FLUKE®
Calibration

7 Tips for Calibrating Pressure Gauges and Transmitters

7 Tips

- Pick the right media
- Stabilize the pressure & display the right resolution
- Prevent contamination
- Importance of exercising
- Dealing with the limited resolution of a dial gauge
- Consider the uncertainty of the electrical measurement
- Automate the data collection

Test Medium

- A gas medium is typically used for calibration to 300 psi (2 MPa), often as high as 3000 psi (20 MPa). Some applications go as high as 15k psi (100 MPa). Typical sources of test gas are:
  - High pressure N2 or Air delivered from a bottle - usually less than 3k psi (20 MPa)
  - Compressed ambient air or N2 from a generator
  - Boosted gas pressures to 100 MPa and greater (requires considerable energy and hardware)
- A liquid medium is typically used for calibration of full scale devices of 500 psi (3.5 MPa) and greater. Liquid pressure controller applications often demand as high as 40k psi (280 MPa). Some applications go as high as 75k psi (500 MPa).
  - Hydrocarbon and synthetic oils
  - Water (water/alcohol mixture)
  - Inert solvents (i.e. Fluorinert), often expensive

Test Medium - Gases

- Advantages of a Gas Medium
  - Does not introduce contamination to the device under test (DUT)
  - Generally clean (not messy) to work with
  - Minimize affect of fluid head, surface tension in tubes, and other influences from liquid medium
- Challenges with a Gas Medium
  - Safety – gas compressed to high pressures has higher stored energy than liquid at equivalent pressure due to lower compressibility
  - Heavy equipment and energy required for high pressure gas
  - Gas is more susceptible to leaks due to low viscosity
  - Requires regulators, filters and sometimes accumulators to produce an adequate supply

Test Medium - Liquids

- Advantages of a Liquid Medium
  - Relatively safe at high pressures – low compressibility means less energy is stored in the test medium
  - Pressure is more easily generated with conventional means (less hardware and less energy to produce high pressures)
- Challenges with a Liquid Medium
  - Can be messy during making and breaking of test connections
  - Can carry contamination between DUTs and from DUT to the reference standard
  - Some devices (DUTs) are not compatible with fluid media
  - Manufacturing - New DUTs need cleaning of fluid before shipping

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Pressure generation Devices

- Many different types of devices can be used to generate and/or stabilize the pressure in the system
  - Pressure Pumps/Comparators
  - Deadweight Testers
  - Piston Gages
  - Pressure Controllers

Why is the pressure Unstable ?

- R is the universal gas constant - Pressure is absolute

$$PV = nRT$$

- Re-arranged for pressure – use as an evaluation tool.

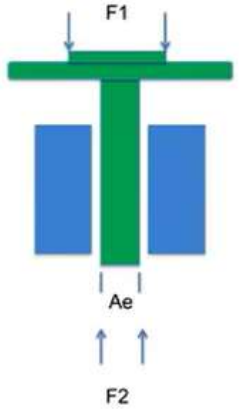
$$P = \frac{nRT}{V}$$

Why is the pressure Unstable ?

- V - Volume Changes
  - Screw pump used to change the pressure
  - Swelling of tubing
- N – Number of molecules
  - Let air into the system to increase pressure
  - Vent the air out of the system to decrease pressure
  - Leak
- T - Temperature changes
  - As pressure changes, the temperature changes with it
  - As pressure goes up, temperature goes up
  - When pressure stabilize, the temperature decreased back to ambient
  - As temperature goes down, the pressure goes down, looking like a leak

How do we Stabilize it

- Pressure Pump/ Comparator
  - Pressure is changed by adding molecules (pneumatic pump) or changing volume (hydraulic pumps)
  - More difficult to stabilize temperature effects , but can be done through manipulation of the variable volume or through patience
- Pressure Controller (Pneumatic)
  - Stabilizes pressure by letting in and venting out air to overcome temperature effects
  - Works best without a leak in the system, but some can “feed a leak”
- Deadweight Tester/Piston Gauge
  - Pressure is defined as Force (generated by the masses) divided by area(effective area of the free-floating piston)
  - The Piston naturally sinks, causing the volume of the system and the number of molecules to change
  - The sinking offsets the temperature effects, creating a very stable pressure



Resolution – Why so many Digits

- Precise reference standards show many digits
- If you have too many digits, the pressure will never look stable
- Reduce the resolution so that a sufficient number of digits for the calibration (rule of thumb – one more than the DUT) but not too many.

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Prevent Contamination

- DUTs are often dirty. Dirt, oil , or other debris can contaminate your reference standards or other DUTs.
- Either clean the DUTs beforehand or take steps to protect the reference standard.
- Devices that can be used:
  - Filter Traps
  - Liquid Traps
  - Separators
  - Uni-directional flow

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What is Exercising and Why Should I do it ?

- Exercising – Taking the DUT to the maximum and minimum of its range multiple times (normally 3 times) at the beginning of the calibration process.
- Why do it ?
  - Some pressure sensing elements (especially those used on dial gauges) will behave differently if they have recently been pressurized.
  - Calibration should, whenever possible, be representative of the actual usage of the instrument
  - Therefore, we exercise the DUT in order to put it in the same state in which it was used.

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Reading a Dial Gauge

- When the pressure is stabilized such that the reference standard is reading the cardinal pressure, the gauge needle will most likely be pointing in between two demarcations.
- How does one interpolate the value ? Usually , not very well.
- A different approach – jog the pressure so that needle is on the cardinal point, and the reference standard will have more resolution and will be easier to read.

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Calibrating a Transmitter - Need to read the output

- To calibrate a pressure transmitter:
  - Apply Pressure
  - Measure the Pressure
  - Provide supply voltage to the DUT
  - Measure the output of the DUT
- The ability to measure the output of the DUT need to be considered when calculating the Test Uncertainty Ration (TUR)
- If the DUT's output is a ratio of the supply voltage, then it needs to be measured and considered

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Automate the Data Collection

- Some level of automation can be accomplished, whether calibrating gauges or transmitters.
- Automation has many advantages
  - Insure the same process is followed every time
  - Eliminate transcription errors
  - Reduce touch time, improving efficiency

Conclusion

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Thank you for your time and attention