

Condensation Control

Revised 2008

Two manifestations of condensation that must be controlled are:

1. Fogging at entrance doors to frozen food storage spaces.
2. Moisture condensation on packages brought from refrigerated spaces into warm, humid environments

These two occurrences of condensation are quite different and are avoided by different measures.

Fogging at Entrance Doors to Storage Spaces

This phenomenon is readily visible when the door to the frozen food storage space is open and the air conditions on the loading dock are humid. The existence of fog is undesirable because the fog is composed of minute drops of water which, when they fall to the floor, freeze and cause slick and dangerous surfaces for workers. Some of the fog migrates to products where it freezes on the surfaces of the packages. This process normally causes no harm to the product, but if it does not evaporate or sublimate by the time the package reaches the retailer the appearance of the product is less desirable.

The mechanism of formation of the fog is shown below in the psychrometric chart. The condition of the air in the frozen food storage space is shown in relation to several possible conditions of the air on the dock.

If the dock air is shown by point A in the graph, this air mixes with some of the air in the freezer space. The condition of the air after mixing lies on a straight line, which if it is to the left of the saturation line results in supersaturated air containing drops of water, commonly called fog.

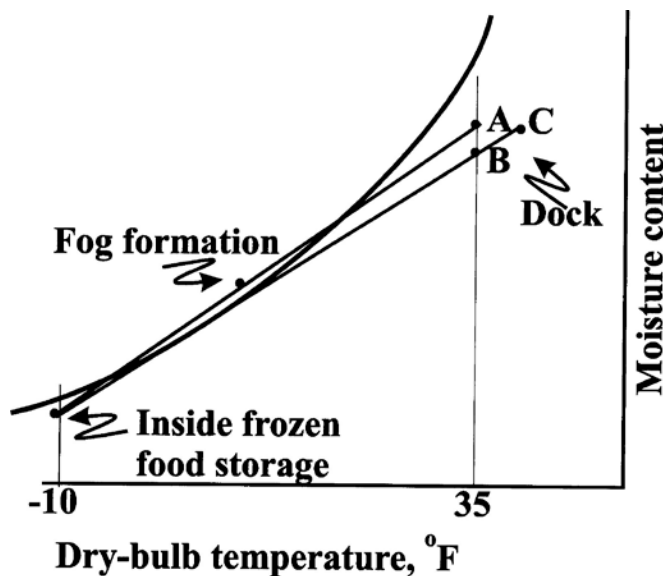


Chart 1: Psychrometric chart illustrating fog formation and its prevention.

The easiest way to prevent the formation of the fog is to alter the conditions of the dock air. If the humidity of the dock air can be lowered from point A to point B, the straight line between B and the cold room is in the limited case tangent to the saturation line of the psychrometric chart, and no fog will form.

There are several ways in which the dock humidity could be lowered from point A to point B, including:

1. To apply heat into the dock by, for example, a coil served by hot refrigerant. This heat forces the cooling coils to operate with greater capacity to maintain the set dry-bulb temperature on the dock and in the process extracts more moisture from the air.
2. To reduce the humidity in the space by installing a desiccant dehumidifier, normally mounted on the roof, thereby extracting air from the dock area and returning low-humidity air.
3. To install an air curtain equipped with a heating coil. The dock air at point A circulates in the curtain and is heated to condition C. When this air mixes with the air inside the refrigerated space the point after mixing is on or to the right of the saturation curve, so fog is avoided.

Moisture Condensation on Packages in Humid Areas

Moisture condensation occurs when the temperature of the surface of the product or package is lower than the dew-point temperature of the surrounding air. When the surface temperature of the product or package is above 32°F (0°C) the condensate forms as liquid water. When the surface temperature is below 32°F (0°C) the condensate is solid; either ice if the water condenses before freezing or as frost if the water vapor passes directly from vapor to solid.

Water vapor in the air of a refrigerated space migrates to the coldest surface, which in the case of an area under refrigeration will be the surfaces of the coil. The coil is equipped with a drain to dispose of the condensate which collects as liquid on the coil or forms from melted frost in the case of a low-temperature coil. Sometimes product stored near a doorway will attract condensate when warm, humid air infiltrates. This condensate will ultimately vaporize and deposit on the coil. Condensation forms more rapidly on metal surfaces than on, for example, cardboard cartons, because the high conductivity of the metal rapidly carries away the heat from the environment keeping the surface temperature cold.

The basic principles for maintaining the product or package free of condensate are:

1. Cover the surface with a vapor-tight material that prevents access by warm, humid ambient air, so that any condensation occurs on the sacrificial cover and the product or package is not affected.
2. When warming a cold product in an air stream, strive for low humidity air that is at least 10°F (5°C) higher in temperature than the surface and attempt to blanket all of the surfaces with a flow at high-velocity. The strategy behind these recommendations is to elevate the surface temperature of the product or package above the dew point temperature as rapidly as possible. Even though the interior of the object is cold, so long as the surface temperature is above the dew point, condensation will not occur.

The more products a warehouse stores, picks and ships, the more issues associated with condensation can negatively impact performance. However, understanding of the root cause, controls and affects of condensation can effectively minimize damage and claims as a result of temperature and humidity changes during distribution. Many warehouse operators decline to store moisture-sensitive products due

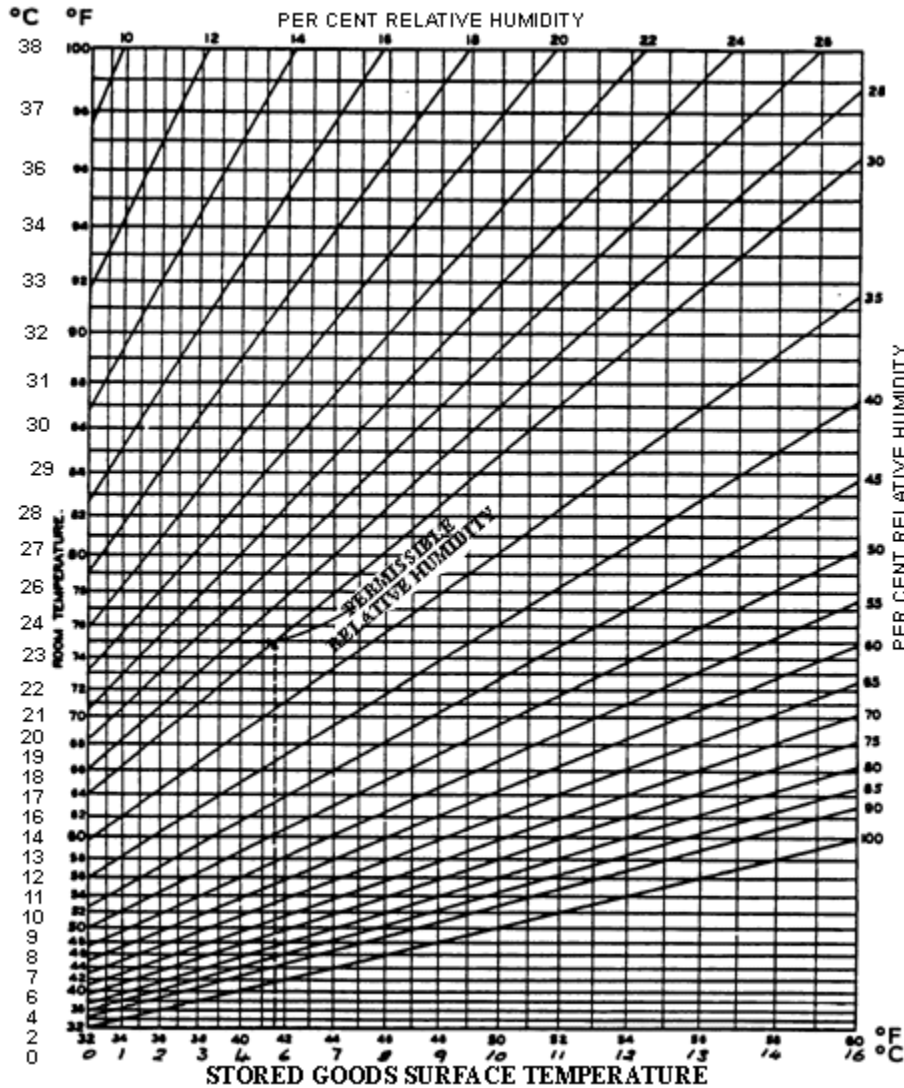
to fear of moisture condensation damage. This over-caution appears unwarranted. Five common and effective methods of controlling condensation are described briefly. It should be noted that in some cases a combination of two or more of the methods might be used.

1. **Raising the temperature gradually by tempering.** This is the most generally used means of preventing condensation since it is applicable to all products. There are two methods of warming up refrigerated products.
 - a. The first method is to turn off the refrigeration and allow the room and contents to warm up at the rate of about 2°F (1°C) each 24 hours. This is the method used with canned milk and other products stored in full room blocks. In this way, about 18 days are required for tempering a lot of canned milk from 30 to 70°F (-1°C to 21°C). This method is impractical with large rooms, rooms with multiple products or rooms separated by moisture permeable walls.
 - b. The second method is to move the product successively to a warmer room. This is used with candies and other products when it is desired to remove broken lots from refrigeration. If a series of tempering rooms is not available, one of the methods given below should be used.
2. **Preventing condensate formation or evaporating it with rapidly circulating, warm, dry air.** This is the most rapid, practical means of warming up products without condensation. It consists of placing individual cans, boxes, or other units of products in a current of warm, dry air, moving at the rate of 500 ft. per minute or faster. The air must move over the top, bottom, and sides of each container on which condensation is suspected. Due to this limitation, cased goods or pallet loads must be spaced so that air will pass between each unit.
3. **Protective Packaging.** Many refrigerated products are virtually free of condensation problems because of excellent packaging. Among these are military rations, boxed candies, most dried fruits, dried milk, butter, cheese, and many others. Protective packaging consists of providing a moisture barrier of aluminum foil, flexible film, or coating about the product or container so that condensate forms on the barrier instead of on the sensitive product. If the package is completely sealed against the entrance of vapor pressure, a product may be safely moved directly from 0°F to 70°F (-18°C to 21°C) without damage from condensation.
4. **Use of temporary moisture barrier during warming up.** As an outgrowth of the remarkable success of protective packaging to prevent damage from condensation, experiments were conducted on the use of a temporary package or "rain coat" to protect the product during the critical warming up period. It was found that by placing the refrigerated products (individual cans, cases, pallets or larger lots) in a temporary, moisture-proof, shrink-wrap enclosure, they could be moved directly from 32 or 0°F to 70°F (0 or -18°C to 21°C) without damage from condensation. The enclosure may be a large, flexible moisture-proof bag, blanket, or a rigid prefabricated box or "room." For this method of preventing moisture condensation to be effective,
 - a) the construction material must be a perfect moisture barrier;
 - b) the package must be sealed against the entrance of moisture vapor;
 - c) the product must be "packaged" in the cold room; and
 - d) the product must remain in the temporary package until it reaches room temperature. The temporary package may then be removed.

- Condition of product while in transit.** Frozen products may be quickly removed from the freezer to an insulated carrier (truck, trailer, or car), quickly and securely closed, and allowed to warm up gradually over a period of 4-6 days without the air on the inside of the carriers reaching the dew point. At the end of the haul, the product can be moved to room temperature without condensation.

Controlling Moisture Condensation

The graph below provides information pertaining to the permissible room relative humidity (RH) without surface condensation. This graphic is for stored goods in transit from refrigerated to non-refrigerated room conditions. To read the graph, follow the intersection of the “Goods Surface Temperature” line with the “Room Temperature” line. The intersecting number on the diagonal RH line gives the relative humidity permissible in room without surface condensation.



Example: If stored goods are to be moved from a room at 41.5°F (5.3°C) to a room at 75°F (24°C), the relative humidity in the 75°F (24°C) room must not be over 30% in order to avoid condensation. As surfaces rise in temperature, a higher relative humidity can be tolerated.

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