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A few important concepts about Pressure Transmitters



Introduction

In present days we witness technological advancements in industrial processes and controls with the advent of microprocessors and electronic components, Fieldbus technology, the Internet, etc., as everything facilitates the operations and guarantees of process optimization and the performance and operational safety. This advancement today permits that pressure transmitters, as well as other variables, may be projected to ensure high performance in measurements so far utilizing analog technology. The analog transmitters then in use were designed with discrete components susceptible to drifts due to temperature, process and local conditions, which required constant adjustments through potentiometers and switches. The digital technology also provided simplicity in use.

The pressure transmitters are widely utilized in processes and applications with numberless functionalities and resources.

This article will cover some details and concepts related to pressure transmitters.

The exactness of a Pressure Transmitter

It is worth remembering that in the past few decades a large variety of equipment arrived to the market in several applications. The exactness of pressure characterization was really valued on the moment it could be translated into measurable values.

The entire pressure measurement system is constituted by the primary element that will be directly or indirectly contact with the process where the pressure changes occur and the secondary element (the pressure transmitter) that will translate this change into measurable values to be used on indication, monitoring and control.

Static performance or exactness depends on how well the transmitter is calibrated and how long it can maintain its calibration. Many times exactness is mistaken for precision, where exactness is associated with the proximity of the value and precision is related to the dispersion of the resulting values of a series of measurements.

The calibration of a pressure transmitter involves zero and span adjustment. Exactness normally includes non-linearity, hysteresis and repeatability effects.

Normally the exactness is indicated in % of the calibrated span.

Some Important Concepts

Usually the relation between a pressure transmitter input and output is predominantly linear ($Y = ax + b$), where **a** is known as gain and **b** is zero or offset, as explained on figure 1.

Range: is the measurement limit and covers from the minimum to the maximum pressure that the transmitter can measure, e.g., 0 to 5080 mmH₂O. The maximum span is 5080 mmH₂O.

Zero: is the smallest pressure at which the transmitter was calibrated.

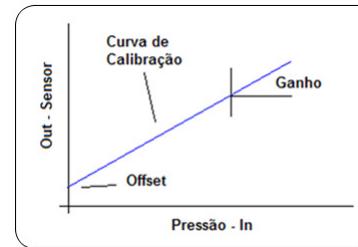


Figure 1 – Calibration Curve of a Pressure Transmitter

URL (Upper Range Limit): is the highest pressure at which the transmitter was set to measure, respected the sensor upper range limit.

LRL (Lower Range Limit): is the lowest pressure at which the transmitter was set to measure, respected the sensor lower range limit.

Span (Range Calibrado): the work range where the calibration is done is known as span, for example, from 500 to 3000 mmH₂O, where the span is 3000-500 = 2500 mmH₂O. The Span is equal to URL – LRL.

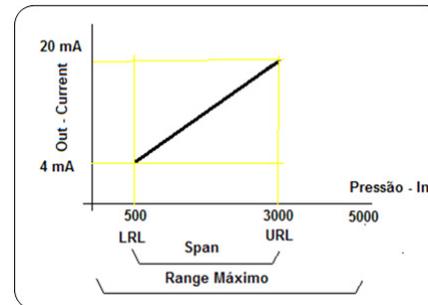


Figure 2 – Calibration Terminology

Zero Suppression (is the quantity with which the lower value surpasses the pressure zero value): the suppression occurs when the transmitter indicates a level above the real. On level measurements, where the transmitter is not installed at the same level than its high socket and there is the need to compensate the liquid column at the transmitter socket. This type of installation is required where the transmitter is at a lower level, which, in practice is the chosen way to facilitate access, visualization and maintenance. In this case, a liquid column is formed with the same height as the liquid inside the impulse socket and the transmitter will indicate a level above the real. This must be taken into consideration and is called Zero Suppression.

Open Tank

PL = P atm (atmospheric pressure)

- TRM low side is open by atmospheric pressure.
- Only by liquids.

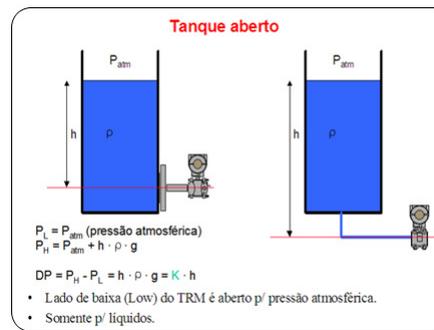


Figure 3 – Indirect measurement using the differential pressure transmitter in open tanks – Zero Suppression.

Zero Elevation (is the quantity with which the zero pressure value surpasses the lower value): As shown on Figure 4, in cases of closed tanks and the differential pressure transmitter is located below its Hi socket and there is no liquid sealing on the Low socket, the liquid column applied to the Hi socket must be compensated, thereby making the Zero Suppression. If there is liquid sealing on the low pressure socket, the compensation is necessary on both the liquid columns applied to the Hi socket and the Low socket. This is called Zero Elevation.

Closed Tank

PL = P top (steam pressure)

- Low side is connected to the tank upper part..
- Only by liquid.

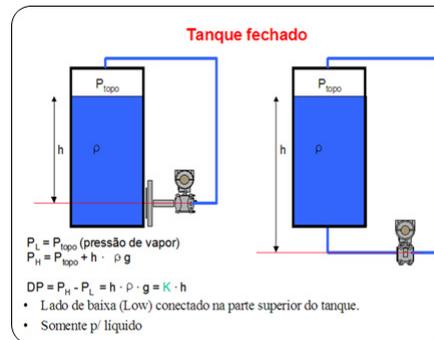


Figure 4 – Indirect measurement using the differential pressure transmitter in closed tanks – Zero Elevation.

Zero Shift – this is a constant error in every measurement and can be a positive or a negative error. It may occur for many reasons, like temperature changes, mechanical shock, different potentials, inadequate grounding, etc. See figure 5.

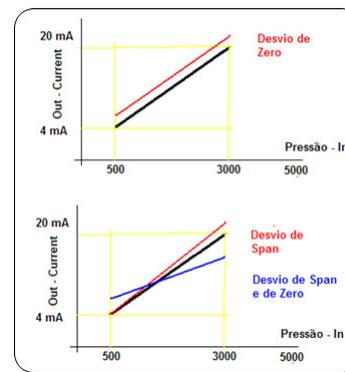


Figure 5 – Zero Shift and Span Shift

Span Shift: a change in the derivation of the input/output relation is referred to a span shift. A span error can be or cannot be followed by an offset error. Typically, calibration errors only involve span errors and are less common than those involving span and zero errors at the same time. The great majority of cases in transmitters a zero shifts. See figure 5.

Hysteresis: is the phenomenon in which the pressure transmitter output differs from the same input applied, depending on the direction in which the input signal is applied, that is, if it is ascending or descending. Normally the pressure transmitter calibration is done using the 0, 25, 50, 75, 100, 75, 50, 25 sequence and 0% of the span. See figure 6.

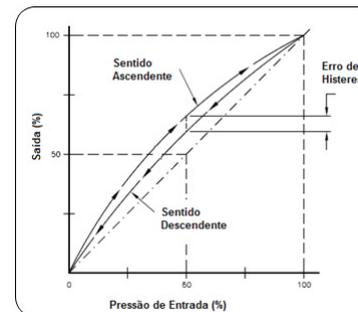


Figure 6 - Hysteresis

Repeatability is the maximum percent shift with which the same measurement is indicated and all conditions are reproduced exactly the same way.

Turndown(TD) or Rangeability: is the relation between the maximum pressure (URL) and the minimum measured pressure (minimum calibrated span). For example, a transmitter range is 0-5080 mmH₂O and will be used on 10:1, indicating which transmitter will measure 0 to 508 mmH₂O. $TD = URL / \text{Calibrated Span}$.

Absolute Pressure: value measured under vacuum conditions, i.e., absence of pressure, also known as absolute zero.

Manometric or Gage Pressure: atmospheric pressure.

Differential Pressure: the pressure measured in relation to a reference.

Static or Line Pressure: pressure over a pressure line where there is a fluid flow. It is the process pressure applied to both sockets of a differential transmitter.

Hydrostatic Pressure: pressure exerted by a liquid under the surface below the same.

Probable Total Error (ETP): all transmitters, regardless of manufacturer have an error depending on several points. This error is known as Probable Total Error (ETP) and depends on certain conditions:

- Ambient temperature variation;
- Static pressure;
- Variation of the power supply voltage;
- Calibrated Span;
- Transmitter URL;
- TransmitterRange;
- Construction Material;
- Etc.

The ETP has the following formula:

$$ETP^2 = Acc^2 + ZeroStaticErr^2 + SpanStaticErr^2 + TempErr^2 + VSErr^2 + StabilityErr^2 \dots$$

- Acc = exactness
- ZeroStaticError = Zero error due to the static pressure influence
- SpanStaticError = Span error due to static pressure influence
- TempErr = Error due to temperature variation
- VSErr = Error due to the power supply voltage variation
- StabilityErr = Stability error

Market

According to users, the principal features of pressure transmitters specifications as per applications are: exactness, reliability, durability/robustness, safety, easy to calibrate, repeatability, temperature stability, easy maintenance, interchangeability, response time, must support communication EDDL and DTM, etc.

- According to ARC – Advisory Group, the pressure transmitter world market in 2008 was 2.38 billion dollars and an estimated 2,8 billion in 2013.

Intelligent Transmitters

An intelligent transmitter combines sensor technology and its electronic.

Typically it must provide the following characteristics: Digital output signal, Digital communication interface, Pressure Compensation, Temperature Compensation, Stability, Must allow easy calibration, Re-range with and without reference, Resourcefulness, Self Diagnostics,

- Easy installations

High reliability

Low installation and maintenance costs, Short installation and maintenance time, Reduction of intrusion/penetration, Space-saving installation, Allow upgrades for Foundation Fieldbus and Profibus PA technologies, etc. Examples: LD301 (HART/4-20 mA), LED302 (Foundation Fieldbus), LD303 (Profibus-PA), LD400 (New Series of SMAR high-performance Transmitters, SIS, etc.).

Users must be attentive to some points:

- **Exactness & Rangeability**: if the required equipment must have such characteristics, analyze the exactness formulas through the entire range. See also other features like response time, Total, PID block, etc... They can be more useful on the applications.
- Models with stability and long-standing guarantee are more expensive. Check if your application really needs it. Normally there are process and installation conditions as requirements for this guarantee to be applicable.
- **Protection to the investment**: analyze if the price of repairs, interchangeability between models, simplified specifications, update for other technologies (Fieldbus Foundation, Profibus PA), service rendering, technical support, reposition time, etc. These are factors that may interfere with the plant availability.

Safe Transmitters

A pressure transmitter specified for critical areas, i.e., for specific safety functions, is designed with low failure probabilities and high operational reliability. There are two concepts in the market. One that is based on the "Prove in Use" notion, and another based on the IED 61508 certification. In practice, many applications are specified with SIL certification to be used with control systems, without the need for safety functions. There is also the "disinformation market" leading to the purchase of more expensive equipment developed for safety functions that will really be used on process control functions, where the SIL certification does not bring the expected benefits and may hamper the utilization and operation of the equipment.

Safety Integrated Systems (SIS) are systems responsible for the operational safety and guarantee emergency shut offs within safe limits, whenever the operation goes beyond these limits. The main goal is to avoid accidents inside and outside the factories, such as fires, explosions, damage to the equipment, provide protection to the production and the property and even more, to prevent life risks or personal health damages and catastrophic impact on the community.

No equipment is totally immune to failures and must always provide safe conditions even in case of failure.

The transmitters certified in compliance with the IEC 61508 must deal basically with 3 types of failures: random hardware failures, system failures and common-cause failures.

What must the user know about transmitters with certification for SIL applications and why they are not the best option for control and monitoring?

- No change in configuration, simulation, multidrop or loop test can be done with the equipment working normally (i.e., requiring safety). In these conditions the output will not be fit for a safe evaluation. In other words, a HART/4-20mA equipment with SIL2 certification will not actually be at SIL level if the HART communication is working and enabled to writings.
- In safe conditions it must have writing protection enabled;
- No local adjustment may be carried out (the local adjustment must be disabled);
- Nothing is totally safe. The intent is to reduce the probability of occurring failures;
- In case of failure, this must be safe, i.e., it can be identified and make corrective measures possible.

Conclusion

This article showed the importance of some concepts on pressure transmitters and some details for users to be attentive when applying them.

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