Adaptive Industrial Solutions
sales@adaptiveind.com
(877) 818-5009

An Explanation of GP:50 Performance Specifications

Introduction:

The performance specifications of GP:50 pressure transducers are typically identified on the sales literature or datasheet for the particular model type. Performance specifications include items such as linearity (or non-linearity), hysteresis, non-repeatability, static accuracy, zero balance, span balance, thermal zero shift, thermal span shift, and total error band. The allowable values of these specifications typically vary depending upon the model type and options ordered.

This series of tech notes provides some insight as to what each performance specification is and how it is determined. Knowing the level of accuracy desired for your particular application is the first step in selecting the proper device. Selecting a device that is overly accurate for your application increases your unit cost. Selecting a device that is less accurate than required could cause waste controlling a precise process, provide erroneous data on a verification test or in extreme cases, cause an unsafe condition to exist if utilized to monitor process pressure conditions. Having a basic understanding of these requirements will help determine the performance specifications you require for your particular application. If your specific application requires tighter specification controls, GP:50 can more than likely accommodate your special requirements. Please consult a GP:50 sales representative for further information.

All GP:50 pressure transducers are provided with some form of a final calibration certificate documenting the performance characteristics have been obtained for that particular device. Some calibration certifications are very basic and some are very involved to determine actual measured errors of each performance specification. Depending upon the criticality of your application, it may or may not be required to have a detailed calibration certificate for the device ordered.

As identified below, this tech note is broken down into three sections to help you better identify what performance specifications you need and which performance specifications you may specifically need verified on the Calibration Certificate provided by GP:50.

- Section 1 discusses room temperature performance specifications.
- Section 2 discusses performance specifications effected by changes in temperature.
- Section 3 discusses the types of calibration certificates that are available.

If you would like additional information on any of the items discussed in this tech note, or on any other matter regarding GP:50 Pressure Transducers, please contact a GP:50 sales representative.

An Explanation of GP:50 Performance Specifications

Section1: Room Temperature Errors

In a perfect world, all Pressure Transducers (PT's) would have a purely linear (straight line) output over its operating pressure range. Unfortunately this is not the case as PT's typically have an output curve as depicted in Figure 1.

Transducer errors describe how close the actual output compares to its ideal value and are commonly expressed within a ± percent of the device's actual Full Scale Output (FSO), defined as the algebraic difference between end point outputs. FSO is commonly referred to as Span.

4-20 mA FSO/Span Example:

FSO = Output 100% - Output 0%
= 20.02 mA – 4.01 mA
= 16.01 mA

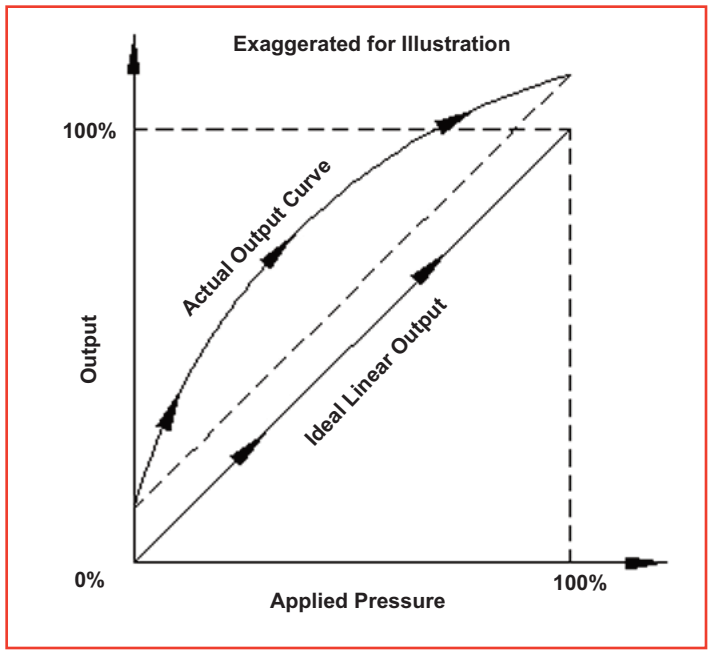

Figure 1: Actual Output vs. Ideal Output

Zero Balance & Span Balance:

The Zero Balance and Span Balance specifications define how close the actual Zero and Full Scale "set-point" values shall be compared to the ideal value as illustrated in Figure 2. Values are expressed within a ± percent of the nominal Full Scale Output.

As can be seen in Figure 2, the Span Balance is dependent upon the actual location of the Zero set point and represents a change in the slope of the output curve.

Typically, the actual Zero and Full Scale output values are initially set at the factory to fall within a tighter tolerance band than specified on the Model's product datasheet.

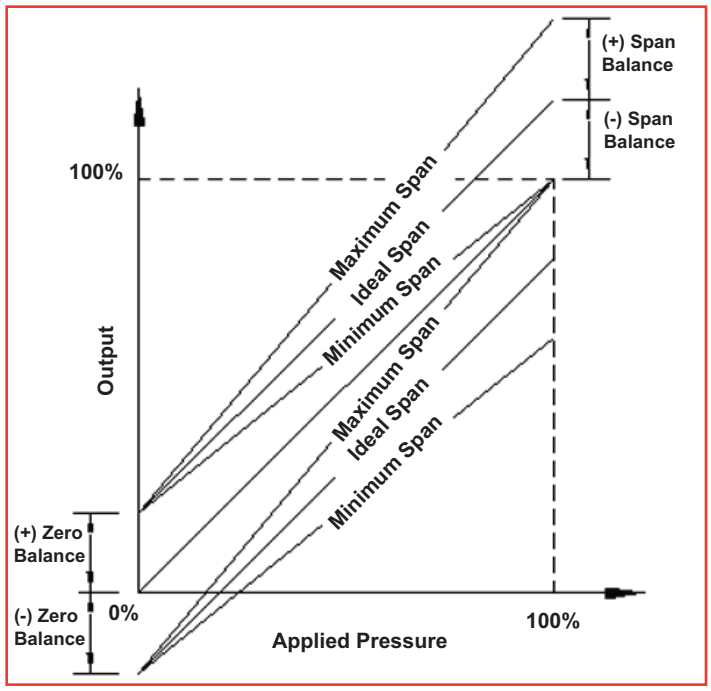

Figure 2: Zero/Span Balance Illustration

An Explanation of GP:50 Performance Specifications

Accuracy or Static Accuracy:

Accuracy is defined as the degree of conformity of a measure to a standard or true value. GP:50 uses the expression of Accuracy or Static Accuracy to define the conformity of the PT specifically at room temperature conditions. When subjected to temperature changes, additional errors which are additive to the static accuracy are introduced (Reference Part 2 of this tech note for additional information).

The Static Accuracy of a PT is comprised of three component errors: non-linearity, hysteresis, and non-repeatability. Specifically it is calculated by taking the root sum square of these component errors as defined below. Static Accuracy is expressed within a ± percent of the device's FSO.

$$Static\ Accuracy = \sqrt{Non\text{-}Linearity^2 + Hysteresis^2 + Non\text{-}Repeatability^2}$$

Non-Linearity:

Non-Linearity errors describe the closeness to which the actual ascending run output curve approximates an ideal straight line. Two common methods exist for defining the "referenced" ideal straight line output, one is the Terminal Point Line and the other is the Best Fit Straight Line (BFSL) as depicted in Figure 3.

Terminal Point Line:
The Terminal Point Line is a straight line drawn between the PT's actual zero output value and its full scale output value.

Best Fit Straight Line:
Using a mathematical formula known as linear regression, the BFSL is drawn through the PT's actual output curve such that the maximum deviation is minimized on both sides.

Non-Linearity errors are expressed within a ± percent of Full Scale Output and shall reference the method used (i.e., Terminal Point or BFSL).

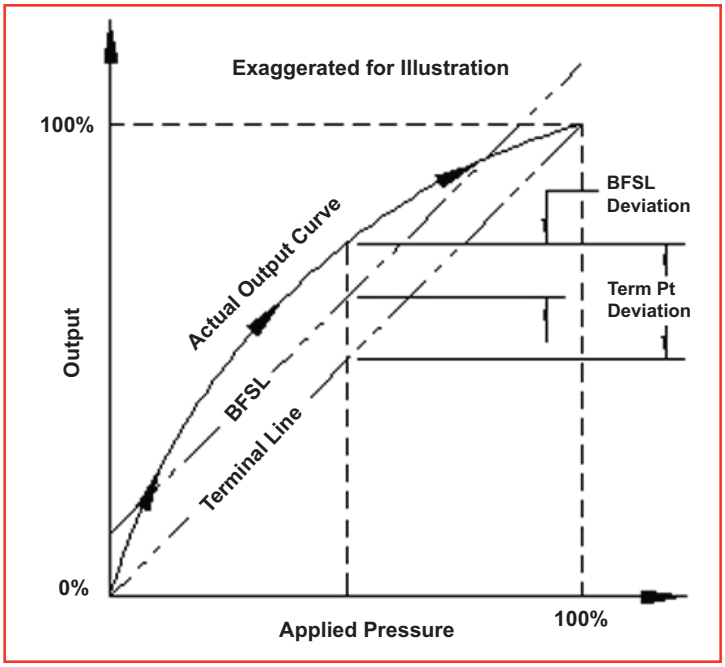

Figure 3: Non-Linearity Illustration

An Explanation of GP:50 Performance Specifications

Hysteresis:

Hysteresis errors occur when the output at a known pressure when first approached from an increasing direction is different when the same pressure value is approached from a decreasing direction as depicted in Figure 4.

Hysteresis errors define the maximum amount of deviation that occurs over the entire pressure range and is expressed within a ± percent of Full Scale Output.

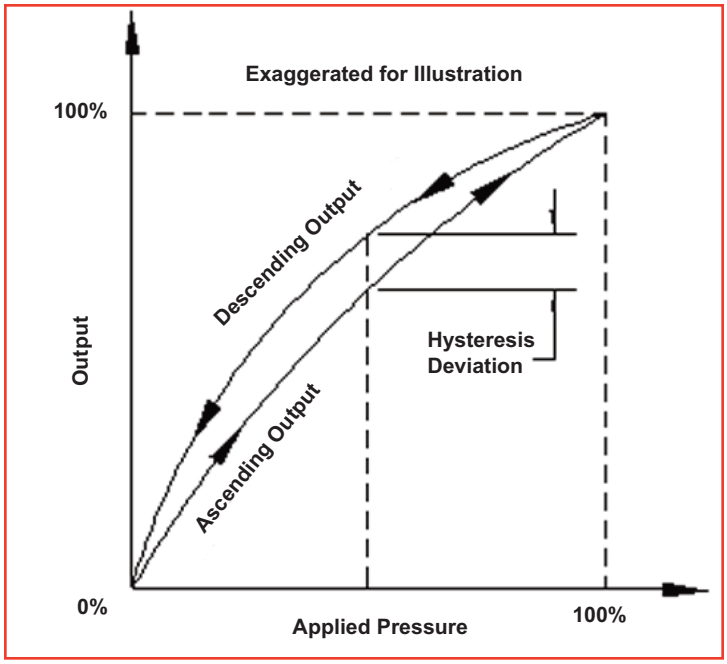

Figure 4: Hysteresis Illustration

Non-Repeatability:

Non-Repeatability errors occur when the output at a known pressure when first approached from an increasing direction is different when the same pressure value is approached, also from an increasing direction but at a later point in time as depicted in Figure 5.

Non-Repeatability errors define the maximum amount of deviation that occurs over the entire pressure range and is expressed within a ± percent of Full Scale Output.

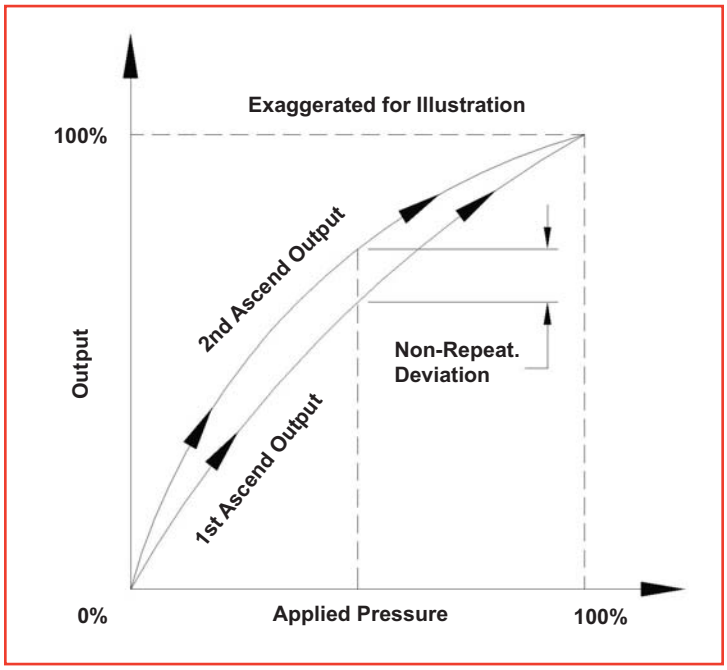

Figure 5: Non-Repeatability Illustration

Zero Repeatability:

Zero Repeatability errors are expressed within a ± percent of Full Scale Output. When specified, the error defines the maximum amount of deviation that can occur in the zero point output as pressure is returned to zero.

If you would like additional information on any of the items discussed in this tech note, or on any other matter regarding GP:50 Pressure Transducers, please contact a GP:50 sales representative.

An Explanation of GP:50 Performance Specifications

Section 2: Thermal Errors

As discussed in Part 1 of this series, the Static Accuracy of GP:50 Pressure Transducer's (PT) only defines the device's room temperature rating. Changes in process and/or ambient temperatures will induce errors that are additive to the device's room temperature static accuracy rating. The Compensated Temperature Range (CTR) of the PT defines the temperature range over which performance specifications will be calibrated and maintained.

Thermal errors typically induce a shift in the PT's room temperature Zero output reading and the room temperature Span (FSO) value (FSO = Output 100% - Output 0%) as the device is either heated or cooled relative to room temperature conditions. GP:50 commonly uses two different methods for characterizing the PT's thermal performance specifications: one method specifies the allowable zero/span shift that can occur relative its FSO over a 100°F temperature shift, the other method defines a Total Error Band width for the PT.

Thermal Zero & Thermal Span Shift:

The Thermal Zero Shift and Thermal Span Shift values define the maximum amount of output shift that can occur due to a 100°F temperature change from 70°F as depicted in Figure 6.

Values are expressed within a ± percent of FSO per 100°F.

It is noted that some competitor product datasheets express similar thermal zero/span shift values over a 1°F change in temperature. GP:50's specifications can easily be converted from a 100°F change to a 1°F change by the unit conversion shown below.

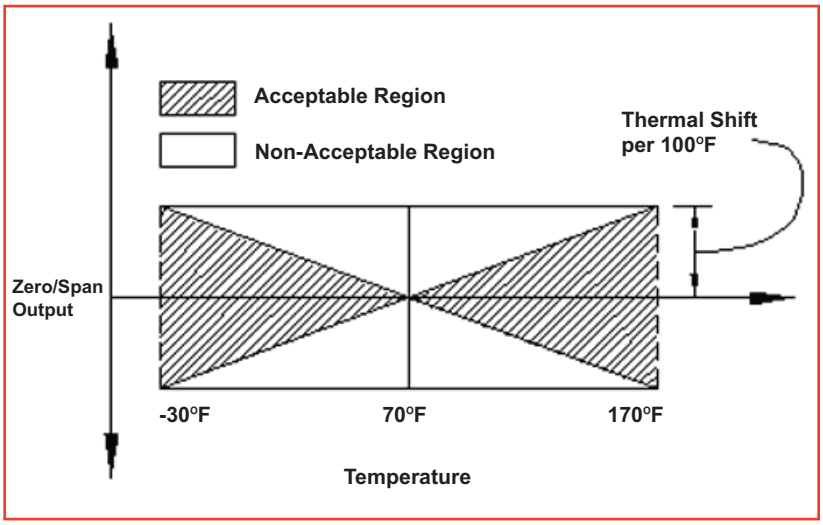

Figure 6: Thermal Zero & Span Shift

$$\text{Thermal Shift}=0.50\%\ \text{FSO per } 100°\text{F}= 0.50\%\ \text{FSO} \times 1/(100°\text{F})=$$

$$= (0.50\%\ \text{FSO})/100 \times 100/(100°\text{F})=0.0050\%\ \text{FSO per } 1°\text{F}$$

A Zero shift results in a parallel shift of the output curve while a Span shift causes the slope of the output curve to change.

An Explanation of GP:50 Performance Specifications

As the CTR increases in value, it is sometimes required to relax the allowable thermal span or thermal zero shift specification requirements as the performance characteristics of electronics can become non-linear in nature at temperatures below 0°F and above 170°F. For example, GP:50's Model 7200 PT can be ordered with two different CTR's, the standard range and the Option GF range as identified in the table below. For the expanded CTR, it can be seen that the thermal zero and thermal span shift allowances were increased to account for the non-linear temperature characteristics of the electronics due to the expanded CTR.

Model 7200	CTR	Thermal Zero Shift	Thermal Span Shift
Standard	-10ºF to 180ºF	±0.50% FSO/100ºF	±0.50% FSO/100ºF
Option GF	-65ºF to 265ºF	±1.0% FSO/100ºF	±1.0% FSO/100ºF

This is depicted graphically in Figure 7 below. At temperatures well above 180°F, the actual thermal shifts can typically still be compensated such that they fall within the standard allowance of ±0.50% FSO/100°F (reference shaded circle). However, there are times when the actual thermal shift after compensation falls outside of the standard range (reference shaded triangle). As such, for the expanded CTR option, the thermal zero and thermal span allowances are relaxed to a wider range which for this example is ±1.00% FSO/100°F.

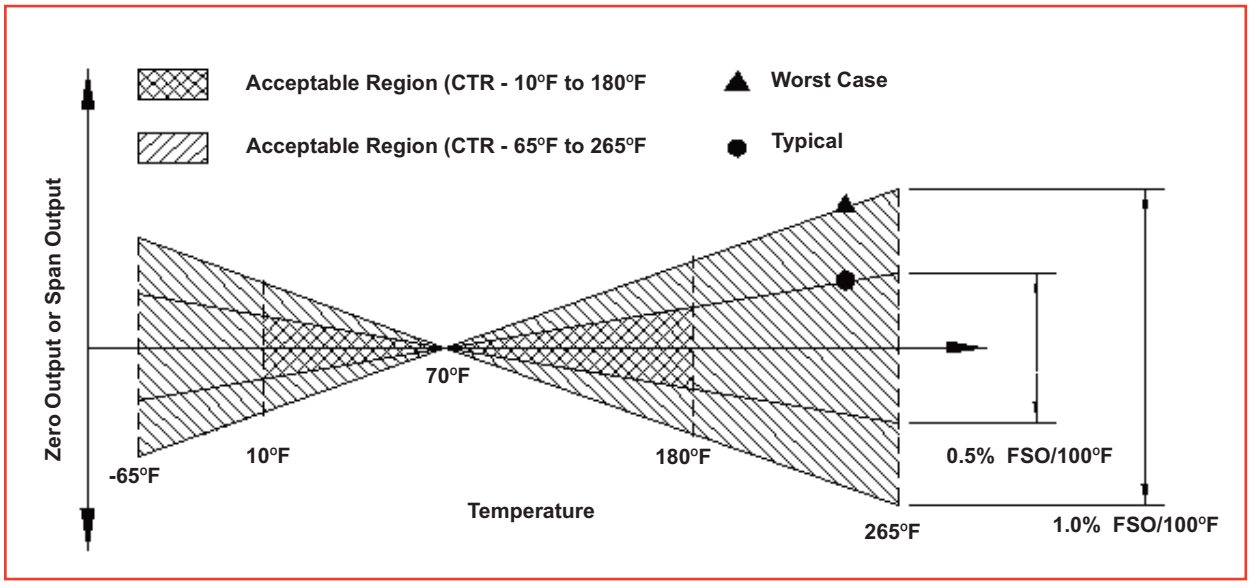

Figure 7: Thermal Zero & Span Shift for Expanded CTR's

An Explanation of GP:50 Performance Specifications

Total Error Band:

When a Total Error Band value is noted on a product datasheet or specification, the value represents the total amount of deviation that can occur between the actual and ideal output over a specified Temperature Range (typically the compensated temperature range) as depicted in Figure 8.

In simplistic terms, the Total Error Band encompasses Zero & Span Balance (set points) at room temperature, the Static Accuracy, the Thermal Zero Shift and the Thermal Span Shift. However, typically room temperature Zero and Span set points are “nulled-out” by the end user once the PT is calibrated within their system. Based on this, GP:50 does not include these values in the Total Error Band of the device as their values are identified separately on the calibration certificate that gets provided with the PT.

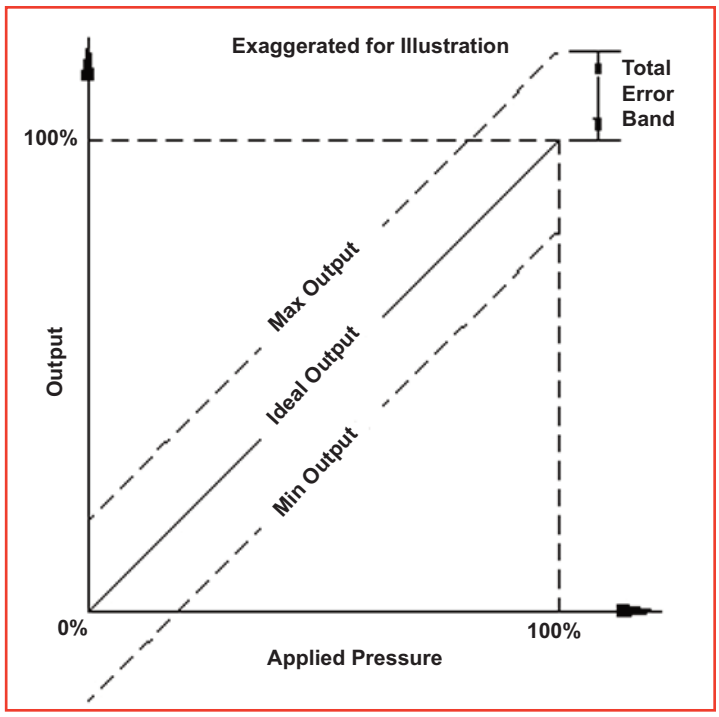

Figure 8: Total Error

The Total Error of GP:50 PT’s represents the addition of Static Accuracy, Thermal Span Shift and Thermal Zero Shift over a temperature range of -30°F to 170°F (70°F ± 100°F). Based upon customer ordering requirements, this error band can also be expressed over the device’s actual CTR.

For example, building upon the previous example using the Model 7200 PT with the expanded CTR option invoked, the Total Error would have been specified as 2.30% FSO over a temperature range of -30°F to 170°F as this model has a Static Accuracy of 0.30% and the Thermal Zero and Thermal Span shift specifications are both 1.00% FSO/100°F. If the Total Error was expressed over the entire CTR (-65°F to 265°F), the Total Error would have been specified as 4.30% FSO as the actual Thermal Zero and Thermal Span Shifts relative to 70°F could shift as much as 2.00% each resulting in the 4.30% Total Error band over the CTR.

The as-built Total Error values are typically 50% better than the stated specification requirement.

If you would like additional information on any of the items discussed in this tech note, or on any other matter regarding GP:50 Pressure Transducers, please contact a GP:50 sales representative.

An Explanation of GP:50 Performance Specifications

Section 3: Calibration Certificates

All GP:50 pressure transducers are provided with some form of a final calibration certificate documenting the performance characteristics have been obtained for that particular device.
As a minimum, all Calibration Certificates provide the following information:

- Date Calibrated
- Customer Name
- Model Number
- Serial Number
- Work Order Number
- Pressure Range
- Electrical Input
- Electrical Output
- Connector Pinout
- Wiring Diagram
- Zero
- Full Scale
- Full Scale Output
- Technician Name

Depending upon the model number ordered, the calibration certificate may also provide verification of some or all of the information reported below. GP:50 can also customize the Calibration Certificate to add verification or identification of additional performance specifications that may be applicable to your application.

- Non-Linearity
- Hysteresis
- Non-Repeatability
- Static Accuracy
- Thermal Zero Shift Hot
- Thermal Zero Shift Cold
- Thermal Span Shift Hot
- Thermal Span Shift Cold
- Comp. Temp. Range
- Total Error
- Calibration Voltage
- QC approval stamp

Aerospace Grade Transducers:

Pressure Transducers built by GP:50's Aerospace Division receive a NIST Calibration (see below) at no cost and typically receive a full Calibration Certificate whereby ALL of the above information is verified/identified on the Calibration Certificate for each device ordered.

Industrial Grade Transducers:

Pressure Transducers built by GP:50's Industrial Division typically receive a condensed Calibration Certificate that only reports the final non-linearity ascending run data. To ensure Static Accuracy requirements are satisfied, the sensor performance characteristics are typically verified of every sensor in the low level state. Although not reported on the final Calibration Certificate, each unit is also run through temperature to determine the necessary amount of compensation that may need to be installed to ensure thermal specification requirements are met.

NIST Calibration:

For an additional fee on Industrial Grade transducers (standard for Aerospace Product), a NIST Final Calibration run can be performed on each unit. This would include verification of the unit's actual Static Accuracy and would also include a GP:50 certification indicating that the test/calibration equipment used was suitable for the pressure range measurement taken and that the equipment used was traceable to NIST standards.

If you would like additional information on any of the items discussed in this tech note, or on any other matter regarding GP:50 Pressure Transducers, please contact a GP:50 sales representative.