Transducers from a Measurement Perspective

When determining the economic impact of measurement uncertainty, the user needs to consider indirect operating costs. Performance from a measurement perspective includes accuracy and repeatability over the required measurement range. To effectively determine the required measurement performance, a thorough understanding of how the manufacturer's latest specifications are derived is required. This includes statements for reference accuracy, total probable error, temperature effect, static pressure effect, stability, and over pressure effect. Temperature and pressure transmitters have long been thought of by many as commodity items, and the specified accuracies have been construed as true for real world applications. Accuracy and repeatability are seldom as good in the real world as in laboratory conditions, and as a result, users need to recognize "real world conditions". Better measurement improves product quality, and provides the user with the opportunity to reduce raw material costs for control applications, improve billing accuracy for custody transfer applications, or lastly, to improve decision making for monitoring applications.

Total Probable Error (TPE) Calculations

TPE is the root mean square (RMS) of all error sources, and has been an accepted method of determining the overall accuracy of a pressure transmitter under a given set of operating conditions. Error sources have typically included reference accuracy, ambient temperature and static pressure, as shown in the formula below.

Equation #1

$$\pm\text{ACCURACY} = \sqrt{(\text{REF})^2 + (\text{TEMP})^2 + (\text{STATIC})^2}$$

Where: ACCURACY= +/- % Span
REF= Reference accuracy % span
TEMP= Temperature effects
STATIC= Static effects (zero and span)

All the terms in a TPE equation must be minimized in order to provide maximum overall accuracy.

Unfortunately, many transmitter users today continue to only look at reference accuracy as the basis of comparison. Reference accuracy simply states how accurately the transmitter can be calibrated on the bench under ideal conditions, and should include the effect of linearity, hysteresis and repeatability. An analysis including all the parameters in equation #2 below provides a method of comparison of transmitter performance while in the process. It provides insight as to how the transmitter will typically perform under the anticipated operating conditions. One should also pay close attention to the turndown the manufacturer is using when calculating TPE values. For most manufacturers, total probable error (TPE) values will double when long term stability and over pressure effects are considered, and turn a published 0.25% (TPE) into a 0.5% error very easily.

Equation #1 does not adequately represent "real world conditions", as there is no consideration for long-term stability or overpressure effect. A more complete analysis would be shown in the formula below.

Equation #2

$$\pm\text{ACCURACY} = \sqrt{(\text{REF})^2 + (\text{TEMP})^2 + (\text{STATIC})^2 + (\text{STABILITY})^2 + (\text{OP})^2}$$

Where: STABILITY= Long term stability (% span)
OP = Over pressure effects (% span)

Long Term Stability

Long term stability (% drift over time) determines within what period of time a transmitter will maintain its calibration. A long-term stability of +-0.1 % URL means that all 'as-found' calibrations will be within +-0.1% of the 'as-left' transmitter records. Since manufacturers do not state at what time in the specified

Continued on next page

warranty the transmitter drift will occur, one should assume that it will take place the day after the unit has been installed, and therefore should be considered in the TPE analysis. If a manufacturer claims a reference accuracy of 0.075%, and a stability factor equal to 0.25%, the TPE value of the combined components equals +- 0.261% as shown in Equation #3.

Equation #3

$$+/-\ 0.261\% = \sqrt{(0.075)^2 + (0.25)^2}$$

A published long term stability factor from Yokogawa equal to +-0.1% may not seem relevant when compared to +-0.25%, but will yield a much lower TPE value equal to +-0.125%. From a measurement perspective, this is substantial considering it is only one parameter in the overall equation.

Over Pressure and Static Pressure Effects

Constant static pressure DP applications are extremely rare, and therefore, it is important to note that most manufacturers' published performance characteristics are true only if the transmitter is zeroed at the specified line pressure. The manufacturer should have published static pressure effects for use in TPE equations.

Pressure equalization using a 3 or 5 way manifold assembly does not always take place successfully, and / or process pressure spikes can occur causing extreme zero shift or catastrophic failure for some manufacturers. Should either of these scenarios go undetected, significant measurement error can be expected. A published overpressure specification like +-0.03% of URL per 2300 psi is required for accurately calculating TPE values. Without it, overpressure error is difficult to quantify.

Conclusion

When determining the required measurement performance for any given application, it is important to consider all the parameters that effect overall transmitter performance. Total Probable Error (TPE) or Total Performance values ultimately stem from the transmitter construction, processor and sensor type. Pressure spikes can cause significant zero shift for some manufacturers, if not total failure, resulting in substantial measurement error. End users no longer have to accept inadequacies like this as there are better alternatives. Digital technologies are available from Yokogawa today for little to no additional cost, eliminating A/D conversion and enabling the user to accurately measure very low flows from differential pressure devices like orifice plates, pitot tubes and venturis. Factory calibration test reports are also available at no additional cost, providing the user with actual tested reference accuracies for TPE calculations. Average calibration test reports from Yokogawa have proven reference accuracies well below the published 0.075%, and closer to 0.030%. DPharp has been designed for "real world conditions", and is virtually unaffected by over pressure or changes in static pressure. Industry Canada approval was recently obtained for both liquids and gases.

The energy industry continues to downsize, right size and merge. Product standardization and outsourcing of engineering, operations and maintenance is much in evidence. This does not, however, relieve the user of the responsibility of being knowledgeable when it comes to their processes and new technologies. Solutions provided in the past are not necessarily the right solutions for the present or future.

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