Pressure and Force Sensors

Selection Considerations

COMPATIBILITY

It is very important to insure compatibility between the pressure or force sensor and the application in which it is used. The following should be considered before a sensor selection is made: (1) material; (2) chemicals; (3) concentration; (4) temperature; (5) exposure time; (6) type of exposure; (7) criteria for failure; and (8) general information such as application environment, protection of the device, and other foreign substances in the area.

In all cases, the customer is ultimately responsible for assuring that the device/material is suitable for the application.

ERRORS THAT AFFECT SENSOR PERFORMANCE

When calculating the total error of a pressure or force sensor, the following defined errors should be used. To determine the degree of specific errors for the pressure sensor you have selected, refer to that sensor's specification page in the catalog.

NOTE: In specific customer applications some of the published specifications can be reduced or eliminated. For example, if a sensor is used over half the specified temperature range, then the specified temperature error can be reduced by half. If an auto zeroing technique is used, the null offset and null shift errors can be eliminated.

Null offset is the electrical output present when the pressure or force on both sides of the diaphragm is equal.

Span is the algebraic difference between the output end points. Normally the end points are null and full scale.

Null temperature shift is the change in null resulting from a change in temperature. Null shift is not a predictable error because it can shift up or down from unit to unit. Change in temperature will cause the entire output curve to shift up or down along the voltage axis **(Figure 1).**

Sensitivity temperature shift is the change in sensitivity due to change in temperature. Change in temperature will cause a change in the slope of the sensor output curve **(Figure 2).**

Linearity error is the deviation of the sensor output curve from a specified straight line over a desired pressure range. One method of computing linearity error is least squares, which mathematically provides a best fit straight line (B.F.S.L.) to the data points **(Figure 3).**

Figure 1
Null Shift Error

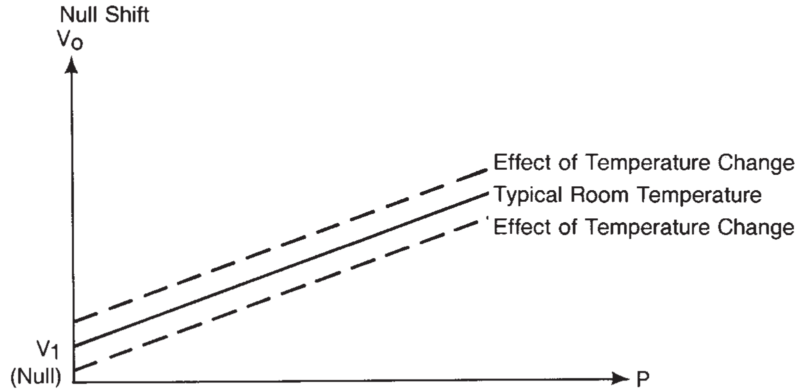


Figure 2
Sensitivity Shift Error

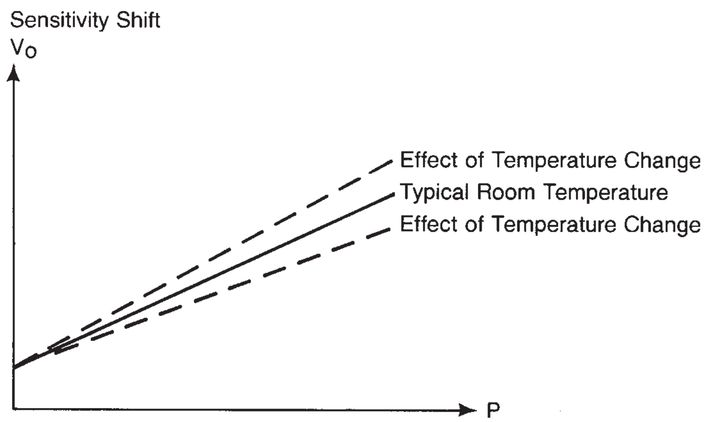


Figure 3
Best Fit Straight Line Linearity

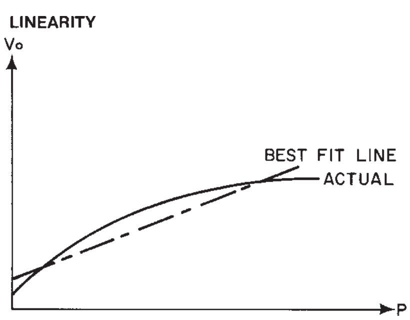
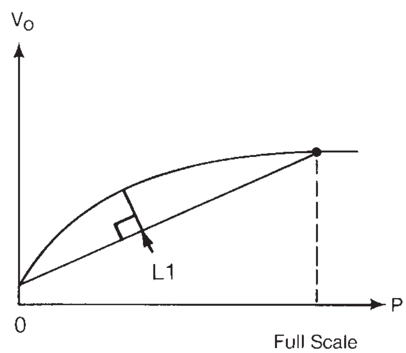


Figure 4
Terminal Base Linearity



Another method is terminal base linearity (T.B.L.) or end point linearity. T.B.L. is determined by drawing a straight line (L1) between the end data points on the output curve. Next draw a perpendicular line from line L1 to a data point on the output curve. The data point is chosen to achieve the maximum length of the perpendicular line. The length of the perpendicular line represents terminal base linearity error **(Figure 4).**

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Repeatability error is the deviation in output readings for successive applications of any given input pressure or force with other conditions remaining constant **(Figure 5).**

Hysteresis error is usually expressed as a combination of mechanical hysteresis and temperature hysteresis. MICRO SWITCH expresses hysteresis as a combination of the two effects **(Figure 6).**

Mechanical hysteresis is the output deviation at a certain input pressure or force when that input is approached first with increasing pressure or force and then with decreasing pressure or force.

Temperature hysteresis is the output deviation at a certain input, before and after a temperature cycle.

Ratiometricity implies the sensor output is proportional to the supply voltage with other conditions remaining constant. Ratiometricity error is the change in this proportion and is usually expressed as a percent of Span.

CALCULATING ACCURACY OR TOTAL ERROR

When choosing a pressure or force sensor, the total error contribution is important. The following methods take into account the individual errors and the unit-to-unit interchangeability errors.

Two methods for calculating total error are:
Root Sum Square (R.S.S.) using maximum values, and worst case error. R.S.S. method gives the most realistic value for accuracy. With the worst case error method, the chances of one sensor having all errors at the maximum are very remote.

Example

An application requires 0-15 psig, 5° to 50° temperature range, 7VDC supply. A 142PC15G will be used for the example (see 142PC15G specifications on page 37).

1. Determine error values

Parameter		**Max. (% Span)**
Null offset	$\frac{.05\text{V}}{5\text{V}} \times 100\%$	= 1.0%
Span error	$\frac{.05\text{V}}{5\text{V}} \times 100\%$	= 1.0%
Linearity		0.75%
Combined null/span shift (Calculate at max. and min. application temperature. Use higher of the two numbers)	$\frac{50°\text{C} - 25°\text{C}}{63°\text{C} - 25°\text{C}} \times 1\%$ shift	= 0.70%
	$\frac{25°\text{C} - 5°\text{C}}{25°\text{C} - (-18°\text{C})} \times 1\%$ shift	= 0.50%
Repeatability & Hysteresis		0.30%
Stability for 1 year		1.0%
Ratiometricity error		1.0%

2. Calculate total error

The R.S.S. method: take the square root of the sum of the squares of the errors determined in Step 1

R.S.S. max. = $\sqrt{1.0^2 + 1.0^2 + 0.75^2 + 0.7^2 + 0.3^2 + 1.0^2 + 1.0^2}$

R.S.S. max. error = 2.3% span max.

Worst Case Error = 1.0 + 1.0 + 0.75 + 0.7 + 0.3 + 1.- + 1.0

Worst Case Error = 5.75% span absolute maximum.

Figure 5
REPEATABILITY

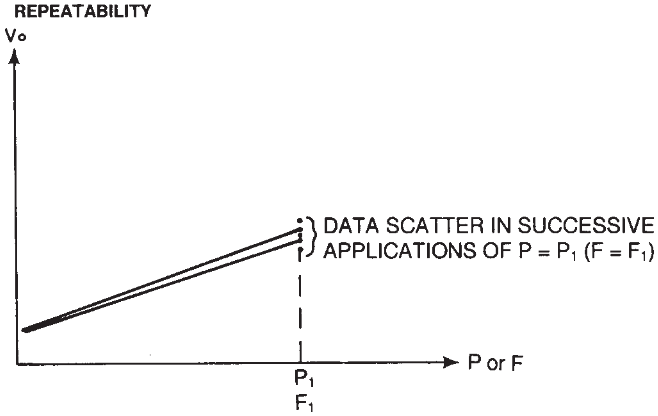

Figure 6
HYSTERESIS