Instrument Resolution

Sentinel B-21/I-21/C-20 Instruments

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Why is instrument resolution (sensitivity) important for pressure decay leak testing?

It determines the achievable leak rate and time cycle for a practical test on a part.

What resolution is required to conduct an acceptable and quick test?

Because most testing applications require a 10% gage repeatability, the instrument must resolve pressure changes 10 to 100 times better than the repeatability error allowed for qualification. For instance if the reject leak rate is 5 sccm, the process must be repeatable to better than ±0.5 sccm. This repeatability band includes instrument, part, and fixture/seal variations. Proper fixture design and adequate fill and stabilization times minimize some of the part and fixture/seal variations. The required test time to achieve adequate test resolution is dependent on the part volume, leak rate, and instrument resolution and repeatability. The instrument resolution required to meet this capability should be at least 10 times better than the ±0.5 sccm leak rate repeatability band. Therefore the leak rate resolution should be 0.05 sccm or better. To translate this leak rate resolution to pressure loss resolution, use the following formula.

$$\text{Pressure resolution} = \frac{\text{Leak rate resolution (sccm)} \times \text{Test time (sec)} \times 14.7 \text{ psi}}{\text{Part volume (cc)} \times 60 \text{ sec/min}}$$

For example:
To test a 500 cc volume part at 50 psi for a 5 sccm reject leak rate within 5 seconds of test time (10-15 sec overall time) requires the following resolution or better.

$$\text{Pressure resolution} = \frac{(0.05 \text{ sccm}) \times (5 \text{ seconds}) \times 14.7 \text{ psi}}{(500 \text{ cc}) \times 60 \text{ sec/min}} = 0.00012 \text{ psi}$$

If the instrument's resolution is only 0.001 psi, the test timer would have to be extended to 50 seconds to provide sufficient test resolution. Therefore total test cycle time is dependent on instrument resolution.

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Optimal Results
To achieve optimal test results in the least amount of time requires the best resolution possible.

The resolution of a pressure decay leak test instrument is controlled by two factors:

- **Range of the transducer (gage pressure transducer or differential pressure transducer)**
- **Analog-to-Digital converter (A/D)**

The test instrument converts the analog output of the pressure transducer into a digital signal for the computer via the A/D converter. Typical A/D converters are 8, 12, 16, and 24 bits. This means that the converter divides the output signal of the transducer by the number of increments provided by that converter. To determine the number of increments that a converter has, perform the following computation.

8 bit = 2^8 = 2x2x2x2x2x2x2x2 = 256 increments

12 bit = 2^{12} = 4096 increments

16 bit = 2^{16} = 65536 increments

24 bit = 2^{24} = 16777216 increments

Typically there is some noise in the conversion that reduces the effectiveness of the converter. Therefore, these converters are not capable of providing a repeatable signal for all increments. As a result they have an effective resolution of typically:

8 bit	200 increments
12 bit	2,048 increments
16 bit	16,384 increments
24 bit	2,096,152 increments

For a 12 bit converter, the resolution or sensitivity of the instrument is calculated by dividing the range of the transducer measuring the pressure loss during test by the effective increments (2048). For instance, an instrument with a 100 psi transducer would have sensitivity of 0.05 psi. For a low leak rate application, a good leak test instrument would require much better sensitivity than 0.05 psi in order to detect a small leak in a reasonable test time. To obtain better sensitivity requires either a better A/D converter or use of a differential pressure transducer (i.e. a more expensive and complex differential pressure instrument) to measure the pressure loss during test. With a differential pressure transducer range of 0.1 psi, a 12 bit A/D could resolve 0.00005 psi. This is equivalent to what a 24 bit A/D system could resolve on a 100 psi gage transducer.

Using an instrument with the best resolution available allows for faster testing because it needs less pressure loss to resolve a repeatable difference between a good and bad part.

Advantages of using gage systems over differential systems

- simpler test system with fewer valves and transducers
- no potential for leaks in the reference side of test pneumatics
- not limited to narrow leak range due to limited differential pressure transducer span
- less chance of damaging a narrow range differential transducer if part has a large leak
- simpler and more accurate mathematical conversion from pressure loss to leak rate
- less internal volume added to test volume
- fewer valves to add heat to test

The Sentinel B-21, C-20, and I-21 pressure decay leak test instruments incorporate 24 bit technology. These instruments provide the best technology at the lowest price with the market's best performance. It is a hard combination to beat considering the many easy-to-use features built into the instruments.