

**The Mechanism of Temperature/Humidity
Fluctuations in Containers**

SAMPLE

Table of Contents

| | | |
|---------|---|----|
| 1 | Container interior temperature..... | 1 |
| 1.1 | Heat transfer in a container | 1 |
| 1.2 | 24-hour cycle of temperature fluctuations..... | 2 |
| 1.3 | Temperature differences between various points in a container | 3 |
| 1.4 | 24-hour cycles of temperature fluctuations differ according to weather | 4 |
| 1.5 | Temperature fluctuations observed in cargo itself | 4 |
| 1.6 | Temperature fluctuations in various phases of a transportation process | 5 |
| 1.6.1 | Temperature fluctuations at vanning / devanning points..... | 5 |
| 1.6.2 | Temperature fluctuations at a container yard | 5 |
| 1.6.3 | Temperature fluctuations at sea..... | 5 |
| 1.6.3.1 | When stowed on deck | 5 |
| 1.6.3.2 | When stowed in a hold | 6 |
| 1.6.4 | Temperature fluctuations during overland transportation | 8 |
| 1.7 | Measures to prevent temperature elevations inside containers | 8 |
| 2 | Relative humidity in container interiors | 9 |
| 2.1 | 24-hour cycles of relative humidity swings | 9 |
| 2.2 | About 100% RH | 10 |
| 3 | About condensation | 11 |
| 3.1 | Mechanism of condensation | 11 |
| 3.2 | Method of inferring the occurrence of condensation..... | 12 |
| 3.3 | Difference by the point where condensation occurs..... | 13 |
| 3.3.1 | Condensation on a container's ceiling and wall surfaces..... | 13 |
| 3.3.2 | Condensation on cargo surfaces | 13 |
| 3.4 | Countermeasures against condensation damage..... | 14 |
| 3.4.1 | To suppress the absolute humidity of air in a container | 14 |
| 3.4.2 | To prevent a drastic temperature change of a surface causing dew formation..... | 14 |
| 3.4.3 | To protect cargos from damage with protective measures, even if condensation occurs | 15 |

1 Container interior temperature

Terminology

| | |
|-------------------------|---|
| Solar insolation | : The direct rays of the sun or the exposure to direct sunlight. |
| Radiation | : Energy radiated or transmitted as rays, waves, in the form of particles. Heat radiation from solar insolation is substantial, and the same amount of heat is radiated from a container in the daytime and nighttime. |
| Heat capacity | : The calories required to raise the temperature of an object by 1°C. The larger the mass of the object, the larger is the object's heat capacity. A large heat capacity means that the object is slow to heat or cool. |
| Specific heat | : The calories required to raise the temperature of 1 g of a substance by 1°C. Specific heat multiplied by the mass of an object gives the heat capacity of the object. |

1.1 Heat transfer in a container

Heat transfer in a container can be illustrated as follows (Figure 1):

| | | |
|------------------|-----------------------------|------------------------|
| Solar insolation | → Container ceiling/walls | → Air in the container |
| | → Surfaces of cargo packing | → Air in cargo packing |
| | → Cargos inside | |

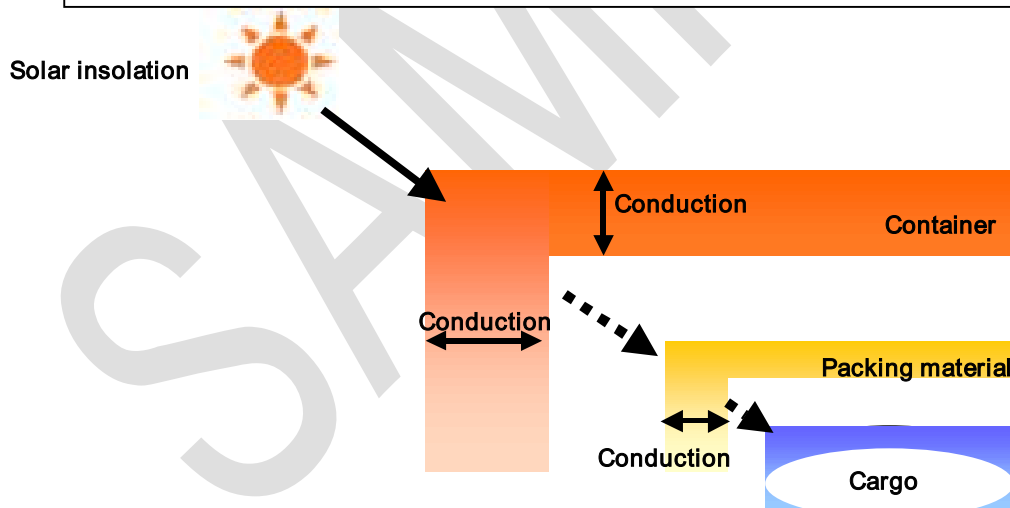


Figure 1: Schematic model of heat conduction in a container

(To be more precise, nighttime radiation and convection both inside and outside a container also contribute to heat transfer.)

In the day, heat from solar insolation is transferred to the container interior through the ceiling and walls of the container, thereby warming the air just inside the container. Next, heat is transferred from that warmed air through packing materials to the interior of the packing, thereby warming the air inside the cargo packing. Heat thus transferred eventually warms the cargo.

At night, when there is no solar insolation, heat is released from the container's ceiling and walls by heat radiation. Similar to the heat flow in the day, heat transfers occur in succession from the container walls and ceiling, to the air in the container near the walls and ceiling, to the surfaces of cargo packing materials, to the air in cargo packing, and finally the cargo surfaces.

1.2 24-hour cycle of temperature fluctuations

When containers are stored in direct sunlight, the 24-hour daily swings in their interior temperatures normally intensify.
When containers are not exposed to direct sunlight, daily temperature swings are moderate.

When a steel container is stored in an open container-yard or in a position subject to direct sunlight on the deck of a container carrier, as illustrated in Figure 2, the container absorbs heat through its ceiling and walls, the temperatures of which rise quickly during the day.

On the other hand, there is no solar insolation at night, and the container ceiling and walls become below an outside temperature because of the outside air temperature and radiation from the container surfaces, which results in the 24-hour cycle temperature swing observed in the container-surface temperature as illustrated in Figure 3.

When a container is stored in shade, however, the container's interior temperature is affected only by fluctuations in the outside air temperature, so the interior temperature's daily swing remains relatively moderate.

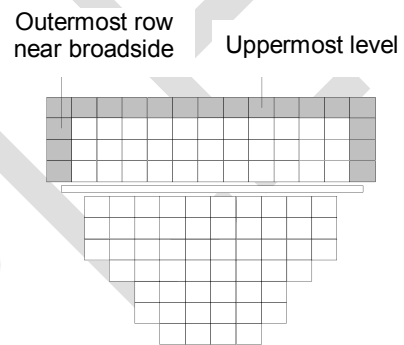


Figure 2: Positions subjected particularly to direct sunlight

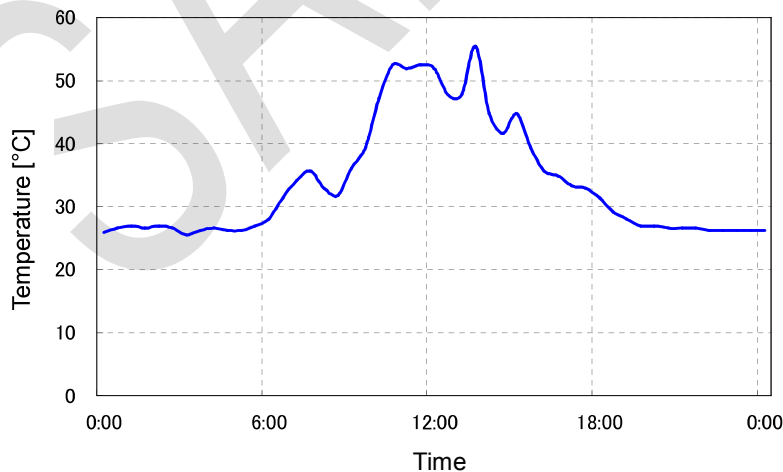


Figure 3: Temperature fluctuations observed of the ceiling of a container stored in a container yard (example)

A 24-hour temperature swing consisting of a rise in the day and a fall at night is observed.