PACKAGING AND TRANSPORT IN CERAMICS, A COMPETITIVENESS FACTOR.

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1. INTRODUCTION

If anything characterises logistics at the moment it is the need to attend to a global market and a trend towards customisation for the consumer and of course, maintaining competitiveness levels worldwide. The immediate translation of this into the world of logistics manifests itself in three variables:

- Speed,
- Agility,
- Minimum distribution cost.

Speed translates into the time distance between us and the customer. Therefore "we are two weeks away from the customer" today and it does not matter where they are. We try to satisfy clients' changing needs with agility and customisation. Therefore, manufacturing and distribution need to be up to speed with this. Additionally, we need to keep costs to a minimum or at least one unit less than our competitors.

We are still missing one factor, the one we refer to when we talk about "supply chains". The return process is on the whole dealt with through returns. This is usually because of lack of conformity between what the customer ordered or what is promised by the sales and marketing department, and what the customer effectively receives.

The foregoing partly explains the tension or harshness that characterises logistics systems today. The effects of this in the international market are severely damaging for us both in terms of margin and image and are due to mistakes and possible rejects.

In the ceramic sector, unlike others like the food, cosmetics or pharmaceuticals sector, the function of product *communication and "display"* in the product packaging is not as relevant. However, the high volume of sales and a strong export character added to the previously argued points indicate that ceramic products packaging demands more than ever to serve not only as protection, but to facilitate the grouping and handling of products throughout the many different steps and intricacies of the distribution process.

2. DEVELOPMENT

The distribution cycle typically ranges from the factory, where production operations are followed by packaging or packing per sales unit and palletising, to the final customer or even the end-user, who is ultimately the one to be satisfied and is the source of many claims.

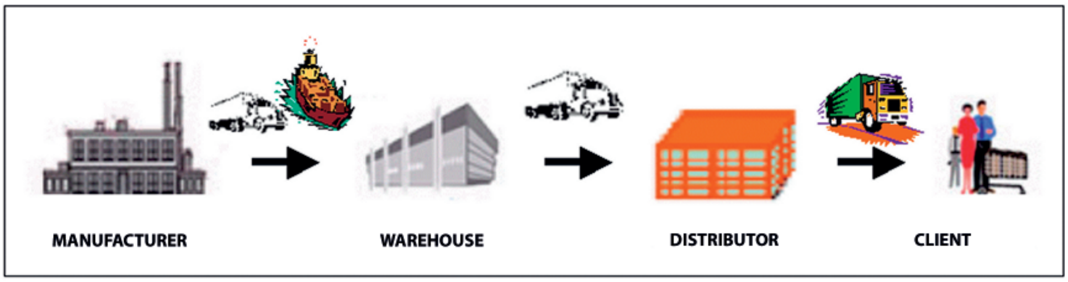

Figure 1. Generic distribution cycle. Source: AIDIMA.

In the typical distribution cycle there are multiple transportations. Most of them are carried by lorry and ship with several intermediary warehouse periods. It is assumed that the dispatched merchandise will be subjected to numerous handling operations given the various loadings and un-loadings throughout the distribution chain.

This means that the way the goods are packaged and the units are prepared for dispatch – usually on pallets – will be critical for by the safe delivery of the products without damage, returns, or charges for defects, therefore complying with the competitive objective to carry out distribution at the lowest cost. Furthermore, achieving these objectives is a fundamental prerequisite in maintaining competitiveness in the export market.

Analysing distribution and all its risks is crucial when designing a packaging system for any merchandise. This way unnecessary risks and superfluous costs will be avoided. The end goal is to design the ideal packaging at the minimum cost.

If we review the entire distribution cycle, we see the numerous risks our products are exposed to.

Starting in the factory, the products experience the first risk of **COMPRESSION** once they have been packed and stacked on pallets. This occurs most of all when they are warehoused while waiting for dispatch and are piled on top of each other. The compression is of a static nature and may last for months leaving the products susceptible to packaging fatigue and collapse.

The manner in which the packages are laid out on the pallets will not only affect productivity regarding cost per dispatched unit, it will also greatly affect the compression strength due to misalignment and a lack of equilibrium in the distribution of the goods.

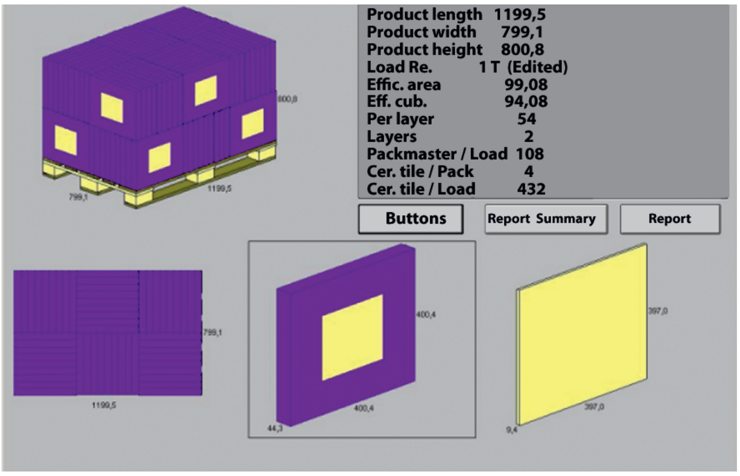

Figure 2. Source: AIDIMA.

Figure 3. Source: AIDIMA.

If we continue with our distribution, the following operation usually occurs in handling to load the goods. This may be carried out in a more or less mechanised way, but the risk involved here is **IMPACT.**

A physical impact can be explained as, a sudden change in the speed of a body, in this case our products. This can be the source of damage, resulting in fractures in the product or displacement of the handled goods due to the fact that it occurs in short spaces of time, as little as a millisecond, and therefore produce high accelerations that lead to great forces on the product.

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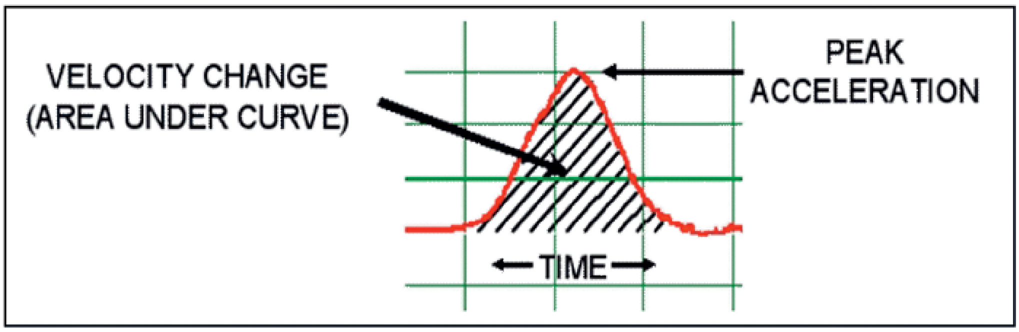

Figure 4. Source: ISTA – Internacional Safe Transit Asociation

$$\text{Aceleration} = \frac{\text{velocity change}}{\text{time change}}\ ; \quad \text{Force} = \text{Product mass} \times \text{Acceleration}$$

Due to the magnitude of these accelerations they are expressed in G's (multiples of gravity) and can be recorded in reality with devices called accelerometers.

When a product suffers impact it experiences shock due to the fact that it suffers a deceleration and the resulting forces can damage it. The occurrence of damage depends on the capacity a product has to withstand a given deceleration. This factor is what is known as the ***fragility index*** and is also measured in G's. Therefore, if the acceleration of the impact exceeds this, the product will be damaged.

The previous concept is the reason why materials such as shock-absorbers, polyurethane, polyethylene EPS, foam, etc, were introduced into the world of packaging.

When it is foreseeable that there will be impact in the handling operations whose acceleration are more than the fragility index of a product, it will be necessary to use shock absorbing materials in critical areas. Their function will be to absorb the acceleration of the impacts, thus minimising the effects of acceleration on the product

GENERIC INDICES OF PRODUCT FRAGILITY	
PRODUCT	FRAGILITY
Extremely fragile (precision equipment)	15 – 25 G´s
Very delicate (medical appliances)	25 – 40 G´s
Delicate (computers, DVD, VCR,..)	40 - 60 G´s
Medium (stereos, TV, etc.)	60 – 85 G´s
Robust (household appliances)	85 – 115 G´s
Very robust (machinery)	> 115 G´s

Table 1. Source: School of Packaging - Michigan State University -

Continuing with the distribution cycle, once the product is loaded in the means of transport, usually lorries or ships in the case of ceramics, another significant risk appears throughout the journey, which is **VIBRATIONS.**

In the context of distribution and packaging, vibration is very common in transport vehicles, lifting equipment, transporters, etc. which will affect every packed product.

We know that vibration consists of an oscillating movement around the point of reference and is characterised by a frequency and range or peak value, and is associated with a sine curve. Every system of inertia with mass, taken from rest and left free tends to vibrate with intensities that may vary but with a frequency that will always be the same. This frequency is called the *"natural frequency"* of a system.

When vibration is caused by an external force, like the vibrations present in vehicles, and transmitted to the products, the system will respond in a different way depending on the frequencies. However, if they reach natural frequency the system will amplify the entering response in resonance and this is the main cause of potential damage.

Transport vehicles normally have vibrations due to diverse factors like, suspension, tires, the state of the road, the type of product and the general driving conditions. All these conditions are changeable and cause vibration to be transmitted to the products. This may not occur as a discrete sine curve but rather a range of frequencies with varying amplitudes caused at random.

The range of frequencies most commonly present in transport lies between 1 Hz and 250-300 Hz, the most common and representative being found in the 1-100 Hz range. Although, the intensities normally present in vehicles are usually not high (tenths of G), there are two factors that make them dangerous:

- The resonance frequency: this can occur due to the products being exposed to a spectrum of frequencies throughout the journey.
- The time factor: a lorry going from coast to coast in the United States can take 50 hours. This is enough time for damage to take place in the products due to the effects of fatigue, friction, wear and tear, loosening of the fastening elements

The vibrations as we have mentioned, occur due to numerous factors. However, studies carried out by the School of Packaging at Michigan State University show that the most significant vibrations depend on the suspension of the vehicles; this is situated between 3-4 Hz, wheels at 15-20 Hz and the platform or surrounding structure at 40-55 Hz.

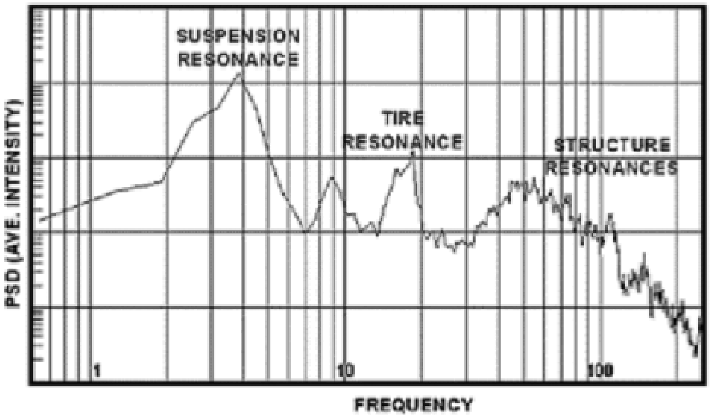

Figure 5. Source: School of Packaging – Michigan State University-

At the moment equipment exists that is capable of recording the vibrations and impacts that occur in the actual distribution cycle, as well as temperature and humidity conditions. This information is subsequently downloaded and analysed using a specific software system that allows us to obtain a precise X-ray of the distribution studied.

The data obtained by this equipment is as follows:

- Number and intensity of the shocks brought about by distribution.
- Levels of vibration obtained during transport.
- Temperature and humidity conditions.

The measurement and data logging equipment is incorporated with electronic devices like "black boxes" that have an internal triaxial accelerometer that allows electronic logging and recording of acceleration events (vibration and shock), environmental temperature and contained relative humidity. In this manner it is possible to see the effects the packaged product is undergoing.

The internal accelerometer measures the accelerations received in the three axes X, Y and Z. In this way the influence of each one can be analysed separately in the behaviour of the packaging system.

After downloading and analysis of the data gathered by the above-mentioned equipment, the result obtained is a random vibration profile that inter-relates the vibration frequencies in Hz with accelerations in g^2/Hz. These profiles are termed PSD (Power Spectral Density).

Figure 6. Source: AIDIMA.

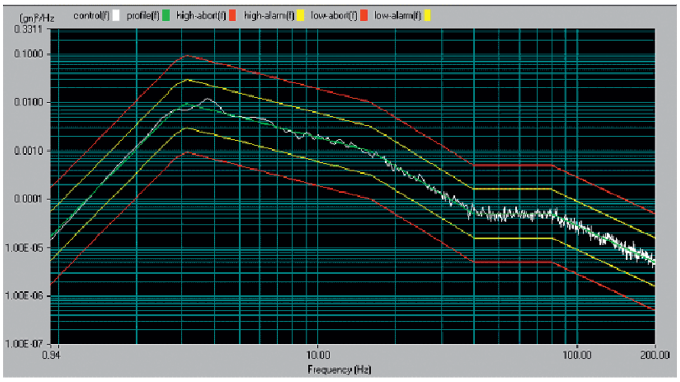

Figure 7. Source: AIDIMA.

Analysis of these profiles allows conclusions to be drawn that help to improve transport conditions as well as analyse the causes of potential damage to merchandise. As a result, corrective action and work methods can be established that reduce damage and optimize the materials and packaging systems.

This information allows us to get a clear idea of the conditions that packaging systems should be capable of withstanding and will help us understand the problems ceramics experience in distribution.

Once the typical profiles of our actual distribution cycle have been obtained, these can be reproduced in a laboratory. This will allow us to simulate the transport of other consignments, of new products or of new packaging conditions. Subsequently, we can introduce preventative methods to distribution before damage is caused or the product is rejected.

The random vibration or transport simulation tests are carried out with electro-hydraulic vibration tables directed by electronic servo-controls that allow the table to make a series of movements with different acceleration and frequencies. This type of movement is dominated by random vibration and the simulation of transport and, as its name implies, it is the most reliable method for reproducing the vibrations that occur in real transport.

Figure 8. Source: AIDIMA.

Figure 9. Source: AIDIMA.

As the vibration tables respond to the parameters requested from the controller, some vibration and shock collection systems are necessary. These are called **accelerometers.** These devices are of reduced size and are secured to the under side of the vibration tables. Their function is to return the real vibration signal of the tables to the controller so that the hydraulic commands can be adjusted in real time and therefore keep the table vibrating in accordance with the determined profile.

The result is the reproduction of real, pre-recorded vibration profiles in the laboratory.

We still have one more risk that may occur in transport and that is **DYNAMIC COMPRESSION.** Conceptually, it is another compression similar to what was previously discussed. However, it has one peculiarity that it occurs in movement (it is dynamic) and the stresses develop horizontally and vertically. Furthermore, due to the "acceleration" factor, these compression forces can be multiplied by ten.

To finish all the distribution stages, other risks that may occur for the packaging are **TEMPERATURE and HUMIDITY.** These reduce the quality of packaging materials such as plastic, springs, wood, paper and cardboard. Cardboard can lose up to 50% of its static resistance in very humid environments.

There is one more risk that may also appear at any point in the distribution phase, which are the **BIOLOGICAL**. Though critical in other products like food, they tend not to affect the distribution of ceramics. However, some exceptions can occur due to the effects of phytosanitary elements present in wood packaging which are regulated by international standards.

The UN phytosanitary regulations (NIMF 15) in force at the moment apply to all types of pallets and wood packaging. The following requirements are imperative: certification of wood origin and another certification for the type of treatment applied to it for debugging.

This regulation has lead to an increase in production costs for wood used in solutions for the life-cycle of the pallet and wood packaging.

In order to meet the second requirement (debugging), two types of treatment are allowed (defined by the FAO in 2001): fumigation with methyl bromide and heating in the centre of the product. These two types of treatment involve a series of inconveniences that bring an added cost to production.

Among the various problems that heating implies, acquiring the installations necessary to carry this out (drying ovens) is the most obvious. These facilities entail an important economic investment and, most of all, given the wide variety of properties associated with each type of wood, they do not guarantee that 65ºC will be achieved in the centre during 30 minutes.

As regards fumigation with Methyl Bromide, it is efficient when it is applied. However, apart from the high levels of toxicity, the low residual level of this product means that there are no guarantees that a re-infestation will not occur sometime later. In addition, it can only be applied in exceptional cases and the Administration is pushing for the prohibition of the application of this product.

The foregoing makes it necessary to use new technologies and formulas that are feasible alternatives to the already existing ones. They must also have a good cost/efficiency ratio. This is an imperative factor in industry today, most of all, in products that have a short usage lifespan as is the case in the field we are focusing on.

In short, this particular aspect has sufficient scope to be treated specially and is beyond the reach of this current presentation.

3. CONCLUSIONS

3.1. PREVENTIVE ACTION

As previously commented the objective of any ceramic manufacturer, in reference to logistics, is to achieve speed, agility, minimum costs and reduce returns. Preventive action is necessary to achieve all of this. Ceramic manufacturers in the international market should ensure that deliveries are completely satisfactory, with a high level of reliability. Therefore, all the information obtained prior to dispatch, including that from the product development phase through to product launching, the conditions of the merchandise and the possible risks throughout the distribution phase, are vital in order to reduce the percentage of incidents..

3.2. KNOWLEDGE OF THE DISTRIBUTION SYSTEM

It is recommendable to make a map of the distribution system that allows identification of the stages and to focus on the products that are featured in regulation 80/20. Eighty percent of sales are due to twenty percent of products and markets.

3.3. IDENTIFICATION OF THE DISTRIBUTION RISKS

It is necessary to go over all the possible risks and evaluate their presence.

There are tools for gathering real data on previous incidents in distribution.

It is good practice to have an internal follow-up and treatment system for these incidents.

3.4. RE-ENGINEERING PACKAGING

A revision of packaging systems and processes used should be carried out and updated systematically in order to improve them. A balance or "trade-off" should always be sought between the costs incurred and the savings received. Over-packaging or excessive damage due to packaging defects should be avoided. A percentage of damage is allowed economically speaking, but the question is "how much"?

There are resources and regulations that may help us evaluate the aptitude of use, such as:

ISO 4180 (EN 24180). Complete filled transport packages. General rule for the compilation of performance test schedules.

ASTM D 4169. Standard practice for performance testing containers and systems.

ISTA Protocols – International Safe Transit Association

3.5. PACKAGING IS NOT A PROBLEM, IT IS JUST ONE MORE ELEMENT TO BE MANAGED

For example, we have commented that in road transport the greatest damaging effects of vibrations are due to the own lorry structure i.e. suspension, wheels and general structure. What are we negotiating with our transport companies?

With appropriate management we can also answer questions like:

Can my current packaging comply with performance requirements?

What causes damage and how can it be remedied?
Is packaging A better than B?
Does the packaging comply with the requirements of a standard or specification?
What means of transport is better?
What are the correct materials?
In what way am I contributing to sustainability?
Are my packaging operation costs correct?
Am I competitive?

Therefore, the technology exists, so do the means, and the market does not forgive. For these very reasons, the ceramic sector cannot afford to fall behind in today's distribution logistics.

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