THE WOOD PALLET INDUSTRY
ITS DEVELOPMENT AND PROGRESS
TOWARD STANDARDIZATION

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Summary

This report outlines the development of the pallet industry and summarizes pallet designs and specifications, presents results of research, and includes a glossary of terms and a selected bibliography.

Introduction

The wooden pallet consists of two faces separated by structural members that provide clearance for the tines of fork-lift trucks or other mechanical handling equipment (fig. 1). The top face, upon which the load is placed, consists of surfaced deck boards of fairly uniform width and spacing. The bottom face may or may not have deck boards capable of supporting loads, but it normally has face boards designed to provide bracing and to distribute the weight of the pallet and its load over a wider area. The structural members separating the top and bottom faces may be stringers providing clearance for lifting forks or other mechanical handling equipment from two directions or they may be separated by wooden blocks or posts, providing clearance from all sides of the pallet (four-way entry). If the posts are properly spaced, clearance may be provided diagonally from the corners as well (eight-way entry).

Wooden pallets may be divided into three general classes; namely: expendable, special-purpose, and general-purpose. The expendable pallet is generally designed for a specific load and is discarded when it has
reached its destination. The special-purpose pallet is designed for the transport of a particular load. The design and construction of expendable or special-purpose pallets is a matter for agreement between the pallet manufacturer and the customer. The general-purpose pallet, as its name implies, is designed for general use in warehousing and shipping. This report deals primarily with the general-purpose pallet.

While the military forces must be credited with stimulating the rapid development of the pallet-in materials handling, the increasing commercial demand has developed pallet construction into a major industry. There has been a tremendous shift of manufacturers, warehousers, and transportation companies to this new system. The major advantages of pallets are (1) substantial savings in handling costs, (2) increased capacity of warehouses, and (3) reduced damage to materials. Other important advantages include reduction in dunnage requirements both in transportation and warehousing, simplified inventory, ease of access to stored material, and greater efficiency in the use of materials handling equipment.

The wooden pallet offers one of the most promising outlets for utilizing millions of board feet of material otherwise often wasted or burned for fuel. Large volumes of low-grade hardwood and considerable quantities of unused slabs are being salvaged for the manufacture of pallets. The relatively short lengths and widths involved permit utilization of large quantities of this material. Considering that only one-third of the total volume of wood in a tree is marketable, under current practices, any product that promises better utilization contributes directly to our national program of forest conservation.

Development of the Pallet Industry

Early Industrial Use

A pioneer lift-truck manufacturer claims to have been the first to conceive the idea of placing a bottom deck under wooden skids or platforms, thus originating the pallet as we know it. This improvement permitted easier stacking or tiering, and better distribution of the superimposed load, which previously had been concentrated immediately under the skids or stringers.

Soon after the pallet was introduced, a third intermediate stringer was added, which required dividing the platform of the lift truck and subsequently led to the development of the fork lift.

Manufacturers of fork-lift trucks designed the earliest pallets as sales promotions. In fact, some manufactured pallets, contracted with lumber yards or millwork plants for their manufacture, or acted as agents for pallet manufacturers. Other companies provided detailed instructions and drawings for several designs of pallets to the purchasers of their equipment. These instructions, however, rarely included information on kinds of wood, nailing schedules, desirable moisture contents, or other data normally included in specifications concerning wooden products.
Although the pallet system proved popular from its inception, it was not until the Navy experimentally tried it out in connection with its expanding warehousing and port terminal program in 1938 that the system received industry-wide attention. Under the stimulus of the Navy's studies and subsequent service-wide adoption, the tremendous potentialities of the system were speedily recognized.

It was not until about 1939 that any establishment specialized in the manufacture of pallets. The National Wooden Pallet Manufacturers Association, an affiliate of the National Wooden Box Association, estimates that there were 16 such concerns in that year.

Expansion During World War II

World War II demands for the movement of huge quantities of war materiel contributed greatly to the development of the pallet system, and the Navy's experience proved its practicality. For example, pallets loaded in a food processing plant in Omaha could be shipped by rail to point of embarkation, loaded on ships, moved overseas, unloaded on freight cars or trucks, and moved up to operational areas without need of breaking the palletized load at any point. In a matter of months, under Navy stimulus, the pallet was transformed from a factory and warehouse handling device to a major factor in wartime transportation.

During this period, equipment manufacturers were encouraged to provide larger and more efficient fork-lift trucks. Early in 1943, the first model of a pneumatic-tired fork-lift truck capable of handling loads up to 6 tons with a lift in excess of 200 inches was manufactured.

With the rapid expansion of this new materials-handling system, the demand for pallets became enormous. It is estimated that the military services used between 55 and 60 million pallets between 1941 and 1945. The peak of pallet production for the military services and their principal suppliers probably occurred in 1945, when an estimated 30 million pallets were produced.

This tremendous demand for pallets could not be met by the infant commercial pallet industry. Consequently, hundreds of small subcontracting plants sprang up in all sections of the country. These plants were developed around small, rural woodworking plants and sawmills. Although they had limited equipment, they usually had access to large volumes of relatively low-grade hardwoods that were satisfactory for the manufacture of pallets.

Postwar Developments

The development of the pallet system during the war years had been closely followed by materials-handling specialists in practically all fields of industry. Consequently, as fork-lift trucks became available for non-military use, many companies converted to this new system.

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By 1949, industrial demand for pallets had reached the point where commercial pallet manufacturers could not meet the demand; therefore, many part-time producers and small sawmill operators who had left the field after the war began to produce pallets. This nonmilitary demand continued to rise; until by late 1950 there were probably 1,000 full- and part-time manufacturers, including perhaps 300 concerns that could be classified as permanent establishments, specializing in pallet manufacture. Of the 23 million pallets estimated to have been manufactured in 1950, 75 percent were probably made by such companies.

Although materials other than wood were used for pallets during the war years, it was not until about 1946 that any extensive development of alternate materials was started. Steel, wire, aluminum, magnesium, solid fiberboard, corrugated fiberboard, plywood, and combinations of these and other materials have been experimented with and are used to some extent. Pallets made of material other than wood, however, account for only a small percentage of the total. All-metal pallets are used in warehouses and factories where long life and resistance to rough handling make such pallets attractive. Collapsible wire pallets are used mostly in warehousing, but also to a limited extent in shipping. Fiberboard and other expendable pallets are especially useful for shipping because of their light weight and low cost.

The pallet industry developed so rapidly that only a few statistics on its wood consumption are available. The 1948 survey of wood used in manufacture, made by the U. S. Forest Service, gives some data. For the entire country, 222,074,000 board-feet of lumber were used in 6.4 million pallets in that year. Of this volume, 37 percent was used in the North Central States, 36 percent in the Northeastern States, and 16 percent in the South. Nearly 80 percent of all pallets were manufactured by industrial concerns for their own use. The center of commercial pallet manufacture in 1948 was in the Northeast, especially New York. The South was second, with the North Central States and Pacific Coast about equal.

Current Trends and Immediate Outlook

Obviously the extent of our rearmament program will materially influence the demand for pallets, not only by the military but also by those civilian industries tied to the mobilization effort. Compared to the insignificant number of pallets available at the start of World War II, both the military and industry now have a supply of reusable pallets estimated in excess of 130 million. Most of these pallets are in reasonably good condition, and military experience indicates that in active use (moved about twice a week), hardwood pallets last about 8 years, softwood ones about 5. In dead storage, or with infrequent moves, hardwood pallets should last about 15 years, softwood pallets about 12. The military forces are procuring from Japan and the Scandinavian countries a considerable number of pallets for our overseas requirements. Total pallet production for 1952 was estimated at 25 million, of which approximately one-third went to the armed forces. Consequently, it is not anticipated that there will be any great upsurge in pallet requirements similar to that experienced in World War II.

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It is generally believed that, outside of total mobilization, the pallet industry can absorb any anticipated increase in production, with little disruption of present facilities.

Up to the close of World War II, most pallets were made from hardwoods. The wood use survey indicated that the consumption of softwood exceeded that of hardwood for pallets in 1948. The total percentage of hardwood used since 1948 has again increased, particularly with respect to commercial producers, who are now believed to be using hardwoods in the ratio of about 3 to 1. This is due to the re-entry of the armed services into the market. However, industrial plants manufacturing pallets for their own use, especially for warehousing, are using increasing quantities of southern yellow pine and eastern hemlock.

During the early years of manufacture, most specifications for general purpose pallets called for carriage bolts as fasteners. Except for pallets designed for heavy-duty stevedoring service or the handling of heavy machinery or equipment, current trends in design and manufacture have shifted to the use of spiral-grooved or annular-grooved steel nails. These nails not only reduce the cost of manufacture below that of the bolted construction but also permit use of lighter wooden members, since no thickness allowance is necessary for countersinking.

Two other developments in the manufacture of pallets appeared almost simultaneously along with the introduction of the spiral- and annular-grooved nails. The first was a trend toward partial substitution of bolts by a new construction method, whereby pallets were made in two sections, each fastened together with nails, and then the two sections were bolted together to form the completed pallet. The second was the development of a patented self-locking combination nut and washer that requires very little countersinking. This nut is being widely used in lieu of the standard square or hex nut and washer, where severe service life or strength requirements demand heavy construction.

Designs, Specifications, and Tests

Progress Toward Standardization

Most pallets manufactured prior to our entry into World War II were unduly heavy and poorly constructed, and there was a wide variety of pallet sizes. With the outbreak of war, this situation changed rapidly. The Navy, capitalizing on its experience, forged ahead in the development and use of uniform specifications. The other services soon adopted the pallet system and developed their own specifications, but no effort was made to coordinate their specifications with those of the Navy. It was relatively late in the war before some degree of uniformity began to appear in pallet design.

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Achievement of the full potentialities inherent in the pallet system rests on the acceptance of a few standardized units. The advantages of standard sizes include: standardization of materials handling equipment; increased efficiency of operating personnel; better utilization of space; simplification of inventorying and shipping records with respect to both pallets and loads; increased efficiency of pallet pools and rental agencies; and lower costs of manufacture and maintenance.

A significant contribution to this matter of standardized size was made in 1946, when a considerable segment of the food-processing industry, together with representatives of transportation companies, terminal warehousing companies, and pallet manufacturers, recommended the acceptance of two sizes as standard for the food industry. These two sizes were a 40-by 32-inch, two- or four-way entry pallet for use with fork-lift equipment of 2,000 pounds or less capacity; and a 40-by 48-inch pallet for use with equipment of 3,000 pounds or more capacity. These recommendations were later released by the Department of Commerce as Simplified Practice Recommendation No. R228-47, "Pallets for the Handling of Groceries and Packaged Merchandise."²

The 40-by 48-inch size is probably the most commonly used, since it is now the standard general-purpose pallet size for the Navy and is also widely used by other branches of the armed services. One of the principal reasons the Navy shifted from its previous standard of 48 by 48 inches was the flexibility of the 40-by 48-inch pallet with respect to railroad and highway use. This is the largest pallet that can be used interchangeably between freight cars and truck or trailer. Two of these pallets can be loaded side by side using the 40-inch dimension on a standard 8-foot highway truck or trailer, or, using the 48-inch dimension, in the standard freight car.

Other pallet sizes widely used are: 32 by 32 inches and 36 by 36 inches, which are especially useful for warehousing; 42 by 42 inches, which is the largest square pallet that can be used interchangeably in freight cars or highway trucks; 48 by 48 inches, which is widely used by industry for freight shipments and is still the standard pallet for some branches of the military; and 48 by 60 inches, which is the largest standard pallet normally used in shipping. It is worth noting that there is a decided commercial trend toward square pallets. Experience has shown that square pallets have five important advantages: (1) ease of palletizing small items, (2) most stable shape for tiering, (3) repairs are expedited (reduced number of items to be stocked), (4) more efficient use of storage and aisle space, and (5) four-way entry design is generally not necessary.

Many large industrial users of pallets are interested in further standardization and are conducting research in their own laboratories along these lines. The American Society for Testing Materials, through a study committee, provides for the exchange of ideas contributing to ultimate progress in standardization of sizes, testing, specifications, and other details of pallet construction.

Specifications

The great majority of general-purpose pallets are manufactured according to five specifications. These include the current Navy specifications for general-purpose pallets, Federal Specification NN-P-71, and the National Wooden Pallet Manufacturers Association specifications, which are commonly accepted for nonmilitary uses. This discussion will be limited to the significant features of each specification.

Copies of Navy specifications may be obtained from the Bureau of Supplies and Accounts, Navy Department, Washington 25, D. C. Federal Specification NN-P-71 may be procured through the regional offices of the General Services Administration. The NWPMA specifications are available from the Association's offices, Barr Building, Washington 6, D. C.

Federal Specifications

Specification NN-P-71, "Pallets; Materials-handling, Wood (General Construction Requirements)," was approved September 23, 1947, for all departments and establishments of the Government. The military forces can and do use this specification whenever the more rigid requirements of the military specifications are not necessary. It covers only the two-way entry pallet, and specifies general principles of design and construction rather than covering specific details. It recognizes 5 types of pallets, 3 of which are of nailed construction, and 2 of bolted construction. It also differentiates between standard or flush type pallets and the sling or stevedore type. A wide selection of wood species is divided into group A, hardwood, and group B, softwood.

Nailing schedules permit the use of cement-coated nails, which have since been found less desirable for general-purpose pallets. Also, deck boards may be as thin as 23/32 inch. No pallet sizes are specified except that the nailed pallets, types I, II, and III, shall not exceed 50 inches in length and 60 inches in width.

Military Specifications

Specification MIL-P-15011(S&A), "Pallet, Hardwood, Four-way, 40" x 48", Nailed Construction, General Purpose," covers a 40- by 48-inch, sling-type pallet designed by the Bureau of Supplies and Accounts of the Navy for general warehousing or shipping purposes. This pallet is of all hardwood construction, suitable for both domestic and overseas storage or shipping. Only the more dense hardwoods are specified, and acceptable moisture content varies by pallet grades. For grade A pallets, deck and stringer boards are limited to an average moisture content of 18 percent with no piece exceeding 22 percent, and the moisture content of the posts must not exceed 35 percent. There are no moisture content limitations for lumber used in grade B pallets. Nails must conform to Federal Specification FF-N-101, "Nails; Spikes; Staples and Tacks," and must be of one of the screw-shank types of either round or twisted stock with helicoid threads.
Specification MIL-P-16496(S&A), "Pallet, Softwood (Hardwood Posts), 40" x 48". Four-way, Nailed Construction, General Purpose," is a more recent pallet specification issued by the Navy Bureau of Supplies and Accounts after consultation with the Forest Products Laboratory. It is patterned closely after MIL-P-15011(S&A), except that deck boards (top, bottom, and subdeck) may be any of the commonly used pines (lodgepole, eastern white, Norway (red), ponderosa, southern yellow, and western white), cypress, Douglas-fir, hemlock, larch, and spruce. Thickness of top deck boards shall be 1-5/8 inches, subdeck and bottom deck boards shall be 1-1/8 inches, as compared to 7/8 inch for all deck boards in Specification MIL-P-15011(S&A).

Both of these military specifications reflect rather clearly the advances in design and construction that have occurred during the last 4 or 5 years. The trend toward standardization is indicated by the acceptance of a uniform size of 40 by 48 inches. There is more emphasis on the use of random-width deck boards and on the importance of specific types of nails and nailing schedules.


Pallet Association Specifications

In 1949 the National Wooden Pallet Manufacturers Association issued, "Minimum Standard Specifications for Warehouse or Returnable Wooden Pallets." In general, the recommendations are somewhat more liberal than the military and federal specifications. For example, this specification permits the manufacturer greater flexibility in the use of random-width deck boards than do the other specifications.

Briefly, the specification recognizes:

Three designs.—Two-, four-, and eight-way entry pallets.

Two styles.—Single- and double-face (double-face divided into reversible and nonreversible).

Three types.—Flush stringer (standard type), single wing or airplane, and double wing or stevedore (sling type).

Practically all species of wood in groups I, II, III, and IV as recognized throughout the box and crate industry, are acceptable.

Thickness of the deck boards, in this specification, is less than in the federal and military specifications for loads up to 2,000 pounds. Deck boards may be 5/8 inch thick as compared to a minimum of 7/8 inch for hardwoods and 1-5/8 inches for softwoods in the military specifications and 25/32 inch for Federal Specification NN-P-71. Size requirements for stringers and subdeck boards are similar to those for military and federal specifications. Nowhere in the specification, however, is any mention made of size of posts.
Nailing schedules in this specification are more liberal. For example, deck boards of less than 4-1/2 inches in width require only 2 drivescrew or annular-grooved nails at all bearing points instead of the minimum of 3 designated in other specifications. The schedules allow the use of drivescrew and annular-grooved nails and cement-coated or chemically etched box nails. Box nails, however, are indicated as being less effective than the annular-grooved or screw-shank nails.

Testing Procedures

Although millions of pallets were purchased by the military services during the war, wartime urgencies prevented any serious consideration of the need for standardized methods or procedures for testing. Immediately following the war, the Bureau of Supplies and Accounts instituted an extensive research and development program on pallets at the Naval Supply Research and Development Facility, Bayonne, N. J. Under this program a standard testing procedure was devised and has been used effectively in developing specifications for Navy general-purpose pallets.

The Navy's procedure consists of 30 tests based largely on properties and characteristics which wartime experience had shown to be important. While some of the Navy tests appear unduly severe, they were designed to show up possible weak points. Certain minimum requirements have been specifically stated in some of the tests; in other instances they are implied in the wording.

Early in 1949, pallet tests were considered by the American Society for Testing Materials (ASTM) and assigned to a special committee for action. In September 1951, tentative methods of standardized tests (ASTM designation: D1185-51T) were accepted by the Society. The testing procedures recommended consisted of five tests that are much simpler and generally more lenient than the Navy tests.

Investigations at Forest Products Laboratory

The Forest Products Laboratory has cooperated with the armed forces on problems involving the utilization of wood since World War I.

During the past 10 years, the Laboratory has cooperated on pallet work with the Navy, principally through the Bureau of Supplies and Accounts; with other military agencies, such as the Ordnance and Quartermaster Corps and the Air Material Command; and on a smaller scale with various industrial organizations.

The experience gained from this work and from the fundamental work by the Laboratory on all phases of wood technology indicates a number of basic factors that must be considered in the design and construction of sound pallets. Probably the four most important factors are: (1) the allowable defects in lumber, (2) sizes of component parts, (3) moisture content of the lumber, and (4) the fastenings.

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Allowable Defects in Lumber

To eliminate excess variability in tests, relatively clear, sound lumber has been used by the Laboratory in its research on pallets. Generally speaking, however, tests have shown component parts to be acceptable if they are free from decay, spike knots, cup, and wane. Navy pallet specifications, based on Laboratory recommendations, permit knots up to 1/3 the width of the piece, surface checks in length up to twice the width of the piece, one split in length not exceeding the width of the piece, chipped or torn grain not exceeding 1/16 inch in depth, occasional 1/4-inch holes not extending through the piece, and worm holes, streaks, and stains.

Sizes of Component Parts

In general, Laboratory pallet work has been limited to pallets constructed of lumber of standard dimensions. Detailed studies might prove these dimensions to be conservative, but trade practices prevent any great deviation from them. However, limited tests have been made to determine the possibility of using short lengths of lumber as a means of economy and as a means of utilizing material which might otherwise be wasted. The results of these tests indicate that pallets constructed with short-length top deck boards butting over the middle stringer or posts are, in general, satisfactory.

Moisture Content

Pallets manufactured of seasoned lumber have a number of important advantages over pallets made of green or inadequately seasoned lumber. Under normal conditions of use, pallets constructed of well seasoned lumber have greater strength, greater dimensional stability, less likelihood of defects due to shrinkage, decreased weight, and greater resistance to insect and fungus damage, than pallets made of green or inadequately seasoned lumber. Pallets designed for rough service and long life should be made of component parts that have been dried to less than 20 percent moisture content.

Observations by pallet inspectors at military and other establishments provide ample evidence of severe damage to both pallets and palletized loads where dry lumber was not specified or where inspection for compliance was not satisfactory. At one military supply depot recently visited by Forest Products Laboratory personnel, loaded pallets were stored in heated warehouses and under dehumidified conditions. A large number of these pallets showed severe nail pulling, cupping, and splitting of deck boards and stringers, and severe splitting and checking of posts on four-way entry pallets, all unmistakable indications that the pallets had been assembled with insufficiently dried lumber. Unquestionably the strength and service life of such pallets had been materially affected by severe moisture changes following fabrication.
Fastenings

Studies of various types of fastenings at the Forest Products Laboratory date back many years. Comparisons of the holding properties of nails as well as the nail-holding characteristics of various species of woods have been reported in numerous published papers. Most of the important types of nails now used in pallet construction have been tested under a wide variety of conditions, and the following facts concerning them stand out clearly:

(a) When used in pallet construction, the common, smooth-shank steel nail should be clinched.

(b) The cement-coated nail, although still widely used in commercial pallet construction, is no longer permitted in most military pallets. Generally, the coating provides higher initial withdrawal resistance, but experience has shown that this higher initial withdrawal resistance is not permanent. It is not recommended for use in pallets designed for long service, although it unquestionably has advantages over the common nail for expendable types of pallets.

(c) The annular-grooved and spiral-grooved nails have greater withdrawal resistance than the common nail, particularly when the wood undergoes moisture content changes. Each type has its advantages under given conditions, and each is generally acceptable in military and commercial pallet manufacture.

(d) The hardened steel types of both the annular-grooved and spiral-grooved nails are more recent developments designed to improve nailing properties through increased stiffness. The hardening process leaves them quite brittle, however, and under certain conditions these nails break more readily than other types of improved nails or even the common steel nail. This is particularly true with respect to the hardened annular-grooved nail, where the diameter of the nail between the encircling ridges has been materially reduced.

Research Needs

It appears that pallets have been designed on the basis of experience gained through use and that there has been little application of fundamental knowledge of pallet behavior resulting from basic research. For example, no serious consideration has been given to the development of formulas for determination of stress factors in pallets. There appears to be little doubt that, in general, pallets are overdesigned today to provide a safety factor compensating for a lack of precise knowledge of stress factors.

Fastenings for pallets.--While a considerable amount of work has been done for the military services on the problem of fastenings, more research is needed. Particularly is this true with respect to the development of fastenings for use with the denser hardwoods, which present difficulties.
in fabrication at the low moisture content required for satisfactory service life. While the hardened-steel, deformed-shank type of nail has made the bolted pallet obsolete, except for the most severe stevedore service, it also has limitations due to its increased brittleness. There are also types of glued fabrication which offer attractive possibilities where severe moisture content fluctuations can be avoided.

Wood requirements for pallet construction. -- Wood species selected for pallet construction have been based largely on the requirements for box and crate construction. The normal service conditions for pallets probably are sufficiently different from those of boxes and crates to justify re-examination of wood species as they apply to pallet manufacture. In this respect, more study is needed in the matter of substituting softwoods for hardwoods. For example, satisfactory strength and other characteristics for deck construction might be achieved by using hardwoods as the outside deck boards to take the rough handling, and using softwoods on the remainder of the deck.

Preservation of pallets. -- The need for developing a preservative treatment for pallets is becoming great. The ever increasing cost of pallets, together with their widening use, especially under conditions conducive to decay, justifies studies in this field. The military forces have several million pallets in storage. Many of these are in knocked-down assemblies. Reports continue to be received indicating evidence of decay or insect damage and requesting information on correct methods of treatment. It is doubtful if pallets constructed of properly seasoned material would be susceptible to decay or insect damage if protected from excessive moisture. Loaded pallets in warehouses are usually safe from insect and decay attack, but empty or knocked-down pallets are often stored in the open with little protection other than canvas or crude wooden shelters.

The cost of treating stored pallets will be high, and must be weighed against the urgencies of the situation as well as the expected life of the pallet. A relatively small number of pallets, subjected to unusually severe exposure conditions, are now being constructed from pressure-treated wood. Several military establishments have considered pressure treatment for new pallets purchased for stockpiling, but have found the cost excessive. Perhaps a simple soak of about 24 hours might suffice. This could also be applied to pallets already stockpiled without too great a cost. New pallets could be given a hot and cold bath treatment, which might provide adequate protection. Consideration might also be given to specifying the more decay-resistant species where the needs would justify the increased cost involved. The heartwood of the cedars, cypress, and redwood has high decay resistance and some resistance to insect attack. Untreated pallets of these species should give reasonably good service under rather severe conditions of storage in the United States.

The problem of foodstuffs and other items that might pick up objectionable stains, odors, or tastes should be more thoroughly investigated. One of the Army Quartermaster Depots is now investigating the possibilities of treating pallets used in shipping and warehousing foodstuffs with a
suitable product to reduce moisture pickup or loss, and inhibit the growth of micro-organisms that might contaminate food. Such a preservative must be nontoxic to humans, tasteless, odorless, stainless, and yet easily and safely applied.

Other research needs.--The research work already accomplished at the Forest Products Laboratory, together with the correspondence in its files, gives a number of promising leads to much-needed studies. Many of the questions raised by industry fall in the field of industrial research and should be handled by either the pallet industry or the large industrial users of pallets. Those problems involving the economics of the pallet system perhaps properly fall in this field, but there are others where the distinction between economic and products research is not sharply defined, or where public interest fully justifies participation in such research. For example, the problem of standardization of pallet size touches not only such interesting economic opportunities as reduced inventory requirements, wider shipping utility, and the as yet scarcely touched field of pallet rental, lease, and exchange pools, but also directly concerns pallet specifications, materials, and design.

Further exploration is needed into the possibilities of utilizing low-grade lumber slabs and short-length pieces in pallet construction. Also, the possibilities of utilizing more species and decay-infected lumber should be investigated.
Glossary

Pallet Design

Two-way entry.--This design permits entry of mechanical handling equipment from two sides only and in opposite directions.

Four-way entry.--This design permits entry of mechanical handling equipment on all four sides.

Eight-way entry.--This design is similar to four-way pallets but with posts arranged to provide for entry of mechanical handling equipment, not only from all sides but diagonally from the corners as well. (Of limited use except in warehousing.)

Pallet Nomenclature

Deck.--This can be subdivided into top and bottom decks. The top deck or face of a pallet carries the load. The bottom deck or face of a pallet helps to distribute the load more uniformly.

Deck boards.--The boards which make up the decks or faces of a pallet, usually referred to as top or bottom deck boards.

Stringers.--These are wooden runners to which the deck boards are fastened, and which serve as a spacer between the top and bottom decks to permit the entry of tines of lift trucks.

Posts.--These are square or round wooden parts or other materials employed on some four-way entry and all eight-way entry pallets in place of stringers, and serve the same purpose. These are also called columns or blocks.

Subdeck boards.--These are used with posts to replace stringers and tie the top deck boards to the pallet. Sometimes called stringer boards.

Pallet Styles

Single-face pallet.--This style has only one deck, the top surface.

Double-face pallet.--This style has both top and bottom decks and comes in two different designs.

(a) Reversible -- This style has identical top and bottom decks upon which goods may be stacked on either deck. This is also referred to as double-face pallet.

(b) Nonreversible -- In this style, the top and bottom have different deck openings. Therefore, goods may be stacked only on the top deck.
Expendable pallet.--Expendable pallets are designed for temporary use or one trip shipments. They are usually of economical construction and have minimum strength factors.

Pallet sizes.--Dimensions should always be stated in inches with the length given before the width. The width should be given as the dimension parallel to the top deck boards.

Pallet Types

Flush stringer.--A pallet in which the outside stringers are flush with the ends of the deck boards. Also called warehouse or standard pallet.

Single-wing.--A pallet in which the outside stringers are set inboard a number of inches on the top deck, while the stringers are flush with the ends of the bottom deck boards. Also called airplane type construction.

Double-wing.--A pallet in which the outside stringers are set inboard of both top and bottom deck boards to accommodate bar slings for handling the pallet. Also called stevedore, general-purpose, or cootie type construction.
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At the request of the Chief of Ordnance, U. S. Army, a series of tests were made of an 8-unit pallet for overseas shipment of 115-pound chemical bombs, M-70, and a method devised for loading this pallet in freight cars. Several exploratory pallets were built and tested, each succeeding design attempting to correct failures in the proceeding. The final pallet was made of nominal 2- by 4-inch southern yellow pine (group II wood) with a center separating section of nominal 1-inch lumber and carrying eight bombs. This design was a special-purpose pallet.

BORKENHAGEN, E. H.


This report describes tests of several designs of pallets for Navy Department to determine one most practical for general purpose. Results indicated that a design using posts 3 by 3 by 5-5/8 inches and deck boards parallel to the 48-inch dimension was most suitable on the basis of weight, number of component parts, and strength.


The results of these tests for the Navy Department indicated that the hardened steel spiral-grooved nail provided the most rigid fastening. The regular steel spiral-grooved (drivescrew) nail of slightly greater diameter was judged a close second with the hardened annular-grooved nail third.
BORKHENAGEN, E. H.


This study was made at the request of the Bureau of Supplies and Accounts, U. S. Navy, and was supplementary to tests made on hardwood pallets assembled with corresponding types of nails. The bright spiral-grooved and annular-grooved regular steel nails showed a higher resistance to withdrawal than did the bright box nail. The lateral-resistance tests showed that the hardened steel grooved-shank nails withstood higher loads than the regular steel grooved-shank nails of equal diameter. In lateral-resistance tests, the hardened steel spiral-grooved nails withstood greater loads than the hardened steel annular-grooved nails.

ERICKSEN, W. S.


The Navy proposed a four-way entry pallet design in which the top and bottom decks were separated by solid stringers. Two cutouts were made in each solid stringer to form two outer posts and an inner post. Tests were made to study the behavior of the stringers when loaded and to determine whether the post, being an integral part of the stringer, added to the stiffness or effectiveness of the member.

A stringer of this type will, when supported at its ends, carry about the same maximum load as if the posts were not present. Such stringers may be designed as a simple beam.

HEICK, R. J.


Tests on new Navy softwood pallets (hardwood posts) showed strength and other factors comparable to those of pallets made entirely of hardwood.
HEICK, R. J.

1952. A Study to Determine the Suitability of Short-length Lumber in Pallet Construction. Forest Products Laboratory unpublished report.

This study was made to compare the strength and other properties of pallets constructed with top deck boards butting over the center stringer with similar properties of pallets constructed with full-length deck boards. Results showed no significant differences.

MARKWARDT, L. J.


This bulletin contains basic information on the important strength properties of 185 principal woods in the United States.

RINGWOOD, J. B.


It was concluded that both hardwood and softwood pallets give satisfactory service. Deflections under the heavy load used were not excessive. All pallets withstood the rough-handling test very well. The softwood pallet was considered to be excessively heavy and of unbalanced construction. The pallet with split-center stringers was less rigid and less capable of resisting diagonal distortion. Also, unless the load is heavy enough to bring the free faces of the two halves of the split stringer into contact with the decks, the bending stresses are concentrated in the top deck and its fastenings.

U. S. FOREST PRODUCTS LABORATORY


This report presents a summary in tabular form of information on 50 important species concerning their nail holding power, in end, radial, and tangential surfaces and the relation between holding power and specific gravity.

Rept. No. R1957 -18-
U. S. FOREST PRODUCTS LABORATORY


This handbook contains basic information on wood as a material for construction and includes data for use in design and specification.


This note contains a short summary of the principal factors that determine the efficiency of a nailed joint.


This report contains a detailed set of basic principles to aid in the preparation of specifications for pallet construction. The principles are based on the strength and other important properties of wood, fastenings, and other factors involved in pallet construction rather than on specific studies of pallet design or construction.


The information in this report was assembled for the purpose of giving Navy inspectors the background information needed to determine whether lumber has been properly cut and assembled to assure a strong, serviceable pallet. The species commonly used for pallets are listed and their important characteristics outlined. Defects that affect strength and service life are described. The important wood properties are treated briefly, and the effects of moisture and shrinkage are explained.

WILSON, T. R. C.


This report summarizes studies made at the Forest Products Laboratory on the strength properties of wood as related to moisture.
B. Specifications for Pallets

FEDERAL SPECIFICATION

NN-P-71 -- Pallets; Materials-handling, Wood (General Construction Requirements).

MILITARY SPECIFICATIONS

MIL-P-15011(S&A) -- Pallet, Hardwood, Four-way, 40" x 48", Nailed Construction, General Purpose.

MIL-P-15943(S&A) -- Pallet, Wood, 48" x 72", Two-way, Stevedore (Cargo).

MIL-P-16496(S&A) -- Pallet, Softwood (Hardwood Posts), 40" x 48", Four-way, Nailed Construction, General Purpose.

U. S. AIR FORCE

Air Force drawing 45D9871 -- Pallet Assembly - Bulk Storage.

NATIONAL WOODEN PALLET MANUFACTURERS ASSOCIATION

Minimum Standard Specifications for Warehouse or Returnable Wooden Pallets.
Figure 1.—Typical wooden pallets of two-way and four-way entry type.