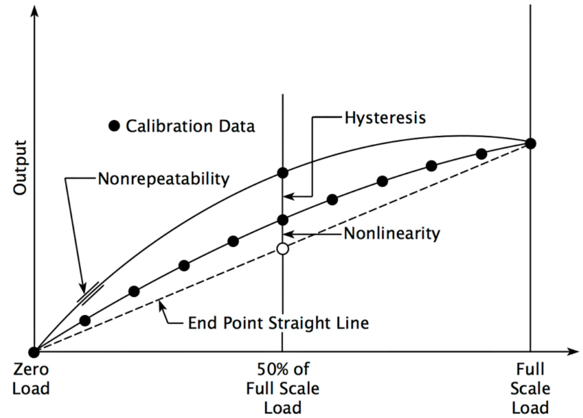
FORCE SENSOR PERFORMANCE SPECIFICATIONS

Accuracy How often is a supplier of force sensors asked, "What is the sensor's accuracy?" Or, putting it another way, "How close to their true values will the force sensor read?" An accuracy statement is not usually found among specifications for force sensors. The best thing to do is to refer the person asking the question to the sensor's specifications for nonlinearity, hysteresis, nonrepeatability, and the temperature effects on zero balance (TCZ) and output (TCO). These errors relate to the performance of the force sensor and will allow the person to more easily compare the force sensor's performance to competitive products. The effects of these errors on the performance of a force sensor do not occur with absolute predictability and are not necessarily additive.

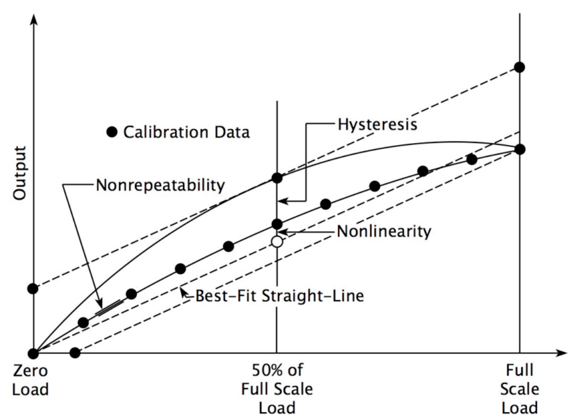
Accuracy Class In the US accuracy class statements usually apply to force sensors used in legal-for-trade applications and are covered by NIST Handbook 44. In Europe OIML R 60 covers force sensors used in legal-for-trade applications. Industry and in-house standards of European manufacturers may also specify an accuracy class for force sensors used in non-legal-for-trade applications. In this case contact the manufacturer to clarify the meaning of the accuracy class statement.

Calibration Method - End Point Linearity The lower curve in the following graph is a plot of voltage vs. applied load. Record voltage at zero load. Then add load in exactly 10% increments recording voltage after each 10% increment is applied and when full-scale load is achieved; a total of 11 load points. The upper curve is a plot of voltage vs. descending load. In this case remove 50% of the full-scale load and then the remaining load and record the voltage at each of the 2 descending load points. Draw a straight line between the zero load point and the full-scale load point on the curves. Maximum deviation of the two curved lines from the straight-line usually occurs at the 50% load point.



Nonlinearity, Hysteresis & Nonrepeatability
End Point Linearity

Calibration - Best-Fit Straight-Line & Least Squares Best-Fit Straight-Line Instead of drawing a straight line as we did in the end point linearity calibration method you can construct a straight line that effectively halves the maximum deviation of the nonlinear ascending curve. Thus, the nonlinearity error is effectively halved. The least squares best-fit straight-line method differs from the best-fit straight-line method in that in the former method the generation of the straight line is accomplished using statistical methods to generate a straight line that is then optimally positioned. Refer to the graph that follows.



Nonlinearity, Hysteresis & Nonrepeatability
Best-Fit Straight-Line & Least Squares Best-Fit Straight-Line

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Combined Error (Nonlinearity and Hysteresis) Combined error is defined as the maximum deviation from the straight line drawn between original no-load and full-rated output points and expressed as percentage of full-rated output and measured on both increasing and decreasing loads. Combined error has increased in use, as a performance specification though there appears to be differences between manufactures on how they determine combined error. Ask the manufacturer using combined error as a specification how it is computed. Also, ascertain if nonrepeatability is incorporated within their combined error statement.

Creep The change in output over time, usually 20 min., when a constant load is applied and temperature and other variables remain constant is defined as creep. Creep is usually included as part of the specifications for force sensors used in weighing applications and rarely included in specifications for force sensors used in dynamic or varying load applications.

Hysteresis In the above graphs hysteresis is the maximum difference between force sensor output readings for the same applied load; one reading obtained by increasing the load from zero load and the other by decreasing the load from full-scale load. Readings to determine hysteresis are usually taken at 50% of full-scale load on the ascending and descending curves. The difference between these two readings compared to the 50% point on the straight line allows one to compute the hysteresis of the force sensor. Hysteresis is expressed as a percentage of full-rated output.

Nonlinearity In the above graphs nonlinearity is the maximum deviation of the lower ascending calibration curve from the end point linearity or best-fit or least squares best-fit line and is expressed as a percentage of full-rated output. Maximum deviation of the increasing curve from the straight line usually occurs at 50% of full-scale load.

Nonrepeatability The maximum difference between outputs for repeated loadings under identical loading and environmental conditions and expressed as a percentage of the full-rated output is defined as nonrepeatability. Usually, three complete calibration cycles repeated immediately one after the other is sufficient to determine nonrepeatability.

Resolution The smallest incremental change in input that produces a discernable change in output, and often expressed as a percent of full-scale rated output of the force sensor or full-scale of the read-out instrument. Resolution is not indicative of a sensor's performance.

Temperature Effect on Output (TCO) Temperature effect on output is the amount of change in the full-scale rated output of the force sensor caused by a change in ambient temperature and expressed as a percentage change in full-rated output per °F or °C.

Temperature Effect on Zero Balance (TCZ) Temperature effect on zero balance is the change in the zero balance of the force sensor caused by a change in ambient temperature and expressed as a percentage change in full-rated output per °F or °C.

Temperature Range, Compensated The range over which a force sensor is compensated to maintain rated output and zero balance within specified limits defines temperature range, compensated. Temperature compensation automatically corrects for any errors caused by a change in temperature. Compensation is normally accomplished within the force sensor by proprietary methods of the manufacturer but can be done, as well, with software.

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