Determining Accuracy and Stability for Digital Pressure Gauges

Like all calibration device manufacturers Martel Electronics spends a great deal of time determining what the accuracy specification is for the products we design. General convention is to publish one (1) year specifications as that is the generally accepted calibration interval for most calibration devices. Pressure measuring devices pose interesting challenges when trying to determine the one year specifications because not only must the long term stability of the electrical circuit be determined you must also determine the stability characteristics of the pressure sensor itself over time and combine those two numbers to arrive at a complete specification.

While there are several ways to state these specifications the most commonly accepted method is to state the one year “accuracy” where accuracy includes linearity, hysteresis and stability (drift) of the product over a specified time interval and temperature range. When manufacturing our pressure gauges we electronically compensate for the temperature effects by running our gauges through a unique temperature profiling process where the gauges are calibrated across several temperatures in an environmental chamber. This profiling process allows us to build an intricate pressure vs. temperature matrix which is used to compensate for ambient temperatures changes so the user can be sure the pressure reading is within specification even at operating temperatures far away from normal room temperatures.

With temperature effects being greatly reduced we can now look at the intrinsic stability of the electronics and the pressure sensor itself over time. When we do this we find that most of the influence comes from the sensor rather than the electronics.

The evolution of modern electronics has produced components that are very stable and the design of our gauges uses these parts. We also use some unique design elements where components that do exhibit long term drift are combined with other parts that offset this drift yielding a very small overall long term drift rate. With this electronic drift being small that leaves the sensor as the largest influence on the accuracy of the device.

Martel uses the latest piezoresistive pressure sensors in all of our pressure products. These sensors come from a variety of manufacturers and are in most cases are custom made for us by the manufacturer to meet our requirements and the higher demands of calibration use. During our internal calibration and testing process we measure the linearity and hysteresis of each sensor. Linearity is easily compensated for as our automated calibration systems are designed use numerous calibration points to build the pressure/temperature matrix mentioned above. This same matrix also allows the firmware within the gauge to correct for any deviations in senor linearity. Hysteresis is also measured during the many upscale/downscale pressures that are applied during the calibration process. Typically hysteresis is a small part of the overall accuracy but if a sensor shows an abnormally high amount of hysteresis it is rejected and replaced with a new sensor and process is restarted.

The final element is the long term stability of the sensor itself. The overall stability is influenced by the baseline zero drift of the sensor combined with the span (or gain) drift of the sensing element over time. For the purposes of calibration the gauge's zero drift is typically a very small part of this influence as calibration devices have a "zero" function that is initiated each time the device is used. So, with the exception of absolute sensors where zero drift must also be accounted for, we can put our focus on the long term span or gain drift.

This data is derived from a combination of empirical testing and sensor manufacturer data obtained over many years of making these devices. In addition to this data our automated calibration systems, along with the technicians who operate them, have developed proprietary guidelines that allow us to predict which sensors could exhibit long term drift so that they can be identified and removed.

We've now discussed all of the major elements that go into determining the overall accuracy of our digital pressure calibration gauges. In order to arrive at the final 1 year specification, we must combine all of the elements and do a statistical analysis to arrive a final accuracy specification.

The generally accepted method for going this analysis is the RSS (Root Sum Square) calculation which is widely used in the field of statistics. The following example shows the calculation for a typical Martel BetaGauge PI-PRO that carries a stated specification of 0.05% of FS.

WHERE:

L= linearity

H=Hysteresis

U=Test standard uncertainty

C= Measuring circuit stability (1 year)

S= Sensor stability (1 year)

Accuracy (1 year) = SQRT [(L)^2 + (H)^2 + (U) ^2 + (C)^2 + (S)^2]

Plugging in the numbers yields:

Accuracy (1 year) = SQRT [(0.009%) ^2 + (.005%) ^2 + (.008%)^ 2 + (0.0035%)^2 + (0.025%)^2]

Accuracy (1 year) = 0.039% of FS

We can see from the results of this equation that the gauge should easily meet the stated 1 year accuracy specification of 0.05% FS.