CALIBRATION THEORY

WHAT IS CALIBRATION?

Definition

The process of comparing the response of an instrument to agree with a standard instrument over the measurement range.

Objective

To determine the deviation between measuring values and corresponding true values (an industrial calibrator is thus a "true value").

TEMPERATURE CALIBRATION

In order to maintain consistent quality of manufactured products, it is necessary to perform calibrations on process sensors and instruments. There are several philosophies for calibration of the measurement and control circuits. The basis of the chosen method should always be to include the temperature sensor.

It doesn't make sense only to calibrate and adjust the electronic part of the loop. A rule of thumb says that only 10% of the total error is in the electronics, the other 90% is in the sensing element. So it is essential that the temperature sensor is tested, meaning physically exposed to the desired temperature. A dry-block calibrator is an easy method to create the "process" temperature.

The output from the sensor can be taken from anywhere in the loop. And the rest of loop might be tested electronically.

PRINCIPLE OF DRY BLOCK TEMPERATURE CALIBRATOR

"Heating up a metal block and keeping the temperature stable"
This is the very basic principle of a dry-block calibrator. The design gives the user a lot of advantages compared to the more traditional liquid baths.

- Heat up and cool down much faster
- No hazardous hot liquid
- Much wider temperature ranges
- Physically smaller and lighter
- Designed for industrial applications
- Models with completely integrated calibration solutions

COMBINED UNCERTAINTY

A calibration is a matter of qualifying the sensor-under-test. Only be knowing the limitations of the sensor it is possible to maximize the process loop. In other words, a temperature reading is only valid if the uncertainty value can be accounted for, eg 60°C ±2°C.

In this case the uncertainty is ±2°C. This means that a temperature reading of 60°C could have any value between 58°C and 62°C. The lower the uncertainty the more accurate are the measurements.

PRESSURE CALIBRATION

There are many different factors that need to be considered when selecting a pressure standard. It is important to evaluate the requirements of the task being performed and

- The overall accuracy of the pressure standard for the application
- Specific application considerations including test fluid, pressure range and task being performed.
- Cost of the inaccurate pressure measurement either on the purchase or sale of product
- Adequacy of the pressure standard to test or adjust safety related systems.
- Requirements for routine maintenance inspections

As a general guideline, the calibration standard used must be four times (4x) more accurate than the device being calibrated.

EXPRESSION OF PRESSURE MEASUREMENT

Low Pressure		**Vacuum**		**Pressure**	
Inches H_2O (20°C)	= 0.036063 PSI	Inches Hg (0°C)	= 0.49114999 PSI	Pascal = 1Newton/m²	= 0.0001450377 PSI
Inches H_2O (60°C)	= 0.036092 PSI	Torr = 1mm Hg (0°C)	= 0.019718 PSI	Bar = 100 Kilopascal	= 14.50377 PSI
Inches H_2O (4°C)	= 0.036126 PSI	Millimeters Hg (20°C)	= 0.019266878 PSI	Kg/cm²	= 14.22334 PSI
Millimeters H_2O (20°C)	= 0.0014198 PSI				
Millimeters H_2O (4°C)	= 0.00142228 PSI				

PNEUMATIC DEADWEIGHT TESTERS

These self-regulating testers offer a high level of accuracy independent of the operator and have earned their reputation as the “standard of primary standards”. They are available for pressure as low as 4 in H_2O (10 cmH_2O) or as high as 1500 psi (100 bar).

Applications

- The ideal primary standard
- Calibrate instruments used in critical process control loops and extend the time between calibrations due to better accuracy and uncertainty.

- Calibrate instruments on custody transfer stations and reduce the uncertainty of the measurement
- Reduce maintenance costs by calibrating your portable digital calibrators and achieve the highest possible accuracy
- Ideal for hazardous locations

Principle of Operation

Pneumatic testers are self-regulating, primary type pressure standards. An accurate calibrating pressure is produced by bringing into equilibrium the pneumatic pressure on the underside of a ball of known area by weights of known mass on the top.

The precision ceramic ball is floated within a tapered stainless steel nozzle. A flow regulator introduces pressure under the ball, lifting it in the tapered annulus until equilibrium is reached. At this point the ball is floating and the vented flow is equal to the fixed flow from the supply regulator. The pressure, which is also the output pressure, is proportional to the weight load. During the operation the ball is centred by a dynamic film of air, eliminating physical contact between the ball and the nozzle.

HYDRAULIC DEADWEIGHT TESTERS

- Repeatability better than ±0.005% of reading
- Accuracy up to ±0.025% of reading and even better using a DADT converter
- Dual volume control valve delivers high volume to rapidly build pressure
- Vernier adjustment for fine adjustment of pump pressure
- Re-entrant type of piston and cylinder assembly maintain accuracy as test pressure increases and improve the spinning/float time.
- Single and dual column versions.
- Enclosed piston/cylinder assembly for safe operation
- Available engineering units: psi, bar, kPa, kg/cm^2

DUAL VOLUME HAND PUMP

The lever action hand pump incorporates a dual volume control valve. This allows the pump to deliver a high volume in order to rapidly fill systems and build pressure. The low volume permits easy pumping at high pressures and a more gradual approach to the point of pressure calibration. A vernier adjustment is provided for fine adjustment to the desired pressure.

OVERHUNG WEIGHT CARRIERS

The weights are placed on a weight tube that is suspended from the piston assembly. Suspended weights have a lowers center of gravity that minimizes side thrust on the measuring piston and cylinder assembly resulting in improved measurement accuracy, and minimized wear on the piston and cylinder assembly.

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RE-ENTRANT PISTON/CYLINDER

Within the re-entrant piston and cylinder design, the test fluid is applied to a chamber on the outside of the cylinder as well as to the inside of the cylinder. The area of the outside of the cylinder is larger than the inside giving a reduced clearance between the piston and the cylinder at higher pressures. This design reduces the rate of fluid leakage, thus increasing the time available for calibration of instruments prior to pumping to restore fluid loss.

POSITIVE OVERPRESSURE PROTECTION

The vertical movement of the measuring piston assembly is restricted by a positive stop. This will prevent the piston from damage caused by accidental removal of the weights while pressurized. These stops are rated at the maximum tester pressure.

U-TUBE MANOMETERS

U-tube manometers for relative and absolute pressures, vacuum and differential pressures.

These devices are primary standards and are void of faults within their physical tolerances. They are designed to measure pressure and are suitable for calibrating high precision pressure sensors.

- Very low maintenance cost. No need for recalibration
- No electronic parts. Can be used anywhere
- Ideal for calibration of transmitters in clean-room applications
- Differential pressure for flow applications
- BAROSCOPE for absolute pressure in metrology laboratories and aerospace applications
- Calibration of handheld instruments used in HVAC applications

Basic Knowledge

The measuring principle of these liquid manometers is based on the following relationship:

$\Delta p = \Delta h \times pm \times g$

The pressure (p) to be measured is to be compared with the height (h) of a liquid column. If the pressure exerted on the two surfaces of the so-called confined liquid is no the same, there is a deflection and consequently a difference in height. The confined liquid continues to rise until the effect of the force of the pressure differentials and weight of the liquid columns are identical. In accordance with the law of physics, the effect of the liquid column on the pressure in the liquid is, in essence, only dependent on height (h) of the liquid column and on density (pm) of the liquid. Further influences are relatively low and know. For highly precise measurements, correction calculations can be made. Recalibration is not necessary.

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SIGNAL CALIBRATION

Complete Loop Calibration

In order to maintain consistent quality of manufactured product, it is necessary to perform periodic calibrations on process sensors and instruments. There are several philosophies for calibration of the measurement and control circuit. The most obvious and representative method is to calibrate the complete measurement circuit, ie from the sensor through the transmitter to the indicator or controller.

Split Loop Calibration

Each component of the process measurement and control system is calibrated as an independent item. The transmitter can be calibrated using a precision signal calibrator. The indicator or controller can be calibrated either as described for the transmitter or by using the MACAL loop calibrator which simulates an output of 4-20mA proportional to the temperature (or pressure). The sensor part can be brought to the workshop for a time saving automatic calibration.

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