Technical Report

Interpreting the specifications of pressure sensors correctly. An aid to orientation.

Specifications provide the user with information about the technical and functional aspects of a product. Since there are no legal requirements or industry-specific standards to regulate content and format, there are as many different types of specifications as there are manufacturers. It is all the more important to know what details are important, where the differences are and what to pay attention to when dealing with the data.

The two terms precision and accuracy are not the same, and have to be correctly distinguished for measuring sensors. Precision includes linearity deviation over the measuring range, hysteresis and non-repeatability. The measured values are more or less close to the final average and can be quantified with a dispersion circle. However, precision does not make any statement about how near the average value of the individual measurements are to the true value. This deviation is the degree of accuracy. Precision is characterized by a dispersion circle around the average value. Accuracy is the deviation of the average value of the individual measurements from the true value.

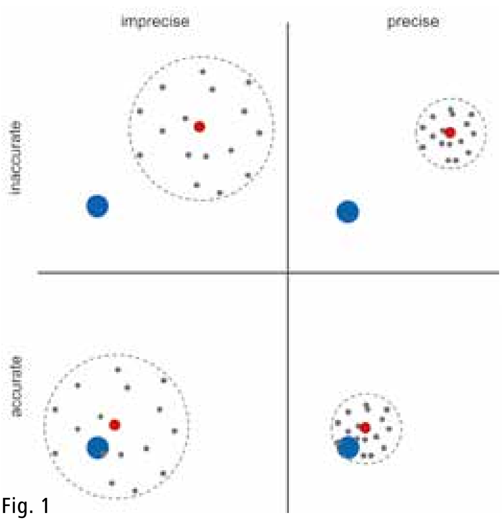

Fig. 1

Fig. 1: Precision and accuracy; Precision → dispersion circle, accuracy → offset

Maximum measurement deviation vs. isolated standard error of measurement

Sensors are specified differently by different suppliers. With some, the maximum measurement deviation is given, while others state the standard error of measurement in isolation. However, these two variables are fundamentally different.

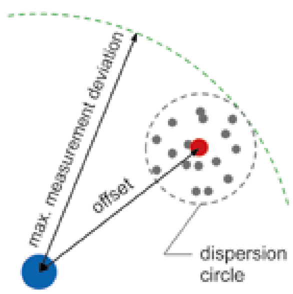

Fig. 2

Fig. 2: Maximum measurement deviation; Maximum measurement deviation = offset + standard error of measurement (dispersion circle)

The standard error of measurement is characterized by the dispersion circle (radius) (precision), while the maximum measurement deviation results from the sum of the offset (accuracy) and the standard error of measurement (precision). The different common specifications give rise to the problem that sensors with the "same value" can be worlds apart. If both sensors are specified with 0.1 % full scale (FS), then the indication of the offset is missing from one. There is no indication of the extent to which the measured value correlates with the true value. It is therefore quite possible that the sensor with 0.1 % FS standard error of measurement corresponds to one with 0.5 % FS maximum measurement deviation. In order to achieve a 0.1 % FS maximum measurement deviation, the sensor would therefore have to be much better, i.e. for example. 0.05 % FS for the standard error of measurement (precision, dispersion circle) plus 0.05 % FS for the offset.

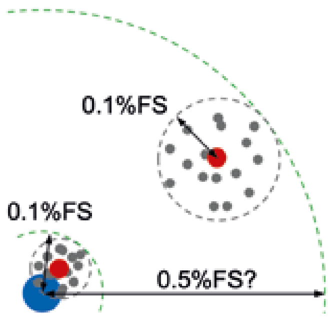

Fig. 3

Fig. 3: Error of measurement and maximum measurement deviation; FS: Full scale

When data sheets do not explicitly specify whether the maximum measurement deviation or the standard error of measurement is meant, thus making it easy to recognize, the small print has to be interpreted. The crux of the matter is whether the zero point deviation and the final value deviation are included in the specification. For example: The specification according to standard errors of measurement includes linearity deviation (according to minimum value setting, BFSL) as well as hysteresis and non-repeatability, zero point, final value and linearity deviation (after a limit point has been set) according to the maximum measurement deviation as well as hysteresis and non-repeatability (EN 61298-2).

Determining the deviations

Further attention must be paid to the identification of deviations, no matter whether for the standard error of measurement or the maximum measurement deviation. Here too, there are two common but different approaches.

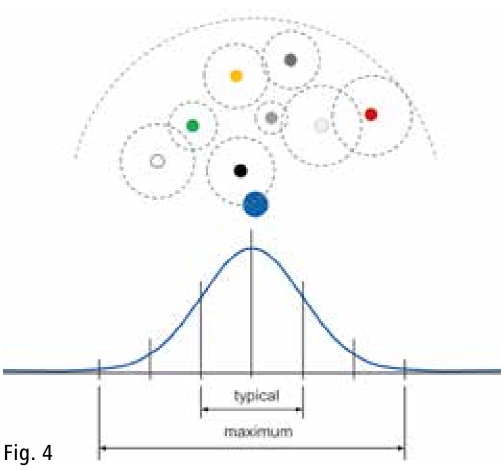

Fig. 4

Fig. 4: Determining the deviation (determining the error); Model creation using normal distribution, shown for the maximum measurement deviation

A large number of sensors are taken and appropriate individual measurements are carried out. When the "typical" error is specified, only 68 % (1 σ) are within the specification. This means that 32 % of the sensors do not correspond to the specification which the manufacturer quotes. It is a sign of high quality if the "maximum" error is specified, because statistically 99.7 % (3 σ) of the measuring devices meet the specification. There is therefore practically no sensor outside the manufacturer's specifications.

Term definition: temperature dependency

The standard error of measurement and / or the maximum measurement deviation are specified in relation to a reference temperature. This is typically 20 °C. Mostly, however, a sensor is used neither at 20 °C nor at a constant temperature. This has corresponding effects on the standard error of measurement and the maximum measurement deviation, which worsen. This is due to the fact that the characteristic can only be adjusted for one temperature. At varying temperatures, therefore, both the position of the zero point and the range error (limit point or minimum value setting) change beyond the pressure range. The temperature coefficient "Zero Point" (TC zero point) describes the influence of temperature on the standard error of measurement or the maximum measurement deviation in a depressurized state. Typically, the coefficient is specified as % FS per 10 °C. A sensor with an initial maximum measurement deviation of 0.1 % FS (at 20 °C) has a corresponding deviation of 0.2 % FS at a TC zero point of 0.05 % FS / 10 °C and an operating temperature of 40 °C. The temperature coefficient "range" (TC range) describes the influence on the standard error of measurement or the maximum measurement deviation over the entire measuring range. Typically, the coefficient is specified as % FS per 10 °C. This is added to the zero point shift and can be equated with a reduction in precision. The illustration is analogous to Fig. 1, i.e. the distance between the true value (blue dot) and the average of the individual measurements (red dot) corresponds to the offset. The dispersion circle (standard error of measurement) reflects precision and is the point cloud of the individual measurements (gray dots). Finally, the maximum measurement deviation, which is illustrated by the green dotted circle segment, results from the dispersion circle and the offset. TC zero point affects the offset. TC range affects the standard error of measurement. Together, TC zero point and TC range affect the maximum measurement deviation.

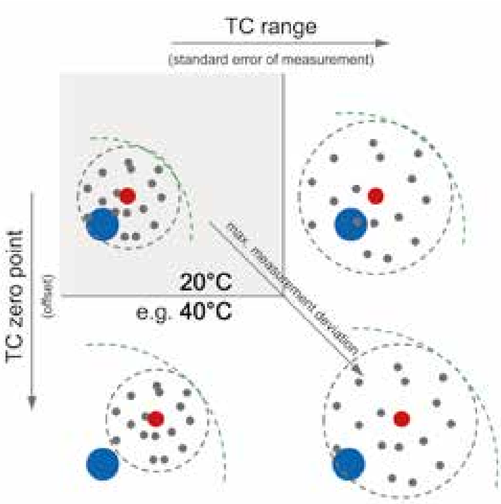

Fig. 5

Fig. 5: Influence of temperature on standard error of measurement and maximum measurement deviation; TC range → standard error of measurement, TC zero point → influence on the offset

Real temperature dependencies

In Fig. 6 it becomes obvious that the temperature dependency of the maximum error of measurement needs to be taken into consideration in the choice of pressure sensors. In the example shown here, all sensors were taken to 0.3 % FS maximum measurement deviation at 20 °C. This means that the important factor here is not the initial accuracy of the reference temperature. If the application covers a wider temperature range, then the temperature stability is usually more important than the initial accuracy. In the diagram, this is shown by the dotted line. Even at temperatures that differ from the reference temperature by more than 10 °C, this sensor with lower initial accuracy is more accurate than most of the other sensors shown. The application in question (operating temperature and temperature fluctuations) must therefore be examined carefully.

Strict specification criteria for high quality and reliability

Baumer supplies excellent pressure sensors that are correctly specified and which guarantee the customers reliable applications. In most cases, Baumer specifies the maximum measurement deviation and not the standard error of measurement in isolation. If such differently described pressure sensors with the "same values" are compared with each other, the one with the best maximum measurement deviation is more precise. If the absolute pressure is to be measured, or referencing is not possible within a measuring system (empty/full or another known state), it is essential that a sensor specified according to maximum measurement deviation should be chosen. The reason for this is that in the case of other specifications, the deviation of the average measured value from the true value is not known, or at least only to a limited extent. Baumer determines the quality of the sensors according to "maximum" and not "typical" error. According to statistics, 99.7 % of the sensors tested for "maximum" error are within the specification, while 32 % of those tested for "typical" error do not meet the specification. Caution is advised with respect to the application temperature range of the sensors, since the maximum measurement deviation can be strongly influenced by temperature dependency. Depending on the application, TC zero point and TC range have to be taken into account. A temperature-stable sensor is to be preferred in all cases. Baumer builds all of its elements according to the "stricter" definition. This means that the customer gets the necessary reliability and high quality.

Further information:
www.baumer.com/pressure

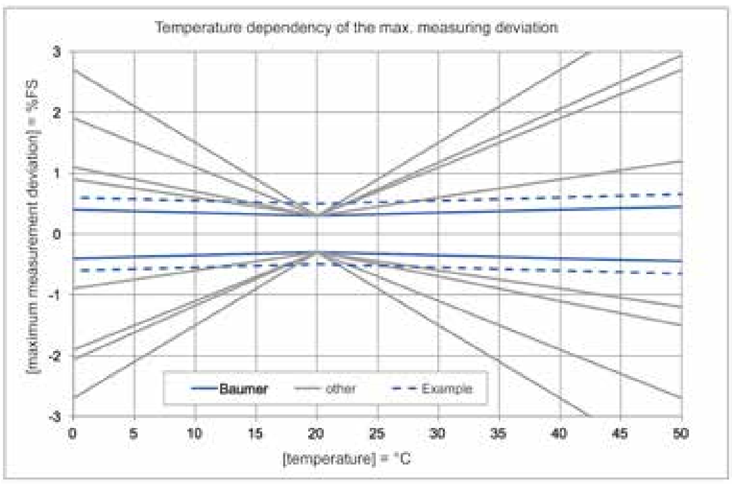

Fig. 6

Fig. 6: Temperature dependency and varying initial accuracy; blue line: highly stable Baumer pressure sensor, gray line: examples of other products on the market, dotted blue line: highly stable Baumer pressure sensor with slightly lower initial accuracy

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