Pallets 101: Industry Overview and Wood, Plastic, Paper & Metal Options

Pallet users face an increasing number of material and design options. Learn about the latest innovations in solid wood, plastic, paper, and metal pallets, and how you can use pallets to reduce costs in your operations.

John Clarke
Technical Sales Director
Grate Pallet, Inc.

Education: BS and MS, Virginia Tech *Activities:* ISTA, NIPHLE, VT Unit Load Short Course Instructor, ASME Pallet Committee Member *Achievements:* Past Director, VT Center for Unit Load Design.

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John W. Clarke
Grate Pallet, Inc.
(540) 832-0807
jclarke@gratepallet.com

The perception we have of pallets is a lot like that of corrugated boxes. While not the glitzy high-profile part of our jobs, they are critical to our operations and we have all seen the consequences when they do not perform as needed. It would be hard to find a company today that does not use pallets. Imagine today's warehouses and shipping operations if products were still manually loaded one box at a time. However, while critical to today's material handling operations, pallets are probably one of the least understood and overlooked components within these operations. Product unitization and distribution systems consist of 3 interactive components: Packaging, pallets, and material handling equipment. Most components used to unitize, store, and ship products are carefully selected, but designers tend to work independently. Many packaging engineers carefully spec the packaging, but have a brief description for the pallet. The same holds true for material handling equipment designers. Pallets are the direct link between your packaged products and the handling environment. As packaging engineers, you are in a unique position to understand the tradeoffs in pallet design, performance, design and material options, and ultimate cost of use.

There are resources available for an in depth knowledge base on pallets listed at the end of this paper. This paper is intended as an overview of the pallet industry, the basic performance parameters that are necessary to optimize pallet design for your application, and current design and material options.

Today's Pallet Industry

Today, there are about 450 million new pallets produced in North America each year (1). About 1.9 billion are in use at any given time (2). The 10 most common US sizes are given in Table 1 (3), along with the typical industries that use these sizes. The 48x40-inch pallet is the most common pallet size in the U.S., representing about 30% of the pallets produced each year. This is typically called the GMA, or grocery pallet.

Table 1: Top 10 pallet sizes in North America in 2000 (Southern Illinois University)

Pallet Size (in.)	Production Rank	Typical Industry
48x40	1	Grocery, common in many other industries
42x42	2	Telecommunications, Paint
48x48	3	Drums
40x48	3	DOD, Cement
48x42	5	Chemical, Beverage
40x40	5	Dairy
48x45	7	Automotive
44x44	8	Drums, Chemical
36x36	9	Beverage
48x36	10	Beverage, Shingles, Packaged Paper

This list totals about 60% of the annual pallet production. The 10th most common size represents less than 2% of the market. There remaining 40% of the market includes hundreds of sizes, typically tailored to specific customers.

Internationally, there are 6 pallet footprints recognized by ISO (4). These are given in Table 2, along with the regions where they are most commonly used.

Table 2: Six pallet footprints recognized by ISO 6780

Metric size (mm)	US size (inches)	Region
1200 x 1000	47.24 x 39.37	Europe, Asia
1200 x 800	47.24 x 31.50	Europe
1219 x 1016	48.00 x 40.00	North America
1140 x 1140	44.88 x 44.88	Australia
1100 x 1100	43.30 x 43.30	Asia
1067 x 1067	42.00 x 42.00	North America, Europe, Asia

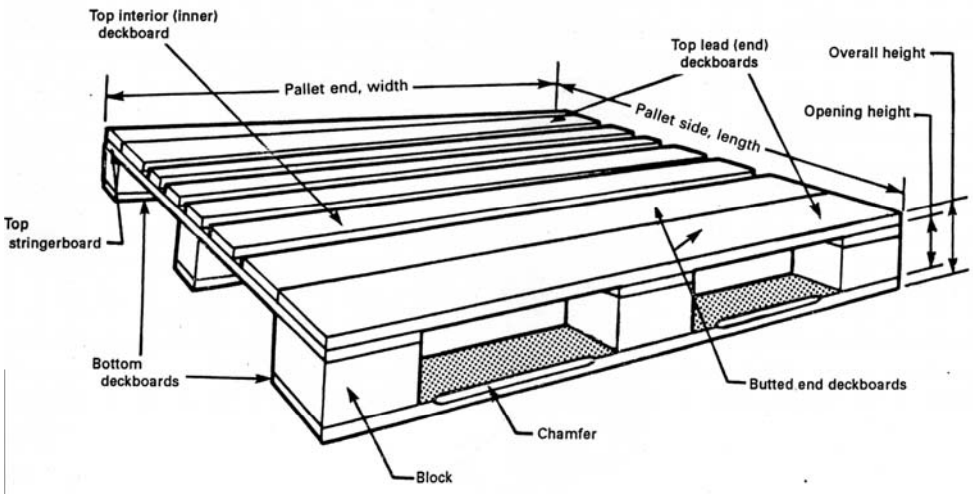
Even though we live in an increasingly global community, most of our pallet sizes are still different for different regions of the world. For example, the 800 x 1200 EuroPallet, a standard size throughout Western Europe for 50 years, is a rare size in the rest of the world. There are trends, however, towards domestic and global pallet size standardization. In the 60's and 70's, the US grocery industry began conversion towards the 48x40" standard footprint, and today this size is not only standard in the grocery industry, but in many other industries as well. In 2002 the EIPS Computer Industry Pallet Task Group recommended the 1200 x 1000 mm size as its primary global footprint (the 800x1200 is also included). This size was selected due to its metric dimensions, current recognition in ISO, the ability to efficiently fill most transport vehicles, and similarity in size to the 48x40-inch US footprint (5). Previously, this industry worked with dozens of pallet sizes and designs. It is expected that in the future, new computer industry warehouses, distribution centers, and shipping practices will be aligned with the standard. Imagine the efficiencies that will result for this industry over the coming decade. It is expected that these efforts will continue in other industries due to the wholesale long term benefits throughout supply chains that result from standardization.

Pallet Terminology

There are 2 main types of pallet designs: block and stringer. This is true regardless of pallet material. A schematic drawing of a stringer class and block class pallet, along with the industry terminology for pallet components, is given below. Detailed pallet terminology can be found in the ASME Standard for pallets (6).

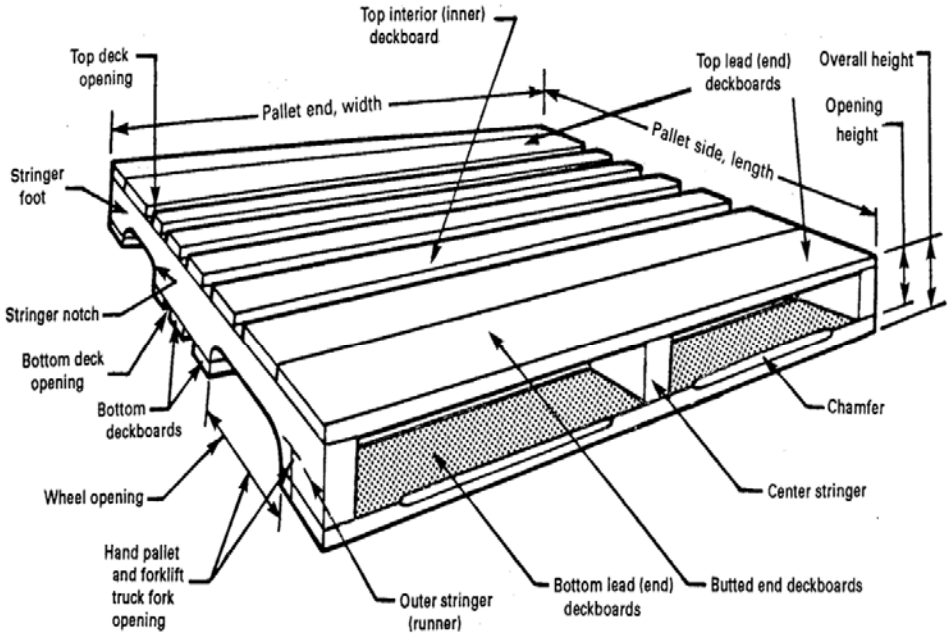
Stringer pallets are more common in the United States. With solid wood, block pallets cost more to manufacture than the equivalent strength stringer pallets. The principal advantage of block pallets is full access on all 4 sides for both forklifts and pallet jacks (full 4-way). Stringer pallets allow only forklift entry on the sides if stringers are notched (partial 4-way entry). If stringers are not notched, pallet jacks and forklifts can only enter on the 2 ends and they are called "2-way."

The size of wood pallets is specified as the stringer length, followed by the deckboard length. Therefore, since GMA pallets have 48" stringers, they are 48x40-inch pallets, not 40x48-inch pallets. The size of block pallets is specified as the top stringerboard length, followed by the deckboard length. Therefore, the EuroPallet is an 800 x 1200mm design. The size of non-wood pallets is typically listed as the longer length first, followed by the shorter dimension.



(b) Block Design – Full Four-Way Entry, Double Face, Nonreversible, Flush

FIG. 1 PRINCIPAL PARTS OF WOOD STRINGER AND BLOCK PALLETS



(a) Stringer Design – Partial Four-Way Entry, Double Face, Nonreversible, Flush

Five Factors for a Balanced Design

There are 5 basic interactive parameters that determine pallet suitability for a given application. These parameters are Strength, Stiffness, Durability, Functionality, and Purchase Price. These parameters are interactive, and optimizing just one (i.e. minimizing price) will impact the others. The proper balance of these 5 parameters will vary, depending on your specific product and distribution environments. They hold true regardless of the pallet material used. Each of the 5 parameters is discussed in more detail below.

Strength is the load carrying capacity throughout the shipping and storage environments. We must design pallets that are strong enough to support the required load.

Stiffness is the resistance of the pallet to deformation under load. Sometimes a pallet won't break under load, but is not stiff enough to protect the product or prevents proper handling. We see many pallets in the marketplace that are strong enough to support the load weight, yet they create pressure points that cause package and product failure. For example, saving $1 on a pallet with thinner decks often requires every corrugated box stacked on that pallet to be stronger to resist damage.

Durability is the ability to withstand the rigors of the shipping and handling environments. If we don't intend to recover the pallet, it just needs the integrity to withstand one trip. For returnable pallets, we need to design for a number of trips that is economically justified. The ideal life of reusables is a function of cycle times, recovery rates, distribution channels, expected ROI's, and future expected changes to warehouses.

Functionality is the compatibility of the pallet with the packaging and material handling equipment. For example, we pay extra to cut notches in a stringer pallet, thereby reducing strength in half, so that forklifts can enter on the sides. Functionality also includes things such as exposure to pest regulations, fire safety, weight, etc.

Price is an important design criterion, and often given more consideration that the other factors. This leads to pallet designs that look economical up front, but end up "costing" much more as they are used. Balance the price of the pallet versus the value of the product delivered without damage to the customer. Balance the price versus potential savings in packaging and material handling savings.

These five parameters are interactive, and optimizing just one will significantly impact the others. The better your understanding of this interactive balance, the more likely you are to select the ideal pallet material and design for your product and material handling environment.

Pallet Materials

Historically, pallets were made of solid wood. Most products experience material conversions over time as innovations or market changes occur. Some examples are:

Boxes	wood to corrugated
Grocery bags	Paper to plastic
Bottles	Glass to plastic

It is interesting to note, however, that the pallet material of choice for the last 70 years remains solid wood. This is unusual for a commodity product. While pallet users today face a wide variety of material and design choices, wood pallets are still used to manufacture about 90-95% of the US market (7). However, since the wood market share is so large, it will likely not increase in the future. While wood should retain the majority of the volume for many years, there are some global trends that could increase the use of other materials. These are trends such as standardization, improved retrieval operations, more reusable pallets, and pest regulations.

Below are the primary pallet material choices and a brief discussion of each.

Wood Pallets

Wood pallets were the original pallet material, and remain the most common pallet material both in the US and around the world. Wood pallets are common because they represent a good balance of the 5 design parameters discussed above, many packaging and material handling systems are “built” around the performance of wood pallets, and they are readily available. Disadvantages are that they have fasteners that can damage products, they have splinters, they give off moisture, can harbor bugs, and there is a lot of variation between pallets.

Wood pallets are easy to prototype. The easiest, fastest, safest, and most economical method to design wood pallets is with a computer aided design procedure called the Pallet Design System, or PDS. PDS users describe the pallet specifications, load analog, support conditions. PDS then estimates pallet strength, stiffness, durability, and the cost to use pallets. Users can then fine tune the design by changing input variables. The end result is the most economical pallet that will safely support the load under the required conditions. Wood pallet specs can also reference the ASME standard for wood pallets (6) to ensure conformance to industry best manufacturing practices.

It should be noted that the largest domestic and worldwide pallet pooling company, Chep, continues to use wood as the primary material for the majority of its pallets. They are testing other materials, but so far continue to favor solid wood.

Plastic Pallets

It is estimated that plastic pallets make up 2% of new pallet production in the US (7), or about 8 million new plastic pallets per year. The most common plastic materials for pallets are HDPE, PP, and PVC. Each of these is about 3-6 times the price of wood per pound, so a 50 pound plastic pallet is much more expensive than a 50 pound wood pallet. The most common manufacturing process is structural foam molding, but other processes include injection molding, profile extrusion, rotational molding, compression molding, and thermoforming. Each process has its advantages and disadvantages. If you want high volumes of a standard design, your best choice would be foam or injection molding. If you needed 100 pallets in a unique design, you would probably choose extrusion or rotational molding.

General advantages are durability, cleanliness, no fasteners, bug free, weather resistance, and design potential. Disadvantages include higher price, difficulty to prototype, low friction, low stiffness, lack of repair options, and fire safety ratings.

Plastic pallets are most common in captive or closed loop warehouse environments supporting 2000 pounds or less. Plastic pallets are common within the automotive, dairy, pharmaceutical, USPS, and beverage industries. Plastic pallets make up 50% or more of the reusable pallet pools in some Asian countries.

Composite Wood Pallets

Composites represent 2-4% of the pallet market, including materials like plywood, Oriented Strand Board, particle board, and laminated veneer lumber. Beer pallets were a historical market for composite pallets. In the past few years, composites have found applications in import/export due to pest regulations. Composites are exempt from pest regulations and often have a lower price than plastic or metal pallets.

General advantages are that composite pallets have a smooth and 100% coverage deck surface, are bug-free, dry, durable, easy to prototype, and can be designed using PDS. Disadvantages are that they cost more than solid wood, are expensive to repair, less weather resistant than plastic or metal, and still require fasteners.

Paper Based Pallets

Paper pallets represent less than 1% of the market, and include corrugated, honeycomb, solid fiberboard, and molded pulp. It is interesting to see the shift in containers from wood to corrugated. Between WWI and WWII, the percentage of wood/corrugated shifted from 80%/20% to 20%/80%. We have not seen this shift in pallets. One of the major reasons is that while a corrugated box is less expensive than a wood box, a paper pallet costs more than the equivalent

wood pallet. Paper pallets continue to find acceptance mainly within niche markets. Recently, new markets have opened driven by international pest regulations and increased airfreight shipping with weight-based charges.

General advantages of paper pallets are that they are lightweight, easily recyclable, have a smooth deck surface, are dry, and bug free. Disadvantages are a price higher than wood, susceptible to moisture, lack of stiffness with flexible loads, low durability, and low product protection.

Metal Pallets

Metal pallets make up less than 1% of the market. Materials include carbon steel, stainless steel, and aluminum. Of these, carbon steel offers excellent durability at the lowest cost. Stainless doesn't need a paint coating, and is preferred for such applications as clean room environments. Aluminum offers the durability of metal at a lighter weight. Carbon steel units are relatively expensive compared to wood, and stainless and aluminum cost about 2-3 times that of carbon steel. The long term cost, however, can be lower than wood.

General advantages are strength, stiffness, durability, bug free, no splinters, sanitary, and recyclable. Disadvantages are higher initial price, weight, low friction, and susceptible to rusting (carbon steel).

Metal is primarily used in captive or closed loop environments where durability and product protection are key measures. Metal units today are increasingly price competitive and lighter in weight. Primary industries include automotive, pharmaceutical, lawn tractors, motorcycles, and tires.

Resources to learn more about pallets and pallet performance:

Unit Load Design Short Course
Virginia Tech
Center for Unit Load Design
(540) 231-5370
unitload@vt.edu
Next course: April 28-30, 2004 and September 22-24, 2004

Pallet Design System Intro Short Course
National Wooden Pallet & Container Association / Virginia Tech
(703) 519-6104
Next course: November 11-13, 2004

Pallet Enterprise. Trade journal for pallet industry
(804) 550-0323 or www.palletenterprise.com

LeBlanc, Rick and Stewart Richardson. Pallets: A North American Perspective. PACTS Management, Inc., www.pactsmgt.com, 2003.

Pallet Test Standards

- PDS, computer program for wood and wood composite pallets
- ASTM D1185
- ISO 8611
- RPCPA Plastic Pallet Test Standards
- ASME MH1

References

1. Pallet Talk, National Wooden Pallet & Container Association, 329 South Patrick Street, Alexandria VA 22314. March 2000.

2. Pallet Talk, National Wooden Pallet & Container Association, 329 South Patrick Street, Alexandria VA 22314. June 1999.

3. Mangun, Jean C. and John E. Phelps. A Survey of the Wood Pallet Industry in the US, 2001. Southern Illinois University Carbondale, January 2002.

4. ISO 6780: Pallets for Materials Handling – Principal Dimensions for Flat Pallets. 2001.

5. EIPS website at http://packaging.hp.com/eips/

6. ASME MH1: Pallets, Slip Sheets, and Other Bases for Unit Loads. 1997. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016.

7. Pallet Talk, National Wooden Pallet & Container Association, 329 South Patrick Street, Alexandria VA 22314. April 2000.