MEAT TECHNOLOGY – INFORMATION SHEET

Cutting edge technology for the meat processing industry

Meat technology – information sheet

Calibration of thermometers and temperature loggers

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Most critical product temperature measurements in the meat industry are made at chilled temperatures (<10°C) or at cooked meat and hot water temperatures (>60°C). Thermometers and temperature loggers should be calibrated near the temperatures they are intended to monitor. Thus, thermometers used in the meat industry should be calibrated at a cold temperature e.g. 0°C and a hot temperature e.g. about 70 to 90°C.

Thermometers used in processing plants should be either calibrated at a known reference temperature such as the melting point of ice or checked against a certified or reference thermometer. It can be difficult to establish the conditions that produce a known temperature and we recommend that a certified thermometer is used to double check the temperature of a melting-ice bath.

Reference temperatures and certified thermometers

Thermometers are calibrated by comparison of their readings with reference temperatures. The reference temperature may be a known physical constant such the temperature of pure melting ice or it may be provided by a certified thermometer. As pointed out above, reference temperatures that are physical constants should be confirmed by a certified thermometer because of the difficulty of accurately reproducing physical constants.

Certified thermometers may be electronic or liquid-in-glass (mercury or spirit). The important point is that the thermometer is certified by a recognised certification agency. A certified thermometer will be checked against several reference points and corrections may apply at each point. It is important to apply the corrections shown on the certificate when the certified thermometer is used as a reference to calibrate a working thermometer. The certified thermometer may require recalibration at intervals. Liquid-in-glass thermometers are unlikely to go out of calibration unless the column breaks and calibration certificates may be valid for ten years. Electronic thermometers should be re-certified at 12-month intervals.

Some misconceptions about calibration are that reference thermometers must be liquid-in-glass thermometers and that boiling water provides a suitable reference temperature. Electronic thermometers can be used to provide reference temperatures provided they are certified. The certified thermometer should be relied on to provide a reference temperature rather than boiling water.

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Figure 1: Calibration of working thermometer in ice/water with reference thermometer.

certified thermometer must be readable to 0.1° C. Thermometers that are readable to 0.5°C cannot be used to calibrate working thermometers to an accuracy better than ± 0.25°C.

A certified thermometer should be purchased and used solely for calibration purposes i.e. the certified thermometer must not be used as a working thermometer. It can be calibrated by an authority such as the National Measurement Institute or another laboratory accredited by the National Association of Testing Authorities (NATA).

Thermometers can be calibrated using sophisticated calibration equipment such as a dry block calibrator, available from instrument suppliers. However in most cases calibration in melting ice (0°C) for cold measurements, or by comparison with a certified thermometer in hot water are effective methods.

All thermometers used to measure process conditions must be calibrated. The frequency of calibration should relate to the expectation of the thermometer going out of calibration and the importance of the measurement. Thermometers used to measure critical limits should be calibrated more frequently than thermometers used to monitor less critical temperatures. Hand-held thermometers which are subject to being dropped and mishandled should be calibrated more frequently than fixed thermometers. It should be sufficient to calibrate hand-held thermometers at monthly intervals but because an out-of-calibration thermometer could lead to non-conforming product some abattoirs choose to calibrate at weekly intervals. If there is a suspicion that a thermometer is damaged or out of calibration it should be checked immediately or taken out of service. All new instruments should be calibrated before they are put into service.

There should be a record of all instruments that are subject to calibration. Each instrument must have a unique identification and the location and accuracy of the instrument should be recorded. Each instrument must be identifiable by its unique identification and after each calibration the instrument should be labelled with the date of calibration, expiry date of calibration and any correction to be applied. Corrections should be expressed as “add 0.2° C” or “subtract 0.2°C” rather than “+0.2°C” or “-0.2°C” to avoid mistakes in the interpretation of mathematical expressions. If the calibration information cannot be applied directly to the thermometer it may be possible to attach the information on a tag.

Calibration in melting ice

Equipment required:

- *Ice* – made from distilled water or good quality tap water – not bore water
- *Mallet* – to break ice into small pieces if required
- *Insulated container* – such as a wide-mouthed vacuum flask or small Esky
- *Water* – from the same source as the ice
- *Stirrer* – to ensure an even mixture
- *Labels, book & pen* – to label the thermometers and record the process.

1. Ensure that the thermometer or temperature logger to be calibrated has equilibrated to the ambient temperature. Fill the insulated container with the crushed ice. The ice should be wet, i.e. starting to melt (it will not be opaque but appear “glassy”). If necessary add some water to wet the ice but if the ice floats on a pool of water there is too much water and the excess should be drained off.
2. Place the thermometer probes in the stirred, crushed ice ensuring that they are immersed to the required depth and do not touch the sides or bottom of the container, but they can touch each other.
3. The required depth of immersion should be checked from the instructions or certification that accompanies the thermometers. The required depth may be marked on the thermometer. Secure the thermometers in place with a clamp. The thermometers must be immersed to the required depth but liquid-in-glass thermometers must also be readable with the top of the liquid column at eye level to avoid parallax errors. Do not lift the thermometers out of the ice mixture to read them. Allow the thermometers to reach a steady reading. A steady reading is reached when there is no difference between two readings taken 1 minute apart. Temperature loggers without a display can be set to record at 1-minute intervals.
4. Note the temperature of the certified thermometer. Record this temperature on the calibration record sheet or log book and apply any correction identified on the certificate. Record the identification of each working thermometer or logger and the stable temperature it reached on your calibration record sheet or log book. Record the difference between the corrected reading of the certified thermometer and the working thermometer reading as the offset or correction. The temperature of the working thermometer must be subtracted from the reading of the certified thermometer to obtain the correction. This will produce a negative number if the temperature reading of the working thermometer is greater than the temperature reading of the certified thermometer. For example, for a certified thermometer that requires a correction of -0.2°C at 0°C the entry on the calibration record should appear as shown in Table 1.
5. Write the correction for each thermometer on a tag attached to the thermometer.

Table 1: Example of Calibration Record

Working thermometer identification	Hand held No. 5	Hand held No. 6
Certified thermometer reading (°C)	-0.1	-0.1
Corrected reading of certified thermometer (°C)	-0.3	-0.3
Working thermometer reading (°C)	0.1	-0.4
Correction to be applied to working thermometer (°C)	-0.4 (Subtract 0.4)	0.1 (Add 0.1)

Calibration in hot water

Equipment required:

- *Heat tolerant container* – such as a Pyrex beaker (~1 litre)
- *Clean water*
- *Heat source* – such as a hotplate
- *Reference thermometer* – NATA calibrated
- *Labels, book & pen* – to label the thermometers and record the process.

1. Heat the water to near the temperature at which the thermometers are to be used. To ensure that the temperature remains stable, the hot water should be transferred to an insulated container such as a vacuum flask or the hot water beaker should be insulated by wrapping polystyrene foam around the sides and bottom of the beaker.
2. Insert the reference thermometer and the thermometers or loggers to be calibrated so that they are immersed to the required depth and do not touch the sides or bottom of the vessel.

   The required depth of immersion should be checked from the instructions or certification that accompanies the thermometers. The required depth may be marked on the thermometer. Secure the thermometers in place with a clamp. The thermometers must be immersed to the required depth but liquid-in-glass thermometers must also be readable with the top of the liquid column at eye level to avoid parallax errors. Do not lift the thermometers out of the water to read them. Allow the thermometers to reach a steady reading. A steady reading is reached when there is no difference between two readings taken 1 minute apart. Temperature loggers without a display can be set to record at 1-minute intervals.
3. Note the temperature of the certified thermometer. Record this temperature on the calibration record sheet or log book and apply any correction identified on the certificate. Record the identification of each working thermometer or logger and the stable temperature it reached on your calibration record sheet or log book. Record the difference between corrected certified thermometer and the working thermometer as the offset or correction. The temperature of the working thermometer must be subtracted from the reading of the certified thermometer. This will produce a negative number if the temperature reading of the working thermometer is greater than the temperature reading of the certified thermometer.
4. Some laboratories may have a stirred temperature-controlled water bath. If this equipment is available it is ideal for conducting thermometer calibrations in hot water.
5. Write the correction for each thermometer on a tag attached to the thermometer.

Calibration in cold water

Preparation of ice/water from a source of pure water can be a time consuming operation. Provided a certified thermometer that has been calibrated by a NATA accredited laboratory is available, calibration of working thermometers and loggers in cold water is an effective method.

Equipment required

- *Insulated container* – such as wide-mouth vacuum flask or small Esky*Cold water* – from the refrigerator
- *Reference thermometer* – NATA calibrated
- *Labels, book & pen* – to label the thermometers and record the process.

1. Fill the insulated container with water at a temperature similar to that of the product you will be measuring.
2. Insert the reference thermometer and the thermometers or loggers to be calibrated so that they are immersed to the required depth and do not touch the sides or bottom of the vessel. The required depth of immersion should be checked from the instructions or certification that accompanies the thermometers. The required depth may be marked on the thermometer. Secure the thermometers in place with a clamp. The thermometers must be immersed to the required depth but liquid-in-glass thermometers must also be

readable with the top of the liquid column at eye level to avoid parallax errors. Do not lift the thermometers out of the water to read them. Allow the thermometers to reach a steady reading. A steady reading is reached when there is no difference between two readings taken 1 minute apart. Temperature loggers without a display can be set to record at 1-minute intervals.

3. Note the temperature of the certified thermometer. Record this temperature on the calibration record sheet or log book and apply any correction identified on the certificate. Record the identification of each working thermometer or logger and the stable temperature it reached on your calibration record sheet or log book. Record the difference between corrected certified thermometer and the working thermometer as the offset or correction. The temperature of the working thermometer must be subtracted from the reading of the certified thermometer. This will produce a negative number if the temperature reading of the working thermometer is greater than the temperature reading of the certified thermometer.
4. Write the correction for each thermometer on a tag attached to the thermometer.

Applying corrections

Corrections are the difference between the reference temperature and the reading on the working thermometer i.e the working thermometer temperature is subtracted from the reference temperature. They may be positive or negative. Corrections are always added to the temperature reading. Some examples are shown in Tables 2 and 3:

If a large correction needs to be applied (say 1ºC or greater), then consider replacing the thermometer.

Table 2: Examples of calculations of corrections to working thermometers

Reference temperature (°C) (corrected)	Working thermometer temperature	Correction
82.2	82.7	-0.5
82.2	82.0	0.2
0.0	0.3	-0.3
0.0	-0.2	0.2
-0.2	-0.4	0.2
-0.2	0.1	-0.3

Table 3: Examples of calculation of true temperature readings

Reading of working thermometer	Correction	True reading
83.2	+0.4	83.6
83.2	-0.3	82.9
0.2	+0.4	0.6
0.2	-0.3	-0.1
-0.3	+0.4	0.1
-0.3	-0.3	-0.6

Adjustable thermometers

Some thermometers can be adjusted so that they read the same temperature as a corrected certified thermometer at a specific temperature. If the thermometer is easy to adjust, the adjustment should be used and no correction will be required. If the adjustment is very sensitive or difficult to use, the adjustment should be left alone and a correction applied as described above.

Note that thermometers can only be adjusted at one temperature. If the thermometer is subject to a hot water and ice point calibration, it can only be adjusted to give no correction at one calibration point. A correction must be applied (if necessary) at the other calibration point.