Application Bulletin: #148

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Pressure and Leak Rate Accuracy
Sentinel I24 and M24
Pressure Decay Instruments

The accuracy of the pressure reading on a pressure decay instrument is a combination of transducer's linearity/hysteresis and the accuracy of the gage used for setting the span of pressure reading on the instrument. The pressure transducer provides a millivolt output proportional to the measured pressure. The absolute pressure transducer has a measuring range of 0 psia to the upper range of the transducer (ie. 20 psia, or other ranges). The output of that transducer will be 0 mv at 0 psia and roughly 100 mv at full scale. The transducer has an accuracy specification of ±0.15% FS.

The pressure decay instrument converts the millivolt output of the absolute pressure transducer into a digital signal via a 24 bit A/D converter. That signal is scaled in the instrument to the predetermined millivolt vs pressure range value for the transducer. Because the display readings on the instrument are always gage pressure (pressure vs atmospheric pressure), the instrument measures the absolute pressure of atmosphere before each test to establish 0 psig. Pressure reading of the instrument is calibrated for gage pressure. The transducer's calibration process first reads the atmospheric pressure to establish 0 psig. Then a valve opens supplying regulated air to the test port. A traceable pressure gage is attached to the instrument's test port. The calibration technician enters the gage pressure reading into the instrument's calibration screen. The Sentinel instrument scales the instrument readings to match the pressure value entered by the technician. The instrument's pressure accuracy is now directly proportional to the accuracy of the calibrated pressure gage used for this procedure. The gages, used to calibrate the instruments at CTS prior to shipping, are checked to our traceable pressure gage in our A2LA certified laboratory. The accuracy of that gage is +0.005 % of reading on a 20 Bar scale.

During the pre-fill, fill, and stabilization cycles the instrument displays the test pressure relative to atmospheric pressure to verify that each test is conducted at the specified pressure between Min Test Press and Max Test Press. The accuracy of the pressure transducer verifies that the actual pressure is within the limits set by Min Test Press and Max Test Press.

The accuracy of the reading on the Sentinel I24 and M24 instruments is a function of the pressure transducer accuracy and the conversion accuracy of the A/D converter.

Pressure = Voltage x Conversion Factor

$P = V \times K$

V is measured voltage and has a tolerance equal to

A/D Span/resolution = $110\ mV/2^{enobs} \sim 110\ mV/2^{17} = 8.4 \times 10^{-4}\ mV$

K is the conversion factor and has a tolerance equal to

0.15% of transducer range/100mv

(Druck PDCR 1000 transducer with advertised accuracy of 0.15% FS)

So, for a 20 PSIA transducer, K = 20 PSIA/100mV = 0.2 PSIA/mV

with tolerance of ± 0.0003 PSIA/mV

In the most general terms, $\triangle V = 110\ mV/2^{enobs}$

$\triangle K$ = transducer range/100 mV x 0.15%

A change in P due to V is equal to:

$P = KV \qquad \delta P/\delta V = K$

$\Delta P, V = (\delta P/\delta V)\ \Delta V$

$$\boxed{\Delta P, V = K\ \Delta V}$$

A change in P due to K is equal to:

$P = KV \qquad \delta P/\delta K = V$

$\Delta P, K = (\delta P/\delta K)\ \Delta K$

$$\boxed{\Delta P, K = V\ \Delta K}$$

Total change to P due to changes in V or K is equal to:

$$\Delta P_{total} = ((\Delta P, V)^2 + (\Delta P, K)^2)^{1/2}$$

$$\Delta P_{total} = ((K\ \Delta V)^2 + (V\ \Delta K)^2)^{1/2}$$

$$\Delta P = [\ ((\frac{xducerSpan}{100mV})(\frac{ADCrange}{2enobs}))^2 + ((FullRangeVoltage)(Accuracy\%)(\frac{xducerSpan}{xducerOutput}))^2\ ]1/2$$

For example: 20 PSIA transducer

$\Delta P = (((20\ PSIA/100mV)(110mV/2^{17}))^2 + ((100mV))(0.15\%)\ (20\ PSIA/100mV)^2)^{1/2}$

$\Delta P = ((1.68 \times 10\text{-}4)^2 + (0.03)^2)^{1/2}$

$= (2.817 \times 10^{-8} + 0.0009)^{1/2}$

$= (0.00090002817)^{1/2}$

$\Delta P = 0.03$ PSIA

For a 20 PSIA transducer, the worse case accuracy error would be $\pm$0.03 PSIA
For a 45 PSIA transducer, the worse case accuracy error would be $\pm$0.06 PSIA
For a 115 PSIA transducer, the worse case accuracy error would be $\pm$0.17 PSIA
For a 215 PSIA transducer, the worse case accuracy error would be $\pm$0.32 PSIA

Calibration of pressure change over time to leak rate

Within the test cycle the instrument monitors the changes in pressure from the beginning of test to the end of test. The parts' leakage characteristics are determined by the slope or change of pressure during the test cycle. The accuracy of this test is not determined by the accuracy of the actual or gage pressure reading but by the sensitivity and repeatability of the pressure change readings relative to a master part and a calibrated leak standard.

The measured pressure changes determined by testing a master part without and with a calibrated leak standard determines the relationship of pressure loss to leak rate. Therefore the accuracy of the displayed leak rate is determined by the accuracy of the calibrated leak standard ($\pm$1.2% of value or $\pm$0.1 sccm, whichever is greater) and the repeatability of the good part test response.

Transducer Specifications
Accuracy 0.15% of Full Scale

Pressure Decay Instrument
Resolution (24 bits) or effectively 5 x 10-7 times transducer range
As low a 2.5 x 10-6 psi. (0.02 Pa)
Tolerance: 8.39×10^{-4} mV

CTS Pressure Calibration Gage
At >1% of scale: +0.005% of reading
At <1% of scale: +0.00025 of full scale
Full scale of Auto Ranging is 20 bar.

Calibrated Leak Standards supplied within each instrument
$\pm$1.2% of value or $\pm$0.1 sccm, whichever is greater