

Engineer's Notebook

Calibration — Quality Assurance

Reading Accuracy Specifications



Calibration

Whether you are evaluating process instruments or calibrators, one of the biggest challenges in calibration management is reading and comparing accuracy specifications. Each manufacturer has a different expression for accuracy, making it difficult to evaluate and compare devices.

An accuracy specification is easier to comprehend if you think in terms of the uncertainty in the measurement. In a simple example, a 100 PSI test gauge has an accuracy specification of $\pm 0.25\%$ of full scale. The uncertainty of any measurement made with this gauge can be calculated by taking the full scale range (100 PSI) times $.25\%$ ($.0025$). Therefore a measurement of 30 PSI made with this gauge has an uncertainty of ± 0.25 PSI or is between 29.75 and 30.25 PSI.

Accuracy/uncertainty specs may be stated a number of different ways: % of Scale, full scale(FS), or range, % of reading, or of indicated value. In addition, on digital instruments, there will typically be an additional specification of \pm a number of counts or digits. If you see a specification expressed in PPM, 1 ppm is $.0001\%$, so 15 ppm is 0.0015% .

To interpret the true capabilities of a device, you need to apply the math in an accuracy specification to a measurement you would typically make.

Two examples:

1. A mA calibrator has a range of 24.00 mA, accuracy is 0.1% of FS ± 1 digit.
 - Full Scale is 24.00 mA
 - \pm digit specs are always farthest to the right of the decimal, in this case, $+0.01$ mA
 - At 20.00 mA this instrument is $\pm(24.00 \times 0.1\%) + 0.01$
 - After rounding, the uncertainty at 20.00 is ± 0.03 mA
2. A pressure transmitter has a range of 0–30 PSI, a 4–20 mA output, and an overall accuracy spec of 0.5% of full scale.
 - Full Scale is 30 PSI
 - Full Scale output is 20 mA
 - Uncertainty in mA at 30 PSI is $20 \text{ mA} \times 0.5\%$ or ± 0.1 mA

If you want to do a comparison of two or more different devices, apply the math in the specifications to the same measurement value (for example 20 mA) made with the various instruments. This will give you a realistic picture of how instruments compare.

Selecting Standards of Appropriate Accuracy

Many organizations use the rule of thumb that calibration standards have an accuracy ratio of 4 to 1 between the standard and the Unit Under Test (UUT). Stated another way, the uncertainty in your calibrator or standard should be no greater than $1/4$ the specified uncertainty in your UUT. For example, if a gauge has an uncertainty of ± 1 PSI at its full scale reading of 100 PSI, you would want to select a standard whose uncertainty was no greater than ± 0.25 PSI at 100 PSI.

Comparing accuracy is not always simple because there are many different ways accuracy can be expressed, and ranges on standards usually do not match ranges on UUTs.

In selecting standards, first choose one whose range is as close as possible to that of the UUT, then compare accuracy by applying the specification math to key calibration points.

For example:

- The UUT is a 30 PSI Transmitter, $\pm 1\%$
The proposed standard is a 100 PSI test gauge, $\pm 0.25\%$
- UUT uncertainty is $30 \text{ PSI} \times 1\%$ or ± 0.3 PSI
Standard uncertainty is $100 \text{ PSI} \times 0.25\%$ or ± 0.25 PSI
- Ratio is $0.3 \text{ PSI} \div 0.25 \text{ PSI}$ or 1.2 to 1.
This would not be an appropriate standard for this calibration.

Such calculations can be time consuming, and they certainly are not something you want to do every time you do a calibration. Ideally, the determination should be done once, and the appropriate standard should be written into the calibration procedure. This practice, coupled with sound management, will help insure the validity of your calibrations.

