



Established 1898

Container Sweat and Condensation Issues in Transporting Organic & Non-Organic Commodities

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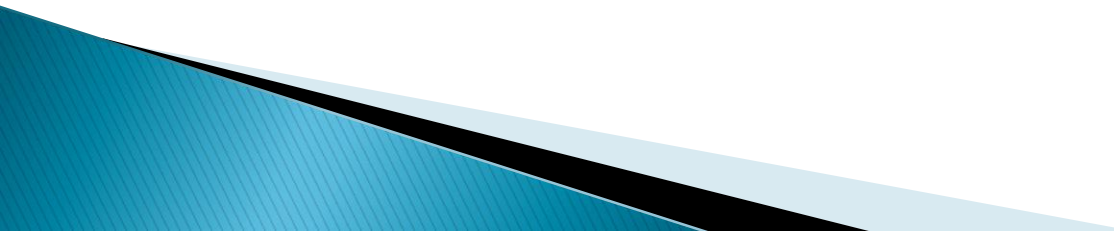
Introduction & Outline

- ▶ What is Condensation?
- ▶ Types of condensation:
- ▶ What causes condensation?
- ▶ Key definitions
- ▶ Condensation Issues:
 - Atmospheric pressure
 - Dew Point
 - Relative Humidity
 - Container Sweat
 - Cargo Sweat
 - Radiation of heat
- ▶ Hygroscopic Commodities
- ▶ Packaging concerns including selection of sea containers and unit packaging design
- ▶ Desiccants & Absorbent Materials
- ▶ Insulation measures
- ▶ Ventilation Strategies and Alternatives
- ▶ Condensation and impact on organic vs. inorganic Commodities
- ▶ Characteristics
- ▶ Prevention strategies

Key Terms & Definitions

- ▶ Condensation
- ▶ Container Sweat
- ▶ Cargo Sweat
- ▶ Saturated Air
- ▶ Dew Point
- ▶ Relative Humidity
- ▶ Saturation & Equilibrium Capacity
- ▶ Dehumidification Mode
- ▶ Radiation of Heat at Terminals and On Board Ship
- ▶ Hygroscopic Commodities
- ▶ Non-Hygroscopic Commodities

Three Shipment Stages

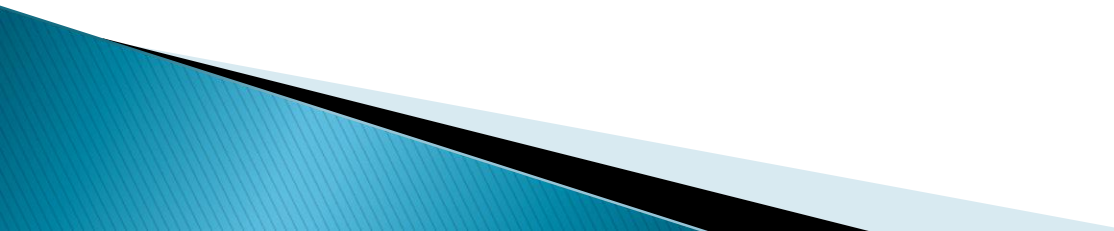
- ▶ The first stage – time from container stuffing until the container is loaded onto a ship. Includes road transport and brief periods of storage.
 - ▶ The second stage is the actual time at sea or aboard a ship.
 - ▶ The final stage begins when container is offloaded from the ship continuing until the freight is discharged from the container. This may include varying periods of time spent in customs, on trains, trucks and in temporary storage
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Xerox Study – Second Stage

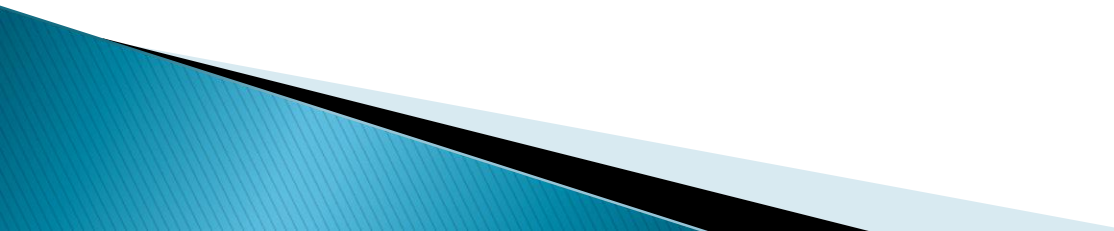
Condensation Impact

- ▶ A two year study conducted by Xerox involved shipping cargo between various lanes and seasons throughout North America, Asia and Europe. Studies concluded that during the actual vessel transit stage, daily cycles of temperature and humidity are usually very minor or completely non-existent (excluding deck cargoes). Temperature changes are gradual, often occurring over days rather than hours. Occasionally, a single temperature/ humidity cycle occurs as the vessel makes stops along the route, extreme conditions are rare. Yet the first and final stage proved daily temperature and humidity cycles are common and may be extreme. These extreme swings play a major role in the underlying cause of condensation conditions and relative damages.

Environmental influences and Condensation Problems

- ▶ Significant temperatures gradients between "summer in the southern hemisphere" and "Winter in the northern hemisphere" are highly possible can severely influence the condensation exposure during an ocean voyage. A sudden fall in temperature can also lead to a higher probability of condensation water formation below the ship's deck or in the container.
 - ▶ The resultant dripping sweat then causes considerable cargo losses. Over intensive cooling of the cargo surfaces may also lead to condensation water formation directly on the cargo (cargo sweat).
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Condensation & Organic Commodities

- ▶ Organic and/or agricultural products retain considerable intrinsic moisture content.
 - ▶ Considered **hygroscopic** cargoes which are in equilibrium with the air in the container and can emit as well as absorb moisture.
 - ▶ The amount of water available within a container of such cargoes is usually much higher than containers loaded with manufactured inorganic product.
 - ▶ Hygroscopic cargoes change temperature comparatively slowly. Thus, when a container is shipped across climatic zones, the cargo adjusts to the changing ambient temperatures much more slowly than the container walls and the air. This delay can cause considerable temperature differences within the container; these are a major driving force for moisture translocation and condensation.
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Organics Condensation



Condensation & Non-Organic Commodities

- ▶ Cargoes which are entirely dry and do not contain measurable levels of moisture, e.g. pure metal products and/or machinery without corrosion protection or surface treatment
- ▶ Extreme variances in relative humidity and dew points causing condensation can have as damaging effect commercially as those which are otherwise in equilibrium such as in the case of organic product.
- ▶ A good example of an inorganic commodity presenting a high susceptibility to condensation is steel cargoes. The main sources of condensation damage to steel are condensation water generated by the conveyance, intermodal container or other means of transport, the cargo itself and within the packaging (particularly hygroscopic packaging materials). Steel cargos require low humidity/moisture conditions and possibly forced ventilation to minimize the condensation risk.
- ▶ Also unsuitable means of transport such as vessels having poor hatch covers or with inadequate ventilation means, damaged containers, uncovered railroad freight cars and trucks, incorrect storage in the open, use of unsuitable tarpaulins, exposed loading in wet weather conditions, and variations in temperature and climatic conditions during long voyages may result in rust damage.

Non Organics condensation



Inside Lid of crate



Water droplets condensed on body of valve



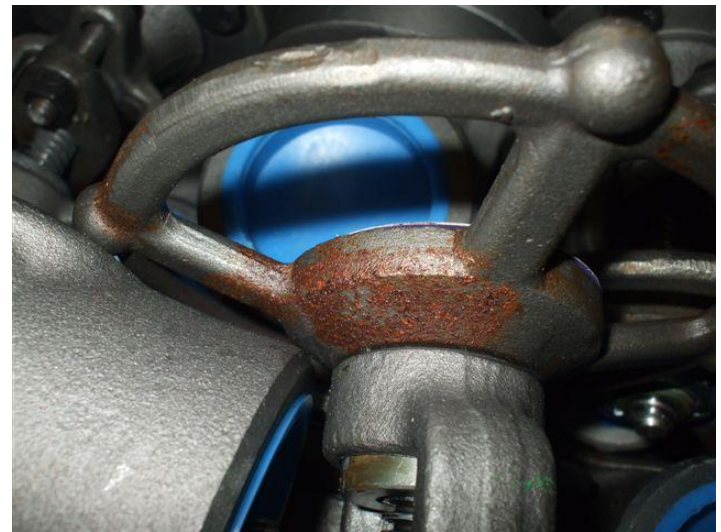
Mold on outside of wood crating



Rust staining of ceiling and sides of steel container



Wet staining of paper liner



Rust on valve from condensation

Ventilation Requirements Steel

- ▶ Goal to reduce the relative humidity to below 60% by appropriate ventilation measures.
- ▶ The inherent nature of steel is such that the surface areas generally exhibit lower temperatures than the external (ambient) temperature anticipated during transit.
- ▶ It is generally understood that if the temperature of the ambient air outside the ship rises, this has only a minimal effect on the temperature of the cargo. In view of this, ventilation with "warm" external air may result in cargo sweat on the "cold" steel, if the temperature of the latter is below the dew point of the ambient air.
- ▶ In such a case, ventilation may encourage corrosion. Considering that a consignment of steel is warmer than the external temperatures anticipated in transit.
- ▶ Ventilation may be performed without any risk of cargo sweat formation but cooling of the ship's sides may cause their temperature to drop below the dew point of the hold air, resulting in ship sweat inside the hold. In this case, the temperature of the hold air should be adjusted by ventilation to match that of the external air.

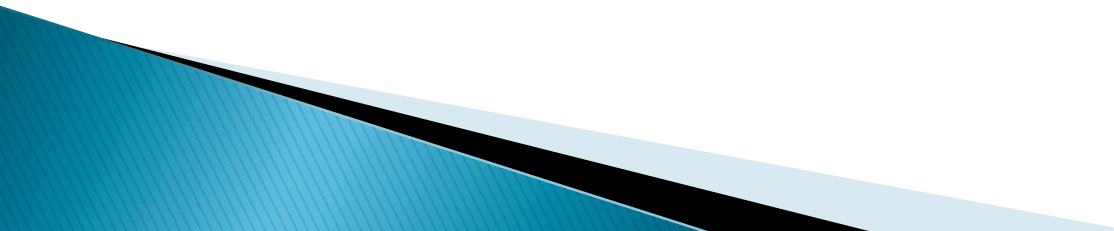
VENTILATION RULE

**“Hot to Cold ventilate
Bold, Cold to Hot
Ventilate Not”**


Shipper's Preparation

- ▶ Packaging Considerations:
 - Commodity packaging
 - BAGGED CARGO
 - BALES & BUNDLES
 - CASES, CRATES, CARTONS:
 - Container Selection flexibility of the container's wall structure considered.
 - Desiccant Selection and Quantity

Container Suitability

- ▶ To Ventilation or not to Ventilate
 - ▶ Equipment Selection
 - General Purpose (GP) Containers
 - Ventilated Containers
 - Fantainers
 - Open Containers
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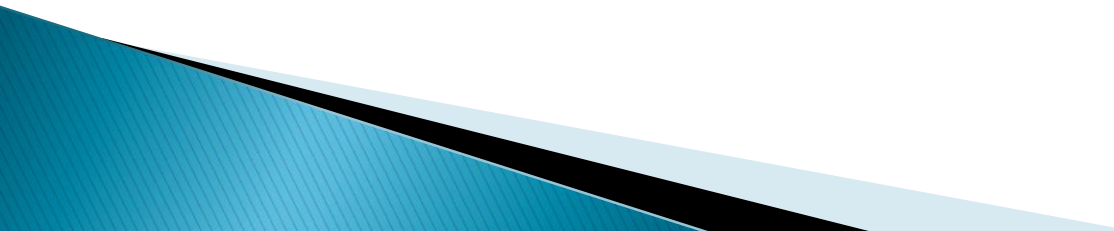
Container Inspection Criteria

- ▶ Confirm weather-tight integrity i.e. watertight against rain and spray
 - Inspection of all sidewalls, roof and floor of the container.
 - Inspect all visible repairs to ensure quality of repair
 - Confirm all door seals are pliable and absent of dry-rot
 - No Light entering through the roof, sidewalls or floor
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Container Stuffing (Pre/post completion)

- ▶ Apply suitable dunnage to separate the cargo from the container's walls and floors. This cannot prevent the formation of condensation, but can significantly reduce its commercial implications.
- ▶ Kraft paper or similar material to line the walls and floors of containers or as protective sheets on top of the cargo. Serves to absorb small amounts of condensation and in some circumstances prevent or reduce staining and similar damage.
- ▶ All wooden packaging, skids and dunnage must be dry. Moisture content should be less than 18%. Particular attention to the container floor is necessary. The humidity of the wood should not be above 18%. The use of de-humidifiers can be beneficial in very special cases to ensure a dry container is presented for loading.
- ▶ Use of handheld devices (moisture meter) as a cost effective means to validating moisture monitoring process.
- ▶ Storage of pallets in dry environment.
- ▶ Consider the insertion of temperature and humidity indicators inside the container to monitor internal container conditions during transit.
- ▶ Use the results of the monitored shipments to gauge the amount of desiccant/protection required for future shipments based on cargo and transit lanes

Types of Desiccants

- ▶ Montmorillonite Clay
 - ▶ Silica Gel ($\text{SiO}_2 \cdot \text{H}_2\text{O}$)
 - ▶ Molecular Sieve (Synthetic Zeolite – $\text{Na}_{12}\text{Al}_3\text{Si}_{12}\text{O}_{48} \cdot 12\text{H}_2\text{O}$)
 - ▶ Calcium Oxide (CaO)
 - ▶ Calcium Sulfate (CaSO_4)
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Application of Desiccants

- ▶ Place desiccants throughout the stow during loading, unfilled header areas and more at the rear after completion of loading. Since desiccants absorb moisture as soon as they are exposed to air, they should be kept in original packaging until ready for use.
- ▶ Appropriate use of desiccant bags or strips (a rule of thumb = 32 one-pound bags of desiccant for a 20-foot container for a typical 30–40day overseas voyage) depending on the following: length of voyage, stowage during voyage: deck or below deck.

How Desiccants Work

- ▶ Most porous adsorbents, such as silica gel, activated clay or molecular sieves rely upon physical adsorption rather than chemical adsorption to accomplish their function.
- ▶ Physical adsorption involves relatively weak intermolecular forces (van der Waals forces and electrostatic interactions) between the moisture and surface of the desiccant.
- ▶ Chemisorbents, such as calcium oxide, involve an actual chemical bond. Physical adsorption of moisture is typically exothermic. The strength of the adsorptive bonds can thus be measured by the heat of adsorption. The higher the heat of adsorption for moisture on the desiccant, the stronger the bonding and the less easily that moisture can be subsequently removed.
- ▶ In a porous desiccant such as the silica gel used by Dri-Box, water is removed from the airspace by multi-layer adsorption, which is the attraction of thin layers of water molecules to the surface of the desiccant. Because the desiccant is very porous, the surface area is high and significant amounts of water can be attracted and adsorbed;
- ▶ By capillary condensation in which the smaller pores become filled with water. Capillary condensation occurs because the saturation water vapor pressure in a small pore is reduced by the effect of surface tension.

Vapor Barrier Packaging & Shrink Wrapping

- ▶ Vapor Barrier Packing involves enclosing electronic items or parts with extremely sensitive metal surfaces in a water-vapor-proof foil barrier. The items are cushioned and activated desiccant is placed in the bag prior to sealing all seams. One corner of the bag is left open and a vacuum is used to remove excess air and the opening sealed. Packing in this method reduces the humidity inside the barrier to very low levels.
- ▶ This method of protection is particularly important for sensitive items that are being shipped via ocean transport where salt-laden moisture could invade and jeopardize product integrity.
- ▶ When items are packed in this method for military packaging, humidity indicator cards are placed inside the bag and this area is marked for opening at periodic intervals to check the condition of the desiccant. Humidity indicator plugs that protrude through the foil barrier are also available so that so the barrier does not have to be opened to check the desiccant status.
- ▶ Vapor Barrier Packing protects the items within the foil barrier for twelve to eighteen months. Different foil materials from standard polyethylene-foil-polyethylene on lighter items to scrim-foil-nylon for large items such as generators weighing hundreds of thousands of pounds.

Examples of Vapor Barriers applied to various machinery for export shipping



Examples of Vapor Barriers applied to various machinery for export shipping



PLASTIC WRAPPING

Examples of Shrink Wrapping applied to various equipment configurations

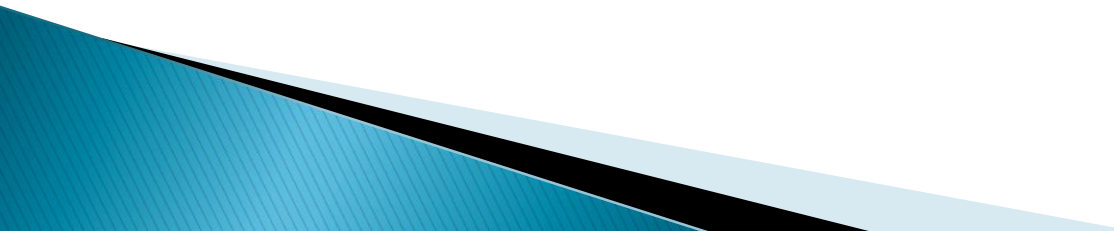


TRANSIT ISSUES

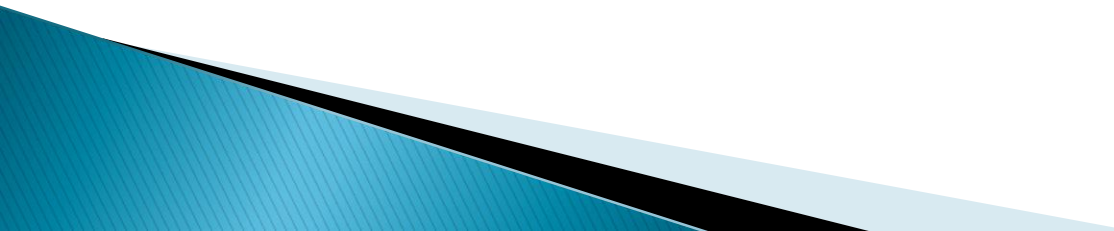
- ▶ **Minimize Radiation of heat at Terminals and On board Ship**
- ▶ Where possible cargoes sensitive to condensation must be protected from the extremes of radiant heat and extreme cold
- ▶ Terminal stack: shaded stow required.
- ▶ Aboard ship: under deck stow or protected inner block deck stow required.
- ▶ Stowage Considerations: Heat sources(Bunker tanks, engine compartments)
- ▶ At destination, advance delivery notification is important to enable delivery to be carried out for sensitive/hygroscopic cargoes arriving at terminals with near zero temperatures. In such cases the cargo can experience what "cold shock" of first night ashore.

Claims and Subrogation

Considerations

- ▶ “All Risks” does not mean “all losses”, but losses caused by *fortuitous circumstances*; namely, accidental losses as opposed to losses that are bound or certain to happen given the nature of the property insured or the voyage in question.
 - ▶ The requirement that the cause of the loss be “fortuitous” excludes the natural and inevitable action of wind and waves, ordinary wear and tear, *inherent defects*, and intentionally caused losses.
 - ▶ What is essential in order to establish that the loss is “fortuitous” is an accident caused by the intervention of negligence, or adverse or unusual conditions without which the loss would not have occurred – There must be some casualty, something which could not be foreseen as one of the necessary incidents of the adventure.
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Claims and Subrogation Considerations

- ▶ Marine “all risks” policies contain a specific exclusion for loss caused by “*inherent vice* or nature of the subject-matter insured”.
 - ▶ The term “inherent vice” refers to a loss “stemming from qualities inherent in the thing lost”.
 - ▶ One of the most frequent applications of the term is in cargo insurance, where it refers to the inherent tendency of the cargo, shipped as it is, to sustain damage.
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Claims and Subrogation

Considerations

- ▶ The “inherent vice” exclusion is also used to describe a loss that, due to the manner in which the cargo is shipped, is regarded as inevitable. For example, fresh eggs shipped without any packing or protection are likely to sustain damage no matter how carefully they are handled. It would stand to reason that chocolates shipped in an ordinary container in the heat of summer are bound to melt. Damage that occurs in the course of ordinary handling and transportation of cargos, without the intervention of fortuity, is due to inherent vice and should be excluded from coverage.

Claims and Subrogation

Considerations

1. Claims and subrogation opportunities are driven by an analysis of the fortuity of a condensation event.
 - ☐ Was inherent vice of the commodity a factor?
 - ☐ Was insufficiency of packaging a factor?
2. *Expert evidence* is required to establish *what caused the damage, what brought the moisture into the container or hold, and how that moisture interacted with and damaged the cargo*. Was the container breached during transit e.g. a hole in a container or serious storm damage allowing water to enter the container or hold.
3. What product is involved?
4. Was there is some accidental or unexpected event *leading to the moisture finding?*
5. The provision of dunnage materials e.g. kraft paper, plastic covering and desiccants might suggest awareness of a potential condensation exposure. Who is responsible to assure that these materials are made available? In the modern container era where many containers move as shipper's load and count is responsibility borne by shipper or carrier?

Closing Comments

Condensation is a insidious exposure which warrants proactive preventative measures and supply chain awareness to assure a thorough understanding of the conditions likely to lead to condensation. Commodity susceptibilities, influencing factors and measures available to prevent and mitigate the potential effects must be considered in any risk avoidance strategy.

Thank You!



QUESTIONS?

