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Brannan Thermometers & Instrumentation

How to calibrate a thermometer

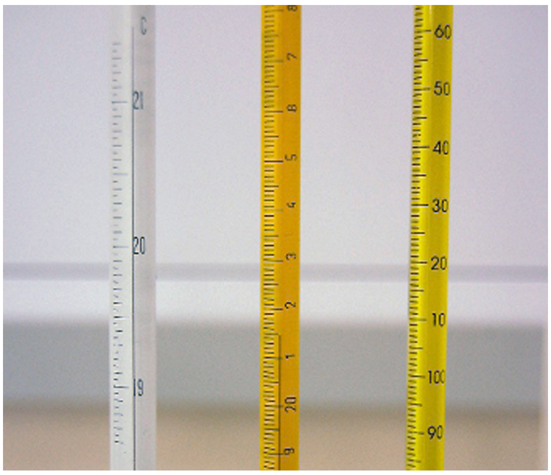
Many processes and applications require liquid in glass thermometers to be calibrated in order to provide traceability back to recognised standards and hence verify their accuracy. Many customers request calibration of their instruments as a result of actions arising from audits, and fail to specify certain criteria which can slow down their request or even result in the wrong points being checked.

We have prepared this list of points to consider when requesting a calibration of a liquid in glass thermometer to help with this process and hopefully allow you to specify the calibration requirements fully and avoid costly mistakes.

Temperature Range

S. Brannan & Sons can carry out UKAS accredited calibrations in our stirred liquid baths between -60° and 250°C.

Many customers require a thermometer to carry out a number of tasks where a wide range of temperatures will be measured, others may only need to know that a single temperature is being maintained. If you have a specific temperature which is critical to your process, it should be the mid-point (or close to) of your chosen scale. These requirements will determine the range (difference between the minimum and maximum temperatures on the scale) of the thermometer you choose.



Example of different scale divisions

Scale Divisions

Thermometers have a range of major and minor scale divisions (e.g. Major divisions of 10° and minor divisions of 1°) depending upon their range. These determine to what level of precision you can read your instrument. It is generally accepted that it is possible to resolve to (see the difference between) 1/10 of a scale so if your thermometer has minor divisions of 1°C you can reasonably estimate the temperature down to 0.1°C. The smaller the minor divisions, then a higher the precision of the device, but the 1/10 rule still applies.
Larger divisions make your thermometer easier to read, but reduce the achievable resolution.

Thermometer length

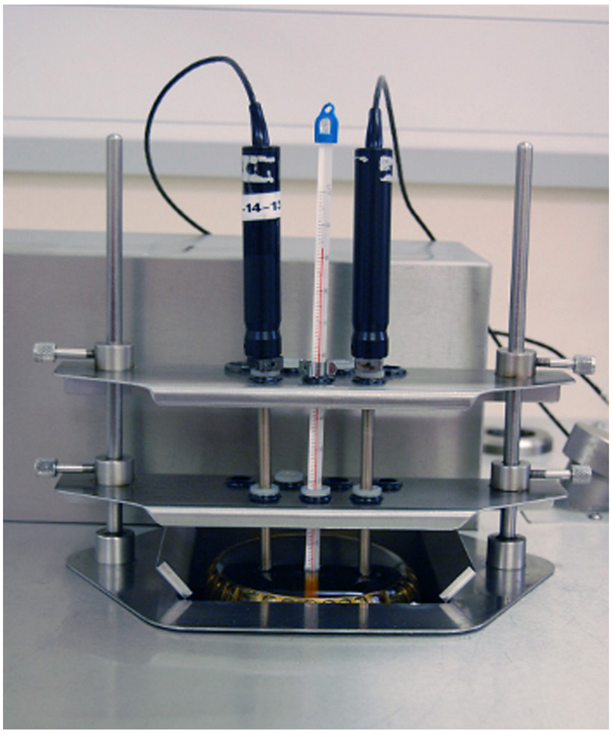
Generally long thermometers can have larger scales and are easier to read than small ones. Short, cramped scales can introduce accuracy and resolution issues, but sometimes the way you are using the thermometer needs it to be short (e.g. height restrictions on jigs etc). Also, to a large extent, the shorter a thermometer the less likely it is to get broken in use.

Long thermometers with a small range give better precision as they have narrow bores and small, but wide readable scale divisions as a result.

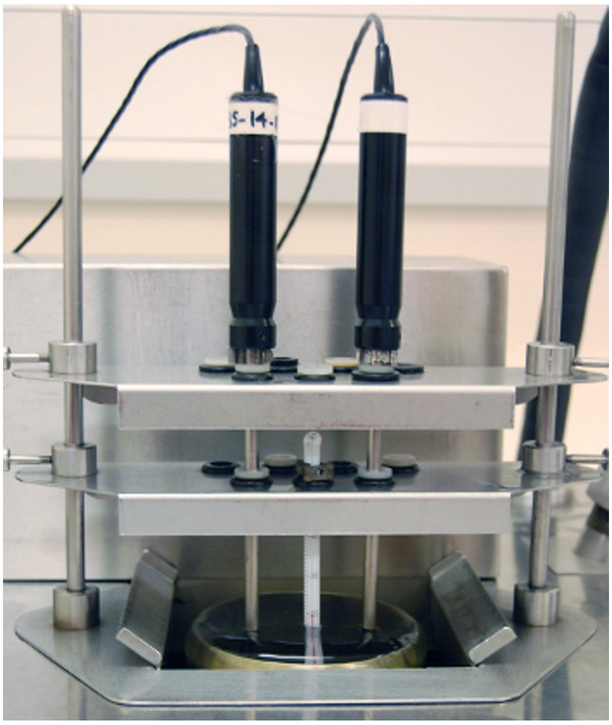
Immersion

Liquid in glass thermometers come in three different immersion types.

Partial Immersion thermometers are only immersed to a given length (generally 76mm), but have to take into account changes in ambient temperature which can lead to small variations in measured values.



Example of partial immersion



Example of total immersion

Total Immersion thermometers are immersed up to the measured temperature and so do not vary with the ambient of the room and consequently introduces less uncertainty into a measurement . This can lead to problems if the resulting immersion depth is deeper than the vessel containing the substance you are measuring.

Complete Immersion thermometers are immersed fully in the medium being measured and are therefore used predominantly for measuring air temperatures as they need to be visible and hence readable.

The bulk of the thermometers we calibrate are either Total or Partial immersion. Total immersion thermometers have less uncertainty associated with their calibration and should be used wherever possible.

Calibration

Calibration points can be drawn on a graph and joined together to form a calibration curve. This therefore allows the user to estimate the corrections at points where a calibration value has not been measured. More calibration points will reduce estimation errors, but each calibration point chosen will incur a cost, so the number chosen will be a trade-off between accuracy and cost.

How many calibration points?

The number of calibration points a customer will require will depend upon the application. If the thermometer is intended for general purpose use across the whole range, then at least three points should be chosen in order to arrive at a calibration curve from which interim points can be interpolated.

If the thermometer is required to keep track of a single temperature in a process, then a single point can be calibrated. It is recommended however that even if only a single point is required, that two other points be checked in order to know the variation around the point and allow interpolation.

Which points to choose?

Calibration points should either be specific to your process, such as -18°C, 0°C and 4°C for fridges and freezers, or cover around 80% of the range of your thermometer scale. A -10°C to 110°C thermometer can easily be calibrated at 0°C, 50°C and 100°C, but the top and bottom extremes of the scale are best avoided as the accuracy can wane in these areas.

It is always best to specify the temperatures you require if at all possible.

Uncertainty

UKAS accreditation requires that an estimate of the maximum errors likely in a calibration value are displayed on the certificate. UKAS calibrations can be carried out on any of the liquid in glass thermometers we produce, but it should be considered that as the accuracy and precision of the thermometer decreases, the uncertainty of the measurement stated on the certificate will increase. Customers should therefore consider this when selecting a thermometer and we would recommend the use of a specification thermometer where low uncertainties are required.

Calibration frequency

We are often asked the question 'When should I recalibrate my thermometer'? This can only really be answered by the user, but generally it will depend upon several factors:

What is the consequence of an incorrect reading? If you waste a batch of wine due to an incorrect temperature reading, the consequences are probably far less than if you are performing a scientific experiment to formulate a new drug. Often, the more precise the scale, the more susceptible the instrument to wandering out of calibration.

How likely is the device to go out of calibration? How often is it used and are the conditions is it used in likely to cause it to become damaged.

Has the device been subjected to any misuse or obvious damage? If the thermometer is used out on site it is perhaps more likely to become damaged or knocked than if were kept in a cupboard in the laboratory between use.

Glass is a visco-elastic material and will creep over time. New thermometers can undergo 'secular change', which is due to relaxation of stresses in the glass set up when it was made. For this reason it is important to check new thermometers more regularly than older ones.

Always keep your old calibration certificates to compare with the new ones and check for drift in the performance of your thermometer. If the thermometer is stable between calibrations you could consider increasing the calibration interval, conversely if it shows big changes then your instrument needs to be checked more frequently.

http://www.brannanshop.co.uk/blog/advice-on-how-to-calibrate-a-thermometer/