



The British Measurement and Test Association

How to specify your calibration requirements

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Foreword

For small to medium-sized businesses, the calibration of measurement and testing equipment can seem a black art. A number of decisions have to be made such as when to calibrate a particular item of equipment, the accuracy required, who should do it and how much it will cost.

Reliable calibration is necessary to ensure the requisite quality of measurement. The end-user, or customer, may well specify the frequency and uncertainty of measurement that they need, leaving it to the testing laboratory to ensure it happens.

This simple guide has been written in response to numerous enquiries from BMTA member companies and interactions with businesses from different sectors. It is intended to help organisations specify their calibration requirements to meet their needs in a way that ensures their equipment is fit for purpose for their own test and measurement applications. A sound understanding of the calibration process encourages better planning, can reduce costs and lead to a better, higher quality of service.

With thanks to NPL, Trescal and Best Measurement for their contribution.



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Fundamentals

1. What are you trying to measure?

This step is a fundamental part of the whole measurement process and will affect your selection of calibration requirements for the instrument chosen for the measurement task.

Consider what it is you are trying to measure, including the following considerations:

- What is the parameter (eg temperature, length, pressure)?
- What range of measurements are required? (eg 0°C to 100°C).
- What resolution is required? (eg 1 mm, 0.1V).
- What accuracy is needed? (eg + 20 %RH, + 0.1bar).

2. Select the appropriate equipment for the measurement

Ensure that you are using the right equipment for the job based on the measurement(s) being undertaken, considering the following:

- Range of measurement.
- Resolution.
- Accuracy including any reduction in accuracy caused by environmental conditions.
- Ease of use/training requirements.
- Robustness for measurement process.
- Speed of measurement (especially where a short-term signal is to be measured or where averaging is needed).
- Analogue or digital? Analogue is useful to see how a signal is changing.
- Availability of equipment, are you limited to what test equipment is available to you?

As much as possible within the constraints of the availability of equipment, you should aim to use the piece of equipment which matches most of the criteria named above. Any shortcomings in meeting these criteria must be considered when making the measurement and when making any decisions reliant on this measurement.

For example: You have to check the accuracy of a temperature controller for an oven with a range of 0°C to 150°C but your thermometer only reads up to 100°C. You find that the measurements meet the specification within the range of your thermometer, but you cannot assume this means that they will also be within specification outside the range tested (you cannot extrapolate with a great deal of confidence and this level of confidence will reduce the further you are away from the actual measured points).

Specifying your calibration needs

3. How to specify your calibration needs for each piece of equipment

You should ensure that your equipment is calibrated to a level that is suitable for your use. So, using the checklists above, you would be expected to specify:

- The range of measurements required (eg 0 to 100bar or 4 to 20mA), including, where needed, matters such as which fluid is being measured by the instrument (eg for a flowmeter) or which gas is being measured (flow meter, gas tester etc).
- The accuracy to which you want your equipment calibrated (eg to manufacturers specification, or +0.1 N, or +10%).
- Any specific points that should be included in the calibration (eg 30%RH, 20°C).
- You may wish to state how many points you want calibrating across a range (eg every 20°C from 0°C to 100°C).
- You would expect your calibration provider to take account of your stated requirements and select an appropriate calibration system that has sufficient accuracy (and delivers a suitably low uncertainty of measurement) to make confident statements about the measured values and any conformance to specification). However, if in doubt you could request a minimum level of uncertainty allowable (eg +0.5°C) bearing in mind that this uncertainty could have an effect on any decisions that you make about the thing you are measuring passing or failing against specification.
- If you are using a piece of equipment predominantly over a small range or even for a single value of measurement you may wish to either limit the range of calibration or specify more calibration points within this range to get a greater understanding of linearity and accuracy over this range.
- You must ensure that all measurements made will be traceable to National Standards (for most people the easiest way to do this is to choose an Accredited Certificate from an Accredited Laboratory, for example, UKAS). Calibration certificates should state this traceability.
- You may wish to inform the calibration provider of your chosen calibration periodicity (how often you specify that it needs to be calibrated) for the item so that this can be included on the certificate and label to prompt the user to only use instruments that are within their calibration period.
- In some rare cases, you may wish to specify a range of local environmental conditions under which the item should be calibrated, usually where your piece of equipment is very sensitive to this.

4. What to check on the calibration certificate when your item is returned from calibration

Don't assume that when an item is returned from calibration, it meets specification or that all your calibration requirements have been met. Calibration providers should contact you to inform you of any issues found on your instrument, but it is better to also check this yourself. Check at least the following:

- If you specified a UKAS (ISO17025) calibration, does the certificate include a UKAS logo with the laboratory's accreditation number?
- Is the item described correctly including its serial number and inventory number (where provided)?
- If provided, is the stated calibration periodicity correct?
- Is the date of calibration correct? It should be within a few days of you receiving the item and a reasonable time after the item was sent to the calibration provider (to allow it to soak to local environmental conditions).
- Has the range of measurements that you requested, including any specified points been included?
- If a statement of conformity to specification was requested has this been included and is it correct (you should check each measurement against your specification)?
- Are uncertainties of measurement stated?
- Are the stated uncertainties of measurement as good as or better than you specified, or when not specified are they appropriate and low enough to be able to confidently decide if a measured value is within specification?
- Has the certificate been signed or authorised? Note that this may be a digital signature.
- Have any accessories provided (relevant to the calibration) been listed, eg 30dB attenuator, thermocouple? These accessories should be uniquely identified by serial/asset number on the accessory and certificate.
- Does the certificate state the environmental conditions (usually temperature and humidity) at the time of calibration and, where specified by you, is this within your requirements?
- Is there a statement of traceability of measurement to national and international standards?
- Are there any points that are marked as out of specification? If so, were you informed in advance by the calibration provider and will they have an effect on what the equipment can be used for (limited use)?
- Are there any additional notes on the certificate relating to any aspects of the performance of the instrument, eg are there any notes about stability, damage, wear etc?
- Have adjustments been made to the instrument by the calibration provider? In which case have pre and post adjustment results been included? Without pre-adjustment results you will not be able to make any decisions about measurements made prior to the instrument being sent for calibration and whether or not these measurements could invalidate any measurements that you had made with the instrument.

Additional items worth checking to understand how your equipment is performing.

- Have any of the calibrated values for the item changed significantly since the last calibration? If so this could indicate wear or drift and the need for future adjustment to nominalise the instrument. You may need to use any “drift” data in your own uncertainty budget.
- Where an instrument is used over a wide range of values do the calibration results show it to be linear or in accordance with an expected non-linear function (eg logarithmic)? If not, it may be difficult to interpolate between calibration points with any confidence.
- Is the item requiring adjustment every (or almost every) time it is sent for calibration? If so, this may suggest that your calibration periodicity is set too long and should be reduced or that the equipment needs to be replaced.
- Has a calibration label been affixed to the item, or where this is not possible has it been provided for you to affix elsewhere?

Examples

5. Temperature indicator and PRT probe

I need to monitor the local temperature within my test laboratory. The nominal temperature is 20°C with limits of +2°C, i.e. between 18 and 22°C. Ideally, I would like to use an instrument that is specified to measure this range of temperatures to an accuracy of +0.2°C or better.

The instrument that I will be using is a digital temperature indicator with a PRT probe. The indicator and probe combination has a specification of +0.1°C which is well within my needs. In fact, it is specified at +0.1°C over the range 0 to 100°C. It has sufficient accuracy specification and resolution and is easy to use but its calibration has expired.

So, I need to send the instrument to a calibration laboratory to be calibrated, but what should I request when seeking a quote for this calibration (other than price!)?

I only use this device to measure the lab temperature, so I'm most interested in points around the nominal of 20°C. It would be useful to know how much the lab is out of specification if any problems arise, so I will ask for it to be calibrated over the range 15 to 25°C which should be more than adequate for my needs.

How many points should I ask for? Well, some of this may depend on the pricing regime offered by the calibration provider who may charge per point. I decide that my minimum requirement would be three points at 15, 20 and 25°C to cover the entire range and give me an indication of how linear the device is, but if it's affordable I will ask for more points to give me even greater confidence in the linearity of the instrument.

I would expect that the calibration provider would have the capability to check my instrument over the required range including the points requested and that they would also have a calibration system that is capable of meeting my specified accuracy requirements. In practice, the latter requirement regarding accuracy would mean that their own uncertainty of measurement (a measure of the accuracy to which they are able to test your instrument at a defined confidence level [usually around 95%]) would be suitable for this calibration. Ideally, you would want their uncertainty of measurement to be ten times or better than your specified accuracy (i.e. +0.02°C or better) but sometimes this is either unachievable or would require a calibration process which would take more time and therefore possibly cost you more. It is at this point that you must decide what is acceptable to you.

In this instance, I will request a calibration with a UKAS certificate as it will give me the confidence I need that my measurements are traceable to national and international standards and that the service provider that I have chosen have been independently audited to show that they have the capability to calibrate this type of equipment.

The current calibration periodicity for this item is 12 months and from what I have seen in the previous calibration records it appears to be quite stable (the results are similar from year to year) so I will ask the provider to put a 12-month periodicity on the certificate and calibration label.

Once you have contacted your chosen calibration provider you may wish to ask them about how the instrument is to be transported (will they collect/deliver?) to and from you, especially for delicate items (eg mercury-filled barometers).

6. Hand-held Digital Multi-Meter (DMM)

I have a hand-held 3½ digit multimeter which is used in my workshop for general purpose use, eg for fault finding on electronic equipment. This means it is possible that I could use almost all ranges and functions so I certainly don't want to specify any form of limited calibration. I bought this particular multimeter based on its specification which suited my day to day needs so I'll ask the calibration provider to calibrate it against the manufacturer's specification.

It's important to me that I can be sure that this meter is functioning within the manufacturer's specification so I'll ask the service provider to adjust the item to nominal if it is found to be out of specification or near to its limits. Along with this (just to be sure) I will ask them to provide pre and post adjustment results (if it needs adjusting) as I may have to review any measurements that I have made should they be outside specification.

When I use this instrument I frequently record measurement results especially when I am using it to align/adjust a circuit as this allows me to keep a record of how the device I am testing is performing over time. If I'm going to record these measurements they are clearly important to me and I would like a high level of confidence that the company I will select to provide this calibration are capable of these measurements and I will therefore tend to search for a UKAS accredited calibration laboratory. However, when offered either a UKAS or a non-UKAS (standard service or in-house) certificate I will have to decide which option I choose depending on how this provider differentiates between the two levels of service. This is a conversation to be had with the calibration provider.

7. Terminology and additional information

Your calibration provider will provide a calibration certificate for your instrument which will include a set of test results and an uncertainty of measurement statement. This uncertainty of measurement is important as it will form part of your own measurement uncertainty when you use the instrument to make measurements.

Although you may not actually calculate your own uncertainty of measurement you should be aware that your measurements can be no better than the uncertainty of measurement that your own instrument has imported through the calibration process from your calibration provider. In addition to this uncertainty of measurement, there will also be environmental effects (eg how temperature may affect your measurements), the resolution of your instrument, its scale linearity and other factors.

Accuracy: how close a measured result is to its true value.

Calibration: the comparison of an instrument against a more accurate one (or against a reference signal or condition), to find (and in some instances to correct) any errors in its measurement results.

Resolution: The fineness with which measurements can be made on an instrument (usually denoted by scale markings or the minimum change in value on a digital display).

Specification: A set of values within which an instrument is expected to perform. These may be limited by environmental conditions or conditions of use.

Traceability: a measurement is traceable if it can be connected to national or international standards through a documented unbroken chain of comparisons.

UKAS: The United Kingdom Accreditation Service.

Uncertainty of measurement: quantified doubt about the result of a measurement.

A more in-depth description of these and other related terms can be found in the [BIPM VIM: International Vocabulary of Metrology](#).

Useful information

[Link to UKAS website](#) listing accredited laboratories

[Link to NPL Good Practice Guides](#) (GPGs)

[Link to Eurolab Cook Books](#)

[Link to BMTA](#)

[BIPM VIM: International Vocabulary of Metrology](#)



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