

**The Mechanism of Vibration / Shock
in Containers**

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Terminology

Acceleration	: The rate at which velocity changes per unit time. Acceleration is generally expressed in m/sec^2 . "G" is also used as a unit of acceleration, in which $1 \text{ G} = 9.8 \text{ m/sec}^2$ (= Gravitational acceleration).
Vibration	: Periodic movement undergone by gear and equipment. [JIS-B-0153]
Period	: The minimum interval at which the same conditions recur in a periodic process. The unit is "sec." [JIS-Z-8106]
Frequency	: The number of waves per unit time; frequency can be expressed as the inverse of the period. The unit is "Hz."
Shock	: A sudden non-periodic movement of gear or equipment. [JIS-B-0155]

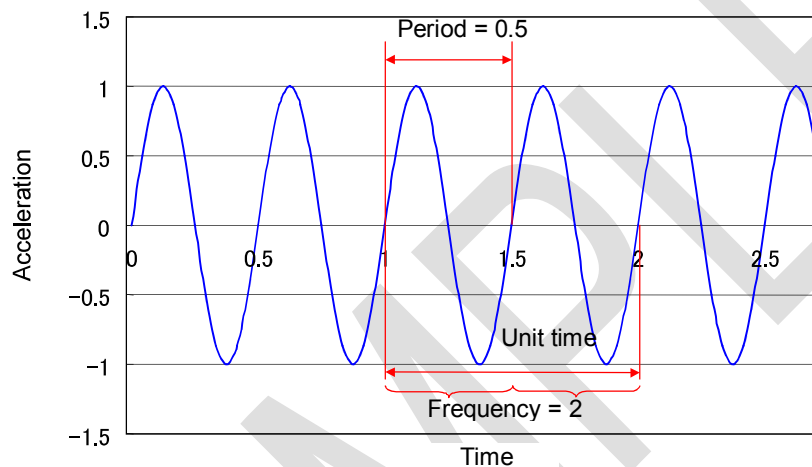


Figure 1: Vibration waveform, showing period and frequency
(In this example, the period is 0.5 and the frequency is 2, the inverse of the period)

1 Types of acceleration in the container transportation process

The types of acceleration in the container transportation process are shock acceleration and vibration acceleration.

Freight containers are generally transported by such means as trucks, railcars, and ocean-going vessels, and are subject to dynamic acceleration during transportation. Similarly, containers are also subject to acceleration during loading and unloading operations at warehouses or container terminals.

Such acceleration can be grouped roughly into vibration acceleration and shock acceleration according to the characteristics of incidents in transportation processes.

Vibration acceleration means the acceleration that continues through a repeating periodicity, and shock acceleration means the non-periodic acceleration that occurs suddenly and momentarily.

During the transportation process, vibration acceleration and shock acceleration are caused repeatedly, and they can sometimes adversely affect the cargo stowed inside the container.

2 Vibration phenomenon

Vibration is a phenomenon in which acceleration occurs continually. It can occur during the transportation of a container by truck or railcar. Vibration can cause material fatigue damage and abrasion of cargo surfaces.

2.1 Characteristics of vibration acceleration

Vibration is a phenomenon in which acceleration occurs continuously and periodically, and it can occur at any time in a transportation process. The magnitude of vibration acceleration is relatively small compared with that of shock acceleration discussed later.

The characteristics of vibration are acceleration, frequency, and duration.

Frequency is the number of waves generated per unit time, and duration is the period for which periodic movements continue.

The effect on cargo stowed inside a container is determined not only by the magnitude of vibration acceleration but also by the frequency, which is closely related to resonance (discussed below) and duration.

2.2 Resonance

When you hit an object with a hammer or the like, the object will start to vibrate. The frequency of that object's vibration thus is called the natural resonance frequency, one that is specific to the object.

When, during transit, the external force of a frequency applied to cargo nears the resonance frequency of that cargo, its displacement, velocity, and acceleration increase. This phenomenon is called resonance; damage from resonance can be prevented by comparing data and avoiding sympathy between the natural resonance frequency of the cargo and the vibration frequencies that may occur during transportation.

The resonance frequency of cargo is determined by its weight and the durability of its packaging and cushioning materials (elastic modulus), so it will be important to design shock-absorbing packaging that inhibits resonance. However, when cargo is composed of more than one component, the resonance frequencies of the individual components should also be taken into consideration.

2.3 Transportation processes tend to cause vibration

Vibration always occurs while a container is in motion. In other words, while they are being carried by truck, railcar, or vessel, cargoes tend to be subject to forces acting on them over long periods of time. Each transportation means tends to cause vibration characteristic of that means, and the frequencies observed during land transportation are generally higher than those observed during ocean transportation.

2.4 Possible cargo damage from vibration

Vibration and the continued acceleration it applies to cargo can cause the following types of damage:

- Material fracture, the result of fatigue (caused by long-term stress on cargo).
- Damage to all or part of the cargo, the result of displacement and resonance.
- Abrasion to cargo surfaces or exterior packaging.
- Collapse of cargo.
- Screws come loose.
- Spillage or inclination of powder or liquid cargo.