protruding fastener point.

stringer: continuous, longitudinal, solid, built up, or notched beam component of pallet, supporting and spacing deck components, often identified by its location as edge (side) or interior (center) stringer.

stringer size: specified by width followed by height and length.

stringerboard: continuous, solid member extending the full length of the pallet, perpendicular to deckboard members and placed between deckboards and blocks.

stringerboard size: pallet and member dimensions, specified by thickness followed by width and length.

unit load: assembly of goods or single item on pallet for handling, moving, storing, and stacking, as single entity.

4 CLASSIFICATIONS

4.1 Classes

- Stringer Pallet (see Figure 1)
- Block Pallet (see Figure 2)

4.2 Use Categories

- Reusable pallet is intended for more than one unit load.
- Purpose-built pallet is designed for a specific unit trip.

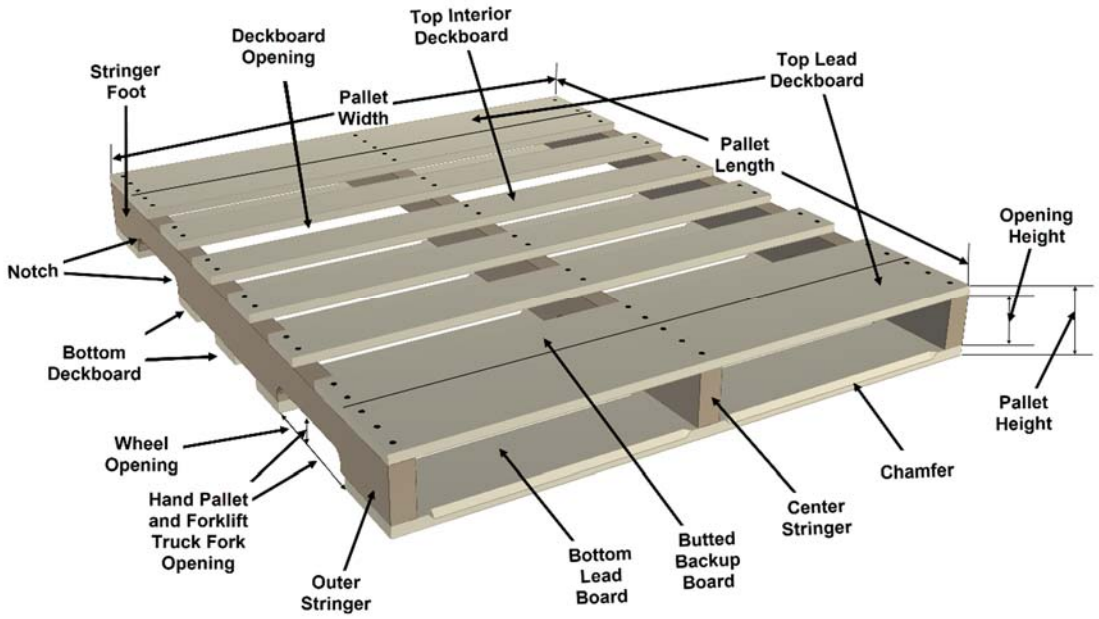

Figure 1. Schematic diagram of a typical stringer pallet with principal parts labeled.

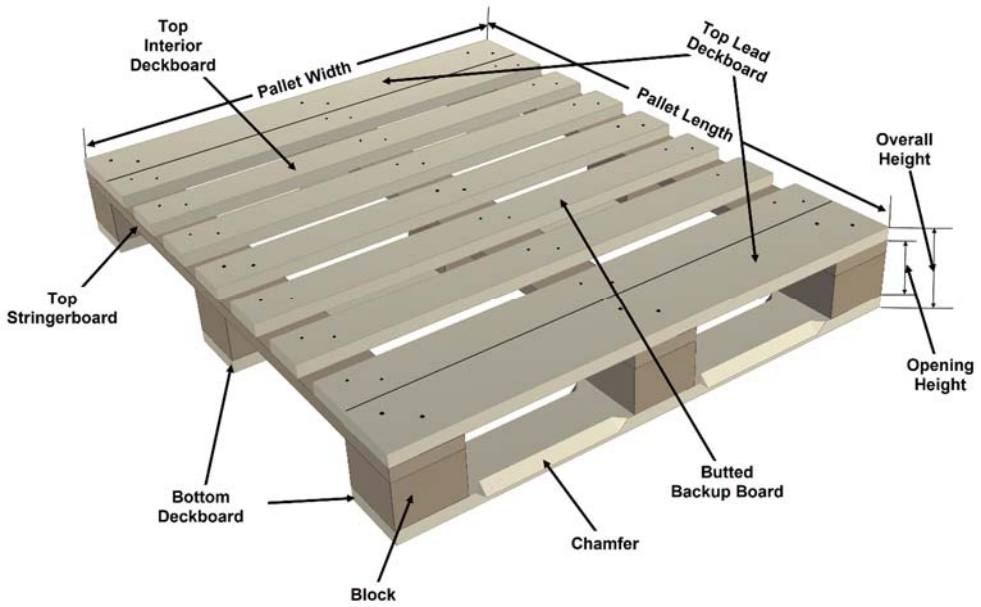

Figure 2. Schematic diagram of a typical block pallet with principal parts labeled.

4.3 Entry Types

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

4.4 Styles

- Single-face
- Double-face, nonreversible
- Double-face, reversible

4.5 Top Deck Constructions

- Deckboard
- Deckboard/stringerboard
- Panel
- Panel/stringerboard

4.6 Bottom Deck Constructions

- Unidirectional bottom deckboards oriented in the direction of the pallet length or width only.
- Overlapping bottom boards oriented in both directions of the length and width of the pallet containing both bottom deckboards and bottom stringerboards.
- Perimeter bottom deckboards oriented in both directions of the length and width of the pallet containing butted boards and end boards (see Figure 3).
- Cruciform bottom deckboards oriented in both directions of the length and width of the pallet containing butted boards, end boards, and connector boards (see Figure 3), or panels with cutouts (see Figure 4).

4.7 Sizes

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

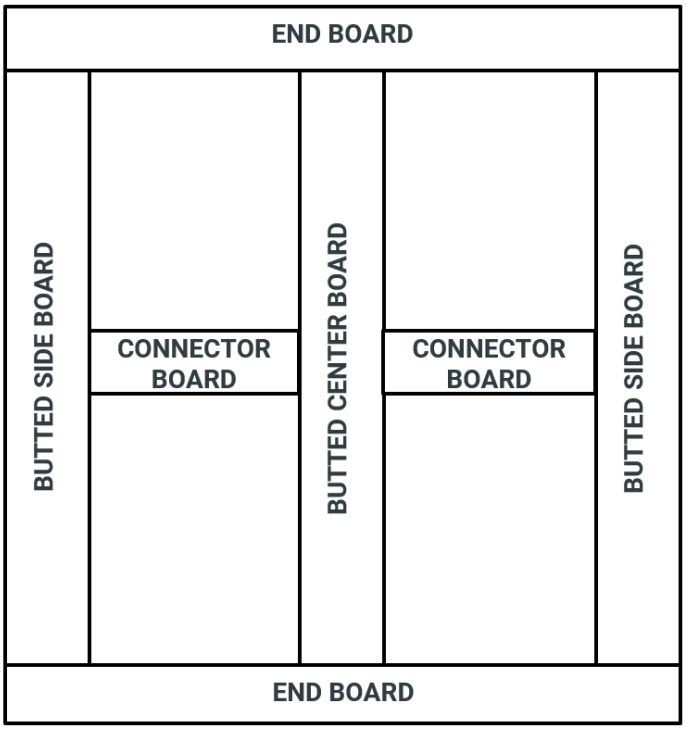

Figure 3. Component names for perimeter and cruciform bottom deck construction.

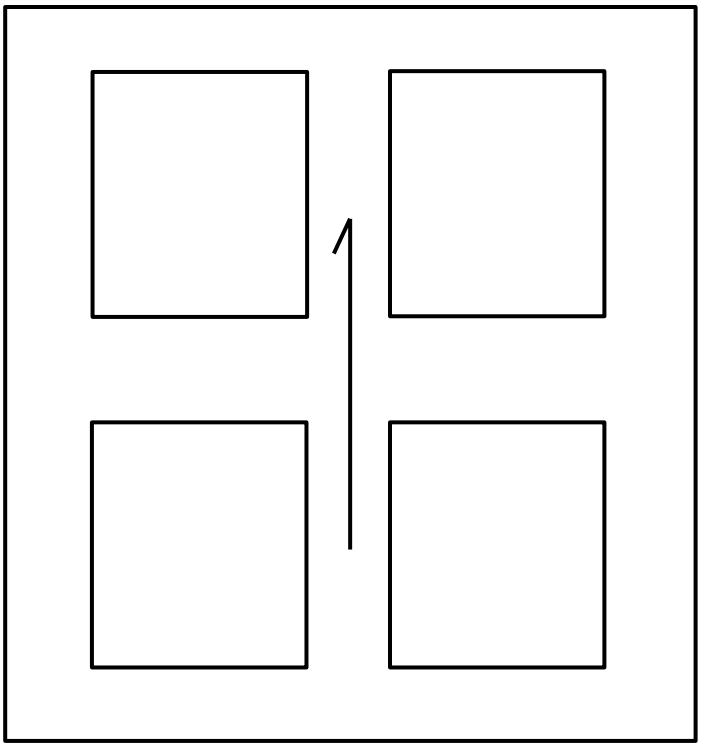

Figure 4. Panel bottom deck showing cutouts.

5 MATERIALS

5.1 Lumber Components

5.1.1 Wood species

The species of woods used in pallet manufacture are numerous. As an aid to the pallet designer, Table 1 contains a classification of many commercially available woods listed according to similarities in mechanical properties, regional availability, and commercial use in pallets[3]. When specifying wood pallets, the wood species permissible in the structure can be indicated by the wood species class numbers given in Table 1.

Table 1: Common wood species used in pallet construction.

NORTH AMERICAN HARDWOODS		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
1	High density Eastern hardwoods	– American beech – Ash (green, white) Birch (sweet, yellow) Black cherry – Black locust Dogwood – Elm (rock, slippery) Hickory – Maple (black, red, sugar) Persimmon – Tan oak
2		– Bigleaf maple – Oregon ash
3	Medium density Eastern hardwoods	– Ash (black, pumpkin) – Hackberry – Maple (silver, striped) – Magnolia – Paper birch – Sweetgum – Sycamore – Tupelo
4	Western hardwoods	– California black oak – Cascara Chinquapin Madrone Myrtle – Oregon white oak
6		– Red alder

7	Low density Eastern hardwoods	– American basswood – Aspen (bigtooth, quaking) – Buckeye – Butternut Catalpa – Cottonwood (balsam, black) – Eastern poplar
21	Eastern oaks	– Red oak – White oak
29		– Yellow poplar

NORTH AMERICAN SOFTWOODS		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
11	Douglas-fir	– Douglas fir (coast, Interior West, Interior North, Interior South) – Western larch – Tamarack
12	Hem-Fir	– Fir (California red, grand, noble, Pacific silver, white) – Hemlock (Western, Mountain)
13	SPF	– Baldcypress – Eastern hemlock – Fir (balsan, subalpine) – Pine (Eastern white, jack, lodgepole, Monterey, Norway, Ponderosa, sugar, Western white) – Redwood – Southern pine (pitch, pond) – Spruce (black, Engelmann, red, sitka, Virginia, white) – Western red cedar
14	Low density softwoods	– Cedar (Alaska, Atlantic white, Eastern red, incense, Northern white, Port Orford)
15		– Red Pine
22	SYP	– Southern yellow pine (loblolly, longleaf, shortleaf, slash)

EUROPEAN SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
31	Imported Hardwoods	– Kapur – Keruing – Mengkulang
32	Dense European Hardwoods	– Ash – Beech Oak Plane
33	Dense European Softwoods	– Douglas fir – Larch (European, Japanese) – Pine (jack, maritime, Scots)
34	Medium Dense Woods	– Dutch elm – Hyrbrid larch – Pine (Corsican, lodgepole) – Poplar (black Italian, grey) – Redwood – Silver fir
35	Whitewood	– English elm – Sitka spruce (Canada) – Whitewood
36	Common European softwoods	– Radiate pine – Spruce (black, Norway, white, Sitka) – White willow
37		– Hybrid poplar
38		– Black Alder
CENTRAL, SOUTH AMERICAN, AND OTHER SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
40		– Prioria copaifera
41		– Radiate pine (Chile)
42		– Gmelina arborea (Costa Rica)
43		– Pinus caribaea (Venezuela)
44		– Pinus elliottii
45		– Pinus taeda
46		– Eucalyptus grandis (Uruguay)
47		– Ponderosa Pine (Mexico)
48		– Patula Pine (Mexico)
49		– Ocote Pine (Mexico)
50		– Pinus durangensis – Martinez (Pino Colorado) (Mexico)

AFRICAN SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
51		– Patula Pine (Madagascar)
52		– Melina wood, – Gmelina arborea (Nigeria)
53		– Patula Pine (S. Africa,Mpumalanga & KZN)
54		– Maritime Pine, Pinus pinaster (S. Africa,Mpumalanga & KZN)
55		– Patula Pine (Tanzania)

OCEANIAN SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
61		– Radiata Pine (Australia)
62		– Maritime Pine (Australia)
63		– Radiata Pine (New Zealand)

SE ASIAN SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
71		– Anisoptera (Malaysia)
72		– Anisoptera (Philippines)
73		– Shorea (Philippines)
74		– Dryobalanops

EAST ASIAN SPECIES		
CLASS NUMBER	**CLASS NAME**	**SPECIES**
81		– Sugi, Japanese Cedar (Japan)
82		– Japanese Larch (Japan)

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

5.1.2 Quality

Definitions and descriptions of defects can be found in Table 2. Lumber components shall meet or exceed the minimum quality indicated by the growth and manufacturing defect limitations contained in Table 3.

Table 2. Wood Characteristics and Imperfections

DEFECT LIST	DEFECT DEFINITION
NATURAL IMPERFECTIONS	
– Compression wood – Decay – Knot, Sound – Knot, Unsound – Localized Grain Disorientation – Slope of grain or cross grain (may also be a sawing defect) – Wane	**Compression Wood –** wood that has less strength from gravity effects during tree growth **Decay –** a disintegration of the wood substance due to actions of wood-destroying fungi, pests, deteriorated, and unsound wood. **Knot, Sound –** 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. **Knot, Unsound –** a knot that is loose and/or deteriorated, has no structural strength. **Localized Grain Orientation -** Localized area in which wood grain is not parallel with long axis of component (versus General grain of wood, which is treated as Cross Grain). Frequently the result of grain disorientation around a Knot which itself is not within the component. **Slope of Grain –** loss of strength that occurs when wood grain is off axis from the main direction of the wood. **Wane –** bark or lack of wood from any cause, except intentionally eased edges, on the edges of the pallet component.
IMPERFECTIONS DUE TO DRYING	

– Checks
– Honeycomb
– Shakes or Splits
  o Warp
  o Bow
  o Crook
  o Cup
  o Twist
	Checks – wood separation along the grain that does not pass through the entire thickness of the component
	
	Honeycomb – internal cracking that occurs from wood drying
	
	Shake or Split – separation within a pallet component not confined to the wood surface, usually intersecting two surfaces. For the purposes of this Standard, a check intersecting only one face of the pallet component will be treated as a split only when it exceeds ½ the depth, width, or thickness of the component.

	Bow – warp that occurs on the plane face of a board from end to end. **Crook –** warp that is along the edge of a board **Cup –** warp that occurs on plane face of a board from side to side **Twist –** warp that occurs along the length of a board from opposite corners
IMPERFECTIONS DUE TO SAWING OR MANUFACTURE	
– Bevel Sawing – Holes – Mismanufacture – Saw Cuts – Step	**Bevel sawing -** Acceptable if no more damaging than allowable wane or allowable size tolerance for deckboards, stringerboards, stringers and blocks. **Holes –** removed wood in the plane of a board **Mismanufacture -** Localized area where wood has been accidentally damaged or removed during manufacture. **Saw cuts -** Same as unsound knot **Step -** Other wise called saw (arbor) mismatch: not to exceed 1/32 in. (0.8 mm) on exposed face of components.

Table 3. Minimum Lumber Component Quality

Lumber Characteristic	PALLET COMPONENT GRADES				
	Select	**Premium**	**Standard**	**Utility**	**Economy***
Sounds Knots[a]	**1/4 of Cross Section** Stringer Notch Area: 1/8 of Above Notch Cross Section	**1/3 of Cross Section** Stringer Notch Area: 1/4 of Above Notch Cross Section	**1/2 of Cross Section** Stringer Notch Area: 1/3 of Above Notch Cross Section	**3/4 of Cross Section** Stringer Notch Area: 1/2 of Above Notch Cross Section	**7/8 of Cross Section** Stringer Notch Area: 5/8 of Above Notch Cross Section
Unsound Knots, Loose Knots, Holes[b]	1/8 of Cross Section	1/4 of Cross Section	1/3 of Cross Section	1/2 of Cross Section	1/2 of Cross Section
Cross Grain	1:6	1:8	1:6	1:4	Not Limited
Localized Grain Disorientation	1/4 of Cross Section	1/3 of Cross Section	1/2 of Cross Section	2/3 of Cross Section	Not Limited
Splits, Checks, Shake[c]	1/4 of Part Length	1/3 of Part Length	1/2 of Part Length	3/4 of Part Length	Must not completely separate Part
Wane[d,e,f]	1/16 of Cross Section	1/8 of Cross Section	3/16 of Cross Section	1/4 of Cross Section	5/16 of Cross Section
	Stringers or Blocks: 1/16 Nail Face x 1/4 Height Boards: 1/8 Width x 1/3 Thickness (Any Length)	**Stringers or Blocks:** 1/8 Nail Face x 1/3 Height Boards: 1/6 Width x 1/2 Thickness (Any Length)	**Stringers or Blocks:** 1/3 Nail Face x 1/3 Height Boards: 1/4 Width x 2/3 Thickness (Any Length)	**Stringers or Blocks:** 1/2 Nail Face x 1/2 Height Boards: 1/3 Width x Full Thickness (Any Length)	**Stringers or Blocks:** 5/8 Nail Face x 2/3 Height Boards: 1/2 Width x Full Thickness (Any Length)
Unsound Wood[e,g]	None	1/8 of Cross Section	1/4 of Cross Section	1/3 of Cross Section	1/2 of Cross Section
Pith	None	Not Limited	Not Limited	Not Limited	Not Limited
Mismanufacture	None	1/16 of Cross Section	1/8 of Cross Section	3/16 of Cross Section	1/4 of Cross Section

* Economy Component Grade permits lumber characteristics which prevent reliable estimates of strength, stiffness, or durability. Design Values are only available for components of Utility Grade and above.

[a] Sound knots are further limited in any portion of the notch area "B" (see Figure 5) to 1/3 of the net cross section above the notch and in any portion of notch area "A" to ½ the net cross section above the notch.
[b] Unsound knots (decay within knot) or holes are limited to ¼ of the net cross section above the notch in areas "A" and "B" (see Figure 5).
[c] Not allowed in the notch area (see Figure 5).
[d] Full thickness of wane on non-exposed surfaces is permitted and should be limited to 2 pieces per pallet.
[e] Fasteners driven through maximum wane or decay should be compensated wherever possible.
[f] 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 (radius) within the notch area (see Figure 5).
[g] No decay (outside of unsound knot) is allowed over or within 2 in. (51 mm) of the ends of the stringer notches.

5.1.3 Moisture content

The moisture content level of pallet components is not limited. For measuring the moisture content of wood, use the following methods:

- ASTM D4442 Standard test methods for direct moisture content measurement of wood and wood-base materials
- ASTM D7438 Standard practice for field calibration and application of hand-held moisture meters

5.1.4 Preparation

Lumber component tolerances apply at time of component manufacture.

5.1.4.1 Dimensions

Lumber components shall have a target dimension. Based on current Good Manufacturing Practices (GMP), the target thickness of deckboards and stringerboards may deviate ±1/32 in. (±0.8 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. 50% of components shall be manufactured within the allowable tolerances outlined below.

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

All Boards:

- **Thicknesses:** ±1/16 in. (±1.6 mm) maximum deviation (including target deviation of 1/32 in. [±0.8 mm])
- **Width:** +unlimited, -1/4 in. (-6 mm) maximum deviation
- **Length:** +1/8 in. (+3 mm), -1/4 in. (-6 mm) maximum deviation

Stringers

- **Width:** ±1/16 in. (±1.6 mm) maximum deviation
- **Height:** ±1/16 in. (±1.6 mm) maximum deviation
- **Length:** ±1/8 in. (±3 mm), maximum deviation

Blocks

- **Width:** ±1/16 in. (±4.7 mm) maximum deviation
- **Height:** ±1/16 in. (±1.6 mm) maximum deviation
- **Length:** ±1/16 in. (±4.7 mm) maximum deviation

5.1.4.2 Deckboard chamfer

The deckboard chamfers, if specified, may be located on both outside faces of bottom end boards and all interior edges of bottom boards adjoining wheel openings. The chamfers should be at an angle less than 45º, located 1/4 in. (6 mm), ±1/8 in. (±3 mm) from the bottom of the board. Chamfers should 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 Figure 5). The recommended opening sizes to be provided by the notch and the bottom deck, if present, are 2 in. (51 mm) in depth to the top of the notch and 9 in. (229 mm) in length. Notches shall have rounded or filleted corners with a radius not less than 1/2 in. (13 mm), nor greater than 1-1/2 in. (38 mm). Square notches are not acceptable. Manufacturing tolerances shall be ±1/8 in. (±3 mm) of actual specified dimensions except for the notch location which shall be within ±3/8 in. (±9.5 mm) of target.

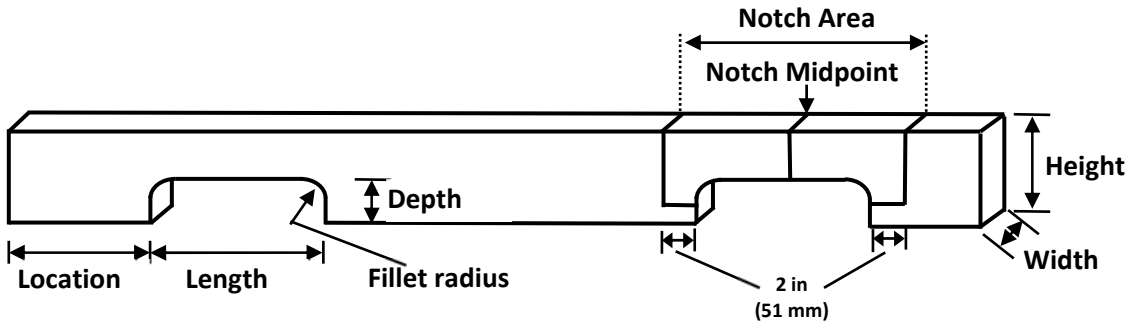

Figure 5. Schematic diagram of a pallet stringer with notch features.

5.2 Wood Panel (Plywood or OSB) Components

5.2.1 Quality

Wood panels shall conform to the latest edition of one of the following standards:

- PS 1 From APA[8] on Structural Plywood
- PS 2 From APA[8] on Performance Standard for Wood-Based Structural-Use Panels
- PRP 108 From APA[8] on Performance Standards and Policies for Structural-Use Panels
- ANSI/HPVA HP-1[9]American National Standard for Hardwood and Decorative Plywood

Each panel deck piece shall be identified with the appropriate trademark of a recognized grading agency. The firm supplying the panels shall furnish certification that the original panels were trademarked.

5.2.2 Grade

Panels as a Performance Component

Unless specified otherwise by the purchaser, panels for panel decks shall be either: Rated Sheathing, Exposure 1; or Rated Sturd-l-Floor, Exposure 1. Exterior is an acceptable alternative to Exposure 1.

[8] APA - The Engineered Wood Association - www.apawaood.org

[9] Decorative Hardwoods Association - www.decorativehardwoods.org

Panels as an Interface Component
Panels that are used as an overlay to facilitate stability, load transfer, and/or any other non-performance applications are not limited by grade.

Panels of any grade may be used to fabricate laminated pallet blocks.

5.2.3 Preparation

5.2.3.1 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.

The face grain of plywood strip bottom deckboards shall run in the direction of the deckboards' length. OSB strips are not permitted to be used as bottom deckboards, unless specified otherwise by the purchaser.

50% of wood panel components must meet or exceed the target width and length dimensions at the time of component manufacture. Wood panel component thickness is mandated by APA Standards.

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 5 1/2 in. (140 mm) wide.
    - **Thicknesses:** per APA Standard
    - **Length and Width:** ±1/8 in. (±3 mm)

- **Laminated Blocks (including individual laminations)**
    - **Width:** ±1/8 in. (±3 mm) maximum deviation
    - **Height:** ±1/16 in. (±1.6 mm) maximum deviation
    - **Length:** ±1/8 in. (±3 mm) maximum deviation

Sides shall not deviate from being square to the block top or bottom by more than 1/8 in. (3 mm), and any deviation from square shall not be in addition to the target width and length.

5.2.3.2 Laminated Pallet Blocks
Pallet blocks may be laminated from panel components using either fasteners (see Section 6.2.6) or adhesives. A water resistant adhesive should be used and applied according to manufacturers' recommendations.

5.3 All other Wood-based Composites Components (Engineered Wood Components)

5.3.1 Blocks

5.3.1.1 Quality

High-density moisture-resistant wood-based composite blocks shall meet or exceed the following criteria:

- **Density:** 32.5 – 42.1 lbs. ft^3 (520 – 675 kg/m^3)
- **Adhesive:** only glue, adhesives, or bonding agent that can assure the stability of the blocks can be used

Table 4 lists the minimum performance requirements of the blocks. Tests are described in Wood-Based Composite Tests[10].

Table 4. Minimum Wood-Based Composite Component Quality.

TEST	REUSABLE PERFORMANCE	PURPOSE BUILT PERFORMANCE
24-hour block soak test		
– Weight change	≤ 25% increase	Unlimited
– Length change	≤ 2% increase	≤ 5% increase
– Width change	≤ 2% increase	≤ 5% increase
– Height change	≤ 6% increase	≤ 6% increase
Side tine compression test	≥ 1,400 lbf. @ 9 in./min.	≥ 1,400 lbf. @ 9 in./min.
Nail insertion force test	≤ 500 lbf. @ 1.5 in./min.	≤ 500 lbf. @ 1.5 in./min.
Nail withdrawal force test	≥ 310 lbf. @ 1.5 in./min.	≥ 200 lbf. @ 1.5 in./min.
Four Point Bend Test		Not applicable

5.3.1.2 Preparation

Wood-based composite blocks shall have target length, width and height uniform in dimension and 50% of blocks shall meet or exceed the target dimension at the time of component manufacture.

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

- **Blocks**
  - **Width:** ±3/16 in. (±4.7 mm) maximum deviation
  - **Height:** ±1/16 in. (±1.6 mm) maximum deviation
  - **Length:** ±3/16 in. (±4.7 mm) maximum deviation

5.3.2 Deckboards, Stringerboards, and Stringers

[10] National Wooden Pallet & Container Association - www.palletcentral.com

5.3.1.1 Quality

High-density moisture-resistant engineered wood laminates shall meet or exceed the following standards:

- ASTM D3043 Standard test methods for structural panels in flexure
- ASTM D4761 Standard test methods for mechanical properties of lumber and wood-based structural material

Only glue, adhesives, or bonding agents that can assure the stability of the deckboards, stringerboards, or stingers can be used.

5.3.2.2 Preparation

Engineered wood components shall have target thickness and width uniform in dimension and 50% of components shall meet or exceed the target dimension at the time of component manufacture.

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

- **Deckboards and Stringerboards**
  - **Thicknesses:** ±1/16 in. (±1.6 mm) maximum deviation (including target deviation of 1/32 in. [±0.8 mm])
  - **Width:** +unlimited, -1/4 in. (-6 mm) maximum deviation
    Length: +1/8 in. (+3 mm), -1/4 in. (-6 mm) maximum deviation

- **Stringers**
  - **Width:** ±1/16 in. (±1.6 mm) maximum deviation
  - **Height:** ±1/16 in. (±1.6 mm) maximum deviation
  - **Length:** +1/8 in. (+3 mm), -1/4 in. (-6 mm) maximum deviation

5.4 Fasteners

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

5.4.1 Driven Fasteners

Driven fasteners include nails and staples. As used in pallets, nails are classified as plain shank, helically threaded, annularly threaded, fluted, 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:

1. Actual measurement of the physical and mechanical characteristics (indicated in Table 5 and Figure 6); and
2. Specification of connection design properties, or
3. Both 1 and 2.

Table 5. Physical and Mechanical Characteristics of Driven Fasteners Used in Pallets[a].

NAILS				STAPLES	
Plain shank	Helically Threaded	Annularly threaded	Fluted/Squared wire	Round wire	Square wire
Length	Length	Length	Length	Length	Length
Wire diameter	Wire diameter	Wire diameter	Wire diameter	Wire diameter	Wire diameter
	Thread length	Thread length		Crown length	Crown length
	Thread-crest diameter	Thread-crest diameter	Flute-crest diameter	Crown width	Crown width
	Number of helixes	Number of rings	Number of helixes		
	Number of flutes		Number of flutes		
MIBANT angle[b] or bending yield strength[c]	MIBANT angle or bending yield strength	MIBANT angle or bending yield strength	MIBANT angle or bending yield strength	MIBANT angle or bending yield strength	MIBANT angle or bending yield strength

a ASTM F680 Standard Test Methods for Nails

b When the MIBANT test is performed, not more than 8% of the fastener shall show partial or complete shank failure.

c ASTM F1575 Standard Test Method for Determining Bending Yield Moment of Nails

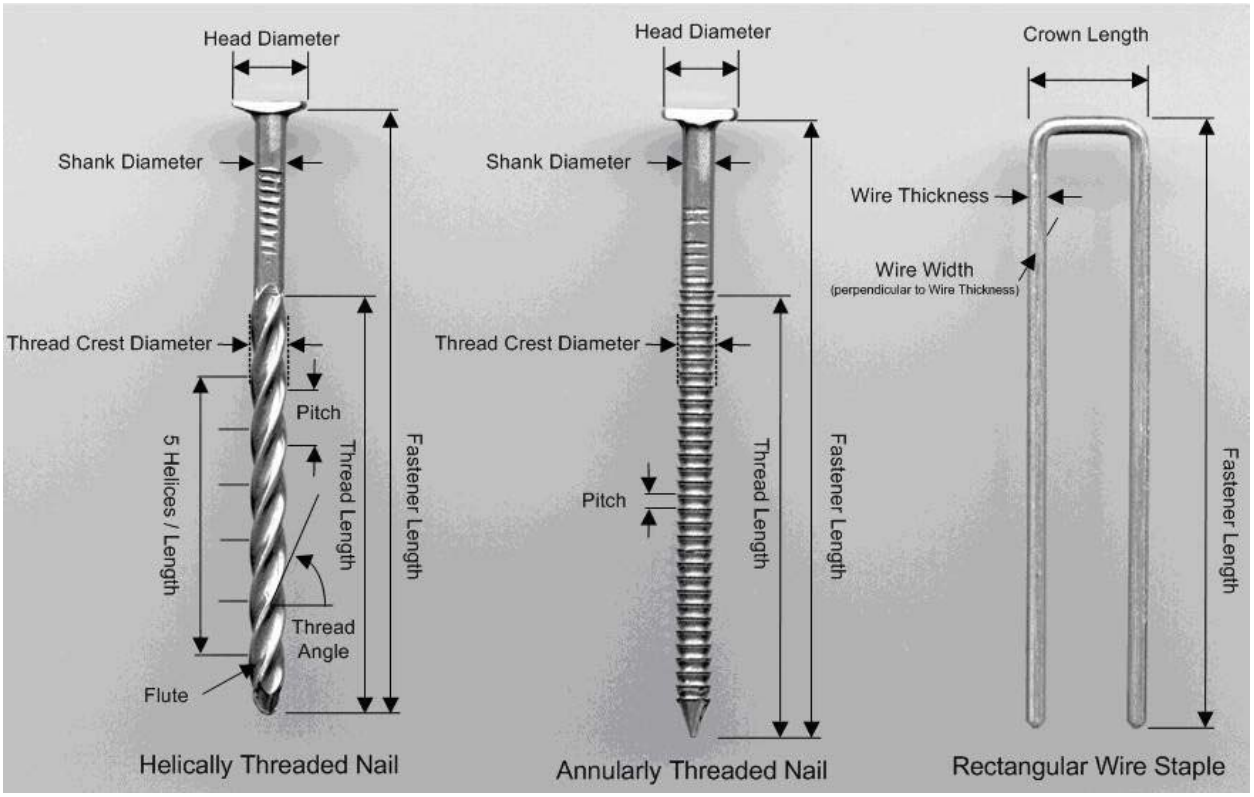

Figure 6. Schematic diagram of driven fasteners used in pallets, indicating the measurements of the physical characteristics in Table 5.

When no pallet performance evaluation is available (see Sections 10 and 11), the fastener length shall provide a minimum penetration of at least 1 in. (25 mm) into the stringer or block, but a longer penetration of 1¼ in. is recommended for optimal connection performance. Otherwise, the depth of fastener penetration shall be sufficient that the evaluation method listed in Section 11 confirms the connection strength meets the specified performance requirement.

Manufacturing tolerances shall conform to those specified in ASTM F1667 and bending yield strength shall not be less than 100,000 psi (690 MPa) or equivalent MIBANT angle measurement. The minimum acceptable characteristics of driven fasteners are specified in Table 6. Design for lateral resistance shall follow the National Design Specification (NDS)[11] with applicable adjustments for fastener shear (C_z) and moisture as described in Connection Design for Wood Pallets[12]. Design for withdrawal resistance shall follow the NDS with inclusion of adjustments for strength level, fastener withdrawal (C_w), and moisture as described in Connection Design for Wood Pallets[12].

Points of driven fasteners

The fastener point dictates pallet manufacturing quality and performance. Various forms of points should be used according to the lumber characteristics of the pallet.

Table 6. Minimum Characteristics of Driven Fasteners[a] for Purpose Built (PB) and Reusable (R) Pallets*

Application		NAILS							STAPLES
		Minimum Penetration	Minimum C_w[b]		Minimum F_{yb}[d]		Minimum head-shank ratio		Minimum crown length
		in. (mm)	R	PB	R	PB	R	PB	in. (mm)
Stringer or block pallets	New	1.25[e,f] (32)	1.9	1.5	F_{yb} > 100 ksi (690 MPA)		2.25	2.00	0.375 (9.5)
	Repair		1.5				2.00		
Clinched mat	All	Complete penetration and clinched	1.0	1.0			2.00	2.00	0.375 (9.5)

*For parameter calculations, see Connection Design for Wood Pallets[12] unless specified.

a Or equivalent connection as determined by comparison of the C_w, C_z, and Fastener Head or Crown Pull-Through Resistance (HPT) multiplied by the minimum number of fasteners per connection in Section 6.2.4.1.

b Fastener withdrawal adjustment.

c Fastener bending yield strength as determined by ASTM F1575.

d For deformed-shank fasteners, penetration includes only deformed portion embedded in the main member.

e For pallets with deckboards that are ≤½ in. (≤13mm) thick, minimum penetration shall be 1 in. (25 mm).

[11] American Wood Council (AWC). National Design Specification for Wood Construction. AWC, Leesburg, VA.

[12] National Wooden Pallet & Container Association, www.palletcentral.com

5.4.2 Bolts

For bolted constructions, steel carriage bolts can be used. Unless otherwise specified, these bolts shall be furnished in the coarse thread series, Class 2A tolerance (ASME B1.1). When steel carriage bolts are employed, washers under the head of the bolt shall be used if specified. If bolts with underhead fins are specified, instead of carriage bolts, washers under the head shall not be used. 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) 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 over sizing 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 "Teenuts," or equivalent, are specified, washers below the head shall not be used.

5.4.3 Wood Screws and Lag Screws

Traditional wood screws and lag screws, generally in compliance with ASME B18.2.1 and ASME B18.6.1, respectively, shall have cut or rolled, single or double threads along two-thirds of their shank lengths, 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 six times the nominal shank diameter of the traditional screw and four times the nominal shank diameter of the lag screw, respectively, shall be the minimum penetration length into the main member. Where pre-drilling is required, the maximum lead hole diameter shall be the nominal fastener shank diameter, and the pilot hole diameter shall not be larger than the thread root diameter. Where lag screws are used, washers under the head of the screws shall be used.

Design for connections with screws and lag screws shall follow NDS for shear and withdrawal. Adjustment for strength design shall use the strength level adjustment factor (KF) equal to 3.32.

6 MANUFACTURE OF PALLETS

6.1 Component Imperfections

For definitions and classifications, see Table 2.

6.1.1 Sound knots

Fasteners may be driven through sound knots.

6.1.2 Unsound knots and holes

Unsound knots or holes should be limited wherever possible 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 should be limited wherever possible when located on the outer edge of endboards, or on the exposed sides of stringers or blocks. Decay below limits as defined and specified in (Table 2)is permitted in the notch area (see Figure 5).

6.1.4 Splits and shake

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.

6.1.5 Panel components

Knots, knotholes, splits in individual veneers and other voids do not 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.

6.2 Assembly

6.2.1 Wood component placement

The placement of wood components shall be as follows:

- All leading deckboards shall be within ±1/4 in. (±6 mm) of their specified location.
- Other wood components shall be within ±1/2 in. (±13 mm) of their specified location, except that bottom boards shall not extend into the stringer notch unless specified.[13]
- Deckboards should be flush to edge of stringer within ±1/4 in. (±6 mm). For wing pallets, placement should be within ±1/4 in. (±6 mm) of specification.

Maximum placement deviation shall be limited to one third of the components in any pallet.

[13] Standard operation conditions of pallet manufacturing equipment may limit the precision in tolerances listed in 6.2.1.

6.2.2 Pallet size deviation

The pallet size shall be limited to plus +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 1/2in. (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 top deck diagonals, whichever is greater.

6.2.4 Fastening - driven fasteners

6.2.4.1 Fastener schedules

Nails and staples

The minimum number of driven fasteners per pallet component is specified in Table 7.

Table 7. Minimum Number of Driven Fasteners.

DECKBOARD WIDTH	MINIMUM NUMBER OF FASTENERS PER CONNECTION OF PURPOSE BUILT OR REUSABLE PALLETS
Under 5 in. (127 mm)	2
5 up to 7 in. (127-179 mm)	3
7 to 8 in. (179-203 mm)	4

Bolts, wood screws, and lag screws

The end deckboards shall have at least two bolts, wood screws, or lag screws, 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.
Panel deck block pallets shall have at least one bolt per block. Bolted blocks that are not round shall have at least one additional pallet assembly fastener per block to prevent block rotation.

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 be permitted if they interact effectively; that is, simultaneously contributes to the stiffness and strength, or both, of the connection. End-grain nailing should be avoided.

Panel deck stringer pallets shall have a minimum of three fasteners at the end of each stringer starting 1 in. (25 mm) from the end and spaced nominally 2 in. (51 mm) apart. Interior fasteners shall be spaced a maximum of 10 in. (254 mm) on center.

When using laminated blocks, the fastener length requires a minimum of 1 in. (25 mm) overlap between the top and bottom deck fasteners (see Figure 7).

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 achieve appropriate fastener withdrawal resistance.

6.2.4.4 Fastener caused splits

Splits with visible fastener shanks (legs) shall be limited. No more than one split with a visible fastener shank (leg) per connection shall be permitted and not more than 1/3 of the components per pallet shall contain these splits at the completion of manufacture.

6.2.4.5 Protruding fasteners

Nail heads, staple crowns screw heads shall be flush or countersunk (below the surface). Countersinking fastener heads shall not significantly affect pallet performance.

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

On block pallets with clinched fasteners, fastener points parallel to the top deckboard are not considered shiners. Fasteners not driven into stringers and blocks shall be compensated.

6.2.5 Fastening - chemical adhesives or glues

Adhesives shall only be used in conjunction with driven fasteners conforming to Section 5.5.

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 Table 6, but equal to the block height (see Figure 7).

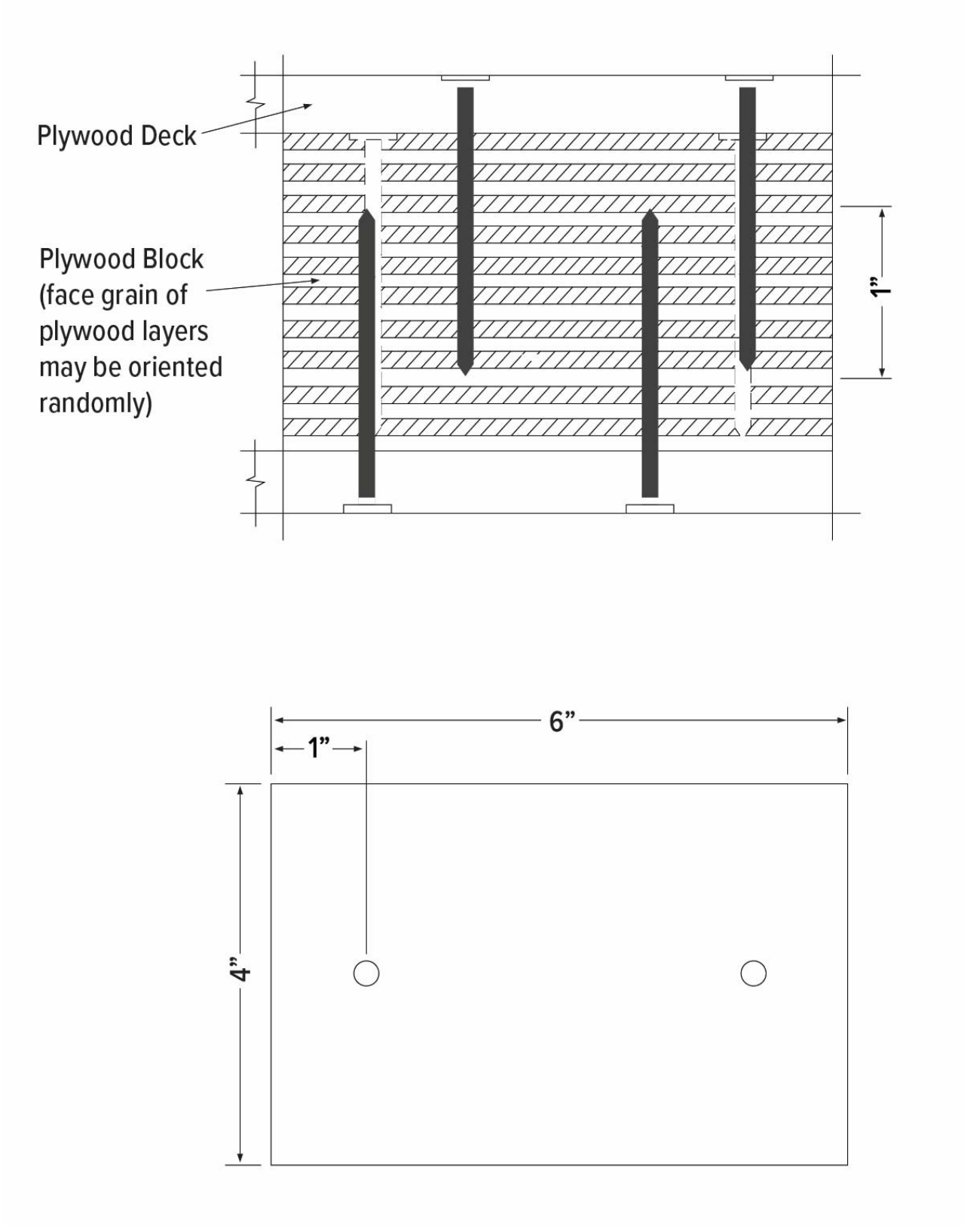

Figure 7. Schematic diagrams of block lamination and fastening.

7 REPAIR OF PALLETS

Properly repairing and recycling wood pallets is an environmentally conscientious practice. All pallets should be removed from service and be repaired or recycled , if determined to be unfit for use.

7.1 Damages

Damaged pallets should be repaired under the following conditions:

7.1.1 **Missing** deckboards, stringers, blocks, or stringerboards.

7.1.2 **Broken** deckboards, stringers, the stringer foot, blocks or stringerboards (see Figure 8).

7.1.3 **Splits** in deckboards or stringerboards of more than half the length, if it cannot be securely fastened (see Figure 9).

7.1.4 **Splits** in stringers or blocks of more than half the height or width and more than half the length (see Figure 9).

7.1.5 **Full width splits** of any length in stringer notches (see Figure 9).

7.1.6 **Missing wood** on more than two connections of the same component, which exposes one or more shanks (see Figure 10).

7.1.7 **Missing wood** of more than a quarter of the board width and half of the board length (see Figure 10).

7.1.8 **Missing wood** at any one connection, which exposes two or more fastener shanks. For 3 1/2 in. (89 mm) wide deckboard and butted joints in perimeter base block style pallets, which exposes one or more fastener shanks (see Figure 10 and Figure 11).

7.1.9 **Missing wood** on structural panel decks in 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 (see Figure 12).

7.1.10 **Delamination** of panel decks missing material due to delamination is limited to a maximum of one-third of the panel's total thickness for any width panel section (see Figure 13).

7.1.11 **Block twist,** which overhangs pallet sides or ends by ½ in.

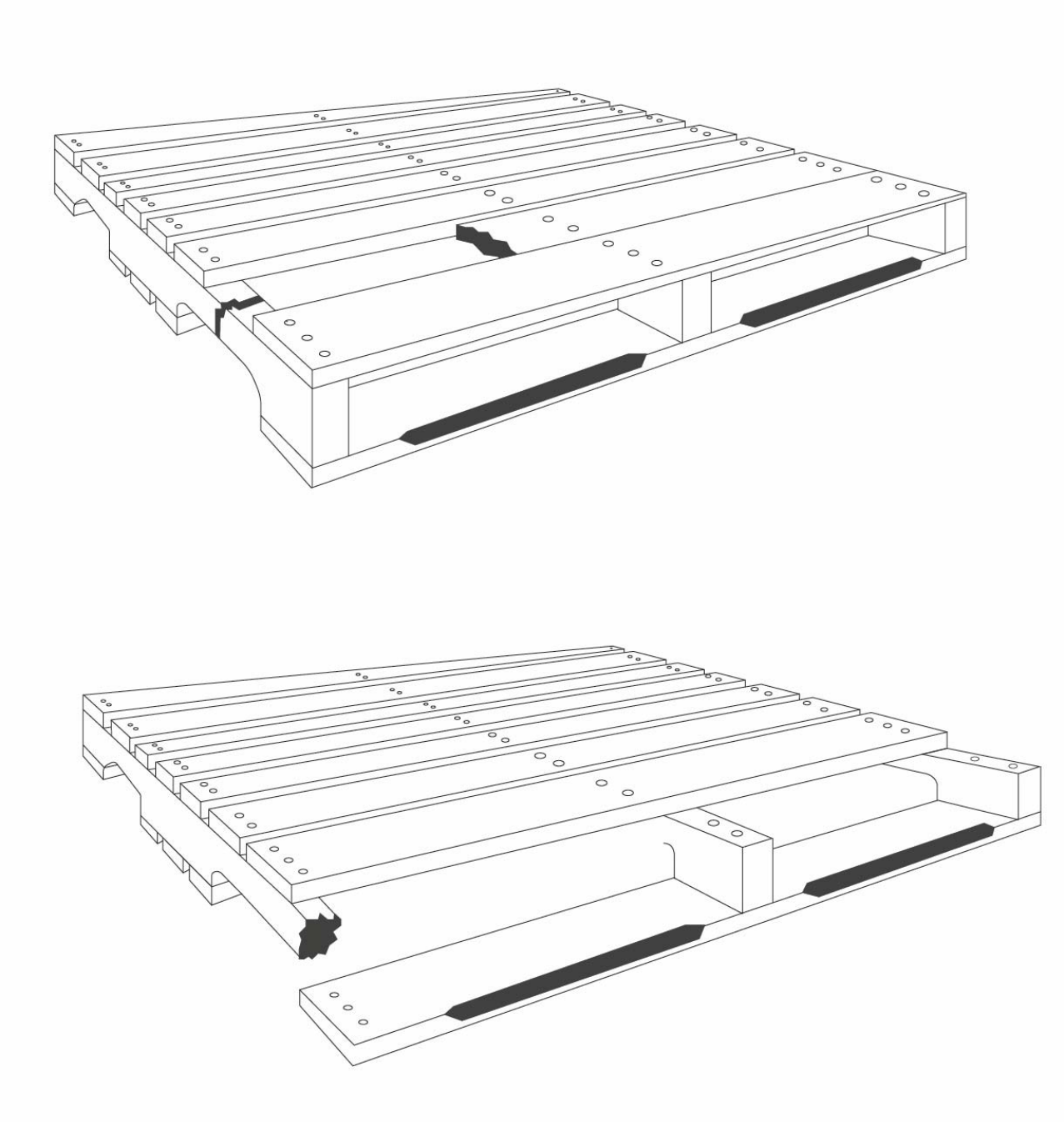

Figure 8. Schematic diagrams of broken deckboard, stringer and stringer foot.

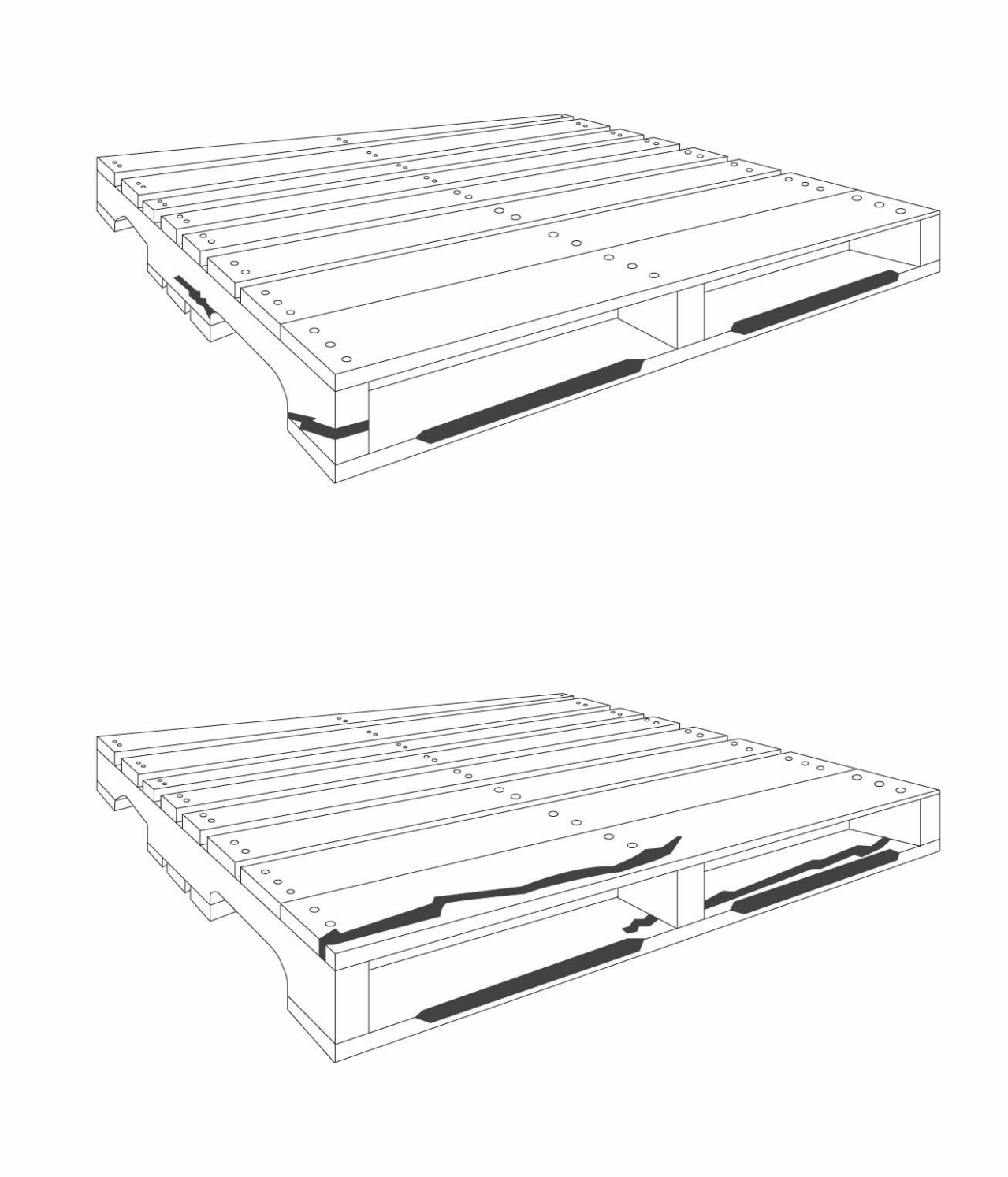

Figure 9. Schematic diagrams of splits in deckboards and stringer.

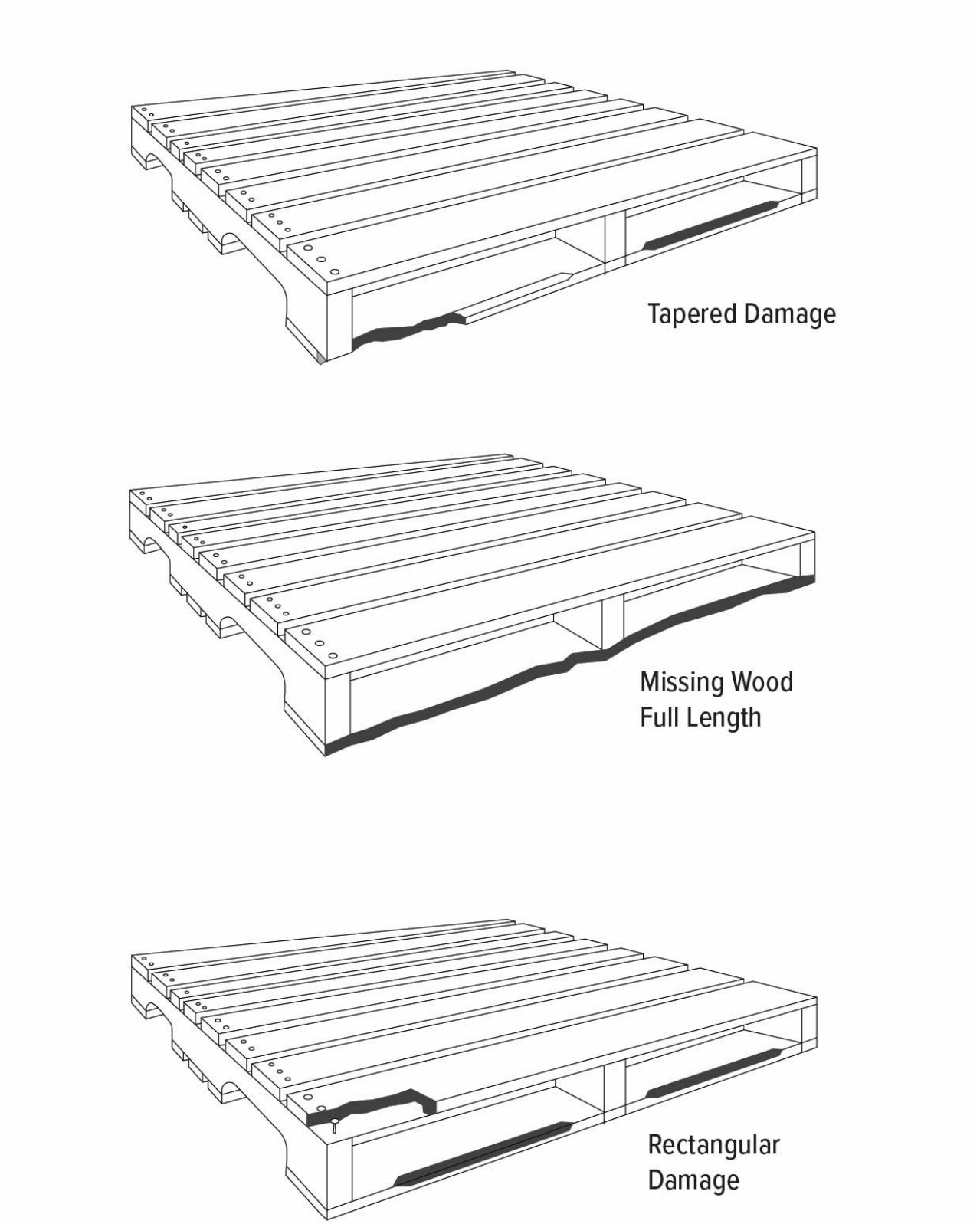

Figure 10. Schematic diagrams of missing wood.

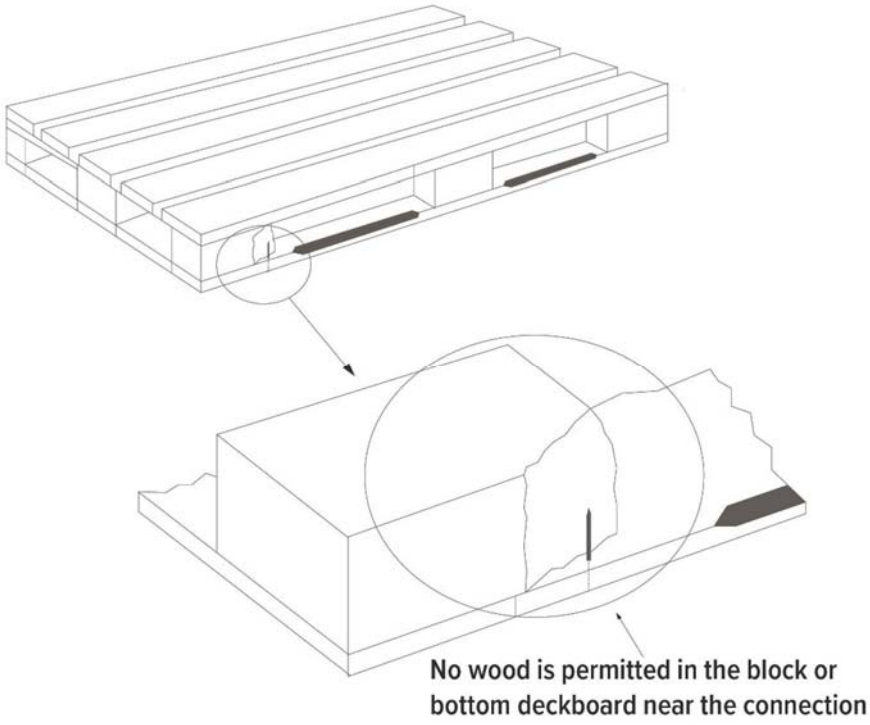

Figure 11. Schematic diagrams of a block class pallet showing the butted connection in the bottom deck of a perimeter base design.

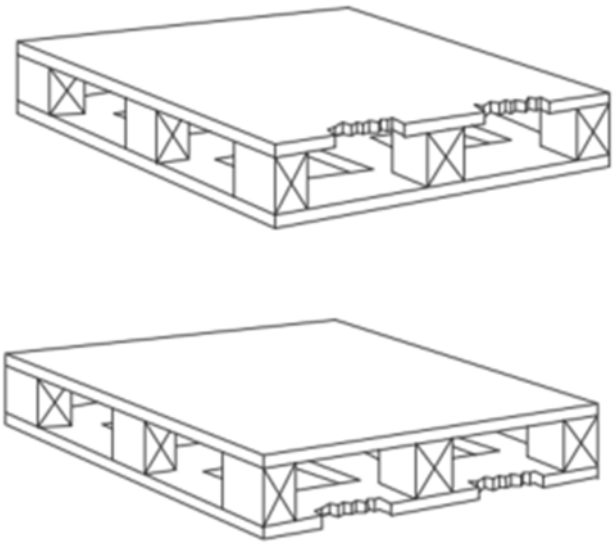

Figure 12. Schematic diagrams showing the allowable locations and extent of missing wood in a block panel pallet.

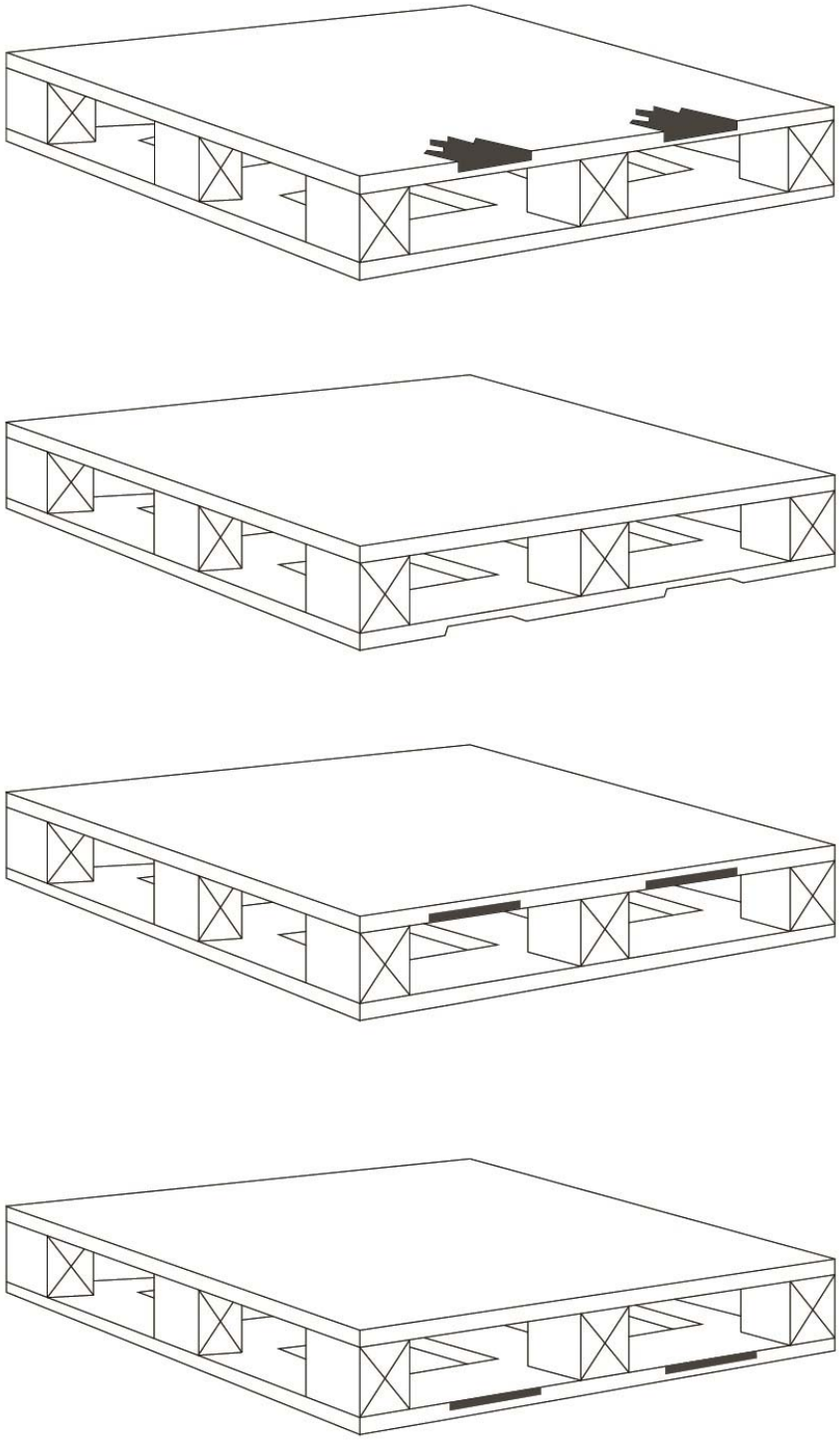

Figure 13. Schematic diagrams of panel delamination.

7.2 Recommended General Repair Procedures

The repair shall be in accordance with the respective classes.

7.2.1 ***Deckboard/stringerboard/block components***

Pallet components with damage as described in Section 7.1 should be removed and replaced with new or used components of similar material and dimensions where material quality and tolerances are given in Section 7.3.

7.2.2 ***Panel Deck Repair***

A minimum width of 3-½ in. (89 mm) should be removed from the entire length or width of a damaged edge of a panel deck that is to be repaired. The removed section must be replaced by a butted leading edge lumber deckboard of the same dimensions. For block class pallets, material should be removed such that a sufficient amount of the remaining panel is available for nailing into the block.

7.2.3 ***Fastener heads,*** crowns or points on exposed exterior pallet surfaces shall be driven flush or below the component surface.

7.2.4 ***Free standing fasteners*** should be driven into the block, stringer, or stringerboard and the joints shall be compensated with additional fasteners.

7.2.5 ***Loose components*** should be removed or securely fastened.

7.2.6 ***Twisted blocks*** *per 7.1.11* overhanging pallet sides or ends shall be squared and refastened with at least two fasteners.

7.2.7 ***Stringers*** - **Damaged stringers may be repaired according to the following methods and criteria defined below:**

Splits: Separation, may be repaired with metal connector plates (see Figure 14).
Superficial splits: The only permissible repair of a completely separated part is the reattachment of a stringer end foot. Repair of cross-grain breaks are not permitted.

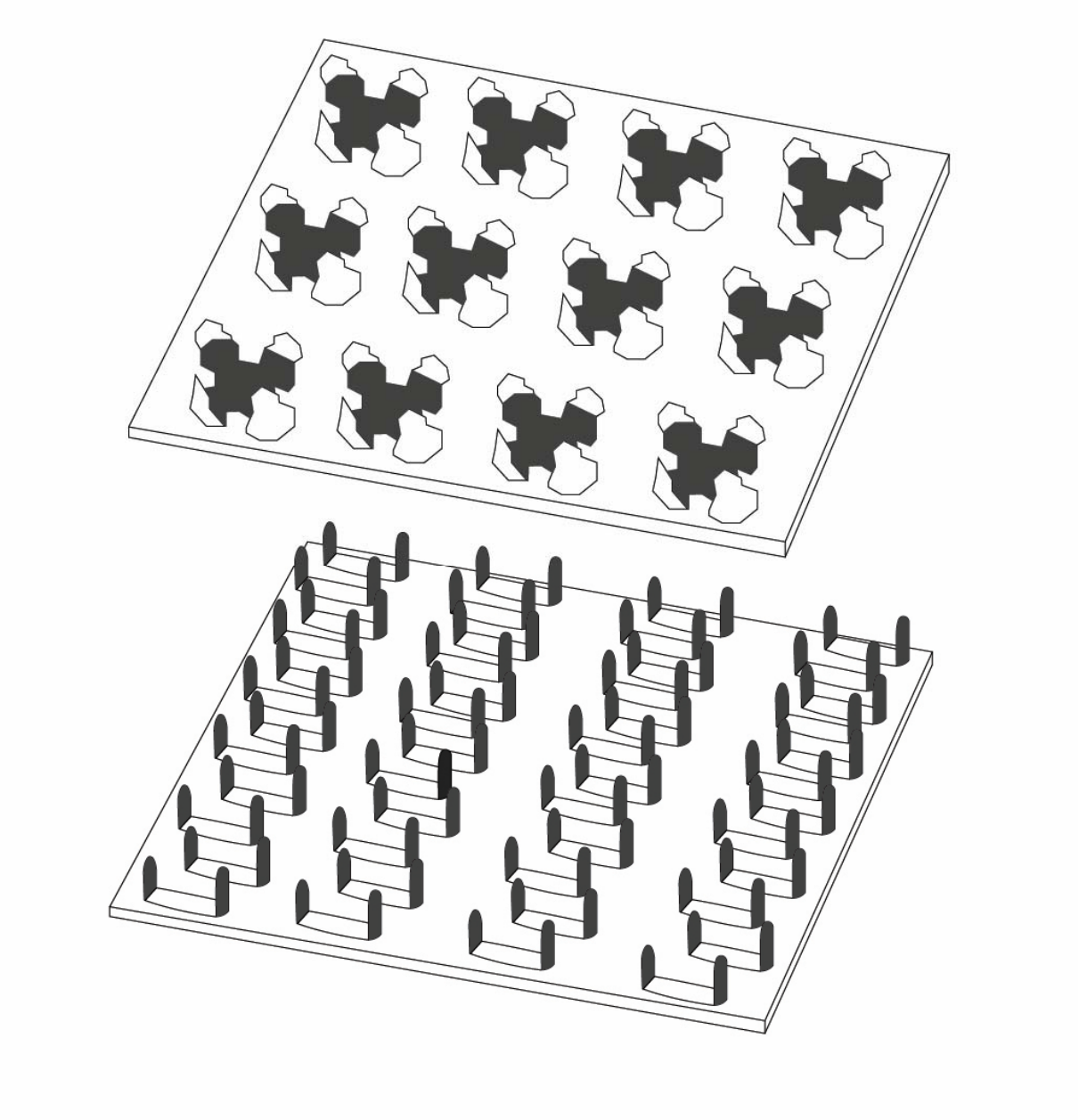

Figure 14. Schematic diagrams of two of the common styles of metal connector plates.

Metal connector plates specifications

- **Size:** Plates shall be a minimum of 2-3/4 in. (70 mm) in length and width and 11 sq. in. (7097 mm^2) in area as determined by external plate dimensions.
- **Material:** Minimum basse-metal thickness: 20 gauge (0.034 in.) (0.9 mm) minimum thickness of uncoated commercial grade sheet steel.
- **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.

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 at locations (see Figure 15). 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 (see Figure 15).

Stringers Repaired with Metal Connector Plates - Notched stringers repaired using metal connector plates, in accordance with procedures described in this Standard, have been shown to restore the stringer to its original strength.

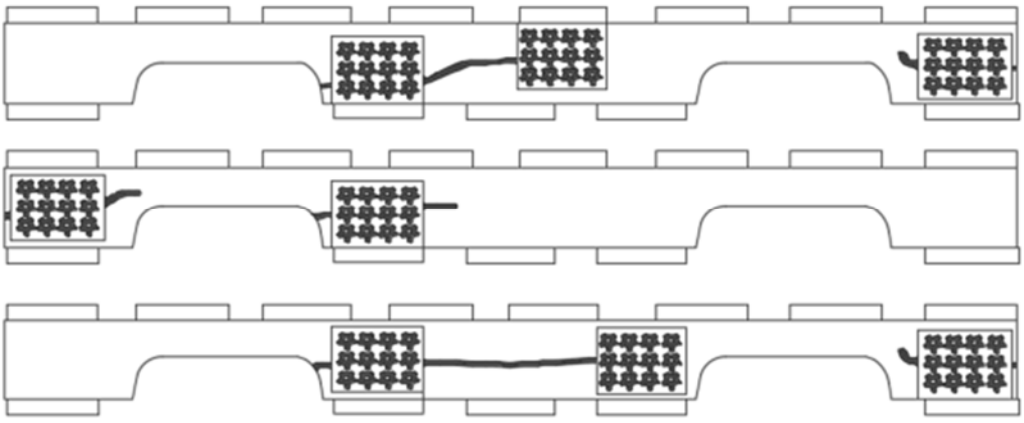

Figure 15. Schematic diagrams showing proper placement of metal plates over splits.

7.2.7.1 ***Companion stringers*** — full length, half, notched, block, C-block, or plugs (see Figure 16)

Companion stringers shall be similar in width (see Table 8) and shall be no more than 1/4 in. (6 mm) "lower" in height than the component being repaired. Companion components shall be fastened to all supported top and bottom deck components using the fastener schedule in Section 6.2.4.1.

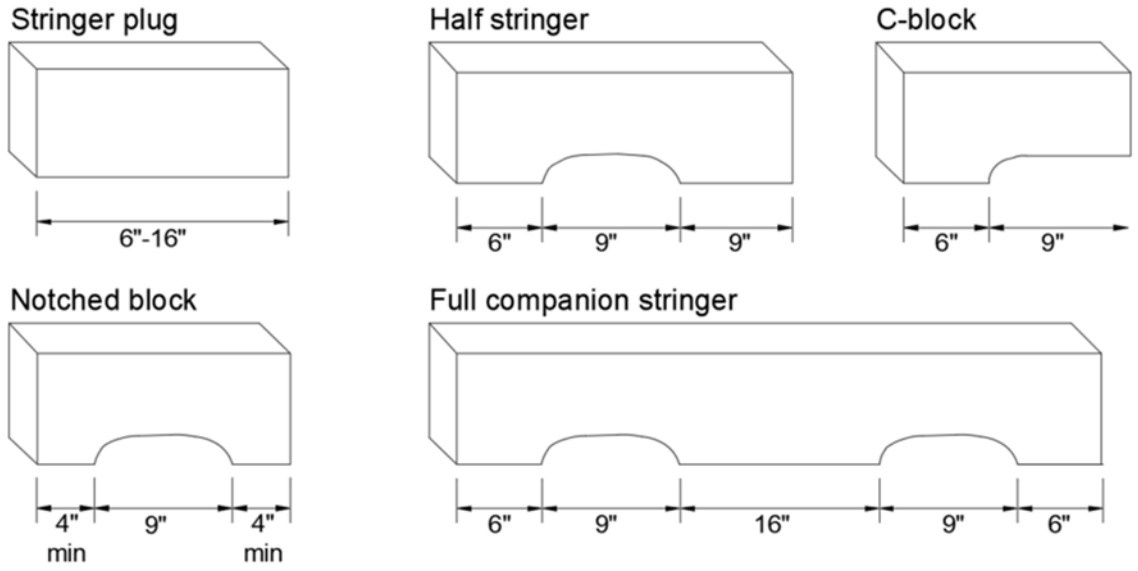

Figure 16. Schematic diagrams of companion stringer components used to repair wood pallets.

Full length companion stringer

This is the strongest companion repair practice and is recommended when both interior notched fillets are cracked or severe cracks are evident between notches. The companion stringer is similar in length to the repaired stringer and contains notches if used to repair a partial 4-way pallet (see Figure 17 and Table 8).

Half Stringers

This may be used when only one notch or stringer "foot" has failed. It is of a similar size and half the length of the original stringer and when necessary, contains a notch of similar size to that being repaired (see Figure 18).

C-block

This may be used when a stringer end foot or above notch area requires repair. The repair component consists of a complete stringer end foot and most of the above notch area. Typically the C Blocks are approximately 14 to 15 in. long (356 to 381 mm) (see Figure 19).

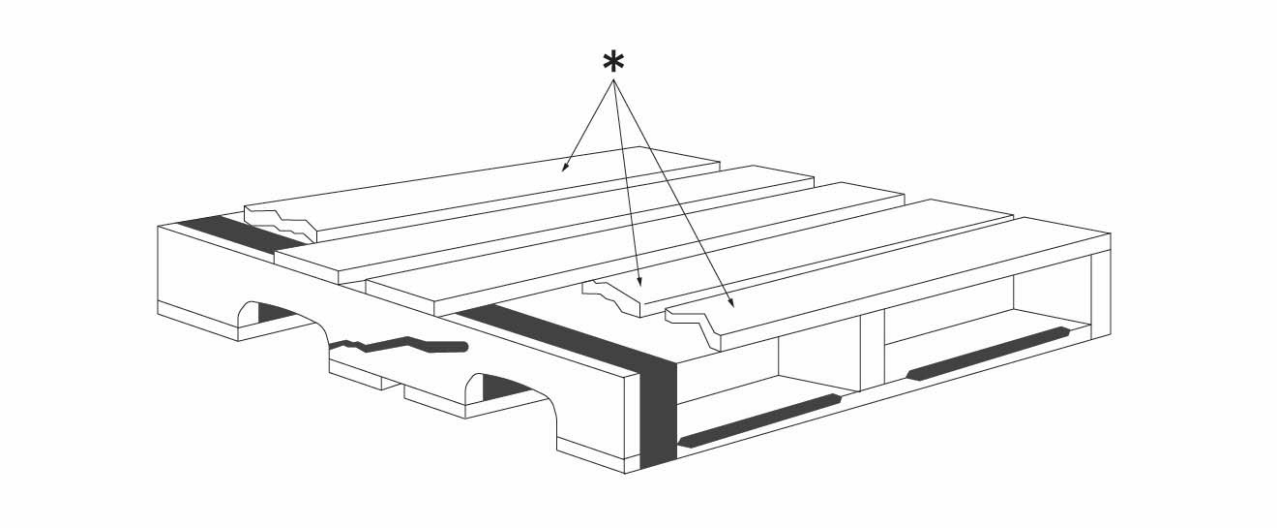

Figure 17. Schematic diagram of a full-length companion stringer repair.
*Deckboards are shortened for illustrative purposes.

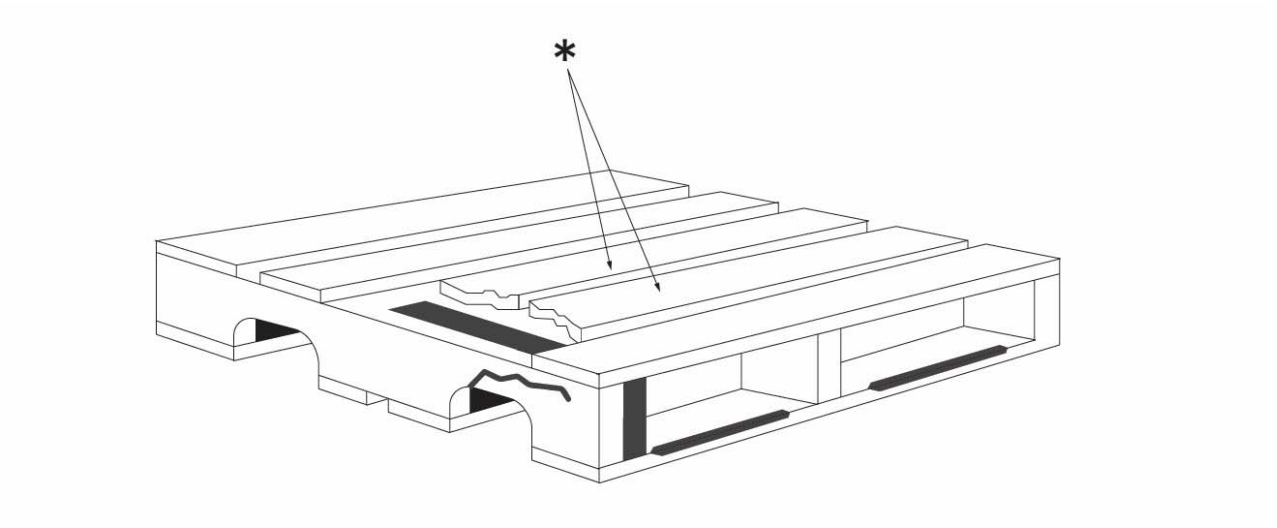

Figure 18. Schematic diagram of half-companion stringer repair.
*Deckboards are shortened for illustrative purposes.

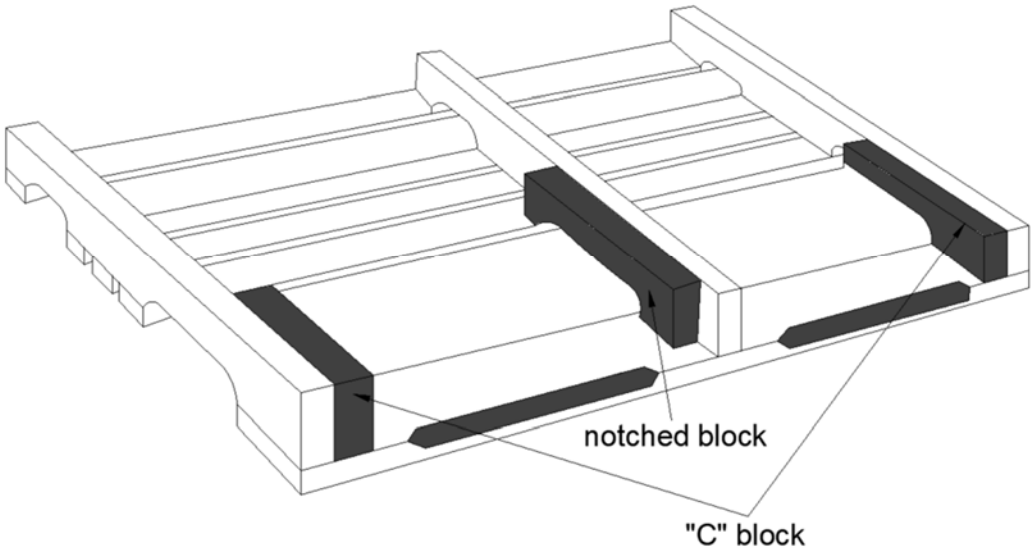

Figure 19. Schematic diagram of C-block and notched block stringer repairs.
*Deckboards are shortened for illustrative purposes.

Notched block
This companion component contains a notch of similar size to the notch being repaired and has two "feet" at least 4 in. (102 mm) long on either side of the notch
(see Figure 19).

Plugs
These are short unnotched blocks, typically between 4 and 18 in. (102 and 457 mm) long that may be used to repair a split stringer foot and between notches in notched stringers (see Figure 20).

7.3 Repair Component Quality

7.3.1 Fasteners
The fasteners used to repair connections or attach replaced components or companion components should meet or exceed the quality described in Section 5.4.

7.3.2 Wood components

7.3.2.1 *Component grade*
New or used components may be used. The component grade should be equivalent or better than the reusable pallet described in Section 5.1 and Table 3.

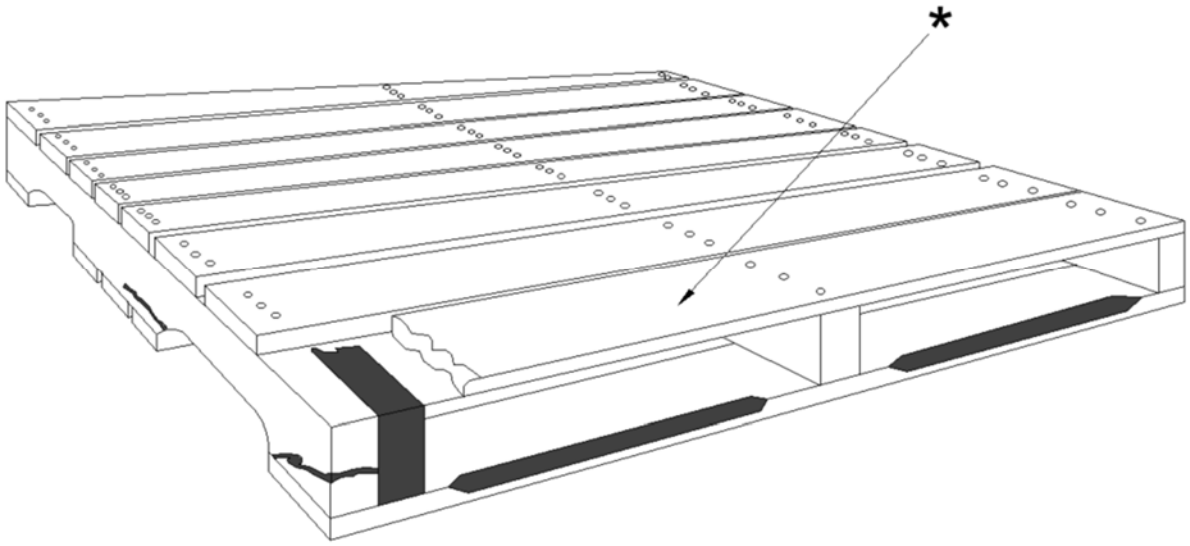

Figure 20. Example of a plug repair of a split stringer "foot."
* Deckboards are shortened for illustrative purposes.

7.3.2.2 *Replacement panels or panel strips*

Shall be of similar grade, performance rating, and dimension, as those components being replaced and should be in conformance with Section 5.2 and 5.4.

7.3.2.3 *Replacement components of similar dimension*

Table 8 defines "similar dimensions" and contains the maximum allowed deviation of replacement components from the component replaced.

Table 8. Maximum allowable deviation of replacement or companion components from component being replaced, repaired, i.e. components of similar dimensions. The tolerances are based on the component dimensions of the original pallet being repaired.

	LENGTH (in.)	THICKNESS OR HEIGHT (in.)	WIDTH (in.)
Deckboard and stringerboard	± 1/4 (± 6 mm)	± 1/8 (± 3 mm)	- 3/8 (- 9 mm)
Stringer	± 1/4 (± 6 mm)	± 1/8 (± 3 mm)	- 1/8 (- 3 mm)
Block	± 1/4 (± 6 mm)	± 1/8 (± 3 mm)	- 1/4 (- 6 mm)

7.4 Repair Workmanship

7.4.1 Flatness

The pallets must be flat on their top and bottom surfaces to within 5/8 in. (10 mm) maximum deviation from the corner-to corner straight line.

7.4.2 Squareness

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

7.4.3 Deckboard spacing

The spacing should not exceed 4 in. (102 mm) between deckboards unless defined in the pallet specification, except where a stringer notch is present.

7.4.4 Overall pallet length and width

The pallet size shall be limited to plus +1/4 in. (+6 mm) and -1/2 in. (-13 mm) of the target dimension length and width for Repaired Pallet Class 1. (± 6 mm) , and ± 1/2 in. (12 mm)for Repaired Class 2 or 3.

7.4.5 Fastening schedule and placement

In conformance with Sections 6.2.4.1. and 6.2.4.2.

7.5 Classes of Repaired 48x40 Notched Three Stringer Pallets

- **Class 1** - Repaired pallets, shall be permitted to contain metal plates, but no companion stringer repairs.

- **Class 2** - Repaired pallets with one or two stringers repaired using plugs and/or notched blocks or longer companion stringers.

- **Class 3** - Repaired pallets otherwise not meeting Class 1 and 2 criteria.

7.6 Additional Descriptions for Class of Repaired Pallets

To better balance pallet economy and performance, the above classes may include additional descriptions such as described below:

- **48x40 Deck Coverage -** This implies seven top deckboards and five bottom deckboards. More top and bottom deckboards better protect product. The pallets are stronger, more functional, and more durable than pallets with fewer deckboards.

- **Four- or Six-Inch Wide Endboard -** Pallets with nominal 6 in. (152 mm) wide, properly fastened end deckboards are more functional and durable. Two properly fastened nominal 4 in. (102 mm) wide endboards, butted together, are equivalent in performance to a single nominal 6 in. (152 mm) properly fastened board.

8 REMANUFACTURE OF PALLETS

The remanufacture of a pallet using recycled pallet parts is an environmentally conscientious practice. All pallets should be removed from service and be repaired or recycled , if determined to be unfit for use.

8.1 Quality of Parts

8.1.1 Fasteners

The fasteners used for the assembly of remanufactured pallets should meet or exceed the quality criteria described in Section 5.4 and 6.2.4.

8.1.2 New wood parts

The quality of new wood parts for use in remanufactured pallets should conform to Sections 5.1, 5.2, 5.3..

8.1.3 Quality of recycled pallet parts

8.1.3.1. Recycled component grades

Recycled components should conform to the quality criteria in Section 5.1.2.

8.2.3.2 Wood species

The wood species used in remanufactured pallets is not limited. However, suggested groupings of wood species of practical value during sortation are listed Table 9. The wood species in each wood species class can be found in Table 1.

Table 9. Wood Species Groups.

WOOD GROUP	WOOD SPECIES CLASSES CONTAINED IN GROUP
Medium/High density woods	All species listed in Species Classes 1, 2, 3, 4, 11, 21, 22
Low density woods	All species listed in Species Classes 6, 7, 12, 13, 14, 29
Hardwoods	All species listed in Species Classes 1, 2, 3, 4, 6, 7, 21, 29
Softwoods	All species listed in Species Classes 11, 12, 13, 14, 22
Mixed woods	All species listed for other wood groups

8.2 Quality of Assembly

Quality of assembly of remanufactured pallets should be according to Section 6, with the following exceptions and additions.

8.2.1 Driving fasteners

Driving fasteners through existing fastener holes in recycled pallet components should be avoided.

8.2.2 Fastener cause splits

Less than half of the components in a reassembled pallet should contain open splits with visible fastener shanks or legs.

8.2.3 Recycled component dimensional variation

Recycled component dimensional variation within each remanufactured pallet, relative to the target dimension (see Table 10).

Table 10. Dimension Tolerances of Components*.
** for each component*

COMPONENT DIMENSION	TOLERANCE
Board Thickness	-0 +1/4” (-0 +6 mm)
Board Width	+unlimited – 3/8” (-10 mm)
Board Length	±¼” (±6 mm)
Stringer Height	-0 +3/8” (-0 +10 mm)
Stringer Width	-0 + unlimited”
Stringer Length	±¼” (±6 mm)
Block Height	-0 +1/8” (-0 +3 mm)
Block Width	-0 +¼” (-0 +6 mm)
Block Length	±¼” (±6 mm)

PART II: PERFORMANCE STANDARD

9 CONDITIONS OF PALLET USE

The use conditions which pallets sustain during unit load material handling vary. Therefore, the conditions of use shall be specified, including 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.

9.1 Unit Load Condition

The description and properties 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) shall be provided.

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 shall be provided.

Maximum and average load levels and load level variations shall be provided.

9.2 Support Conditions

Maximum unsupported free span along the pallet length and width shall be indicated.
Maximum number of unit loads in a stack shall be indicated.
Measurements and locations of bearing areas between the pallet stringers or stringerboards and top and bottom decks and their supports shall be indicated.

10 MEASURES OF PALLET PERFORMANCE

Pallet performance shall be specified in terms of strength, stiffness, and durability. Pallet performance is directly correlated to the type and quality of fastener, grade, species, and moisture content of lumber components, the material handling environment, and the interaction of the pallet with the unit load.

- **Strength -** determines safe working loads for each condition of use. When reusable pallet conditions exist, the pallet and pallet component performance shall be based on the minimum design or safe working load.

- **Stiffness -** determines maximum deflection of pallets and/or pallet components for each condition of use.

- **Durability –** determines the overall service life of the pallet. Purpose Built or Reusable categories (see Section 4.2).

Purpose Built pallets are initially designed for use with a specific unit load. This category of pallets requires sufficient damage resistance to survive at least one trip without requiring repair.

Reusable pallets are designed and intended for repeated uses for more than one unit load. This category of pallets requires sufficient damage resistance to survive multiple trips without requiring repair.

11 TEST PROCEDURES

11.1 Testing for 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 series. Pallets for materials handling – Flat pallets International Standards Organization (ISO)
www.iso.org

ASTM D1185. "Standard Test Methods for Pallets and Related Structures Employed in Material Handling and Shipping."
ASTM International
www.astm.org

11.2 Testing of Computer Models

The computer software for predicting pallet and unit load performance is the Pallet Design System© (PDS)[5].

[5] The Pallet Design System (PDS) can be used for designing, selecting and predicting the performance of wood pallets. PDS is available through: NWPCA, www.palletcentral.com

PART III PHYTOSANITATION STANDARD

12 PHYTOSANITATION OF WOOD PALLETS

Treatment and marking of export wood pallets must conform to the International Standards for Phytosanitary Measures Publication No. 15 (ISPM 15) Regulations of wood packaging material in international trade. ISPM 15 has been adopted by the United States and its trading partners as their import requirements for wood pallets.

Treatment or quality mark (Figure 21) should include the following:

- IPPC logo
- Two-letter U.S. abbreviation
- Unique number assigned by an inspection agency to the facility
- HT,MB, or DH SF abbreviation

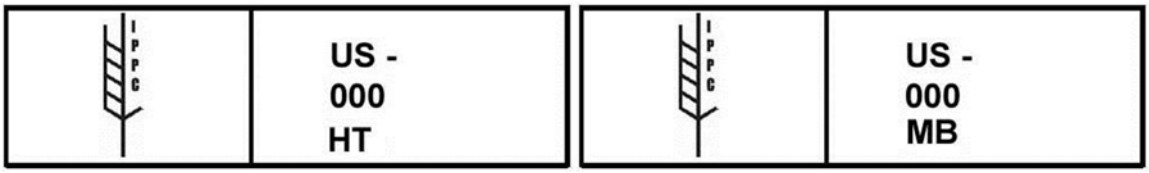

Figure 21. Examples of HT and MB treatment marks.

Wood pallets can be ISPM 15-compliant by adhering to any of the following:

12.1 Debarked

Wood pallets must be made of debarked wood. Any number of visually separate and clearly distinct small pieces of bark may remain if they are:

- Less than 3 cm ($1^3/16$ in.) in width (regardless of length), or
- Greater than 3 cm ($1^3/16$ in.) in width, with the total surface area of an individual piece of bark less than 50 cm^2

12.2 Heat-treated (HT) Wood Pallets

Heat treatment and marking of wood pallets shall conform to ISPM 15 and the enforcement regulations and policy of the American Lumber Standards Committee (ALSC) Wood Packaging Material (WPM) Program.

12.3 Methyl bromide (MB) Fumigated Pallets

Fumigation and marking of wood pallets shall conform to ISPM 15 and the enforcement regulations and policy of the American Lumber Standards Committee (ALSC) Wood Packaging Material (WPM) Program.

12.4 Dielectric Heating (DH) of Wood Pallets

Dielectric heating and marking of wood pallets shall conform to ISPM 15 and the enforcement regulations and policy of the American Lumber Standards Committee (ALSC) Wood Packaging Material (WPM) Program.

12.5 Sulfuryl Flouride Fumigation (SF) of Wood Pallets

Fumigation and marking of wood pallets shall conform to ISPM 15. Not approved for use in the US.

12.6 New Pallets

New pallets that will be used for export shipment must be ISPM 15-compliant.

12.7 Reused Pallets

Used wood pallets that are ISPM 15-compliant that are not repaired or remanufactured do not require retreatment and remarking. However, repaired, remanufactured and combo pallets must be retreated and remarked by an ALSC monitored facility to be ISPM 15-compliant; old ISPM 15 marks of repaired or remanufactured pallets must be obliterated.

ANNEX A

STANDARDS CONCERNING WOOD PALLETS AND CONTAINERS

National Wooden Pallet and Container Association (NWPCA)
www.palletcentral.com

- NWPCA Uniform Standard for Wood Pallets
- NWPCA Uniform Standard for Wood Containers

Material Handling Industry of America (MHIA)
www.mhia.org

- MH1 Pallets, Slip Sheets, and Other Bases For Unit Loads (2005 edition)
  - Part 1 Definitions and Terminology Covering Pallets and Related Structures
  - Part 2 Sizes of Wood Pallets
  - Part 3 Wood Pallets
  - Part 4 Export Pallets
  - Part 5 Driven Fasteners for Assembly of Pallets and Related Structures
  - Part 6 Protocol for Measuring Quality of Pallet Nails and Staples
  - Part 7 Testing Procedures for Pallets and Related Structures
  - Part 8 Slip Sheets
  - Part 9 Wood Pallets for Military Use
  - Part 10 Performance Specification for Pallets to be Used in Automated Unit-Load Material Handling Equipment

ASTM International
www.astm.org
D10 Packaging

- ASTM D1185 Standard Test Methods for Pallets and Related Structures Employed in Material Handling and Shipping
- ASTM D4169 Standard Practice for Performance Testing of Shipping Containers and Systems
- ASTM D6055 Standard Test Methods for Mechanical Handling of Unitized Loads and Large Shipping Cases and Crates
- ASTM D6179 Standard Test Methods for Rough Handling of Unitized Loads and Large Shipping Cases and Crates
- ASTM D6198 Standard Guide for Transport Packaging Design
- ASTM D6199 Standard Practice for Quality of Wood Members of Containers and Pallets
- ASTM D6253 Standard Practice for Treatment and/or Marking of Wood Packaging Materials

F16 Fasteners

- ASTM F680 Standard Test Methods for Nails
- ASTM F1575 Standard Test Method for Determining Bending Yield Moment of Nails
- ASTM F1667 Standard Specification for Driven Fasteners: Nails, Spikes, and Staples

D07 Wood

- ASTM D1761 Standard test methods for mechanical fasteners in wood
- ASTM D3043 Standard test methods for structural panels in flexure
- ASTM D4442 Standard test methods for direct moisture content measurement of wood and wood-base materials
- ASTM D4761 Standard test methods for mechanical properties of lumber and wood-base structural material
- ASTM D5456 Standard specification for structural composite lumber
- ASTM D5457 Standard specification for computing reference resistance of wood-based materials and structural connections for load and resistance design
- ASTM D7438 Standard practice for field calibration and application of hand-held moisture meters

International Organization for Standardization (ISO)

www.iso.org

55 Packaging and distribution of goods

55.180 Freight distribution of goods

55.180.20 General purpose pallets

- ISO 445 Pallets for materials handling – Vocabulary
- ISO 6780 Pallets for intercontinental materials handling - Principal Dimensions and Tolerances
- ISO 8611-1 Pallets for materials handling - Flat Pallets - Part 1: Test methods
- ISO/TS 8611-2 Pallets for materials handling - Flat Pallets - Part 2: Performance requirements and selection of tests
- ISO/TS 8611-3 Pallets for material handling - Flat Pallets - Part 3: Maximum working loads
- ISO/TR 11444 Quality of sawn wood used for the construction of pallets
- ISO 12776 Pallets - Slip sheets
- ISO 12777-1 Methods of test for pallet joints - Part 1: Determination of bending resistance of pallet nails, other dowel-type fasteners and staples
- ISO 12777-2 Methods of test for pallet joints - Part 2: Determination of withdrawal and head pull-through resistance of pallet nails and staples
- ISO 12777-3 Methods of test for pallet joints - Part 3: Determination of strength of pallet joints
- ISO 13194 Box pallets – Principal requirements and test methods
- ISO 15629 Pallets for materials handling - Quality of fasteners for assembly of new and repair of used, flat, wooden pallets
- ISO 18333 Pallets for materials handling - Quality of new wooden components for pallets
- ISO 18334 Pallets for materials handling - Quality of assembly of new, wooden, flat pallets
- ISO 18613 Repair of flat wooden pallets

International Plant Protection Convention (IPPC)
www.ippc.int
- International Standard for Phytosanitary Measures (ISPM) Publication No. 15 Regulation for wood packaging material in international trade

American Society of Mechanical Engineers (ASME)
www.asme.org
- ASME B1.1 Unified inch screw threads (UN and UNR thread form)
- ASME B18.2.1 Square, hex, heavy hex and askew head bolts and hex, heavy hex, hex flange,
- lobed head and lag screws (inch series)
- ASME B18.6.1 Wood screws, inch series

National Institute of Standards and Technology (NIST)
www.nist.gov
- PS 1-07 Structural Plywood
- PS 2-04 Performance Standard for Wood-Based Structural-Use Panels
- PS 20-05 American Softwood Lumber Standard

APA – The Engineered Wood Association
www.apawood.org
- PRP 108 Performance Standards and Policies for Structural-Use Panels

Hardwood Plywood and Veneer Association (HPVA)
www.hpva.org
- ANSI/HPVA HP-1-2004 American National Standard for Hardwood and Decorative Plywood

National Hardwood Lumber Association (NHLA)
www.natlhardwood.org
- Rules for the measurement and inspection of hardwood and cypress

SPECIFICATIONS CONCERNING WOOD PALLETS AND CONTAINERS

North America

American Society of Agricultural and Biological Engineers (ASABE)
www.asabe.org
- Agricultural pallet bins (ASAE S337.1)

APA - The Engineered Wood Association
www.apawood.org
- Softwood plywood pallets PP 61-80
- Collapsible big bin
- Collapsible slim bin

ASTM International
www.astm.org
D10 Packaging
- ASTM D6039/D6039M Standard Specification Open and Covered Wood Crates
- ASTM D6251/D6251M Standard Specification for Wood-Cleated Panelboard Shipping Boxes
- ASTM D6254/D6254M Standard Specification for Wirebound Pallet-Type Wood Boxes
- ASTM D6256/D6256M Standard Specification for Wood-Cleated Shipping Boxes and Skidded, Load-Bearing Bases
- ASTM D6573/D6573M Standard Specification for General Purpose Wirebound Shipping Boxes
- ASTM D6880 Standard Specification for Wood Boxes
- ASTM D7478/D7478M Standard Specification for Heavy Duty Sheathed Wood Crates

Canadian Pallet Council (CPC)
www.cpcpallet.com
- 48x40 in. stringer pallet

Committee for Graphics Arts Technology Standards (CGATS)
- Graphic technology - Pallet loading for printed materials (1995)

The Electronic Industry Pallet Specification (EIPS) Task Group
www.hp.com/packaging/EIPS/
- Electronic Industry Pallet Specification, 2003

Grocery Manufacturers Association of America (GMA)
www.gmabrands.com
- Recommendations on the Grocery Industry Pallet System (1992)

Department of Defense

www.assist.daps.dla.mil/quicksearch

- A-A-52586 Pallet, material handling, wood stringer construction, 4-way partial, 48 x 40 inches
- MIL-C-3774B Crates, Wood: Open 12,000 and 16,000-Pound Capacity
- MIL-DTL-2427H Box, Ammunition Packing: Wood, nailed
- MIL-C-3774B Crates, Wood: Open 12,000- and 16,000-pound capacity
- MIL-C-21215A(1) NOT 1 Crates, Pallets, Ammunition
- MIL-P-15011J Pallet, Material Handling, Wood Post Construction, 4-Way Entry
- MIL-P-15943D(5) Pallet, material handling, wood, ship cargo, stevedoring, 48 inches long by 72 inches wide, 2-way entry
- MIL-P-45449B Pallets, units, wood, for shipment of projectile metal parts, and projectile ammunition
- MIL-P-87089 Pallets, material handling, molded wood particles 40 x 48 inch, 4-way
- MIL-STD-147 Palletized Unit Loads
- MIL-STD-299 Visual inspection standards for nailed wood boxes and wirebound wood boxes used in small arms ammunition
- QSTAG-880 ED.1 Military pallets, packages and containers
- STANAG-2828 ED.6 Military pallet, packages and containers

European Union

European Pallet Association (EPAL)

www.epal.eu

- 800 x 1200 mm EUR
- 1200 x 1000 mm EUR 2
- 1000 x 1200mm EUR 3
- 800 x 600 mm EUR 6
- Box pallets
- Pallet collars

Chemical Industry (CP) Pallets

- CP1 1000x1200 mm
- CP2 800x1200 mm
- CP3 1140x1140 mm
- CP4 1100x1300 mm
- CP5 760x1140 mm
- CP6 1200x1000 mm
- CP7 1300x1100 mm
- CP8 1140x1140 mm