MEAT RESEARCH NEWS LETTER

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MEAT RESEARCH LABORATORY

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CONDENSATION

Have you noticed water droplets forming on the outside of a glass of beer or lemonade on a hot day? Of course you have. It is called condensation and this News Letter will deal with some aspects concerning condensation in the Meat Industry.

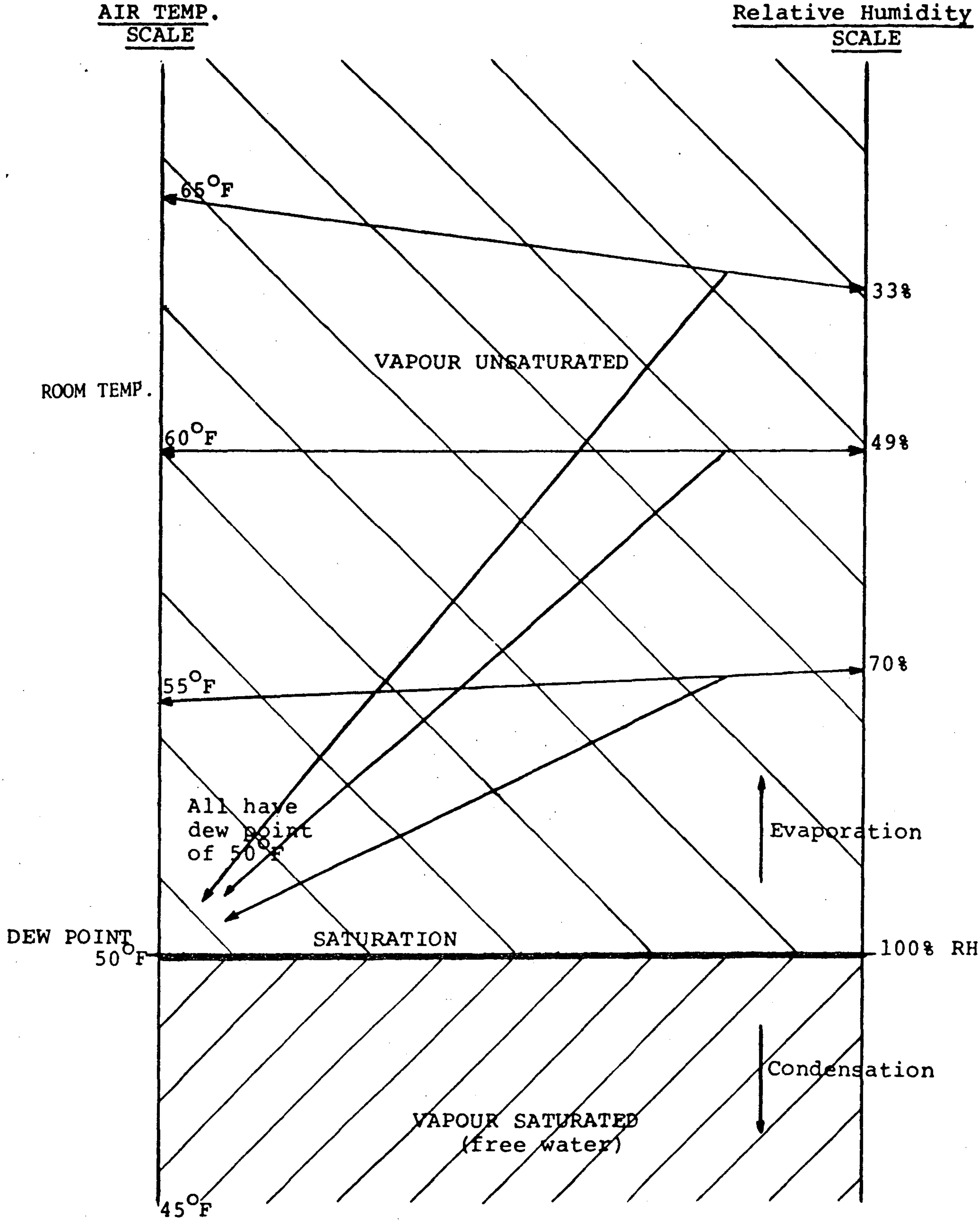
WHY CONDENSATION OCCURS

If a sample of air containing water vapour is cooled down slowly without change of volume, a temperature is reached at which water will start to condense out either as droplets in the air (fog) or as liquid water on solid surfaces in contact with the air. Condensation will begin at the coldest point in the system. The temperature at which water vapour starts to liquify in any sample of air is termed the DEW POINT of that sample. Conversely, if the system is now heated fog or liquid water will evaporate at all points above the dew point. The dew point of a particular sample of air is related to its temperature and relative humidity - if the dew point is known the relative humidity at any temperature can be calculated or conversely if the temperature and relative humidity are known the dew point can be found. When the temperature of a volume of moist air reaches its dew point its relative humidity is 100% and it is said to be saturated. For temperatures above the dew point, relative humidity falls whilst below the dew point it will be maintained at 100% as excess water condenses. Figure I gives an indication of how these concepts fit together.

The idea of dew point is useful in discussing condensation phenomena - the dew point of a mass of moist air is independent of its temperature at temperatures above the dew point, whereas the relative humidity of a closed system above the dew point changes with temperature. In a sense, the dew point is a measure of the amount of water vapour in a particular sample of air - if water vapour is added or removed the dew point will change.

FIGURE I

Diagram showing relationship of dew point to air temperature and relative humidity



In the above diagram the three sets of conditions all have a dew point of 50°F.

When water condenses on a cold surface a considerable amount of heat is liberated (roughly 1050 BTU/lb at $50^{o}F$). Consequently, if heat is not removed from the surface its temperature will rise. At the same time, owing to the removal of the water vapour from the air, its dew point will fall (unless there is a source of water vapour in the system) and the system will reach equilibrium when the surface temperature and the dew point are the same, that is, when the air is saturated or at 100% RH. In contrast, evaporation requires the input of heat.

We may summarise the above in <u>three rules governing condensation</u>:

(1) Condensation will take place on a surface if its temperature is less than the dew point of the surrounding air,

(2) it will continue provided there is a heat leakage path allowing for the removal of the latent heat of condensation, and

(3) provided a supply of moisture is available to the surrounding air.

Rules (2) and (3) are really contained in (1), e.g. if no heat leakage paths exist, the temperature of the surface will rise and eventually come to the dew point so that no further condensation will take place. If there is no moisture supply, condensation will cease as soon as the dew point falls to the temperature of the cold surface. They have been put in this fashion because whilst rule (1) determines whether or not condensation will take place, (2) and (3) set the rate at which condensation occurs.

TYPES OF CONDENSATION

Condensation on a surface occurs either as a film or as droplets.

The mechanism determining which type of condensation will take place is not fully understood. The type of condensation appears to vary with surface and moist air condition, temperature and other factors. The rates of condensation are different for both - droplet condensation being faster than film for the same conditions. Very clean surfaces will support film condensation whereas impurities in the vapour or on the surface (especially fatty materials) promote droplet condensation.

WHERE CONDENSATION WILL OCCUR

Using the above three rules, it is possible to predict which areas in plants are likely to be troubled with condensation:

(1) Walls or ceilings between colder and warmer areas.

e.g. The walls between blast freezer or freezer stores and other facilities. Here the "hot" side of the wall can be maintained below the dew point by conduction of the latent heat of condensation to the cold side.

(2) Doors and other openings between cold and warm areas.

Heat leakage in the vicinity of doors may be considerably greater than that through the wall i.e. condensation will appear near doors whilst it may not be present on walls.

(3) Ductwork.

Temperatures inside a duct carrying refrigerating air must be colder than that of the surrounding air. Often the rooms in which ducts are used are working areas with high relative humidity and high dew point. This leads to duct surface temperatures well below the ambient dew point. If the duct is simply of sheet metal construction an excellent heat leakage path is available to allow the formation of copious quantities of condensation.

(4) Areas in Cold Rooms which have Intermittent Contact with Outside Air.

External air generally has a dew point well in excess of the cold room internal surface temperatures. During times of contact with this external air, considerable condensation may take place. After closing the door and turning on the refrigeration the heat released by condensation will be removed from the wall. However, the moisture deposited on the wall will only be removed by evaporation and this is a slow process. If this door is opened again, condensation is repeated with a consequent build up of water on the wall.

These examples by no means exhaust the situations where condensation can occur. It is hoped that they serve to show how the causes of particular cases can be explained and perhaps corrected.

DEALING WITH THE PROBLEM OF CONDENSATION

As with any problem two types of remedy are available.

(1) Prevention
(2) Cure

In the first case, we wish to prevent condensation altogether and in the second, once condensation has formed, we would like to remove it as rapidly as possible. This second approach might be useful as a cure in cases of intermittent condensation, e.g. at certain times during chilling, to ensure that condensation is present only for a minimum of time. We have already noted that water can be removed by evaporation. Under most plant operating conditions, however, evaporation processes are inefficient in comparison to those producing condensation. In general, once condensation has formed, it is difficult to remove it using means normally available in plant operations. Control of the refrigeration can be used to give periods of high moisture removal. However, this will also remove water from products in the area.

Prevention methods depend largely on the nature of a particular problem. Some methods are given below and are based on application of the rules governing condensation:

(1) Maintenance of Surface Temperatures above the Room Dew Point.

This may be done by mounting heaters on surfaces which are affected e.g. steam pipes may be used on ceilings and electrical heaters have been used on door surrounds. These systems are expensive and require continuous input of heat which may have to be removed by a refrigeration system. When steam systems are used care has to be taken to see that sufficient steam is supplied so that the system is effective over the whole of its length.

(2) Lowering of the Dew Point within the Affected Area.

Dew point can be reduced by the use of low evaporator temperatures or by the use of hygroscopic liquids. Low evaporator temperatures can be used when heatloads are high but this will also produce product shrinkage. When heatloads are small (e.g. in holding rooms), low evaporation temperatures can lead to low temperature overshoot producing temperatures below freezing. Installations involving hygroscopic fluid systems (e.g. lithium chloride brine sprays) are expensive and can give rise to contaminant carry over to products, and they require regeneration or replacement of absorbent materials.

(3) The Removal of Heat Leakage Paths.

Permanent heat leakage paths exist between continuously worked areas (blast freezers, freezer stores etc.) and their surroundings. Heat conduction is reduced by insulation and it is possible to provide sufficient insulation to avoid external temperatures which are lower than the dew points of the surroundings. The thickness of insulation needed to prevent this condensation or "sweat" is generally greater than that required to give acceptable heat leakage from a refrigeration point of view. Charts are available for the calculation of the thicknesses necessary for various conditions. This is one of the matters which should be considered at the design stage of plant construction.

Rather than using metals, which are excellent conductors of heat, it may be advisable to seek alternatives in some constructions e.g. the use of plastic door surrounds would provide less leakage than metal ones. The interposing of false ceilings can decrease the heat leakage sufficiently to prevent condensation. In these cases, care has to be taken to ensure the ceilings are vapour tight. If ductwork is insulated it is possible to reduce considerably the occurrence of condensation on their undersides.

(4) The Removal of Sources of Air with a High Dew Point.

In wet areas or after cleaning, as little water as possible should be left on floors, the more so if the water and/or floors are warmer than other parts of the room or its fittings. Wash water on carcasses entering chillers should be reduced to a minimum. Doors should be kept closed as much as possible and cold areas which are adjacent to areas working at ambient temperatures should be fitted with some form of self closing doors and/or air curtains. Traffic between the two areas should be reduced to a minimum. This is all the more important during those months of the year when humidities and temperatures are high. It may be possible to prevent contact of warm moist air with cold surfaces by sweeping a jet of cold air accross the surface. Ducted air or fans placed in strategic positions can direct flows of low dew point air at troublesome surfaces to prevent contact with moist air.

Many of the above recommendations involve new construction and/or alterations, which are costly and inconvenient in working areas. The problem of condensation should be thoroughly considered at the design stage of the building of new plant and appropriate modification included during construction.

In a number of cases the effectiveness of the above corrective procedures can only at present be guessed. Their actual effect under various plant operating conditions have not been thoroughly studied. As part of its programme the Meat Research Laboratory is to commence investigations on condensation. A questionnaire on condensation has been distributed to most plants in Australia and it is hoped that answers to the questions will give a clearer picture of condensation difficulties. This, together with the results from the investigation, will enable the Laboratory to make more definite recommendations to eliminate or prevent condensation.

NEWS JOTTINGS

A second Ageing School was held during March of this year. Do not hesitate to write or phone if you have queries on ageing meat, or any other matters.

Next Issue will be Cleaning and Sanitation.