

**A COMPARISON OF PALLET
STRENGTH *and* FUNCTIONALITY**
Litco's Engineered Molded Wood Pallets
Compared to
GMA-Style New and Repaired Wooden Pallets

By: Dr. Marshall S. White

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Executive Summary

By: Page Clayton, Packaging Sales Engineer

Packaging is typically the last thing to be considered for a new product design. This becomes a hurdle downstream for skilled packaging engineers to come up with effective protective, and transport packaging solutions, while still meeting a targeted budget amount.

Initially, the product and packaging design team will usually focus efforts on the protective, (primary packaging). After that has been completed, there is normally not enough money left over to pay for a pallet (transport packaging) properly designed for protection, strength and functionality.

The root problem is that a pallet is not considered to be value-added component, but as a commodity to be purchased for the lowest price. This misconception leads to improperly matched packaging and pallet designs, resulting in excessive damage due to unintended unit load interactions and warehouse damage. The assumed cost savings when using pallet price as a decision driver, turns ultimately into a financial liability with damaged product returns and unhappy customers.

The answer to this problem for packaging engineers is to consider protective, and transport packaging (pallets) as a unit load. To focus on designing a unit load that will carry the product safely through the most demanding supply chains. This can be affordably accomplished by making it a priority to choose components that work in complete harmony.

One important example to consider in pallet design is pallet stiffness. This is the resistance to deformation from load, is the most important characteristic and can improve unit load performance by:

- Providing more stability to unitized goods that are moved on forklifts
- Reducing compression forces of packaged product and reduce compression damage
- Reducing the vibration stresses on packaged product when being transported
- Cause product shipped to be more stable and resistant to load shift during transportation
- More evenly distributes a package's load across the surface of the pallet reducing stress interactions
- Provides an opportunity to reduce the specifications, amount and costs for primary packaging

This white paper compares Litco's Inca brand of engineered molded wood pallets that are made in the USA, to new and rebuilt GMA-style pallets. It demonstrates why Litco's Inca molded wood pallets are the best solution to balance pallet function, performance and overall cost. These pallets have been proven in the field and have been tested at The Center for Packaging and Unit Load Design, Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, Virginia to be strong and stiffer than, 48" x 40", GMA-style pallets.

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Background Eighty-four (84) percent of all products distributed within the US are all or in part palletized when moving through supply chains from manufacturer to customer. The function of the pallet is to facilitate the distribution and protect the product. Many characteristics of a pallet influence these functions.

Generally, these characteristics can be grouped into two categories, **Pallet Strength** and **Pallet Functionality**. These are called the “limit states” of performance of load bearing structures, like pallets.

Pallet Strength:

Strength is typically defined as the average load that causes failure. Strength is separate because all load bearing structures must first be designed to adequately support the load that is placed on top.

Pallet Functionality:

Functionality is a term applied to all other characteristics of the pallet that affects its use. Functionality characteristics of a pallet include: stiffness, weight, size, design, recyclability, durability, moisture content, etc. All of these pallet characteristics impact the efficiency of the unit load portion of all supply chains.

Research objectives

- 1) To compare the strength and functionality of the extra heavy-duty, 48” x 40” Litco Inca molded wood pallet to, GMA-style new and repaired pallets.
- 2) To determine from this comparison, the relative impact of each design on supply chain operating efficiency.

Research scope

The performance comparisons are based on test results referenced in the text. The focus will be on use of these pallet designs for shipping product one-way. The tests referenced in this document include new, Litco Inca molded wood pallets and new, remanufactured, A, B, and C grade, repaired GMA-style pallets. The GMA pallets are made of mixed hardwoods and softwoods with deck boards typically from 0.500 to 0.688 inches thick and stringers typically 1.25 to 1.5 inches wide.

Figure 1 shows Litco's Inca molded wood pallets in a nested mode along with views of the top and bottom decks. The Inca pallets tested were a 48" x 40" extra heavy-duty capacity. Their static and dynamic weight carrying capacity is similar to the GMA-style pallets.



Figure 1

Figure 2 is a photograph of the typical GMA-style new and repaired pallets similar to those tested.



Figure 2

Comparative pallet strength

There are two measures of non-rack-able, shipping pallet strength: 1) Dynamic strength when supporting loads on forklifts, and 2) static strength when supporting loads on the warehouse floor.

Table 1 contains a summary of the strength test results of Litco’s Inca molded wood pallet and the GMA-style pallets. The ranges represent the variation in the GMA pallet and the Inca pallet.

The static strength of Litco’s Inca pallet is greater than any of the GMA new or repaired pallets tested. Based on these tests, the static safe working load of the Inca pallet is about 50% to 70% greater than the capacity of the GMA pallets tested.

The dynamic capacity of the Litco Inca molded wood pallet tested is less than the GMA-style pallets. However, when the safety factor of 2.0 per ISO 8611¹ is applied, the safe working load or design load capacity of the Inca pallet is about 2,500 pounds², uniformly distributed.

Table 1 Comparative pallet strength

Pallet Type	Static Strength (Lbs.)	Dynamic Strength (Lbs.)
Inca Molded Wood Pallet Extra Heavy-Duty	16,240– 21,558 ²	5,107 – 6,217 ³
GMA-Style Wood Pallet (New)	9,546 – 14,342 ⁴	6,542 – 8182 ⁴

Comparative pallet deck stiffness

The most important functionality characteristic of a pallet is its stiffness or how much it deforms under load. Simply put, “stiffer pallets are better.”

Stiffer pallets:

- 1.) Are more stable when moving palletized product on forklifts
- 2.) Reduce the compression of packaged product and reduce product compression damage
- 3.) Reduce the vibration stresses on packaged product when being transported

- 4.) Cause product shipped to be more stable and resistant to load shift during transportation
- 5.) Reduce the effect of vertical vibrations on product compression

Table 2 contains the measured range of stiffness of Litco’s Inca molded wood pallet and GMA-style pallet decks. The deck of the Inca pallet is at least six times as stiff as the deck of the GMA pallet. This will result in more stable unit loads during shipping and handling and less product damage resulting from load slip on the pallet.

Table 2 Comparative pallet deck stiffness

Pallet design tested	Stiffness
Inca Molded Wood Pallet Extra Heavy-Duty	60,115– 86,262 pounds/inch ²
GMA-Style Wood Pallet (New)	10,000 – 11,000 pounds/inch ⁵

Relative resistance to rough handling

The resistance of a one-way, shipping pallet to rough handling is important. All of the mechanical stresses imposed on the packaged product in a unit load during handling and shipping pass through the pallet first. A broken pallet can no longer protect the packaged product.

Forklifts impacting the top deck edges cause the most common pallet damages. Table 3 contains the results of deck edge impact tests conducted according to the methods in ASTM D 1185⁶. The edges of the deck of Litco’s Inca molded wood pallet are more resistant to fork tine impacts than the GMA-style pallets tested. The extra heavy-duty Inca pallet is 52% more resistant to this damage and will therefore better protect packaged product from the rigors of supply chain handling.

Table 3 Relative resistance of the pallet deck-to-impacts

Pallet design tested	Cumulative kinetic energy at failure
Inca Molded Wood Pallet Extra Heavy-Duty	8500 ft.-pounds ⁷
GMA-Style Wood Pallet (New)	5587 ft.-pounds ⁴

Comparative physical characteristics of Litco’s Inca molded wood pallet and new and rebuilt GMA-style wood pallets

Table 4 below lists the physical characteristics of five versions of the GMA pallet and Litco’s Inca molded wood pallet. These characteristics are weight, moisture content, flatness of the top deck board, and top deck coverage. The following is a summary of the comparisons.

Pallet weight

Litco’s Inca molded wood pallets are 10% to 33% lighter than the GMA-style pallets depending on design.

Lighter weight pallets are easier to handle manually when they are lifted and moved empty. There will be fewer injuries and workers’ compensation claims. When shipping heavy unit loads, more product can be shipped per load when lighter weight pallets are used.

Moisture content

Litco’s Inca molded wood pallets typically contain up to 86% less moisture than new GMA-Style wood pallets and up to 30% less moisture than used/repared GMA wood pallets. Therefore, the instances of moisture-related contamination are substantially less on an Inca press wood pallet.

Drier pallets are less likely to contaminate moisture-sensitive packaging and products, such as paper or metal packaging or products. This is especially true when shipping products in freight containers for export. They are also more resistant to the growth of mold.

Variation range of top deck board thickness

Because of the molded design, there is no variation in the surface of the top deck of Litco’s Inca molded wood pallets. They are consistently flat.

However, there is a significant variation in deck board thickness within the GMA-style pallet decks. This means, that in addition to any bending of the pallet deck, the deck is not flat. Such variation can potentially interfere with the smooth operation of certain designs of product palletizers. Also, the compression stresses on the packaged product will be concentrated over the thicker deck boards and may lead to product damage.

Top deck coverage

The surface bearing area on Litco’s Inca molded wood pallet deck has about 15% less coverage than the GMA-style, deck board design due to the leg and rib cavities. However, for most packaged products, relative flatness and the higher stiffness of the Inca pallet deck can offset the effect of the lower surface bearing area.

Table 4 Physical characteristics of Litco’s Inca molded wood pallet and GMA-style wood pallet designs

Pallet design	Avg. weight (pounds)	Moisture content (%)	Variation Range of top deck board thickness (inches)	Top deck coverage (%)
GMA-A grade	48.1 ⁵	11.6 ⁵	0.147 ⁵	66 ⁵
GMA-B grade	50.3	11.9	0.158	65
GMA-C grade	46.4	10.2	0.186	65
GMA-Reman.	44.8	10.8	0.192	65
GMA-New	50-60	50	0.092	65
Inca Molded Wood Pallet Extra Heavy-Duty	40.2 ^{4,5,7,8}	7 ^{4,5,7,8}	Flat	55 ⁵

Other functionality characteristics

Empty pallet storage – Because Litco’s Inca molded wood pallet designs are nestable, one can store up to 2.5 times more empty Inca pallets on the floor of a warehouse than a GMA-style pallet. When shipping empty pallets, at least 2.5 times more empty Inca pallets can be placed in a trailer for shipping. Thus, indoor storage and the shipping of empty Inca pallets cost less than a GMA-style pallet.

Sanitation/Export ready – The hot-pressing process of molding—at temperatures exceeding 350 degrees Fahrenheit—sanitizes Litco’s Inca molded wood pallet. The Inca pallet is not regulated by the International Standard for Phytosanitary Measure for Solid Wood Packaging Material (IPPC-ISPM 15)⁹. The Inca pallet is exempted because it is considered “processed wood.” GMA-style pallets must have a special license stamp and be heat-treated or fumigated before they are used for international shipments.

However, because GMA pallets are used in many different geographical areas to ship many different products, used GMA pallets are prone to chemical contamination. White and Mcleod¹¹ found that such wood pallets could be contaminated with many chemicals, such as pesticides and wood treatments.

Due to the high wood density from forming the pallet in a 1,200-ton press at over 1,000 psi, the Inca pallets are less likely to contaminate shipped products. Also, they are less likely to transport invasive forest pests during the international shipment of products than the GMA pallets.

Materials handling efficiency – According to the US¹² and International¹³ pallet standards, Litco’s Inca molded wood pallet is a “full” 4-way design. The GMA-style pallet is a “partial” 4-way design. This means that the Inca pallet can be lifted from both ends and sides by forklifts and pallet trucks (pallet jacks). The GMA pallet is limited to lifting by forklifts from the sides. With larger side openings, unit loads on Inca pallets can be moved faster. This also permits handling equipment to operate with shorter turning radii.

As a result, more product can be staged in shipping and receiving areas in a warehouse when on an Inca, 4-way, pallet. Also, the full 4-way design of the Inca pallet permits easy loading and unloading of more product in a trailer, because it will be easier to ship two unit loads, 48 inches, across the trailer width.

Safety, no exposed nail heads and nail points – Litco’s Inca molded wood pallet is a one-piece engineered design that has no nails and loose deck boards. Exposed nail heads and points are often found on new, used, and repaired GMA-style pallets due to improper fasteners and fastening technique. The exposed nail heads, also called nail “pops,” occur during pallet handling as joints loosen. Suddarth and Angleton¹⁴ (1956) showed that nail heads popping is also caused by the wood shrinkage as it dries during pallet use. These exposed nail heads and points are a hazard and they cause product damage and “leakers” by puncturing packaging. The protruding nails cause injuries when the GMA pallets are handled manually.

Sustainability – (Note: This section is not an original part of Dr. White’s research. It was supplied by MBDC and inserted here by Litco.)

Litco’s Inca molded wood pallet is the first pallet to achieve the honor of *Cradle to Cradle Certification*TM by McDonough, Braungart Design Chemistry (MBDC)¹⁵. This was earned for demonstrating leadership in integrating recycled content into products and working to design eco-intelligent products.

Inca pallets are both eco-efficient – doing more with less materials and eco-effective – and they are intentionally designed to be more “good” and less “bad.” The materials have been accessed for human and environmental health down to 100 parts/million.

Through design engineering, the Inca pallet achieves a high level of strength and stiffness while utilizing fewer resources. This is accomplished by designing the top deck ribbing to resist bending and by achieving a specific density of wood during the molding process.

Summary

The strength and functionality of Litco's Inca molded wood pallet and the GMA-style wood pallet are compared based on published test results. As a shipping pallet, the Inca pallet would be more functional than the GMA pallets in most supply chains:

- 1.) When used as a one-way shipping platform, the Inca pallet will improve supply chain operational efficiency.
- 2.) There will be less product damage and product contamination when shipping on an Inca pallet compared to a GMA pallet.
- 3.) There will be fewer injuries associated with the use of the Inca pallets compared to using a GMA pallet.
- 4.) Using the Inca pallet will significantly increase shipping and materials handling efficiency.

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About Litco

Litco's Inca molded wood pallets come in a variety of sizes and dynamic load carrying capacities to meet your individual needs. To learn more about our line of Inca pallet sizes and weight capacities, contact Litco International toll free at 1-800-236-1903, visit our website at www.litco.com, or browse our Inca molded wood pallet section at <http://www.litco.com/molded-wood-pallets/>

Litco International, Inc. specializes in transport packaging solutions, including pallets for domestic and export shipping, core plugs, and custom-made load securement items so that the products arrive at your customer's location in good condition. *All Litco products are designed to carry your products safely on through the most demanding supply chains.* Litco was established in 1962 and ships from facilities located in Dover, Ohio; Warren, Ohio; Sardis, Mississippi; and Wellford, South Carolina.

About the Author

MARSHALL (MARK) S. WHITE, President of White and Company LLC. White and Company LLC (www.whiteandcompany.net) is a consulting and software development company specializing in pallet, packaging, and unit load design. Dr. White is also Professor Emeritus at Virginia Polytechnic Institute and State University, Blacksburg, Virginia, and a graduate of Colorado State University and Virginia Tech with B.S., M.S. and Ph.D. degrees. He taught graduate and undergraduate courses in the Packaging Science option and served as Director of the Center for Unit Load Design and The Pallet & Container Research Laboratory. He was responsible for the research, technical assistance and educational programs offered by the Center on behalf of the pallet, packaging and container manufacturers and user industries. The main thrust of these efforts has been the investigation of the relationship between the design of unit loads and their performance during storage and distribution of consumer and industrial products. The focus is on studying the dynamic and static mechanical interactions between packaging, pallets and unit load handling equipment. He has published widely on the subject of CAD/CAM design of pallets and containers and the dynamic sequence of palletized unit-loads in shipping environments. Dr. White was recognized by Modern Materials Handling Magazine as one of the Top Ten Materials Handling

Professionals for his revolutionary ideas on the “Systems- Based” alternative to the existing “component-based design” of Global supply chains. Dr. White has been a member of The US Institute of Packaging Professionals, and the American Society of Testing and Materials D-10 Committee on Packaging. For the latter, he co-chaired of the pallet Testing Task Group.

He has also served as Head of the U.S. Delegation to the International Organization of Standardization (ISO) TC-51 Technical Committee on Pallets, and past Chairman of the MHI/ANSI MH1 Committee on US Pallets Standards. As convener of various ISO working groups, Dr. White was responsible for drafting many of the current ISO pallet standards. As Chairman of the MHI/ANSI US Pallet Standards Committee, he was responsible for drafting many parts to the MHI/ANSI MH1 “Pallets, Slip-sheets, and Other Bases for Unit Loads.”