Cal-Tek Company, Inc.
Measure with Confidence

Understanding Specifications

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Introduction

In a perfect world, your calibrated instrument would read perfectly…

However, we all live in the real world. There are many factors that go into determining how a device will represent a given measured value. Before we consider error that may be the result of measurement technique or calibration uncertainty, we need to first interpret the design specifications of the instrument being used.

Buyer Beware

It is very important that the instrument user is aware that multiple sets of specifications may exist for a single instrument. In some cases, instrument manufacturers will have a 'banner' specification that is put in cut sheets and advertising. The banner specification may not tell the whole story.

A banner specification might present an accuracy specification of ± 0.05%. However, delving deeper into publications such as the User or Service Manuals might provide any number of additional factors you need to be aware of:

- Is the ± 0.05% a Percentage of Full Scale or of Reading?
- Is the ± 0.05% limited to a portion of the instruments range (e.g., 10% to 90% of range)?
- Is the ± 0.05% dependent on a specific calibration interval (e.g., Calibrate every 90 days)?
- is the ± 0.05% only obtainable at a certain ambient temperature range?

You need to also consider other factors such as how the instrument might be used as part of a system. A temperature meter might sport a banner specification of ± 0.05%, but what does that mean if it is used in conjunction with a thermocouple that provides a tolerance of only +/- 1 degree?

This white paper will attempt to explain some of these factors and simplify the tangled web of specification terminology.

Terminology

Percent Full Scale

This is often abbreviated as % FS.

Let's say for example that your instrument has a specification of ± 0.05% FS. If your instrument has a range (or Full Scale) of 1000.00, then the tolerance is 1000.00 X 0.05% or ±0.50.

It is important to note that for instruments whose tolerance is in percent of full scale, the closer they are used to the full scale value, the less of a factor the tolerance becomes (see Table 1).

Table 1

If the instrument is used at 25% of its Full Scale: Measured value = 250.00 Tolerance (from Full Scale calculation) = ±0.50 0.50 is **0.2%** of 250.00	If the instrument is used at 75% or its Full Scale: Measured value = 750.00 Tolerance (from Full Scale calculation) = ±0.50 0.50 is only **0.06667%** of 750.00

Note that if you are dealing with an analog instrument that has a range of -1000 to +1000, your Full Scale is 2000. Sometimes used in the analog world is a term called End Scale (ES). For the same instrument, if it is zero-centered, the End Scale value is 1000.

Percent of Reading

For the Percent of Reading term, the tolerance is applied to whatever the measured value is, regardless of where you are in the operational range of the instrument.

If your instrument has a specification of ± 0.05% of Reading and you are taking a measurement a 500.00, your tolerance would be simply 500.00 ± the 0.05%. This equates to 500.00 ± 0.25.

LSD

In instrumentation, LSD refers not to the 60's and 70's, but is an acronym for Least Significant Digit. The value of the least significant digit is dependent on the resolution of the instrument. It is most commonly expressed together with one of the other terms we've defined, e.g., "± 0.05% of Reading, ± 2 LSD".

Here, your tolerance would be 500.00 ± the 0.05% (± the 2 LSD). With a display resolution of hundredths, this equates to 500.00 ± 0.25 (± 0.02). So, your tolerance at 500.00 would be anywhere between 499.73 and 500.27.

Device-Specific Terminology

Pressure Gauges

Certain industries have developed languages of their own. Pressure gauges are one example. Here you will find the instruments categorized by Grade (Grade A, B, 1A, etc.).

A Grade B gauge will have an accuracy of ± 3% of span on the lower and upper ends of the scale, with a ± 2% accuracy in the middle 50% of the of the scale.

Generally, pressure gauge tolerances are expressed in percent of Full Scale (or Span), but some may be Percent of Reading.

Scales and Balances

Scales and balance specifications are typically listed by manufacturers in a series of individual terms. These include Repeatability, Linearity, Readability (resolution), and Eccentricity (off-center loading effect).

Given the challenge of interpretation, weighing devices are often calibrated to a standard specific to the industry, such as *NIST Handbook 44* or *USP, Chapter 41*.

Other Factors

Keep in mind, there are other factors to consider when making your measurements that are not included in the numerical expression(s) of your instrument's tolerance. These may include warm up and stabilization times.

Summary

Specifications are a language unto themselves. Fortunately, if you are a Cal-Tek Company, Inc. customer who gets the *With Data* or *Accredited* levels of calibration, we have done the work for you in determining the measurement limits for your instrument.

These are provided in the MIN and MAX columns for each calibration test point on your calibration certificate.