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Calibration Principles

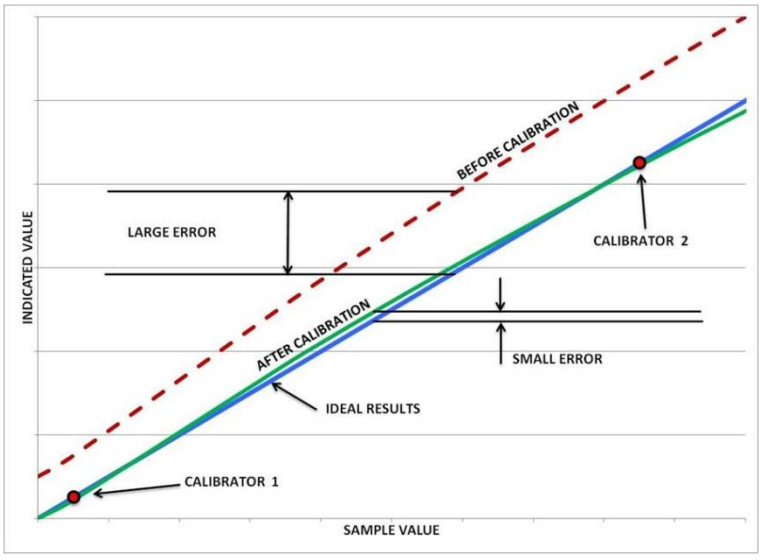
Calibration is the activity of checking, by comparison with a standard, the accuracy of a measuring instrument of any type. It may also include adjustment of the instrument to bring it into alignment with the standard. Even the most precise measurement instrument is of no use if you cannot be sure that it is reading accurately – or, more realistically, that you know what the error of measurement is. Let's begin with a few definitions:

- Calibration range – the region between the within which a quantity is measured, received or transmitted which is expressed by stating the lower and upper range values.
- Zero value – the lower end of the calibration range
- Span – the difference between the upper and lower range
- Instrument range – the capability of the instrument; may be different than the calibration range

For example, an electronic pressure transmitter may have an instrument range of 0–750 psig and output of 4-to-20 milliamps (mA). However, the engineer has determined the instrument will be calibrated for 0-to-300 psig = 4-to-20 mA. Therefore, the calibration range would be specified as 0-to-300 psig = 4-to-20 mA. In this example, the zero input value is 0 psig and zero output value is 4 mA. The input span is 300 psig and the output span is 16 mA.

Be careful not to confuse the range the instrument is capable of with the range for which the instrument has been calibrated.

Ideally a product would produce test results that exactly match the sample value, with no error at any point within the calibrated range. This line has been labeled "Ideal Results". However, without calibration, an actual product may produce test results different from the sample value, with a potentially large error.



Calibrating the product can improve this situation significantly. During calibration, the product is "taught" using the known values of Calibrators 1 and 2 what result it should provide. The process eliminates the errors at these two points, in effect moving the "Before Calibration" curve closer to the Ideal Results line shown by the "After Calibration"

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curve. The error has been reduced to zero at the calibration points, and the residual error at any other point within the operating range is within the manufacturer's published linearity or accuracy specification.

Every calibration should be performed to a specified tolerance. The terms tolerance and accuracy are often used incorrectly. In ISA's The Automation, Systems, and Instrumentation Dictionary, the definitions for each are as follows:

- Accuracy - the ratio of the error to the full scale output or the ratio of the error to the output, expressed in percent span or percent reading, respectively.
- Tolerance - permissible deviation from a specified value; may be expressed in measurement units, percent of span, or percent of reading.

Example: you are assigned to perform the calibration of the previously mentioned 0-to-300 psig pressure transmitter with a specified calibration tolerance of ±2 psig. The output tolerance would be:

*2 psig/300 psig*16 mA = 0.1067 mA*

The calculated tolerance is rounded down to 0.10 mA, because rounding to 0.11 mA would exceed the calculated tolerance. It is recommended that both

It is recommended that the tolerance, specified in measurement units, is used for the calibration requirements performed at your facility. By specifying an actual value, mistakes caused by calculating percentages of span or reading are eliminated. Also, tolerances should be specified in the units measured for the calibration. Calibration tolerances should be determined from a combination of factors. These factors include:

- Requirements of the process
- Capability of available test equipment
- Consistency with similar instruments at your facility
- Manufacturer's specified tolerance

The term Accuracy Ratio was used in the past to describe the relationship between the accuracy of the test standard and the accuracy of the instrument under test. A good rule of thumb is to ensure an accuracy ratio of 4:1 when performing calibrations. This means the instrument or standard used should be four times more accurate than the instrument being checked. In other words, the test equipment (such as a field standard) used to calibrate the process instrument should be four times more accurate than the process instrument.

With today's technology, an accuracy ratio of 4:1 is becoming more difficult to achieve. Why is a 4:1 ratio recommended? Ensuring a 4:1 ratio will minimize the effect of the accuracy of the standard on the overall calibration accuracy. If a higher level standard is found to be out of tolerance by a factor of two, for example, the calibrations performed using that standard are less likely to be compromised. The out-of-tolerance standard still needs to be investigated by reverse traceability of all calibrations performed using the test standard. However, our assurance is high that the process instrument is within tolerance.

Traceability

Last but not least, all calibrations should be performed traceable to a nationally or internationally recognized standard. For example, in the United States, the National Institute of Standards and Technology (NIST) maintains the nationally recognized standards. Traceability is defined by ANSI/NCSL Z540-1-1994 as "the property of a result of a measurement whereby it can be related to appropriate standards, generally national or international standards, through an unbroken

chain of comparisons." Note this does not mean a calibration shop needs to have its standards calibrated with a primary standard. It means that the calibrations performed are traceable to NIST through all the standards used to calibrate the standards, no matter how many levels exist between the shop and NIST.

Traceability is accomplished by ensuring the test standards we use are routinely calibrated by "higher level" reference standards. Typically the standards we use from the shop are sent out periodically to a standards lab which has more accurate test equipment. The standards from the calibration lab are periodically checked for calibration by "higher level" standards, and so on until eventually the standards are tested against Primary Standards maintained by NIST or another internationally recognized standard.

The calibration technician's role in maintaining traceability is to ensure the test standard is within its calibration interval and the unique identifier is recorded on the applicable calibration data sheet when the instrument calibration is performed. Additionally, when test standards are calibrated, the calibration documentation must be reviewed for accuracy and to ensure it was performed using NIST traceable equipment.

Calibration Services for:	
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Temperature	Conductivity
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M.G. Newell offers a variety of calibration services that keep your operations consistent and cost effective. Contact your local account manager for rates and plan options.

References:

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