

Which vibration tests realistically simulate transportation of equipment?

Vibration tests are essential to ensure that equipment arrives safely at its destination. These tests simulate the shocks, vibrations and impacts that products undergo during transport by road, sea, rail or air. By replicating realistic transport conditions, we can better protect fragile equipment from damage. In this article, we answer the most important questions about vibration testing and how it contributes to reliable transport solutions for sensitive equipment.

Which vibration tests are used for transport simulation systems?

Three main types of vibration tests are used for transport simulation systems: sinusoidal tests, random vibration tests and shock tests. Each type of test simulates specific transport conditions and provides insight into how products respond to different types of stress.

Sinusoidal vibration tests use regular, predictable vibrations at specific frequencies. These tests are ideal for identifying resonance points in a product – the frequencies at which a product is particularly sensitive to vibrations. During a sinusoidal test, the frequency is slowly increased (a “sweep”), allowing us to see at which frequencies the packaging or product is most vulnerable.

Random vibration tests are more realistic than sine tests because they simulate multiple frequencies simultaneously, just like in real transport. These tests generate random vibrations within a certain frequency range and at different intensities. For example, they mimic driving on a bumpy road or turbulence during a flight. Random tests are valuable because they show the combined effects of different vibrations on your product.

Shock tests simulate sudden, short-term impacts such as falls, bumps or landing after a jump. These tests measure how well a product and its packaging can withstand extreme, short-term loads. Think of situations such as setting down a container, an emergency stop during road transport or landing an aeroplane.

The combination of these tests provides a complete picture of how your product behaves under different transport conditions. By understanding which tests are most relevant to your specific transport scenario, you can make targeted improvements to your packaging design.

How do international standards influence the quality of vibration tests?

International standards ensure reliable, reproducible and comparable vibration tests. They provide standardised test methods that are recognised worldwide, giving you the certainty that your packaging meets the requirements for international transport.

The **ASTM D4169** standard is one of the most commonly used test protocols for transport packaging. This standard describes different test levels and procedures based on the expected transport conditions. ASTM D4169 not only covers vibration tests, but also drop, compression and climate tests, enabling a complete evaluation of your packaging.

The **ISO 13355** standard focuses specifically on random vibration tests for packaged products. This standard defines methods for simulating random vibrations and provides guidelines for test duration, frequency range and intensity. ISO 13355 is important because it helps to replicate realistic transport conditions in a

controlled test environment.

ISTA procedures (International Safe Transit Association) offer various test protocols for specific transport scenarios. ISTA has developed procedures for different packaging types and distribution channels, from small parcels to large pallets. These procedures are practical and help identify weaknesses in your packaging design.

Following these standards has several advantages. First, they ensure consistency in test results, regardless of where or when the test is performed. Second, they provide a common language for packaging specialists worldwide. Third, they provide clear acceptance criteria – when has a test passed and when has it failed?

By testing according to these recognised standards, you can confidently demonstrate that your packaging meets the requirements for safe transport, which is especially important when transporting [sensitive equipment for defence applications](#).

Why do vibration profiles differ per transport method?

Vibration profiles differ greatly per transport method because each mode of transport generates unique movement patterns, frequencies and intensities. Understanding these differences is crucial for developing effective packaging solutions.

Road transport produces a wide spectrum of vibrations. The frequencies vary depending on the vehicle type, speed, road quality and vehicle suspension. Typically, frequencies range between 1 and 200 Hz, with peaks around 3-5 Hz (vehicle suspension) and 10-20 Hz (wheel resonances). Road transport can also cause sudden shocks due to potholes, speed bumps or emergency stops.

Air freight generally has lower vibration intensities than road transport, but presents unique challenges such as pressure changes, low temperatures and turbulence. Most vibrations during flights are between 2 and 50 Hz. Take-off and landing are particularly intense, causing strong vertical accelerations.

Sea transport generates slow, rhythmic movements with low frequencies (0.1-2 Hz) due to wave motion. These movements may seem mild, but can cause significant fatigue damage over longer periods (weeks or months). In addition, severe storms can lead to sudden, powerful movements.

Rail transport produces regular, repetitive vibrations due to the interaction between wheels and rails. The dominant frequencies are between 4 and 60 Hz. Characteristic are the shocks when coupling wagons and when passing switches.

Test protocols are adapted to these specific transport methods by selecting the appropriate frequency ranges, amplitudes and test duration. For products that are transported using multiple transport methods, combined test protocols are often developed that cover all relevant vibration profiles.

By taking into account the specific characteristics of each transport method, you can optimise your packaging for the actual conditions your product will encounter. This prevents both over- and under-protection, resulting in cost-effective and reliable packaging solutions.

What exactly do modern vibration testing devices measure?

Modern vibration testing devices measure various parameters that are essential for understanding transport risks. These measurements provide insight into how products respond to different vibrations and help identify potential weak points.

Frequency is measured in Hertz (Hz) and indicates how many vibration cycles occur per second. Different transport methods generate different frequency ranges, and products react differently to specific frequencies. Modern testing equipment can accurately measure and generate frequencies from 0.1 Hz to over 2000 Hz.

Amplitude indicates the size or intensity of the vibration and is usually measured in millimetres (mm) or inches. It describes how far an object moves during a vibration. Larger amplitudes mean more intense movements that can cause more stress on the product.

Acceleration is measured in g-forces or m/s² and is a crucial parameter because it is directly related to the forces acting on a product. High acceleration values can lead to structural damage, loosening of components or displacement within the packaging.

Resonance occurs when the frequency of external vibrations matches the natural frequency of a product or component. Resonance amplifies vibrations, which can lead to extreme movements and potential damage. Test equipment can identify resonance points by measuring the product's response at different frequencies.

In addition to these basic parameters, advanced systems also measure:

- Power spectral density (PSD), which reflects the energy distribution across different frequencies
- Transmissibility, which indicates how vibrations are transmitted from the packaging to the product
- Damping properties, which show how well packaging materials absorb vibrations

The collected data is analysed using specialised software that generates graphs, spectra and statistical analyses. These analyses help to identify critical frequencies, evaluate packaging performance and predict potential transport risks.

By accurately measuring and analysing these parameters, we can develop packaging solutions that provide exactly the right protection for specific transport scenarios.

How do you translate test results into better packaging solutions?

Translating vibration test results into effective packaging solutions is a crucial step in protecting your products. With the right interpretation and application, you can make targeted improvements that significantly reduce damage during transport.

Start by **analysing the weak points** that emerge from the tests. Look specifically at which frequencies cause the most damage, which product components fail first, and under what conditions problems occur. These insights point directly to the aspects of your packaging that need improvement.

When **selecting packaging materials**, it is important to choose based on the test results. Different materials have unique cushioning properties:

- Foam materials such as polyethylene or polyurethane are effective at absorbing shocks and high-frequency vibrations
- Corrugated cardboard offers good protection against mid-frequency vibrations and light impacts
- Air cushions and bubble wrap are suitable for lightweight products and protect against shocks
- Wooden crates or aluminium cases offer structural protection against heavy impacts and compression.

The **construction techniques** of your packaging are just as important as the materials. Test results may indicate the need for:

- Improved fixation to limit movement within the packaging.
- Strategically placed reinforcements at vulnerable points.
- Multiple layers of protection for extremely sensitive components.

- Special suspension systems that isolate critical frequencies

Remember to **test iteratively**. After making improvements, retest to verify that the problems have been solved without creating new weaknesses. This cycle of testing, improving and retesting leads to optimised packaging solutions.

It is also important to find the **balance between protection and cost**. Excessive protection leads to unnecessary costs and environmental impact, while insufficient protection results in product damage. Test results help you determine the right amount of protection for your specific transport scenario.

By systematically translating test results into concrete packaging improvements, you can develop solutions that effectively protect your products from the specific challenges of transport, regardless of the destination or transport method.

Conclusion

Realistic vibration tests are essential for developing packaging solutions that truly protect your valuable equipment during transport. By choosing the right tests, following international standards and applying test results intelligently, you can significantly reduce transport damage.

Understanding the different vibration profiles for each transport method enables you to provide targeted protection for specific transport scenarios. Modern testing equipment provides detailed insight into how your products respond to different transport conditions, leading to better, cost-efficient packaging solutions.

At Faes, we understand that fragile equipment deserves optimal protection. We use advanced vibration testing to develop customised packaging that perfectly matches your specific transport challenges. This ensures that your equipment arrives at its destination safely, intact and ready for use.

Frequently Asked Questions

What are the most common mistakes made when performing vibration tests?

The most common mistakes are choosing a test protocol that is too short and does not provide a realistic simulation, not securing the product correctly to the test platform, and ignoring resonance points. Incorrect test parameters are also often selected that do not correspond to the actual transport conditions. To avoid these mistakes, it is important to work with experienced test specialists and follow the appropriate international standards.

How can I determine whether my current packaging provides sufficient protection without extensive testing?

Although extensive testing is the most reliable method, you can make an initial assessment by looking at transport damage history, performing a visual inspection of returned products, and comparing your packaging with industry standards for similar products. A quick “field test” in which you expose the packaging to limited transport conditions can also provide insight. Keep in mind that these methods do not offer a complete guarantee and do not replace professional testing.

What data should I collect during actual shipments to improve my vibration testing?

To optimise vibration testing, it is valuable to collect data on acceleration, shock, and vibration during actual transport. This can be done with data loggers that record g-forces, frequencies, and temperature changes. Also note transport routes, vehicles used, weather conditions and any special events during transport. This

data helps to create test profiles that more accurately simulate actual transport conditions.

How does testing electronic equipment differ from other products?

Electronic equipment requires specific attention during vibration testing due to sensitive components such as printed circuit boards, connectors and displays. Tests should focus not only on structural integrity but also on functional operation after exposure to vibrations. Pre- and post-test functional checks are often performed to detect subtle defects. In addition, it is important to test for electrostatic discharge and electromagnetic interference that may occur during transport and handling.