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AN IMPLEMENTATION OF ENVIRONMENTAL FRIENDLY MULTI REGIONAL PACKAGING AND LOGISTICS SOLUTIONS FOR SEMI-FINISHED GOODS

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ABSTRACT

In order to take advantage of the global economy, manufacturing companies have developed a complex and an extended supply chain which includes manufacturing components or parts in LCCs (low-cost countries) and shipping them to factories near to their consumer market for final assembly, customization and distribution. These activities involve several different organizations that follow widely different approaches in logistical management. In order to sustain the long shipment distances in different geographic regions, (i.e. China-Mexico-US-Europe), handling & environmental conditions & shipping modes (Air vs Ground vs Sea); suitable, flexible and economical packaging solutions are required. This flow of semi-finished goods usually requires packaging materials such as carriers (i.e. wooden pallets) and moisture inhibitors (i.e. desiccants) to protect the goods. Competitive pressures, environmental consciousness, customer awareness and legislative requirements have driven manufacturers to review business practices and redesign solutions that are environmentally friendly, as well as help reduce costs in the long run. The author of this paper will present an experience where "non-traditional" packaging is used as an economical and environmental friendly solution to globally transport goods between multiple facilities.

INTRODUCTION

Industrial or inter-plant packaging is intended for the handling & protection of parts or semi-finished goods when they are transported among manufacturing facilities. Traditional solutions for inter-plant packaging include but are not limited to wooden pallets, corrugated boxes, foam, desiccants, plastic bags and other materials.

As it generally occurs with the final packaging, industrial packaging such as customized foam trays, desiccants and plastics bags are disposed once the goods are received in their final destination. Wooden pallets may be reused for a short period of time or recycled. However as the flow of semi-finished goods is only in one direction, the excess of wooden pallets is discarded along with other low cost materials to garbage silos or burners.

According to the US EPA, the United States Environmental Protection Agency, annual generation of municipal solid waste in the United States has increased from 88 million tons in 1960 to 236 million tons in 2003 [1]. Containers and packaging made up almost one third of those 236 million tons. The waste generated by the industrial processes involved in the packaging supply chain dwarfs municipal waste. Industry in the United States is reported to create 7.6 billion tons non-hazardous waste each year [2]. This situation has forced more than 25 countries to define environmental packaging design requirements and in 30 countries to require package reporting and advanced disposal fees to companies [3]. In addition, the average growth rate for containers and packaging through 2010 is projected to be 1.8 percent annually, more than any other product category [4].

From an economic perspective, although inter-plant packaging serves a critical role in the movement of goods; it represents additional cost for companies in the packaging material itself, the space and process needed for its disposal. In this context, a review of inter-plant packaging solutions can be a source of cost reduction with direct impact to companies' bottom line as well as allow the companies to comply with the environmental requirements.

While companies frequently look to reduce costs using lower cost parts and improving their process, inter-plant packaging has been one of the more overlooked areas. The focus of this paper is to discuss the innovative inter-plant packaging solution explored and implemented by the service provider with significant cost reduction using an environmental friendly approach.

TRADITIONAL SOLUTION

The original traditional solution initially proposed for the inter-plant packaging included: (1) a standard wooden pallet as show in figure 1, (2) a set of top and bottom EPE, Expanded Polyethylene, foam tray to protect the good during transportation as show in figure 2 (used inside a corrugated box), and (3) a corrugated box for extra protection and for stacking as show in figure 3. The combination of these three parts made a bundle or stack of 36 units as show in figure 4. The fact that this solution is a very common packaging approach, almost an industry standard, depicts the need for holistic analysis of supply stream flow for packaging solutions.

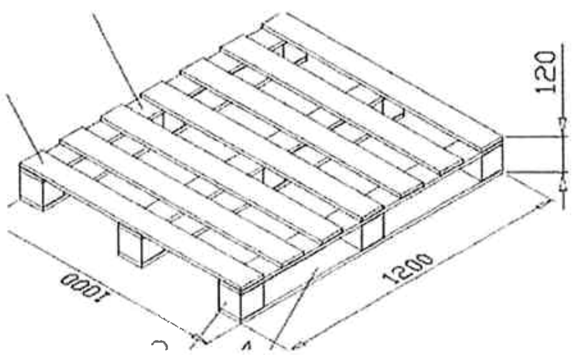

Fig. 1: Wooden pallet used in traditional solution

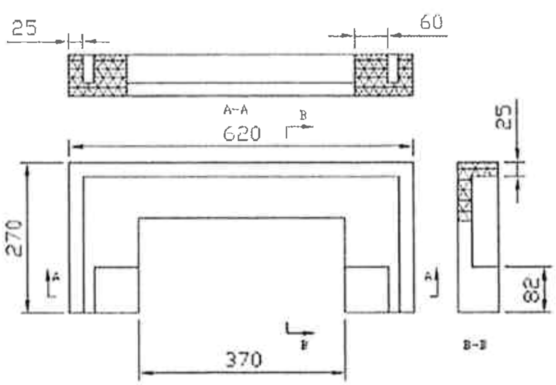

Fig. 2: EPE bottom tray traditional packaging

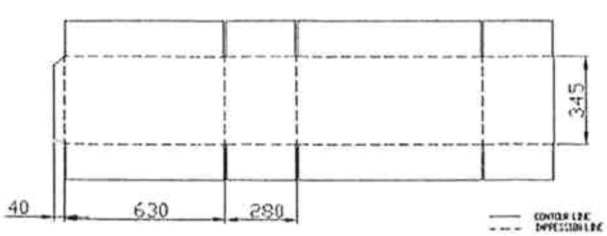

Fig. 3: Corrugated board traditional packaging

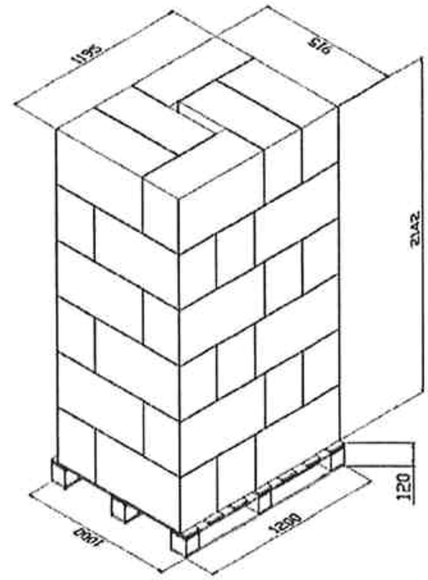

Fig. 4: Bundle per traditional packaging

ALTERNATIVE PACKAGING SOLUTION

Using the environmental packaging design flowchart of the EPG, the Environmental Packaging Guideline for the Electronics Industry [4], as the formal procedure for the packaging design, the following steps were taken:

a. **Identify environmental goals and initiatives**: Our goal was to provide a cost-effective and environmental friendly solution within the frame of the company's policies and applicable regulations for China and Mexico.

b. **Identify the destination of the package**. The semi-finished modules are assembled in China and delivered to Chihuahua, Mexico for final integration of the product with other parts or components. The material stream flow is inter-plant and only downstream (one direction). In this context, the most feasible end-of-life option is **multiple end-of-life** design i.e. reuse and recycling. The **cradle-to-cradle** option would be not suitable due to the high cost needed to ship back the empty packaging to China even in a dismantled form.

c. **Identify applicable regulations**: Since February 1st of 2006, wood packaging material used in imports of goods and products has been subject to compliance with the provisions of Mexican Official Standard NOM-144-SEMARNAT-2004 [5], which sets out internationally accepted phitosanitary measures for wood packaging material used in international trade. According to this regulation, effective February 1st of 2006, all goods that are carried on wood skids or dunnage must bear an identification mark and will be subject to a visual inspection by the Federal Environmental Protection Agency ("Profepa"). The materials subject to compliance with NOM-144 are: wood or wood products (excluding paper products) used in supporting, protecting or carrying a commodity, such as pallets, dunnage, crating, packing blocks, drums, cases, load boards, pallet collars, and skids, including wood packaging material used to secure or support a commodity, either internally or externally, provided it is made of solid wood, rather than of a processed wood material (agglomerate wood). The only phitosanitary measures approved by NOM-144 are Heat Treatment (HT) or the Methyl Bromide (MB) Fumigation. According to Mexican Ministry of the Environment and Natural Resources ("Semarnat"), more than 100 companies are currently authorized to treat and mark wood packaging material in Mexico. NOM-144 compliant versions of traditional packaging are expensive, require additional paper work and have longer transit lead time.

d. **Identify mode of shipping**: Considering freight costs, weight of the units (25 pounds per unit) and demand forecast, ocean freight is the best cost-benefit alternative. Three types of containers were considered: general purpose 20-feet, 40-feet, and 40-feet high cube (HC) containers.

Container (ft)	Inside (L x W x H) (mm)	Door (W x H) (mm)
40'	12015 x 2236 x 2375	2337 x 2281
40' HC	12027 x 2350 x 2693	2337 x 2578
20'	5893 x 2353 x 2388	2337 x 2281

Tab 1: Dimensions of ocean freight containers

It is important to mention that 40' HC containers are 318 mm higher than 40' containers with 297 mm higher doors than any other type of containers.

The respective shipping costs in US dollars for each container type are showed in table 2.

Container	Origin Charges	Door to Port (Pickup)	Port to Port
20'	503	785	2,275
40'	612	825	3,050
40' HC	612	825	3,050
Container	Port to Door (Delivery)	Destination Charges	**Total**
20'	665	620	**4,848**
40'	665	785	**5,937**
40' HC	665	785	**5,937**
Origin charges= THC, Stuffing, Handling, Port Charges, docs, etc. Destination charges= BAF, CAF, PPF, GRI, THC, Handling, Port Charges, etc. Freight= Pick+ Delivery+ Port to port Total = origin charges + freight charges + destination charges			

Tab 2: Typical shipping cost

e. **Identify product specific requirements**: The four elements that are required to meet the functional requirements of the packaging solution are:

(1) Unit load pallet for bundle transportation,
(2) Cushioning material for shock and vibration,
(3) Barrier for contamination, and
(4) Dry agent.

The economic viability of the proposed package solutions as compared to the traditional solution is essential for its approval. Marketing considerations and final customer's awareness in packaging of the semi-finished products is irrelevant in this particular case; therefore, the purpose of the packaging is limited to protect the product and minimize cost with the least negative environmental impact satisfying the four elements outlined above. The strategy selected to achieve this purpose is to minimize shipping and packaging cost per unit by increasing the number of units per container (container utilization) while reducing the cost of package per unit by exploring environmentally friendly packaging alternatives.

f. **Select raw materials**: Aligned to the strategy selected, which is described in step e, the selection of raw materials for each of the four elements is based on the space volume needed and their associated cost and environmental impact. Raw materials should use the least space possible allowing more products to be shipped per container. A representative calculation of the stack up is shown in figure 5. With that in mind, the following alternatives were proposed

a. **Load Pallets**: A slip-sheet is proposed as an alternative to traditional pallets. The slip-sheet is used as a unit load support device in vehicle delivery and transportation of products. When slip-sheets are supported by a pallet board, roller conveyor surface, flat load carrying surface, or a cart or lift truck, the structural strength of the slip-sheet supports the products load weight. With the slip-sheet supported by one of these transportation devices the unit load can easily be transported both internally within a facility and externally between two facility locations [8]. Since the slip sheet is significantly thinner, it maximizes container utilization, provides an additional 120 mm replacing the height occupied by a traditional pallet and allows re-use and re-cycling. However, it is necessary to use a special push/pull forklift [9] and provide specific training to handle slip sheets at both the origin and destination plants. This is avoided when using traditional pallets as they use standard forklifts typically available in all locations which are operated by personnel with standard training.

b. **Cushioning material**: Cushioning material absorbs a proportion of the kinetic energy when the package suffers impact or is dropped, protecting the product. The main requirements needed when selecting cushioning materials are: dampening and recovery capacity, insensitivity to climatic conditions, low risk of corrosion, and cost-effective. Expanded plastics are plastics that have reduced density as these materials are expanded during manufacturing. There are four standard available expanded plastics Expanded Polyethylene (EPE); Expanded Polypropylene (EPP); Expanded Polystyrene (EPS); and Expanded Polyurethane (EPU) [4]. For our particular case, EPS is the best alternative because it is the most cost-effective option and has high resilience. However, its tendency to absorb and release water vapor would require the use of a desiccant. To reduce its environmental impact, a 6-unit tray top and bottom was design with the minimum material, low density, needed instead of individual trays. The maximum recycled content (50%) recommended by the United States EPA, was specified.

c. **Contamination barrier**: Contamination of the product needs to be avoided as much as possible. Polyethylene (PE), Polypropylene (PP), and Polyvinyl Chloride (PVC) are possible alternatives but their environmental impact varies as it is presented in the table below. The alternative selected due to its low environmental impact is PP bags. The rankings *Low, Medium, High*, attributed to each type of plastic. *Low* indicates the least amount of negative environmental impacts and *Highest* indicated the largest amount of negative environmental impacts [7]

Impact to	**PE**	**PVC**	**PP**
Energy use	Medium	Highest	Low
Water	High	Highest	Low
Air	Highest	Medium	Low
Toxicity risk	Medium	Highest	Low

Tab 3: Environmental impact of contamination barrier

d. **Dry agent or desiccant** is a substance with very hygroscopic properties, which absorbs water vapor from the air surrounding it. A number of different substances are capable of doing this, but only a relative few of them are of practical use. Possible options of desiccant are molecular sieve, silica gel, active clay (montmorillonite), CaO, and CaSO4. The desiccant is mainly selected based on adsorptive capacity and rate of adsorption. An environmental responsible solution to use active clay which is a non-hazardous, natural and reusable alternative was selected.

g. **Design the package**: Bulk packaging approach is a more efficient alternative than individual packaging because less packaging material is needed and less container space is required. In addition, bulk package requires less time than the individual package alternative. The bulk package solution cost per unit is about 50% the cost of individual box package. With the selected packaging option, it is necessary to identify the most efficient container size. The most number of units per each type of container and costs per unit are compared in table 4. The lowest cost per unit is using a 40' high cube container.

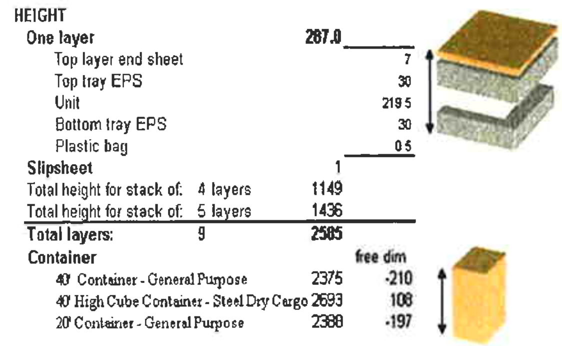

Fig 5: Height capacity per container type (mm)

Container	Max Units	Cost Shipping	Cost per unit
20'	**384**	$ 5,937	**$ 15.5**
40'	**432**	$ 4,848	**$ 11.2**
40' HC	**972**	$ 5,937	**$ 6.1**

Tab 4: Cost per unit

Table 5 shows a cost comparison using slip sheets and wooden pallets. 1.04 USD per unit can be saved using slip sheets instead of wooden pallets. The number of units needed to offset the investment needed to handle slip sheets is 14,400 units is shown in table 6 which, according to the proposed production schedule, can be achieved within one month.

	Pallet		**Slip-sheet**	
Total units per container (***units***)		***864***		***972***
Shipping cost ($)		5,937		5,937
Packaging cost ($)		1,874		1,835
Bulk packaging ($)		1,547		1,740
Per unit ($)	1.79		1.79	
Pallet or slip sheet cost ($)		327		95
Per unit ($)	9.09		2.65	
Number of pallets slip sheets		***36***		***36***
Total cost per container ($)		7,811		7,772
Total cost per unit ($)	9.04		8.00	
Savings per unit (slip sheets) ($)			1.04	

Tab 5: Comparison between pallet and slip-sheet

Total Investment ($)	**15,000**
- Push/Pull system	13,000
- Additional equipment for Forklift	1,000
- Training	1,000
Savings per unit ($)	**1.04**
Payback (units)	**14,400**

Tab: 6 Payback with slip sheets

SUMMARY

An environmental friendly multi regional packaging and logistics solutions for semi-finished goods was discussed in this paper. The challenge for the project was to come up environmentally friendly alternative packaging solutions that would also result in cost savings. A holistic view was necessary in order to achieve this. The basic principles outlined in a industry recognized packaging standard were used as guidance in order to select the optimum solutions. The feasibility of using slip sheets resulting in ship space optimization over traditional predominantly wooden pallet solution was demonstrated. The proposed solution has since been deployed successfully in manufacturing. The solutions proposed helped comply with the environmental legislative requirements as well as customer packaging specifications as well as provide additional cost savings.

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