Simulation testing for beverage packaging optimization

SAFE LOAD
testing technologies

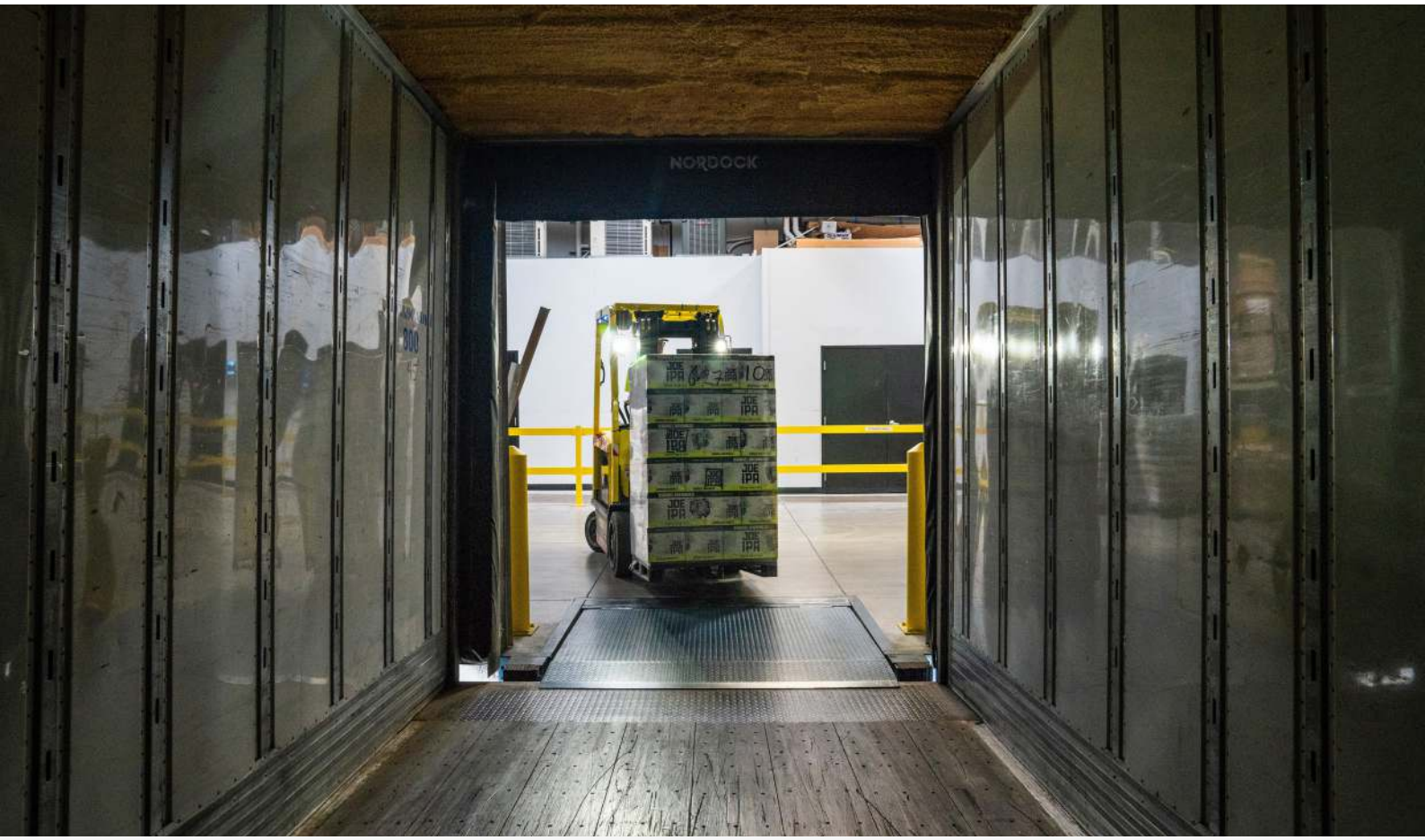
Index

1. Beverage packaging: an evolving industry

The beverage sector is in full **growth.** According to data published by Stadista, the soft drinks market is expected to grow by **9.32% (CAGR 2021-2026),** while the alcoholic beverages market is expected to grow by **6.9%** in 2022.

This means, the size of the global beverage packaging industry will also increase to cope with the growing market demand. In fact, **Allied Market Research** estimates that the beverage packaging market will reach $133.3 billion by 2026, which would be a compound annual growth rate of 5.6% from 2019 to 2026.

This increase in the consumption of beverages, both alcoholic and non-alcoholic, poses a challenge for the main market participants, who face major challenges related to changes in consumer behavior, sustainability and logistical efficiency.



1.1 Main challenges for the beverage packaging sector

Beverage packaging is a complex process due to the wide range of beverages available on the market that require different containers and materials, such as glass, polymers, metals or cartons, for their preservation and distribution.

Proper design and implementation of beverage packaging not only extends the shelf life of the beverage itself, but also makes it convenient for users, saves waste-related costs and improves distribution cycle efficiency, reducing shrinkage losses.

It is precisely during the transportation and distribution of beverages that the industry faces the most challenges, including problems with packaging, which hinder the distribution process and raise costs considerably.

This is due to the idiosyncrasies of the beverage sector, characterized by:

- **High product turnover**

  The high turnover of beverages in supermarkets and other establishments where beverages are sold requires small volume but highly regular transportation.

  For example, it is common to ship beverages in "less-than-truckload shipping" mode. This shipping model multiplies the number of times the product is handled and therefore the chances of product damage, which is one of the main challenges facing the industry.

  In order to mitigate this problem, it is common for beverages to be packed in crates and then bundled onto pallets for transport. In addition, for extra protection during shipping, pallets are stretch-wrapped using stretch film or stretch hood, creating safer and more stable unit loads.

  This step is critical, as one of the most common problems during transport has to do with improperly secured loads. When trucks have to make a sudden stop or an extremely sharp turn, these movements can cause improperly packed loads to fall and, in some cases, break the walls of the truck, spilling onto the road and causing serious accidents.

  This not only has an impact on the goods, as it generates losses and additional costs, but also puts drivers' lives at risk.

The new sustainability standards

Because of its characteristics and its proximity to the end customer, the beverage packaging sector is being profoundly affected by new sensitivities and social awareness around sustainability and care for the planet. Consumers, who are increasingly aware of the impact of beverage packaging on the environment, are demanding more sustainable and environmentally friendly solutions.

More than half of consumers say they make conscious decisions about purchasing a product based on whether its packaging is environmentally friendly.

In support of this change, governments and organizations around the world are working on new regulations and directives to deal with packaging waste, which causes serious environmental problems. This is the case of the **European Directive 94/62/EC on packaging and packaging waste,** whose mission is to prevent the production of this type of waste, and to promote reuse, recycling and other forms of recovery.

For their part, companies are working on the design of new packaging that meets the requirements of governments and consumers, without increasing their costs. One of the trends in the packaging sector is the incorporation of new **eco-friendly materials,** that can be reused and recycled.

- For example, at the European level, the **ACE** association of beverage carton manufacturers has set a target of achieving **90% collection** rates by 2030, as well as a **recycling** rate of at least **70%** for its packaging, along with a reduction in the carbon footprint.
- Following this roadmap, ACE also ensures that by 2030 all beverage cartons will be made from **recycled or reusable materials** and **sustainably sourced** raw materials.
- For its part, UNESDA Soft Drinks Europe guarantees that its packaging will follow a circular model by 2030: its PET bottles will be made from 100% **recyclable or recycled plastic,** in addition to collecting 90% of the **waste** created and generating **reusable solutions.**
- These companies thus aim not only to meet but to exceed the targets set by legislation, taking the lead in sustainability that will make a difference.

Main challenges during the transportation of beverages

Each specific product and distribution cycle has its own characteristics and potential **setbacks** to solve: from road transport over more unsafe routes to extreme weather conditions.

However, the beverage industry shares certain specific hazards that can occur during transportation and handling of goods:

- **Instability.** The transportation of beverages in bottles is highly unstable, since, when transported in a vertical position, it is more difficult to generate rigid and stable load units. This is due to the slender shape of the container, which makes it very easy for its center of mass to shift away from its base, causing displacements and falls.

  The European Agency for Safety and Health at Work estimates that improper load stability is responsible for **25% of accidents** involving trucks.

  Consequently, companies must go deeper into the packaging design and validation phase to ensure that the cargo will remain safe and stable in the face of movements such as accelerations or vibrations inherent to transport, thus avoiding economic losses due to shrinkage or non-compliance with regulations and directives related to the transport of goods.

  In addition, typical unit loads in beverage transportation must be properly secured with bars, straps, or other elements, preventing accidents caused by load instability.

- **Breakages.** The use of fragile materials such as glass is common in beverage packaging: the breakage of a primary packaging (a single bottle or can) can result in the disposal of a large part of the unit load due to contamination.

  Stretch-wrapped unit loads also present challenges for companies, as well as opportunities for optimization. Stretch film breaks can cause the goods to shift and fall off. As a result, the walls of the truck can crack or open, leading to spillage of goods on the road and serious accidents. These mishaps not only generate added economic costs, but also put lives at stake.

  It is therefore essential to choose the right tertiary packaging solution. A poor choice of **stretch film** or stretch hood type or volume can lead to overpackaging situations: more material is used than necessary for fear that the load will not withstand the distribution cycle, unnecessarily increasing transport and material costs. Similarly, an inappropriate application can

lead to under-packaging, which puts both the goods and those involved in the transport at risk.

In addition, poor stretch film placement can lead to other problems, such as damage caused to the packaging by applying too much pressure during stretch wrapping. As a result, the load may deform or tip over, releasing and breaking the goods inside.

It then becomes evident that companies must prevent this type of mishap by minimizing uncertainty through the testing of unit loads and distribution packaging.

All these challenges point to an undeniable reality: it is necessary for companies involved in the beverage industry to **redesign their packaging strategies,** creating safe, optimized and sustainable solutions.

To this end, any redesign process must include **simulation tests** focused on the distribution cycle. Only through testing protocols with specific equipment is it possible to guarantee **product safety,** while optimizing costs and generating more efficient processes that ensure an efficient and functional distribution cycle.

2. Keys to safe beverage packaging transportation

As we have seen, a common combination for beverage packaging involves using primary packaging (bottles, cans, cartons...), in some cases secondary packaging, such as cardboard boxes, which are then grouped on **pallets,** using **stretch film** or **stretch hood** to secure the product.

In order to ensure the safety of the product + packaging during transport, we highlight the following **key** points:

2.1 Proper placement of stretch film

Poor stretch film placement can lead to various problems, such as damage to the packaging if too much pressure is applied.

Faced with this problem, there are several points that the company must verify that they are complied with:

- Ensure that the application of the stretch film is adequate to avoid instability problems.
- Calculate the right amount of film to use. There are several optimizations at play here: from improving sustainability to reducing material and transportation costs.
- Establish suitable wrapping protocols.

2.2 Correct positioning and securing of the load on the pallet

It is essential that the goods are placed correctly on the pallet, distributing the heavier goods at the bottom and arranging the larger loads on the outside of the pallet, avoiding gaps between products (filler material should be added if necessary to avoid this scenario). It is equally important to distribute the goods equally on the pallet, avoiding that the unit load takes the shape of a pyramid.

Companies must ensure that cargo is securely fastened using bars, straps, or other lashing devices to guarantee the stability and safety of the goods during handling and transport.

In addition, there is a specific regulation that companies that transport their goods by road, within the European territory, must comply with. **Directive 2014/47/EU** establishes a series of measures and test methods to ensure that

goods transports circulating on EU roads are in good condition and, therefore, that they circulate safely. This ensures that there is no **risk of an accident** due to poor load securing.

Find out more about load stability and Directive 2014/47/EU in our eBook **'Improve sustainability, safety and cost savings in goods transport'.**

2.3 Packaging optimization and validation

To ensure product safety during the distribution cycle, it is important to test beverage containers and packaging under laboratory conditions before they face actual distribution conditions.

To this end, there are various test methods that allow companies to carry out transport simulations on their loads in order to optimize them and improve their safety and efficiency.

It is possible to identify different testing methods for each type of beverage packaging:

2.3.1 Primary packaging

Its main purpose is to protect and preserve the product, and it is in direct contact with the product, as well as including all the information about the product to inform the consumer.

At this level, compression tests are very useful to determine the number of stacking levels that are possible without damaging the bottles, as well as drop tests to determine the strength or resistance of the containers.

2.3.2 Secondary packaging

It is used primarily for logistical and storage purposes, to protect and bundle individual units of product. Examples of secondary packaging include cardboard boxes that would contain beverage bottles or cans, or shrink wrap that wraps and bundles PET soft drink bottles.

Some of the most common assays for secondary packaging include:

- The **Edge Crush Test** (ECT) is a test that measures the ability of corrugated board to provide security for goods during transportation. This test can be performed with a compressometer.
- The **Drop Test,** to measure the resistance to shocks and impacts
- Creep Test: it is a test that allows to know the evolution in time of a material that supports load on itself under static conditions.
- Static Shear Test: used to determine the amount of horizontal force a material, whether plastic, aluminum or glass, can withstand before breaking.

2.3.3 Tertiary packaging

It is used to protect not only the product but also its secondary and primary packaging.

Consumers generally do not see tertiary packaging, as it is usually removed by retailers before products are displayed for sale.

In the case of beverage packaging, the most commonly used tertiary packaging is stretch film. This material is used to pack the products on the pallet creating unit load units, so that they are safer and more stable for handling and transportation. There are other tertiary packaging solutions on the market, such as stretch hood, which is becoming more and more important.
Among the tests carried out on stretch film and stretch hood, the most important are tests to evaluate the stability of the load when faced with the horizontal accelerations and decelerations typical of road transport. These tests include:

2.4 Stability Test

The **EUMOS 40509:2020** test method stands out, the results of which enable companies to optimize unit loads to ensure that they will remain stable and safe during road transport.

Thus, by means of horizontal stability equipment, it is possible to measure elastic and plastic deformation.

There are two options here. On the one hand, the standard horizontal stability machine is an advanced solution, essential for verifying the redesign of beverage packaging. The machine allows to simulate horizontal accelerations and decelerations in line with major international standards such as EUMOS 40509 and US FMCSA load safety requirements.

On the other hand, the compact **innSlide Boomerang** (the world's smallest acceleration tester) is specifically designed to comply with the EUMOS 40509 protocol to measure the stability and stiffness of the load and to optimize the packaging.

In both cases, it is possible to integrate the **innVision Pro** system, a unique pallet stability recording and analysis technology designed by Safe Load Testing Technologies to measure load deformation during simulations in a laboratory environment.

innSlide Safe Load

2.5 Tilt Testing

Consists of a test procedure to evaluate in a laboratory context the stability of the load under conditions similar to transport. This method can be used both in the load characterization or validation phase, thanks to the **Tilt tool,** specifically designed to perform stability tests in line with the **EN 12195 standard.** The innTilt family solutions can also be used for quality control and is a very useful tool for packaging optimization since repeatability is guaranteed.

During transport, beverage packaging is also exposed to different types of risks, with vibrations being an essential factor to take into account when considering the integrity of the load.

innTilt Safe Load

2.6 Vibration tests

Vibration tests allow to know the protective capacity of the packaging against vibration movements produced during the distribution cycle.

Vibration simulation can be conducted through equipment such as a vertical vibration table. However, Safe Load Testing Technologies' patented solution includes a vertical vibration table together with the **Pitch & Roll module,** which accurately incorporates the pitch and roll motions produced by various means of handling and transport. In this way, results are obtained closer to reality.

innTilt Safe Load

2.7 Rotational drop tests

Drop tests provide insight into how vertical and rotational impacts can affect the integrity of the packaging and the products it contains. In this way, the information obtained can be used to design appropriate packaging to protect products against drops during the distribution cycle.

With the **Drop Tester** it is possible to simulate both vertical and rotational drops that affect packages and products during handling and distribution.

In addition, there are other transport simulation tests that will enable companies in the beverage industry not only to ensure cargo safety, but also to improve environmental sustainability.

However, each company must consider its own needs in order to choose the most appropriate packaging test methods according to its own test protocols or international **standards** for transport simulation.

innTilt Safe Load

3. Advantages of transport simulation for beverage packaging optimization and validation

Faced with the challenges of the distribution cycle, **transport simulation machines** become the essential method to detect problems in time and anticipate possible damage, as well as to generate safe transport and improve logistics efficiency.

In essence, transport simulation allows to **verify** that the chosen beverage packaging is adequate to ensure product safety. In addition, they are the indispensable tool for the **redesign** of packaging solutions, verifying new materials or configurations.

Thus, transport simulation provides the following advantages.

- Ensures **safe transportation** of goods.
- Allows to **reduce costs,** choosing options with cheaper materials or using less materials without compromising the safety of the products.
- **Minimizes losses** due to product shrinkage.
- Enhances the verification of the redesign of packaging solutions to achieve greater **sustainability,** again without compromising the safety of transported goods.
- Enables compliance with national and international **standards and regulations,** including Directive 2014/47/EU, essential for road transport on European territory.
- Allows the optimization in the use of **stretch film,** directly related to the improvement in sustainability and economic costs.

4. Success story: Optimization of beverage packaging in multinational brewery

This was the case of a multinational brewery with a turnover of 1.3 billion euros whose objectives involved:

- Growing their business
- Minimizing their environmental impact by reducing CO2 emissions
- Optimizing their packaging costs
- Analyzing the stability of the load following Directive 2014/47/EU and the EUMOS 40509 method included therein

This brewing company is committed to the environment, and one of its main objectives is to reduce CO2 emissions from the products it manufactures and distributes.

In recent years, the company has focused its efforts on reducing the carbon footprint of its products, acting mainly on primary and secondary packaging, minimizing its thickness and reducing its weight, without compromising the quality of its products.

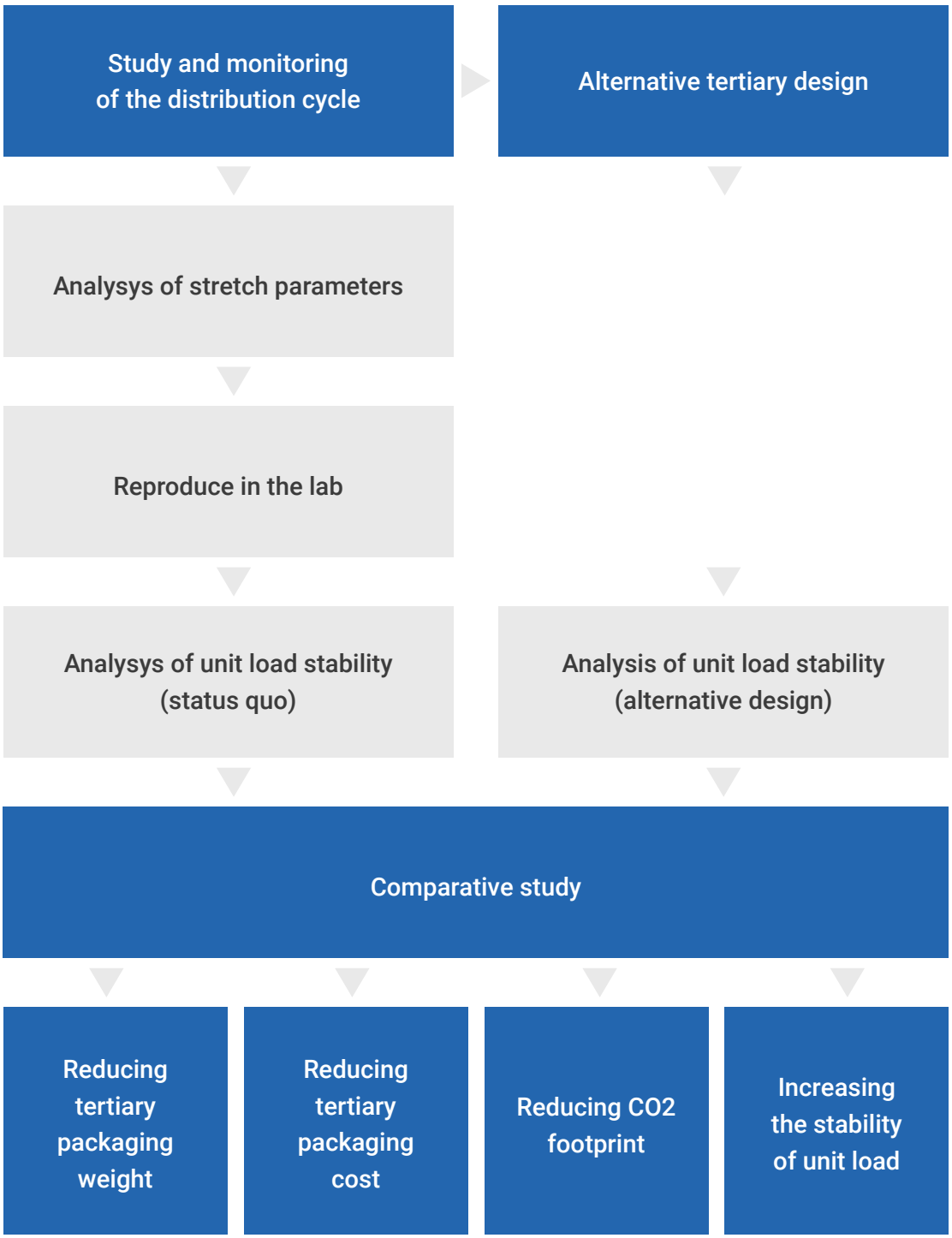
Although the optimization of the primary and secondary packaging achieved the expected results, the brewery still needed to further reduce its carbon footprint.

The company therefore considered reducing the 23-micron stretch film they were using as tertiary packaging. This posed a dilemma, as a poor stretch film decision could affect load stability and therefore transport safety. While it is true that the reduction of CO2 emissions is an important point in their strategic framework as a company, transport safety is even more important, to avoid possible damage to third parties due to the lack of stability of the palletized units they are transporting.

The solution proposed by Safe Load Testing Technologies was to analyze the behavior of the tertiary packaging they were using, in order to optimize it to withstand its distribution cycle.

After knowing the needs and objectives of the company, the first step was to create a roadmap to establish the necessary steps to provide a solution to the needs of the brewing company.

This roadmap consisted of the following procedures:



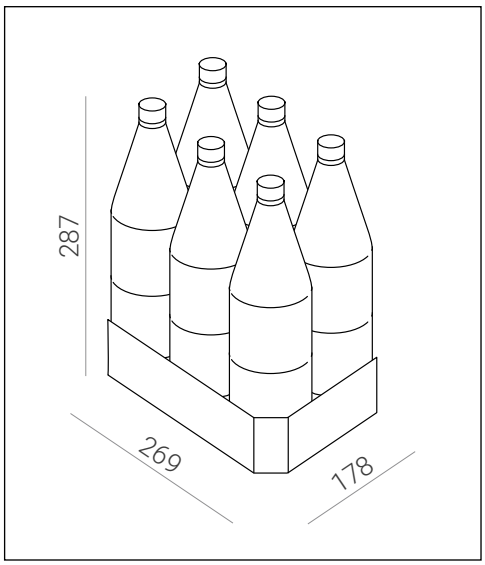
4.1 Study and monitoring of the brewing company's distribution cycle

The first step to understand how the distribution cycle affected their products was to analyze the configuration of their packaging.

For this purpose, two of the products with the highest demand were chosen: 1-liter bottles of beer and 25cl. bottles.

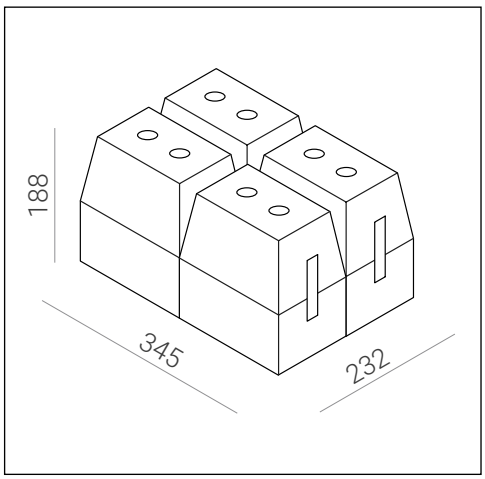
- **1l bottle in 2x3 tray (MSM)**

  Primary packaging:
  1000 ml glass bottles.
  Secondary packaging:
  Carton tray + Shrink wrapping
  Contains 6 glass bottles
  Tertiary packaging:
  Palletized cargo 76 packs (456 bottles) 4 layers of 19 packs (total height 1307 mm). Tertiary packaging, EUR pallet, 5 cardboard interlayers and 23 micron stretch film



- **25cl NR (4 semi-c 2x3 packs)**

  Primary packaging:
  250 ml glass bottles.
  Secondary packaging:
  Carton packs-6 + Carton packs-4
  4 carton packs of 6 glass bottles each.
  Tertiary packaging:
  Palletized cargo 77 packs (1848 bottles) 7 layers of 11 packs (total height 1460 mm). Tertiary packaging, Europallet and 23 micron stretch film.



Subsequently, in this phase, the distribution cycle of the brewery's two products was monitored, from the time they left the brewery until they reached the end customer.

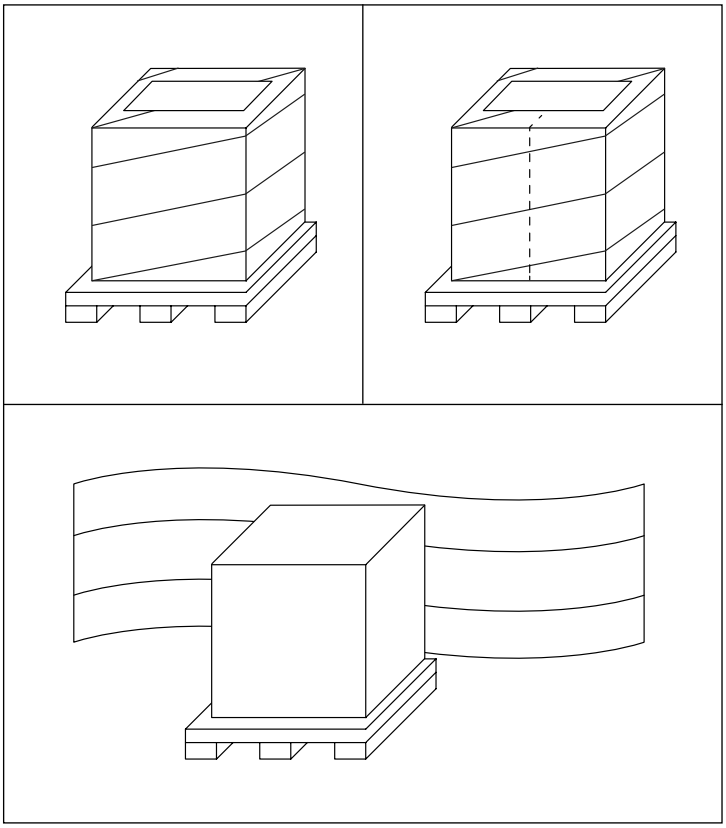
For this purpose, the innRecord **Data Recorder** was placed on the truck and all events and actual risks (shocks, accelerations, frequency and strength of axial and angular vibrations and rotation in two axes, rolling and pitching movements, etc.) that the load endured during handling and transport were recorded.

The recorded information was recorded on the innRecord microSD card, which, after analysis, allowed the engineers to characterize the distribution cycle in detail and design test protocols according to the real conditions in which the loads are transported.

4.4.1 Analysis of anger parameters

IIn the case of the brewing company, it was essential to study the sequence and parameters of stretch wrapping of the loads in order to propose an alternative to the 23-micron stretch film they were using.

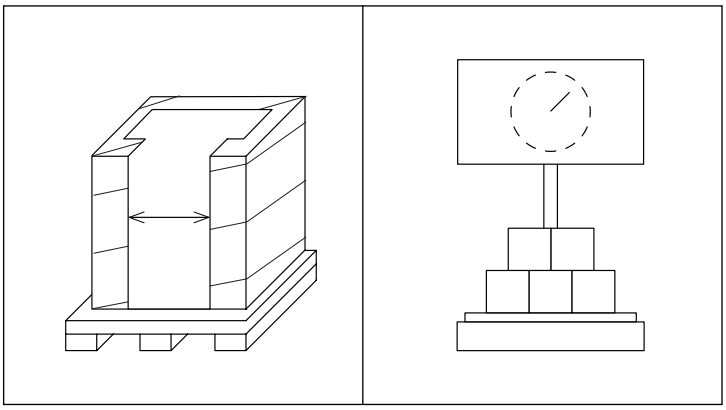
Stretch wrapping parameters measurement



Gap

Weight

% Tension
100 x snap back gap
Perimeter of the load



The analysis was carried out on samples of the two selected products. For this purpose, the merchandise was placed on pallets and the wrapping sequences and configurations that the company was using so far on its palletized loads were carried out. The material used to wrap the goods was 23-micron stretch film and the results of the analysis showed the following results:

Wrapping Scheme	1L	25cl
	nº Turns	nº Turns
Band between upper layers	3	2
Going down till wooden pallet	6	7
Band at the lower part of the unit load with the pallet	4	3
Going up till top of the unit load	6	8
Band at the upper part of the unit load	4	3
Total	23	23

Parameteres measured after wrapping the unit load	1L		25 cl	
	Value	Gap	Value	Gap
% Upper layer tension / Gap	14,5%	570 mm	11,2%	440 mm
% Intermediate layer tension / Gap	13,0%	510 mm	9,1%	360 mm
% Down layer tension / Gap	14,3%	560 mm	10,4%	410 mm
Residual thickness of the film	7–8 micron		7–8 micron	
Consumption of film per pallet	271,6 g		283,2 g	

The objective of the wrapping sequence analysis was to obtain information to detect optimization points, such as:

- The perimeter of the pallet and of the stretch film used
- The percentage of tension in the palletized load (at the top, in the middle and at the bottom)
- Residual thickness on the pallet
- Stretch film consumption per pallet
- The wrapping sequence used so far by the brewing company

4.1.2 Laboratory reproduction of the parameters

Thanks to the information obtained in the previous step, the Safe Load Testing Technologies engineering team identified the most suitable transport simulation tests for the company's palletized unit loads, in order to detect optimization points and propose solutions that would allow them to achieve their objectives.

In this way, a sequence of tests was established on the unit loads (primary, secondary and tertiary packaging + product) to analyze their behavior during transport:

4.2 Rotational drop test

These were subjected to drop tests to determine how vertical and rotational impacts affected the integrity of the packaging and the products it contained. The information obtained was then used to design a suitable packaging capable of protecting the products against falls during the distribution cycle.

The tests will be carried out with **Drop Tester equipment,** capable of simulating both vertical and rotational drops that affect packages and products during handling and distribution.

4.3 Multi-axis vibration test

During distribution, beverage packaging is exposed to different types of vibrations that affect the integrity of the load.
Therefore, during the test phase, not only vertical vibrations were simulated, but also angular pitching and rolling movements were included in order to generate a stress on the stretch film equal to that suffered during transport.

Vibration simulation was carried out with Safe Load Testing Technologies' vertical vibration + pitch & roll system.

Multi-axis vibration testing: analysis, benefits and characteristics.

4.4 Stability testing according to EUMOS 40509

In beverage packaging oriented transport testing, it is essential to include the simulation of horizontal accelerations and decelerations (acceleration, deceleration, and braking). These movements, mainly produced by various road transport, can compromise the rigidity and safety of the goods.

Unit load stability is essential for beverage packaging and the typical unit load model in this sector, pallets.

Therefore, the stability test was included in the test sequence. The objective of this test was to measure the load deformation and the capacity of the tertiary packaging to resist horizontal accelerations and maintain stability.

The tests were conducted with the **innSlide Boomerang** stability machine, an advanced solution for simulating horizontal accelerations and decelerations in mid-stroke, the testing method of which is currently under patent.

With the information extracted from the different tests, a tertiary packaging and alternative load configurations were designed, with the objective of carrying out a comparative study between the initial load (status quo) and the new tertiary packaging proposals.

4. 5 Alternative tertiary design (new stretch film and stretching parameters)

Following the analysis and transport simulation tests carried out on the palletized loads, Safe Load Testing Technologies proposed a reduction in the thickness of the stretch film in order to achieve the objectives set by the company. For this purpose, a new wrapping scheme was defined and a new 15 micron DDK stretch film material was used.

The objective of the new tertiary packaging was to reduce the use of stretch film without compromising the stability and safety of the load during transport.
To check that the new configuration was suitable for the goods and the distribution cycle, the load with the new tertiary packaging was subjected to the above

protocol. The objective of this test was to evaluate the stability by applying the same level of horizontal acceleration with respect to the initial tests (status quo).

4. 6 Comparison of proposed designs for tertiary beverage packaging

This last step consisted of a comparative analysis of the status quo of the tertiary packaging used by the company, with the alternative design proposed by the Safe Load TT engineering team.

This comparison was carried out on samples of the two products, both 1L bottles of beer and 25cl bottles.

The study showed the load wrapping parameters with the 23-micron stretch film (status quo) versus the proposed 15-micron alternative.

Parameters measured after wrapping the unit load	Status quo (23µ)	Alternative (15µ)
Total Wrap Turns	23	15
Upper layer tension	11,1%	
Intermediate layer tension	9,6%	
Down layer tension	11,4%	
Residual thickness of the film	7–8 micron	7–8 micron
Consuption on film per pallet	284 g	174 g

Optimization	Alternative		
Productiviy	34,7%	↑	
Applied tension	13%	↑↑	
Weight	38'7%	↓↓	110 g

4. 7 Tertiary packaging optimization results

Thanks to the optimization process carried out by Safe Load Testing Technologies, the multinational brewing company achieved all the objectives set within its strategic framework:

They achieve SAFER UNIT LOADS with OPTIMUM PACKAGING SYSTEM

The loads were optimized to make them **safer and more stable,** in compliance with **Directive 2014/47/EU.** In addition, **the average film consumption per pallet was reduced** by **37.5%,** i.e. approximately 103 grams on average per wrapped pallet.

In addition, it was possible to **increase the capacity / production of the proposed stretch film** up to **28%** more than the average wrapping capacity used so far by the brewing company.

In terms of carbon footprint reduction, savings of 33% of total CO2 emissions were achieved on average per wrapped pallet. Extrapolated to a production volume of 1,000,000 pallets per year, the company was able to achieve **185 tons of annual CO2 emissions savings.**

In addition, **a reduction of 1,500 hours of machinery use** was achieved, with great benefits in terms of maintenance and equipment lifetime.
This also resulted in **annual savings of €110,250.**

Do you need a correct simulation test for the packaging of your beverages or any other product? **Contact us.** With our extensive experience, Safe Load Testing Technologies offers our customers the best solutions to their needs, we are here to help you!

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