MONITORING CHILLER OPERATIONS

By

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The measurement of temperature, air velocity and relative humidity have a significant role in producing a satisfactory product in the meat industry.

Firstly, meat must be produced in such a manner that no harmful bacteria are allowed to grow and cause food poisoning. To do this, the surface temperature of the carcasses must be reduced to below 7°C as soon as possible. No mater how strict the dressing procedures are, there will always be a slight contamination of intestinal bacteria on the meat surface. The temperature and available moisture on the surface must be reduced quickly to prevent the growth of these organisms.

Secondly, the meat must have a satisfactory shelf life. This is obtained by reducing the surface temperature to below 7°C in a minimum time. If the temperature is reduced too quickly the meat will toughen due to cold shortening. This can be prevented by electrical stimulation or aitch bone hanging. If too slow a chilling is practised, surface bacteria will grow causing sliminess and poor keeping.

Thirdly, carcasses must be chilled in a way to obtain the minimum weight loss under the conditions that are available at the abattoirs. If an abattoir was slaughtering 200 cattle, 4,000 sheep and 500 pigs per week, a reduction of 0.5% in the weight loss would represent approx $70,000 per year at current prices.

To obtain correct readings of temperature, air velocity and relative humidity the limitations of the instruments must be known. They vary according to:

1. The design accuracy and the sensitivity of the instruments.

2. The operator's skill.

3. The condition of the instruments.

Thermometers

A NATA certified mercury in glass thermometer should be obtained for checking other thermometers used in the abattoir. These cost approximately $80 and should be handled carefully. The same thermometers without certificates cost $30. These have a accuracy of ±0.5°C for the range of -10°C to 110°C. Being mercury in glass they are difficult to read under poor lighting conditions and are easily broken. They are not recommended for routine temperature checks of carcasses or boxes of frozen meat unless the operator is very careful and aware of the problems that would arise from broken glass and mercury in the meat.

Alcohol in glass thermometers are easier to read but lack the accuracy of mercury thermometers. They should be constantly checked against a standard thermometer.

Bimetallic Coil Thermometers

These rely on a laminate of two dissimilar metals made into a helix. (Figure 1) When the temperature changes there is a difference in expansion of the two metals which causes a twisting effect. This is transmitted by a shaft and a gear to a pointer. These are the popular "Tel-Tru" thermometers and are suitable for measuring the temperature of fresh or frozen meats as they are made of stainless steel and have a plastic dial cover. However, they lack accuracy if they are not handled correctly. If the stem becomes bent or if the dial moves they give inaccurate readings. The current models have an adjusting screw which enables them to be checked against a certified thermometer and recalibrated. The sensing element of these is approx. 5cm long so where a temperature gradient exists, they are not as accurate as an electronic thermometer.

Electronic Thermometers

There are three types of electronic thermometers and they have sensors that may be thermistors, resistance wires or thermocouples.

A thermistor is a bead of metallic oxides, the resistance of which is proportional to the temperature. This change in resistance can be converted to a temperature reading.

Resistance sensors are metal wires which have a resistance which is also proportional to the change in temperature. They are more robust and faster to respond than thermistors.

Thermocouples are made of two dissimilar wires joined to form a junction. An electromotive force is produced at the junction and it is proportional to temperature. The emf producded is read or recorded on a millivolt meter and converted to a temperature. The temperature of the unknown junction is referred to a junction of known temperature. This known junction is usually iced water at 0°C. A typical thermocouple diagram is shown in Figure 2. The distances of the unknown temperature junction from the known temperature junction and the recording instrument can be 30-40 metres without any loss of accuracy. This allows the temperature to be read outside the chillers or freezers.

Meters with digital readouts and automatic temperature compensation are available.

A hand held digital readout Resistance Temperature Device (RTD) having an accuracy of ±0.5°C is available for $350 for the recording instrument and $190 for the probe.

A hand held digital readout thermocouple with an accuracy of ±1% is available for $220 for the recording instrument and $90 for the probe. These are temperature compensated and are cheaper to repair. With this type of instrument it is also simpler to make up other leads for other purposes.

Chiller Temperature Measurement

Chiller temperatures are usually measured with dial thermometers.

The cheapest and least accurate are the Bourdon tube vapour pressure type. The scale on these is non-linear and they should only be used for temperatures in the upper ranges of the scale. They cost approximately $80 depending on the length of the capillary.

A more accurate and more expensive type is the mercury in steel dial thermometers. They cost approximately $200 depending on the length of the capillary. The scale on these is linear and they are accurate over the full length of the scale. However, steel corrodes and if the mercury escapes, it is quite dangerous.

A new type using nitrogen and a stainless steel capillary tube is available and it has the same accuracy with less hazards for approximately the same price as the mercury in steel.

Overall, electronic thermometers have many advantages and they are very versatile. They can be used for liquid, air or meat. They can be provided with digital readouts or can provide a printed readout of remote temperatures 24 hours per day. The sensors are small, they have a low thermal capacity so are quick to respond and give the temperature at a specific point.

Use of Thermometers

After a thermometer has been chosen it's subsequent performance depends on the skill of the operator. It is important to check regularly the calibration of all thermometers. This can be done by placing the thermometer sensor in a vacuum flask filled with ice and water. Ice made from distilled water is preferred. In this mixture the thermometer should read 0°C after about 1 minute and provided the mixture contains an excess of ice and is regularly stirred, the reading should not change. A more accurate calibration can be made by comparing the performance of the thermometer against a certified thermometer. The advantage of this method is that the accuracy of the thermometer can be checked over it's whole range.

The temperature in a chiller should be taken at several positions and recorded as an average temperature. The thermometer should be allowed to fully respond to the temperature change. This could take as long as one minute for slow acting thermometers. In chillers, the temperature should be taken where there is reasonable air movement. It should not be taken in the direct blast off evaporators or near doorways or walls where false readings would result.

A deep butt temperature is often specified for carcass meats. This temperature can be measured by pushing the thermometer through the hole in the aitch bone so that the sensing tip of the thermometer lies alongside the thigh bone (see Figure 3). If the thermometer is placed in this way, the sensing tip should be in the deepest and therefore the warmest part of the carcass.

Figure 4 shows the variation in temperature which can occur in a carton of meat after 27 hours in a blast freezer. To measure the temperature at the warmest part in the carton, the thermometer should be inserted through the long side wall of the carton at a point midway between the carton ends and slightly above the mid-point between the top and the bottom. Drill a hole or drive a spike into the carton to provide a tight fitting hole to insert the thermometer. These placements for measuring carcass and carton temperatures provide a long thermal path through the meat. This reduces the conduction which could occur through the metal stem of the thermometer.

Surface temperatures of meat should only be taken with electronic thermometers. They have small sensor tips and should be inserted 2-3mm below the surface of the meat. "Tel-Tru" type thermometers are not suitable as not enough of the sensing tip can be embedded in the zone 2-3mm below the surface.

Air Speed Measurements.

The air speed in chillers affects chilling rates, carcass weight loss and condensation. The instruments which are suitable for measuring air velocity in chillers are vane anemometers and hot wire anemometers.

A vane anemometer is a set of light vanes mounted on radial arms attached to a spindle. The air passing over the vanes rotate them like a windmill. The speed of rotation is proportional to the air velocity. Vane anemometers are suitable for measuring air velocities. The instrument must be correctly aligned at right angles to the direction of the flow of air.

A hot wire anemometer consists of an electrically heated wire which is cooled as air passes over it. The rate of heat loss from the wire is proportional to velocity of the air passing over it. Hot wire anemometers are more accurate than the vane type and can measure air velocities from 0.05m/sec to 10m/sec. They are very sensitive to changes in air velocities and are not suitable for measurements in gusty conditions.

Relative Humidity Measurements.

Relative Humidity is a measure of the amount of water vapour in the atmosphere. The atmosphere can hold a certain amount of water vapour at a given temperature. Relative humidity is the amount of water vapour in the atmosphere expressed as a percentage of the maximum amount of water vapour the air could hold at that temperature.

Instruments for measuring relative humidity are based on the wet and dry bulb principle. Assman and sling type psychrometers are most commonly used in the meat industry. A psychrometer consists of two accurate thermometers fixed into a frame which can be whirled around on a handle. The bulb of one of the thermometers is covered with a cotton wick wetted with distilled water. When the psychrometer is whirled the thermometer without the wetted bulb should remain at ambient temperature and the thermometer with the wetted bulb should fall in temperature. Water evaporates from the cotton wick on the bulb causing the temperature to fall. The fall in temperature is dependant on the relative humidity of the atmosphere. When whirling ceases, the thermometers should be at a constant reading. The temperatures are then read against psychrometric tables which give the relative humidity of the atmosphere.

Hair hygrometers are also available for measuring relative humidity. These consist of lengths of hair which absorb and desorb water according to the relative humidity. The hairs change length as they absorb water and this length change can be used to indicate relative humidity. Hair hygrometers are slow to respond to changes in relative humidity and are affected by temperature. The instrument must be calibrated with a sling type psychrometer at the temperature at which it will be used.

Electronic thermometers can be used for measuring and recording relative humidity. The air speed over the wetted wicks must be at least 3m/sec. and this can be achieved by using electric or clockwork fans to drive air over the wet and dry bulbs of the thermometer.

If there is a build up of salts on the cotton wick from using non-distilled water there will be a reduction of evaporation and an inaccurate wet bulb temperatures will result. The wick should be replaced with a new one and fresh distilled water used.

Very few abattoirs try to control the relative humidity in their chillers and if some control was practised condensation problems could be alleviated and weight loss could be reduced.

Weight Loss

Weight loss from carcasses is the amount of water lost by evaporation from slaughtering to chilling to delivery from the abattoirs. Different works have different figures for weight loss and they are very variable. However, some works take the carcass weight as the weight before washing and others take the hot/wet weight after washing. Some large fatty beef carcasses gain approximately 1% of their weight after coming out of a pressure washing cabinet. There is a high rate of evaporation during the first 4-5 hours after leaving the slaughter floor. The evaporation proceeds at a much reduced rate during chiller storage and this is very dependant on air movement and relative humidity. A typical weight loss from a beef side would be 0.5% from the wash booth at the end of the slaughter floor to the chiller entry. A further 1.7% from the start to the finish of a 24 hour chilling cycle, and a further 0.5% during chiller storage for a weekend.

For an accurate measure of weight loss of beef, scales with a capacity up to 250kg which can read 200g are required. When such fine sensitivity is needed the scales must be calibrated accurately and the ordinary scales in abattoirs lack this sensitivity. This accuracy cannot be maintained with beam scales which are commonly used in abattoirs. However, it can be obtained from digital scales which use weight cells for determining the weight. Sets having a maximum weight of 250kg and 10,000 graduations are available for $4,000. These are very robust and give very few problems. Being electronic, the weight can be fed into a computer and recorded against other information on that animal.

Currently a set of beam scales cost approximately $2,700. The extra cost to purchase electronic scales is well worth it for the greater accuracy and the better control of weight loss.

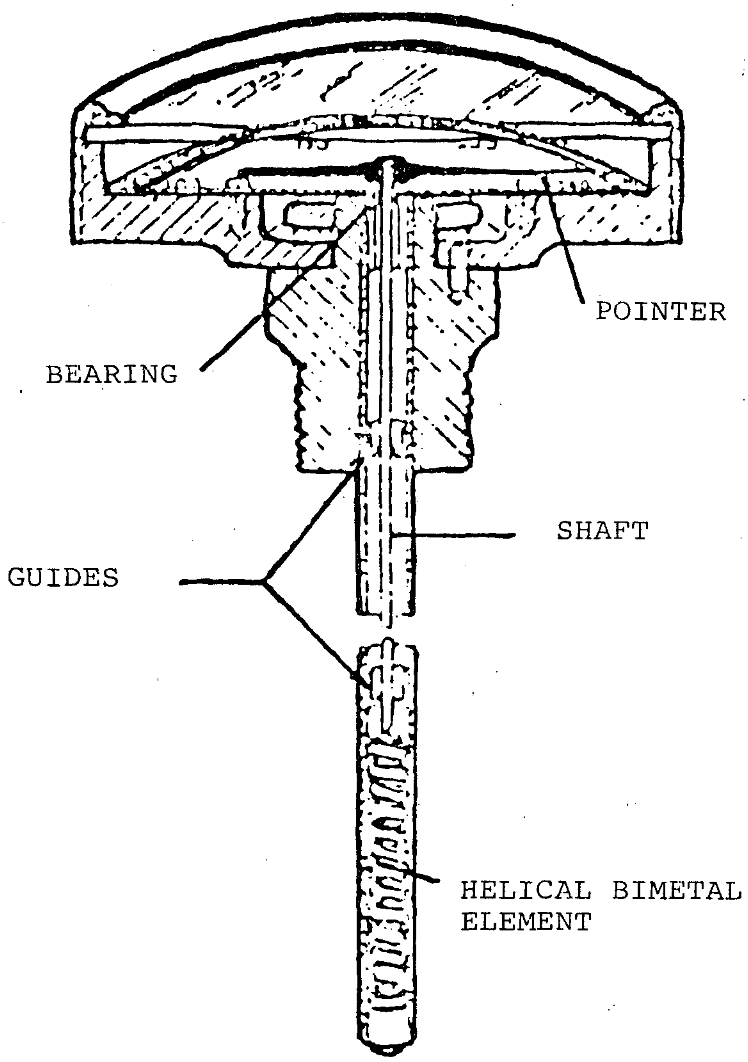


FIGURE 1: SECTIONAL VIEW OF AN INDUSTRIAL THERMOMETER USING A HELICAL-TYPE BIMETAL ELEMENT.

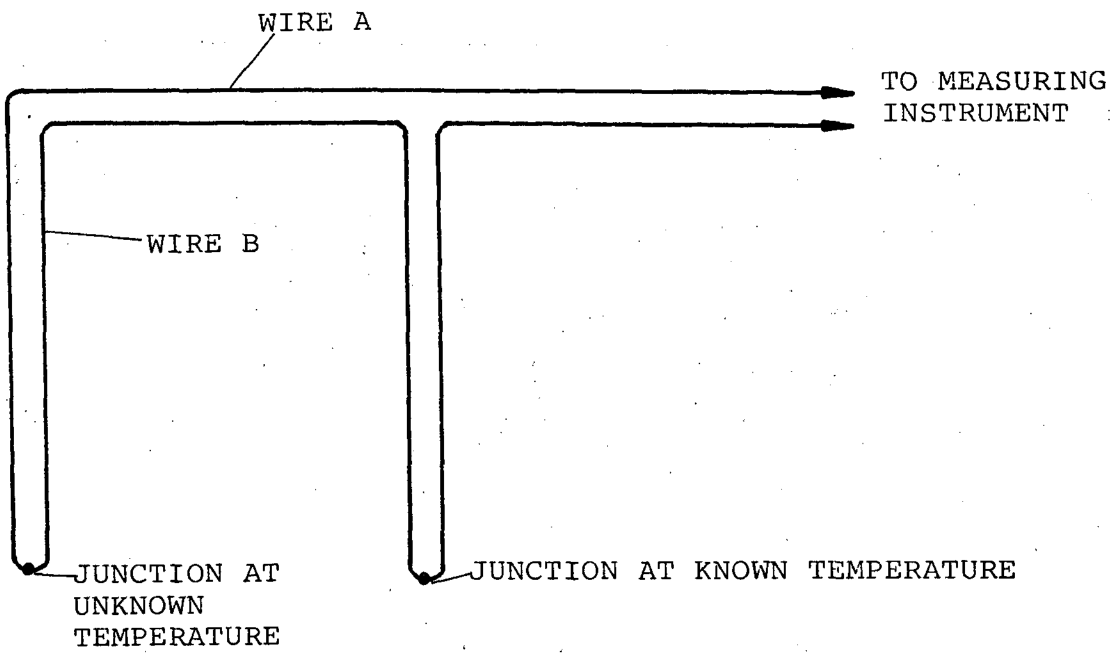
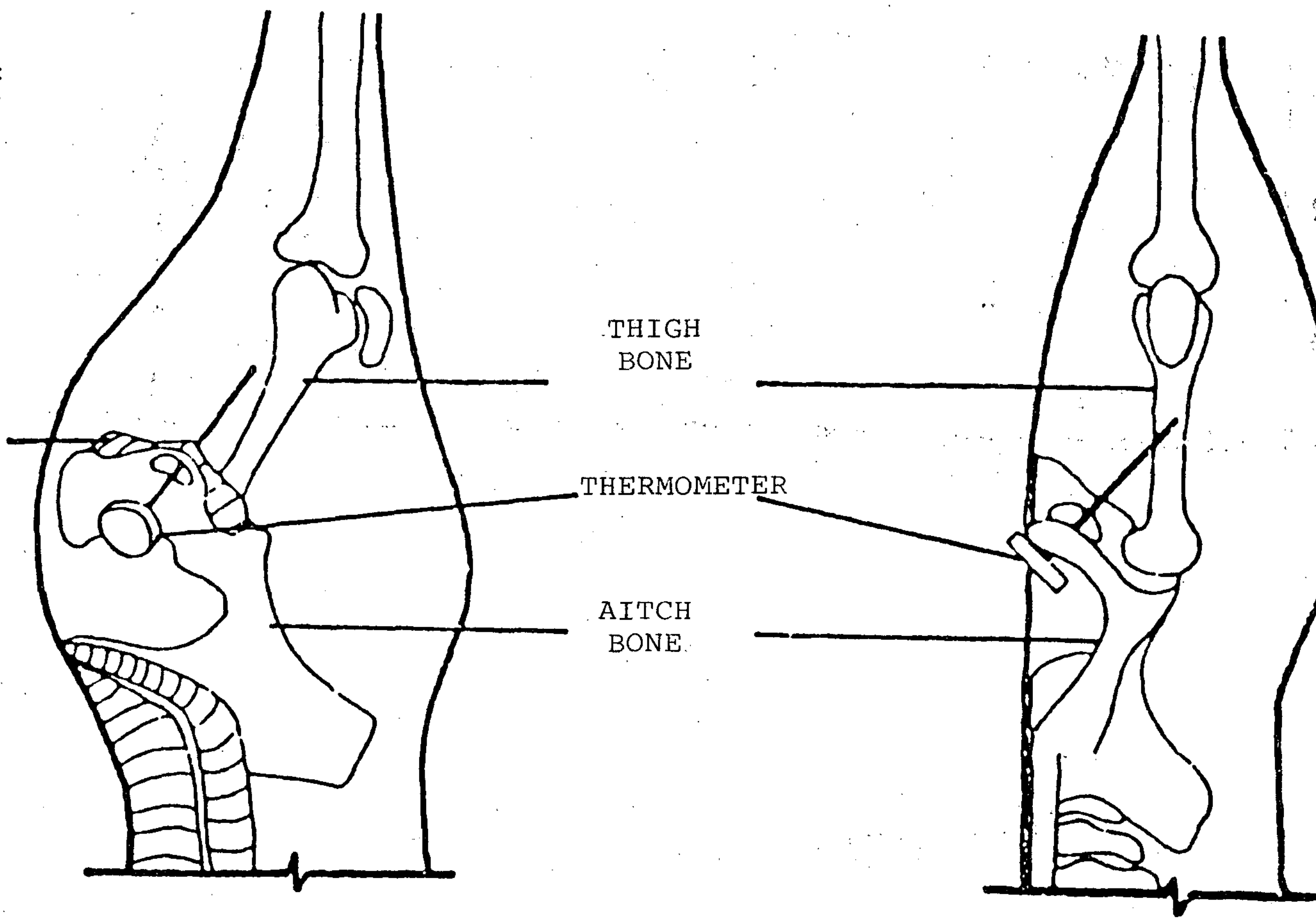


FIGURE 2: THERMOCOUPLE CIRCUIT.



Insert the thermometer through the hole in the aitch bone.

FIGURE 3: PLACEMENT OF THERMOMETER FOR DEEP BUTT TEMPERATURE MEASUREMENT.

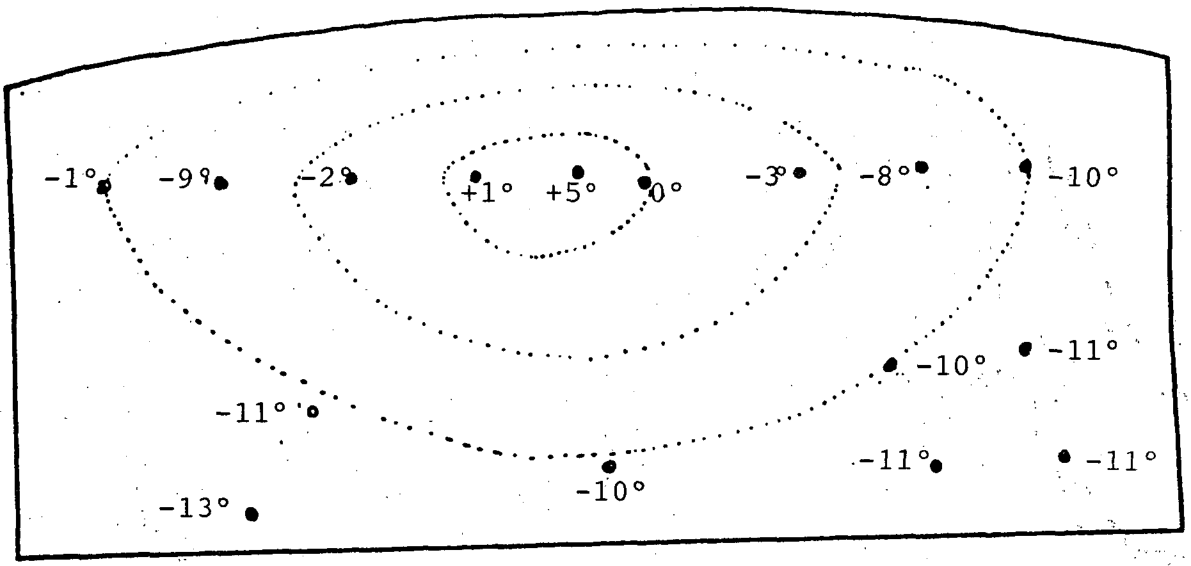


FIGURE 4: TEMPERATURES (°C) IN A CROSS SECTION OF A CARTON AFTER 27 HOURS FREEZING.