

## Section 9 – Glossary, Unit Conversions & Kulite Reports

### 9.1. Glossary of Terms

#### A

**Acceleration Sensitivity (Error)** The maximum difference at any measurand value between the output with and without the application of a specified constant acceleration along specified axes. Normally specified in transverse and perpendicular directions. (% FSO/g)

**Accuracy** The ratio of error to Full Scale Output often expressed in percent of Full Scale output. (%FSO)

**Acceptor** A material added as a dopant to a semiconductor to make it p-type by accept-in valence electrons and leaving holes behind that can conduct electric charges. Normally Boron is used for doping Silicon.

**A/D** Abbreviation for analogue to digital

**A/D Converter** An electronic device used to convert an analogue voltage to a digital signal.

**Altitude** The vertical distance above a specified reference datum such as sea level.

**Ambient Conditions** The conditions (Pressure, temperature, etc.) of the device's environment.

**Analogue Output** An output of analogue voltage derived from processing of digital and/or analogue input to circuitry within an (electronic) device. Normally a continuous function of the measurand except as modified by device resolution.

**Angstrom** A unit for Ultra-high frequencies equal to ten raised to the power -10 meters.

**Annealing** A heating process that reverse damage to the crystal structure or to activate dopant.

**Attitude Error** The error due to the orientation of the device relative to direction of the force of gravity on the transducer.

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#### B

**Bandwidth** The highest frequency signal component that can pass through input amplifiers without being attenuated.

**Best Fit Straight Line** A line midway between two parallel straight lines closest together and enclosing all output points of the instrumentation between zero load and full scale.

**Breakdown Voltage Rating** The voltage (AC or DC) which can be applied across the transducer insulation without causing arcing or conduction above a specified current.

**Bridge Resistance** Resistance of the transducer bridge elements ( input or output impedance).

**Burst Pressure Rating** The pressure which may be applied to the sensing element or the transducer case just prior to rupture of either. A minimum number of applications and time duration are also often specified.

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#### C

**Calibration** A test to determine the output signal of the device with a steady input excitation and known values of the parameter under controlled conditions

**Calibration Curve** A graphical representation of the device output vs. measurand under controlled conditions.

**Calibration Cycle** The application of controlled values of a parameter proving an output signal over the full range of the instrument in ascending and descending order.

**Compensated Temperature Range** Range of Temperatures over which the transducer has been corrected by the addition of a circuit to correct the output for errors induced by changes in bridge resistance due to temperature.

**Compensation** Addition of supplemental device, circuit, or special materials to reverse known source of errors.

**Combined Linearity and Hysteresis** Square of the sums of squares of error due to non-linearity and that of and hysteresis non-linearity.

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## D

**D/A** Abbreviation for Digital to Analogue.

**D/A Converter** A device for converting a digital signal to an analogue signal.

**Damping** An energy absorbing factor that in conjunction with the natural frequency determines the limit of frequency response and the response time characteristics of a transducer. In response to a step function of the parameter a periodic (underdamped) system oscillates about the voltage level before stabilising at its final steady output; an aperiodic (overdamped) system comes to the final steady output without overshooting; and a critically damped system is defined as one that is at the point of changing from a periodic to a aperiodic system.

**Dead Volume** Total volume of the pressure port cavity of a transducer with room barometric pressure applied.

**Decibel** A unit of logarithmic measure based on the ratio of power related quantities such as sound, volts, or watts to a specified reference in same units.

**Deposition** The procedure of deposit materials onto a substrate by means of vacuum, electrical, screening, or vapour techniques.

**Dice or Die** A section of a processed wafer, usually rectangular, which contains one functional circuit.

**Dielectric** An insulating layer. A material that has high resistance.

**Dielectric Strength** Same as breakdown voltage.

**Diffusion** A process used in semiconductor production by adding small amounts of impurities or dopants to a semiconductor.

**Digital Output** Transducer output that represents the magnitude of the parameter measured in terms of discrete quantities or codes in a system of notation. 0 and 1 are commonly used. Digital and analogue are common output types.

**Donor** A material added as a dopant to a semiconductor to make it n-type by donating valence electrons which can conduct electric charge. An example is phosphorus.

**Dopant** A material added in minute quantities to a semiconductor to alter it's electrical conducting characteristics. They may be donors or acceptors.

**Doping** The process of adding a dopant to semiconductor material.

**Drift** A undesired change of a reading with no change in the input signal or operating conditions.

**Dynamic Characteristics** The characteristics of a transducer which describes its response to variations in measurand pressure over time.

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## E

**Electrical Connection** The portion of the transducer assembly used to connect, disconnect, and reconnect the electrical wiring that carries excitation voltage, signal or current to and from the transducer.

**Environmental Conditions** Specific external conditions, such as shock, vibration, temperature, moisture, etc. to which a transducer may be exposed during normal operations.

**End Point** Output signal at upper and lower limits of the transducer range.

**End Point Line** Line drawn between the end points of a transducer calibration.

**Environmental Conditions** Specified external conditions, such as shock, vibration, temperature, moisture, etc. to which a transducer may be exposed during normal operations.

**Environmental Conditions, Operating** Specified external conditions, such as shock, vibration, temperature, moisture, etc. when a transducer is exposed to must perform as specified.

**Error** The mathematical difference between the indicated value and the true value of the parameter signal.

**Error Band** The band of maximum deviations of output values from a specified reference line or curve due to those causes attributable to the transducer. Usually described as plus or minus some value of transducer full scale output.

**Excitation** The external electrical voltage and/or current applied to a sensor assembly to initiate the proportional output. Usually expressed in ranges the transducer may be subjected to without damage. The value of this voltage is set by calibration and any serious deviation from this value will negate the calibration.

**Extrinsic Semiconductor** A semiconductor that has been doped either n-type or p-type. Electrons and holes are present in unequal proportions (by 4 to 8 orders of magnitude).

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## F

**Frequency Modulated Output** An output in the form of frequency deviations from a centre frequency, where the deviation is a function of the measured parameter.

**Frequency Output** An output in the form of frequency which varies as a function of the applied measurand.

**Frequency, Natural** The frequency of free (not forced) oscillations of the sensing element of a fully assembled transducer.

**Frequency, Resonant** The input frequency at which a transducer responds with maximum output amplitude. If there is more than one frequency the lowest is the resonant frequency

**Frequency Response** The change with frequency of the output/parameter amplitude ratio (and of the phase difference between the output and the parameter) for sinusoidal varying measurand applied to a transducer within a specified range. It is normally considered at plus or minus 3 dB and is given by the approximation.  $F.R. = 1/2\pi \text{ Freq. Response} = 1 \text{ divided by } 2 \text{ times } \pi \text{ times time constant}$

**Full Scale Output** The value of transducer output at the maximum rated load minus the output at the minimum rated load.

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## G

**Gage Factor** A measure of the ratio of the relative change of resistance to the relative change in length of a resistance strain transducer (strain gage).

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## H

**Hysteresis** The maximum difference in output, at any measurand value within the specified range, when the value is approached first with increasing and then decreasing measurand. Normally expressed in % FSO.

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## I

**IEEE** Abbreviation for Institute of Electrical and Electronics Engineers.

**Input** Measurand signal (and/or exciting voltage or current).

**Input Impedance** The impedance (presented to the excitation source) measured across the excitation terminals of the transducer. Unless otherwise specified the impedance is measured at room temperature, etc.

**Insulation Resistance** The resistance measured between specified insulated portions of a transducer when a specified DC voltage is applied at ambient conditions- room temperature etc.

**Ion** The result of an atom losing an electron and becoming positive or gaining an electron and becoming negative.

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## J, K, L

**Leakage Rate** The maximum rate at which a fluid is observed or permitted to leak through a seal. The type of fluid, differential pressure across the seal, and the direction of flow should be specified. Units are normally volume or pressure drop per unit of time.

**Least Squares Line** The straight line for which the sum of the squares of the residuals( deviations) is minimised.

**Life, Cycle** The specified number of full and/or partial range excursions over which a device will operate within specified performance criteria.

**Life, Operating** The length of time over which device will operate to a specified performance.

**Life, Storage** The length of time over which device can be stored at specified conditions and still operate to a specified performance.

**Linearity** The closeness of a calibration curve to a specified straight line expressed as % FSO.

**Load Impedance** The impedance presented to the output terminals of the transducer by the external circuitry connected to the device.

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## M

**Maximum Ambient Temperature** The value of the highest (and the lowest) ambient temperatures that a (Minimum) transducer can be exposed to with or without excitation applied, without being damaged and subsequently suffering performance degradation.

**Maximum Excitation** Value of excitation voltage or current that can be applied to the transducer at room conditions without causing damage or performance degradation.

**Measurand (Parameter)** A physical quantity, property, or condition, which is measured, Sometimes called input, parameter, or variable.

**Measured Fluid** The fluid that comes in contact with the sensing element. Chemical and/or physical properties of this fluid may be specified to insure proper transducer operation and life.

**Mounting Error** An error due to mechanical deformation of the transducer caused by mounting the device and/or making the electrical connection.

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## N

**Natural Frequency** See Frequency, Natural

**Non-Linearity** See Linearity. Normally expressed as % FSO.

**Non-Operating Conditions** Any conditions outside of operating conditions that might cause transducer to malfunction.

**Non-Repeatability** Breakdown of the transducer characteristics of repeatability a small amount of which is contained in an acceptable error band. Usually expressed as % FSO.

**Null** A condition, such as of balance, which results in a minimum absolute value of output.

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## O

**Operation Mode** A description of how the transducer is used to provide a usable signal representing a measurand variation.

**Operating Conditions** See environmental conditions.

**Operating Temperature Range** Temperature range the operating transducer will be subjected to.

**Output** The electrical quantity produced by the transducer which is a function of the applied measurand.

**Output Impedance** The impedance across the output terminals of a transducer presented by the transducer to the associated external circuitry.

**Output Noise** The RMS or peak to peak, as specified, ac component of a transducer's DC output in the absence of measurand variations.

**Output Range** Design band of output for specified input.

**Overload** The maximum value of a measurand that can be applied to a transducer without damage or change in performance beyond a specified tolerance.

**Over Pressure** See Overload.

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## P

**Pressure Range** Lowest to the highest pressures to be measured by a specific transducer.

**Pressure Media** See measured fluid.

**Proof Pressure** The maximum pressure, which may be applied to the sensing element without a change in the transducer performance beyond specified tolerances. Differential pressure transducers must have the reference pressure specified and whether the reverse pressure is applicable.

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## Q, R

**Range** The measurand values over which a transducer is designed to measure. Indicated by upper and lower values.

**Rated Electrical Excitation** The electrical voltage supply the transducer sensing element for normal operation given the specified output with the application of a known measurand.

**Reference Pressure** The pressure applied to the opposite side of the sensing element- ambient pressure for gage and perfect vacuum for absolute designs.

**Reference Pressure Error** The error in transducer output resulting from errors in the reference pressure value within a specified reference pressure range.

**Reference Pressure Range** The range of pressures that can be applied to the backside of a sensing element without changing the pressure transducer's performance beyond specified tolerances. If no tolerance is specified, none is allowed.

**Reference Pressure Sensitivity Shift** The sensitivity shift resulting from variations of a differential pressure transducer's reference pressure within specified limits.

**Repeatability** The ability of a transducer to reproduce output values when the same measurand value is applied repeatedly under the same conditions and in the same direction.

**Reproducibility** See Repeatability

**Residual Unbalance** Zero measurand sensing element output

**Resolution** The magnitude of output step changes as measurand is continuously varied over the range.

**Resonance** Amplified vibrations of transducer components, within a narrow frequency band, observable in the output as a vibration applied along a specific transducer axis.

**Resonant Frequency** The input frequency at which a transducer responds with maximum output amplitude. If there is more than one frequency the lowest is the resonant frequency

**Response Time** The length of time required for the output of a transducer to rise to a value normally specified as 98 % of the value of a step change in measurand expressed in milliseconds.

**Rise Time** The length of time required for the output of a transducer to rise from a small specified percentage of it's final value to a large specified percentage of it's final value as a result of a step change in the measurand.

**Room Conditions** Normal specified ambient conditions. Normally 77 F + or - 18 F, 90 % RH, and 29 + or - 3 in Hg.

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## S

**Self-Heating** Internal heating as a result of electrical energy dissipated within the transducer.

**Sensing Element** The part of the sensing element that responds directly to the measurand.

**Sensitivity** The ratio of the change in transducer output to a change in the value of the measurand.

**Sensitivity Shift** A change in the slope of the calibration curve due to a change in sensitivity.

**Sensor** Instrumentation device, such as transducer.

**Sound Pressure Level (SPL)** A unit that is 20 times the logarithm to the base 10 of the ratio of the pressure of the measured sound to the reference pressure of 20 micronewtons per square meter.

**Span** The algebraic difference between the limits of range.

**Stability** The ability of a transducer to retain its performance characteristics for relatively long period of time. Normally expressed in % FSO.

**Static Calibration** A calibration performed under room conditions and in the absence of any vibration, shock, or acceleration.

**Static Error Band** See Error Band.

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## T

**Temperature Error Band** The error band applicable to increased or decrease environmental temperature usually expressed in % FSO/ 100 F.

**Temperature Range, Compensated** See Temperature range, operating. Compensated temperature range is the interval of temperature range that was considered when designing compensation module for a specific transducer.

**Temperature Range, Fluid** The range for temperatures of the measured fluid, when it is not the ambient within which operation of the transducer is intended, and all specific tolerances for the temperature error band apply.

**Temperature Range, Operating** The range of temperatures, given by their extremes, within which the transducer is designed to operate with no permanent damage to the transducer.

**Thermal Coefficient of Resistance (TCR)** The relative change in resistance of a conductor or semiconductor per unit change in temperature over a stated range of temperature normally expressed in ohms per degree F or C.

**Thermal Compensation** The addition of circuitry to alter output changed by temperature error back toward specified values at room temperature.

**Thermal Sensitivity Shift** The sensitivity change due to changes of the ambient temperature from room temperature (design conditions) toward the limits of the operating temperature range.

**Thermal Zero Shift** The zero measurand transducer output shift due to changes of the ambient temperature from room temperature to the specified limits of the operating temperature range.

**Transducer** A device which provides a usable output in response to a specified measurand.

**Transient Response** The response of a transducer to a step change in measurand. It is indicated by Time Constant, Ringing Period, and Response Time.

**Transverse Acceleration** An acceleration perpendicular to the sensitive axis of the transducer.

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## U, V

**Vibration Error** The maximum change in output, at any measurand value within the specified range, when vibration levels of specified amplitude and range of frequencies are applied to the transducer along specified axes.

**Vibration Sensitivity** See Vibration error.

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## W, X, Y, Z

**Warm-up Period** The period of time required from the time the excitation voltage is applied to the transducer until the output of the unit is within the specified tolerances for the applied measurand.

**Weight** Weight of the transducer normally not including any portion that varies such as cables.

## 9.2 Pressure Unit Conversions

### 9.2.1 Units of Measurement

FROM	PSI	PASCAL	BAR	MILLIBAR	IN. Hg	IN. H2O	mm Hg	mm H2O	ATM	kg/cm2
TO										
PSI	1	0.00014504	14.504	0.014504	0.49118	0.036127	0.019337	0.0014223	14.696	14.223
PASCAL	6894.6	1	100000	100	3386.5	249.08	133.32	9.8068	101320	98067
BAR	0.068946	0.00001	1	0.001	0.033865	0.0024908	0.0013332	9.8068E-05	1.0132	0.98068
MILLIBAR	68.946	0.01	1000	1	33.865	2.4908	1.3332	0.098068	1031.2	980.68
IN. Hg	2.0359	0.00029529	29.529	0.029529	1	0.073552	0.039368	0.0028959	29.92	28.959
IN. H2O	27.68	0.0040147	401.47	0.40147	13.596	1	0.53525	0.039372	406.78	393.72
mm Hg	51.714	0.0075006	750.06	0.75006	25.401	1.8683	1	0.073558	760	735.59
mm H2O	703.05	0.10197	10197	10.197	345.32	25.399	13.595	1	10332	10000
ATM	0.068045	9.8692E-06	0.98692	0.00098692	0.033422	0.0024583	0.0013158	9.6788E-05	1	0.9678
kg/cm2	0.070305	1.0197E-05	1.0197	0.0010197	0.034531	0.0025399	0.0013595	0.0001	1.0332	1

### 9.2.2 Decibel Formulae

				Power:	dB	=	$10 \log \frac{W}{W_0}$		
				Pressure, Voltage,	dB	=	$20 \log \frac{P}{P_0}$		
				Charge, etc.	dB	=	$20 \log \frac{E_1}{E_2}$		
Ratio (except power)	-	dB	+	Ratio (except power)	Ratio (except power)	-	dB	+	Ratio (except power)
1.000		0.0		1.000	.316		10.0		3.16
.988		0.1		1.012	.251		12.0		3.98
.977		0.2		1.023	.199		14.0		5.01
.966		0.3		1.035	.158		16.0		6.31
.955		0.4		1.047	.126		18.0		7.94
.944		0.5		1.059	.100		20.0		10.00
.891		1.0		1.12	.0316		30.0		31.62
.841		1.0		1.12	.0100		40.0		100
.794		2.0		1.26	.0032		50.0		316
.708		3.0		1.41	$10^{-3}$		60.0		$10^3$
.631		4.0		1.58	$10^{-4}$		80.0		$10^4$
.562		5.0		1.78	$10^{-5}$		100		$10^5$
.501		6.0		2.00	$10^{-6}$		120		$10^6$
.447		7.0		2.24	$10^{-7}$		140		$10^7$
.398		8.0		2.51	$10^{-8}$		160		$10^8$
.355		9.0		2.82	$10^{-9}$		180		$10^9$



## 9.3 Kulite Reports

- 9.3.1 Andrew Bemis “High Pressure Transducers”
- 9.3.2 Dr. A. D. Kurtz, A. A. Ned, Glenn Beheim “6H-SiC Pressure Sensor for High Temperature, Low Pressure Applications”.
- 9.3.3 Dr. A. D. Kurtz, Boaz Kochman “Dual Resonant Beam Pressure Transducer”.
- 9.3.4 Joe VanDe Weert “Fuel Pump Transducer”.
- 9.3.5 Adam Kane “Miniature combination Pressure/ Temperature Sensors with Redundant Capability”.
- 9.3.6 Wolf Landmann “Solid State Replacements for Electro-Mechanical Pressure Transducers”.
- 9.3.7 Dr. A. D. Kurtz, Dr. J. W. H. Chivers, A. A. Ned (Kulite) & Professor A. H. Epstein (MIT) “Sensor Requirements for Active Gas Turbine Engine Control”
- 9.3.8 Adam Kane “High Accuracy DC Combustion Transducers”
- 9.3.9 Andrew Schwartz “Subminiature Load Cells”.
- 9.3.10 Dr. A. D. Kurtz, Joseph VanDe Weert & Boaz Kochman “Static Pitot Transducer”.
- 9.3.11