Measurement of Surface Temperatures of Chilled Carcasses and Sides

The proposed FSIS 'Mega Rule' includes requirements for carcase surface cooling rates from time of exit from the slaughter floor.

McNeil, et al.\(^1\) have shown that rapid surface cooling rates are achievable with good chillers and with a range of beef side and carcase weights.

The proposed FSIS Rule says that '... the method used to measure the surface temperature of a carcase or a raw meat product would be at the discretion of the establishment. Pressing the side of a temperature probe against the meat surface is the easiest and most inexpensive method. Because air has low heat capacity relative to meat, this method should give a good estimation of the meat surface temperature. Shielding the probe from room air should increase the measurement accuracy. For shielding, one suggestion is to place two carcasses together and measure (between) the contacting surfaces. Shielding the probe from room air with a food contact material having low heat conductance and capacities, such as a dry sponge in a plastic bag, after proper sanitising, would also be effective.'

The ARMCANZ domestic requirement specifies surface temperatures for load out and for transport (as does the proposed FSIS Rule).

Surface temperature measurement is critical in the control of meat spoilage organisms and organisms of concern to public health.

Evaluation of instruments for measuring surface temperatures (Trial 1)

Various methods of surface temperature measurement were compared:

**Infrared Non-Contact Thermometer**

This method is very easy to use - point, pull trigger and read (requires only one hand). The response time is less than 0.5 seconds.

This instrument uses a laser beam to pinpoint the area of the surface to be measured. It identifies the radiant heat emitted by the surface. The radiant heat emitted depends on the temperature and emissivity (a measure of the efficiency of emitting infrared radiation) of the surface.

Emissivity variations in carcase surfaces occur; however, these are small - their effect on temperature readings is insignificant compared to the resolution of the instrument. Hence, for
measuring carcase surface temperature, an instrument with a fixed emissivity of 0.95 is adequate.

The price of units is around $1.000 to $2.000 each, depending on the options selected at the time of order. The ability to measure < 0°C should be included as an option.

The distance from the surface is important (the area measured increases with the distance). The target area being measured must be filled by the meat surface i.e. one must not be so far away that the target area covers part of the body and part air (or chiller structure). When purchasing equipment, the range and measurement area should be specified. Manufacturers’ instructions must be followed.

The Raytek Model PM4 was used for the trial. This has variable emissivity (0.10 to 1.0), and a resolution of 1°C. For abattoir use we would recommend a model with fixed emissivity which indicates in 1°C or 0.1°C resolution.

**Digital Thermometer**

An Anritsu Model HFT-7 -200°C to 1200°C with 0.1°C resolution using K-type thermocouples was used with both a standard 200 mm long 3 mm diameter spear probe and an Anritsu Model N-231K-00 surface probe specifically designed for surface temperature measurement.

The spear probe was used to measure surface temperatures in the following ways as suggested in the proposed FSIS ‘Mega Rules’:

- The side of the probe was pressed against the meat surface.
- The probe was placed between the surfaces of two adjacent sides (the shoulder and flank were used in the trials). This is the most difficult method to use – it should not be used where two carcases are already touching – therefore, the operator must move carcases together and maintain contact during measurement. This gives an average of two surfaces and is unaffected by air temperature.
- The probe was shielded from room air by covering the contact area with a dry sponge in a sterile plastic bag while pressing the probe against the side of the carcase. A supply of clean bags must be carried.

Allow sponge to equilibrate to chiller temperature before use.

The response time for spear probes is approximately 5 seconds and for surface measuring probes, less than 2 seconds. One must make sure the tip of spear probes containing the thermocouple, contacts fat or meat surface.

**Calibration and Temperature Compensation**

The accuracy of each thermometer was confirmed against a standard thermometer before commencement of the trials. On-plant calibration methods are outlined in Reference 2.

All temperature measuring instruments include an internal mechanism for correcting the indicated reading for the ambient temperature of the instrument. The digital thermometer used was capable of rapid adjustment for the changing environment between ambient conditions and use in a chiller at 0°C to 10°C. The infrared thermometer, however, required 2 to 5 minutes to adjust when moved from ambient to chiller conditions and errors of +3°C occurred when used immediately upon entering a chiller. For further information on precautions to be taken, refer to the paper ‘Evaluation of Non-Contact Infrared Thermometry for Measuring the Temperature of Pig Carcasses in Chillers’ (1). This error would not exist with a permanent infrared head fixed in the chiller.

**Variation in Results**

With the exception of the temperature compensation errors noted above, all methods are capable of measuring surface temperatures to ±1°C which is commercially acceptable. Bare thermocouple systems (probe only or surface thermometer) produced the lowest readings in every case. The probe and sponge or the infrared thermometer produced the highest readings. Placing the probe between carcases always produced an intermediate result near the mean of the other two methods. The surface measuring probe is less affected by air temperature or accurate positioning than a standard probe.
Evaluation of surface temperature measuring methods (Trial 2)

In another trial at a different export works, four techniques for measuring the surface temperature were compared and there was found to be little difference between the methods. Refer to Table 1.

Table 1. Carcase surface temperatures measured with a spear probe using various techniques (162.2 kg side weight, 3°C air temperature)

<table>
<thead>
<tr>
<th>Measurement Site</th>
<th>Probe 1-2 mm under &amp; parallel to surface</th>
<th>Probe pressed on surface</th>
<th>Probe shielded with sponge</th>
<th>Probe between sides pressed together</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt</td>
<td>16.2</td>
<td>15.7</td>
<td>14.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Flank</td>
<td>9.0</td>
<td>9.6</td>
<td>9.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Shoulder</td>
<td>12.8</td>
<td>13.0</td>
<td>13.1</td>
<td>11.3</td>
</tr>
</tbody>
</table>

The chiller control suggested above is most easily and conveniently achieved with an infrared thermometer placed in a fixed position.

When the surface temperature of the meat is close to the air temperature, continued use of high air velocities is of little value in chilling. The internal heat capacity and conductivity in the deep butt controls the rate of deep butt temperature fall, not the heat transfer rate at the surface.

Thermal centre meat temperature measurement

For guidance on deep meat measurement refer to Meat Technology Update 95/1, ‘Measurement of Temperatures in Fresh Processed Meats’ (4).

Summary

The following methods are satisfactory for surface temperature measurement when properly carried out:

**Electronic digital thermometers with a temperature sensing device in the tip of a stainless steel probe**

- **Spear Probe**
  The probe is inserted parallel to and 1 to 2 mm under the surface to immerse the shaft below the fat with the sensing tip located at the point where the temperature is to be measured.

- **Spear Probe**
  Press the side of the probe hard against the meat/fat surface.

- **Spear Probe**
  Place the probe between the surfaces of two adjacent carcasses and measure the temperature between the contacting surfaces.

- **Spear Probe**
  Place the probe against the fat surface, shielding it from room air with a food contact
material having low heat conductance and capacities, such as a dry sponge in a plastic bag, after proper sanitising.

- **Surface Measuring Probe**
  The head of the probe is placed on the point to be measured.

**Infrared non-contact thermometer**
- This instrument uses a laser beam to pinpoint the area of the surface to be measured.

**Acknowledgement**

The support of the Meat Research Corporation in this publication is gratefully acknowledged.

**References**


4. *Meat Technology Update 95/1*, ‘Measurement of Temperatures in Fresh Processed Meats’.

**Need Additional Help or Advice?**

If you need any further advice or assistance, your nearest Australian Meat Technology Regional Manager can assist you.

- **Brisbane**: Mr Barry Johnson (07) 3216 6222
- **Mr Peter Husband** (07) 3216 6222
- **Sydney**: Mr Bill Spooner (02) 672 1698
- **Mr John Green** (03) 9690 8766
- **Melbourne**: Mr Chris Sentance (08) 223 1677
- **Adelaide**: Mr John Morris (09) 472 1433
- **Perth**