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Standard

Electrical Transducer Nomenclature and Terminology

ISA-S37.1 — Electrical Transducer Nomenclature and Terminology

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Preface

This Preface is included for information purposes and is not part of S37.1.

This Standard has been prepared as a service of ISA toward the goal of uniformity in the field of instrumentation. To be of real value, it should not be static, but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Standards and Practices Board Secretary, ISA, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709, e-mail: standards@isa.org.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to users of ISA Standards in the USA of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI and SI-acceptable metric units as optional alternatives to English units in all new and revised standards to the greatest extent possible. *The Metric Practice Guide*, which has been published by the American Society for Testing and Materials as ASTM E380-72 (ANSI Z210-1973), and future revisions, will be the reference guide for definitions, symbols, abbreviations and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all concerned individuals and interests in the development of ISA Standards. Participation in the ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual of ISA or any of the standards which ISA develops.

This Standard supersedes ISA Tentative Recommended Practice RP37.1-1963, which was developed by ISA Subcommittee 8A/RP37.1 (M.E. Binkley, H.N. Norton, T.A. Peris, and A.A. Zuehlke) between 1960 and 1963 to fill a need for standardized transducer nomenclature and specification terminology required, at that time, primarily by the aerospace industry.

As production techniques of electrical transducers advanced, associated measuring techniques and systems became more established, and as new transducer designs became more readily available, they found increasing applications in all industries and sciences in addition to those types of transducers already in widespread use. Hence, it became necessary for ISA to develop uniform transducer nomenclature and terminology for use in as many technological fields as possible.

Using RP37.1-1963 as a starting point, Committee SP37 (consisting of the chairmen of Standards Committees on individual transducer types as well as the cognizant Standards Director) created a draft version of new S37.1 which was mailed to a large review board, representing a wide variety of fields, in 1968. The results of this review indicated the general acceptability of the new Standard to most industries, sciences, and educational institutions. Numerous suggestions for improvements and clarifications were also received by the Committee. Each comment was evaluated, and suitable revisions were made with Committee concurrence.

The preparation of this Standard was coordinated with the government-sponsored Inter-Range Instrumentation Group (IRIG) as well as with ISA Committee SP51 (Measurement & Control Terminology).

The following individuals served on the 1969 SP37 committee:

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This Standard was approved for publication by the ISA Standards and Practices Board in October 1982.

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Contents

1 Purpose

1.1 This Standard establishes:

1.1.1 Uniform nomenclature for transducers.

1.1.2 Uniform simplified terminology for transducer characteristics.

2 Scope

2.1 This Standard covers transducers used in electrical and electronic measuring systems.

2.2 It is realized that this Standard may not be wholly suitable for transducers used in automatic control systems and in some other specialized applications.

2.3 Emphasis on the usability of this Standard in all types of written and verbal communications has been placed in the following order of precedence:

I) Users' and manufacturers' specifications, including catalogs and advertising.

II) Calibration and test procedures and reports.

III) Technical papers, educational and reference material, and periodicals.

IV) Other communications.

2.4 A recommended manner of assigning nomenclature to transducers is shown in Section 3.

2.5 Recommended terminology for transducer characteristics is shown in Section 4.

2.6 The word "simplified" (see 1.1.2) denotes the most brief, adequate definition which could be derived. The definition may be supplemented as deemed necessary by the user of the term.

3 Nomenclature

3.1 Nomenclature requirements

Nomenclature of transducers should consist of the following:

3.1.1 The noun "transducer";

3.1.2 A first modifier denoting the measurand;

3.1.3 When required, a second modifier restricting the measurand;

3.1.4 A third modifier denoting the electrical transduction principle; the adjective form should be used whenever possible.

3.1.5 An optional fourth modifier denoting the mechanical link in the transducer or any noteworthy special feature. (May be followed with the word "type.")

3.1.6 When required, a modifier phrase restricting the modifier.

3.2 Usage in titles

When used in titles of drawings and specifications, headings in lists, indices, and tabulations, and when indicated by other requirements which may be applicable, the sequence shown in 3.1 should be used.

Examples:

1) "Transducer, Pressure, Differential, Potentiometric, 0 to 10 psid."
2) "Transducer, Sound Pressure, Capacitive, 100 to 160 dB."
3) "Transducer, Acceleration, Reluctive, ±3*g*."
4) "Transducer, Pressure, Absolute, Strain Gage, Amplifying, 0 to 500 psia."

3.3 Usage in Text

For all other purposes, such as use in a sentence or in captions under pictorial representation, the exact opposite of the sequence shown in 3.1 should be used.

Examples:

1) "A ±20*g** piezoelectric acceleration transducer was installed on the mounting plate."
2) "A 0 to 300°F resistive surface temperature transducer was bonded to the tank skin."
3) "Hinge motion was measured with a –2 to +8 degree dc-output reluctive angular-position transducer."

3.4 Omission of modifiers

When generalization of transducer types or categories is desired, the omission of modifiers should proceed in the order opposite to sequence shown in 3.1 whenever possible.

Examples:

1) “Procurement of 150 potentiometric linear-displacement transducers of various ranges has been initiated."
2) "Bulletin 0-0-400 describes our capacitive liquid-level transducers."
3) “The additional test requirements apply only to differential-pressure transducers."

3.5 Nomenclature and examples

The construction of typical transducer nomenclature and examples of modifiers are shown in Table 1.

*Note that the the standard value of the acceleration of gravity at the earth’s surface — a unit of measurement — is abbreviated “g_n.” A measured value of the acceleration of gravity at the earth’s surface is indicated by “*g*.” The SI mass unit “gram” is abbreviated “g.”

3.6 Optional use of alternate nomenclature

Use of alternate nomenclature is optional in the following special cases:

3.6.1 "Accelerometer" instead of preferred "Acceleration Transducer" or "Transducer, Acceleration."

3.6.2 "Tachometer" instead of preferred "Angular Speed Transducer" or “Transducer, Angular Speed."

3.6.3 "Strain Gage" instead of "Resistive Strain Transducers" or "Transducer, Strain, Resistive."

3.6.4 "Thermocouple" instead of "Thermoelectric Temperature Transducer" or "Transducer, Thermoelectric, Temperature."

3.6.5 "Flowmeter" instead of preferred terms "Flow Transducer" (or "Flow-Rate Transducer") or "Transducer, Flow (or “Transducer, Flow-Rate").

3.7 Nomenclature glossary

Some of the nomenclature of Table 1 needs clarification because of the particular meaning intended for transducers. Words appearing as bold, in definitions, are defined in Section 4. The terms in Table 1 with an associated asterisk (*) are defined below, for purposes of their use as modifiers in a transducer nomenclature.

3.7.1 First modifier definitions

Attitude: The relative orientation of a vehicle or object represented by its angles of inclination to three orthogonal reference axes.

Displacement: The change in position of a body or point with respect to a reference point.

> **NOTE:** Position is the spatial location of a body or point with respect to a reference point.

Flow rate: The time rate of motion of a fluid, usually contained in a pipe or duct, expressed as fluid quantity per unit time.

Heat flux: The quantity of thermal energy transferred to a unit area per unit time.

Humidity, absolute: The mass of water vapor present in a unit volume of air or other fluid.

Humidity, relative: The ratio of the water vapor pressure actually present to the water vapor pressure required for saturation at a given temperature, expressed in per cent.

Jerk : The time rate of change of acceleration. Expressed in feet/s³, cm/s³, g_n/s (Refer to footnote under 3.3).

Light: An electromagnetic radiation whose wavelength is between approximately 10^{-2} and 10^{-6} cm.

> **NOTE:** By strict definition only visible radiation (4×10^{-5} to 7×10^{-5} cm) can be considered as "light."

Nuclear radiation: The emission of charged and uncharged particles and of electromagnetic radiation from atomic nuclei.

Pressure, absolute: The pressure measured relative to zero pressure (vacuum).

Pressure, differential: The difference in pressure between two points of measurement.

Pressure, gage: Pressure measured relative to **Ambient pressure**.

Sound pressure: The total instantaneous pressure at a given point in the presence of a sound wave, minus the static pressure of that point.

Strain: The deformation per unit length produced in a solid as a result of stress.

Table 1 — Construction of typical transducer nomenclature and examples of modifiers

Main Noun	First Modifier Measurand (Examples)	Second Modifier (Restricts Measurand) (Examples)	Third Modifier (Electrical Transduction Principle) (Examples)	Fourth Modifier [3] (Sensing Element. Special Features or Provisions) (Examples)	Range [8] (Examples)	Units [9] (Examples)
Transducer	Acceleration	Absolute	*Capacitive	AC Output	0 to 1000	A
	Air Speed	Angular	*Electromagnetic	*Amplifying	±5	°C
	*Attitude	Differential	*Inductive	*Bellows	–100 to +500	cm
	Attitude Rate	Gage	*Ionizing	*Bondable	–430 to –415	cm/s
	Current	Infrared	*Photoconductive	*Bonded		deg [10]
	*Displacement	Intensity	*Photovoltaic	*Bourdon-Tube		°F
	*Flow Rate	Linear	*Piezoelectric	*Capsule[4]		fps
	Force	Mass	*Potentiometric	*DC Output		
	*Heat Flux	Radiant	*Reluctive	*Diaphragm		Hz
	*Humidity	Relative	*Resistive	Digital-Output		ips
	*Jerk	Surface	*Strain Gage	*Discrete Increment		in.
	*Light	Total	*Thermoelectric	*Dual-Output		K
	Liquid Level	Volumetric		Exposed Element		kgf
	Mach No.			Frequency Output		lb/min.
	*Nuclear Radiation			*Gyro		m
	*Pressure			*Integrating		mmHg
	Speed[1]			*Self-Generating		N
	*Sound Pressure			*Semiconductor		% RH
	*Strain			*Servo[5] [6]		psia
	Temperature			Switch		psid
	Torque			Toothed-Rotor		psig
	Velocity[2]			Triaxial		psid
				*Turbine		psig
				*Ultrasonic		rad/s
				*Unbonded		
				Vibrating-Element[7]		
				Weldable		

(*) see Section 3.7 for definitions

(1) Scalar quantity.

(2) Vector quantity.

(3) Nomenclature may include two of these terms.

(4) Preferred to “Aneroid.”

(5) Preferred to “Force Balance” or “Null Balance.”

(6) When this modifier is used the third modifier (transduction principle) may be omitted.

(7) When this modifier is used together with “Frequency Output” the third modifier may be omitted.

(8) Defined in Terminology, Paragraph 4.4.

(9) Abbreviations used for units of Measurand used in specifications should generally be in accordance with ANSI Y10.19-1969 Units Used in Science and Technology, Letter Symbols for.

(10) Use for angular measurements.

3.7.2 Third modifier definitions

Capacitive: Converting a change of **Measurand** into a change of capacitance.

Electromagnetic: Converting a change of **Measurand** into an **Output** induced in a conductor by a change in magnetic flux, in the absence of **Excitation**.

Inductive: Converting a change of **Measurand** into a change of self-inductance of a single coil.

Ionizing: Converting a change of **Measurand** into a change in ionization current, such as through a gas between two electrodes.

Photoconductive: Converting a change of **Measurand** into a change in resistance or conductivity of a semi-conductor material by a change in the amount of illumination incident upon the material.

Photovoltaic: Converting a change of **Measurand** into a change in the voltage generated when a junction between certain dissimilar materials is illuminated.

Piezoelectric: Converting a change of **Measurand** into a change in the electrostatic charge or voltage generated by certain materials when mechanically stressed.

Potentiometric: Converting a change of **Measurand** into a voltage-ratio change by a change in the position of a movable contact on a resistance element across which excitation is applied.

Reluctive: Converting a change of **Measurand** into an ac voltage change by a change in the reluctance path between two or more coils or separated portions of one coil when ac **Excitation** is applied to the coil(s).

> **NOTE:** Included among **Reluctive Transducers** are those employing differential-transformer, inductance-bridge, and synchro-elements.

Resistive: Converting a change of **Measurand** into a change of resistance.

Strain-Gage: Converting a change of **Measurand** into a change or resistance due to strain.

Thermoelectric: Converting a change of **Measurand** into a change in the emf generated by a temperature difference between junctions of two selected dissimilar materials.

3.7.3 Fourth modifier definitions

Amplifying: With integral **Output** amplifier.

Bellows: A **Pressure sensing element** of generally cylindrical shape whose walls contain deep convolutions, and for which the length changes when a pressure differential is applied.

Bondable: Designed to be permanently mounted to a surface by means of adhesives.

Bonded: Permanently attached over the length and width of the active element.

Bourdon Tube: A **Pressure sensing element** consisting of a twisted or curved tube of non-circular cross section which tends to be straightened by the application of internal pressure.

Capsule: A **Pressure sensing element** consisting of two metallic diaphragms joined around their peripheries.

DC Output: With integral demodulator, rectifier or frequency integrator.

Diaphragm: A **Sensing element** consisting of a thin, usually circular, plate which is deformed by pressure differential applied across the plate.

Discrete increment: Providing an **Output** which represents the magnitude of the **Measurand** in the form of discrete or quantized values.

Dual-output: Providing two separate and noninteracting **Outputs** which are functions of the applied **Measurand**.

Gyro (a contraction of gyroscope): A **Transducer** which makes use of a self-contained spatial directional reference.

Integrating: Providing an **Output** which is a time integral function of the **Measurand**.

Self-Generating: Providing an **Output** signal without applied **Excitation**. Examples are **Piezoelectric, electromagnetic,** and **Thermoelectric transducers.**

Semi-conductor: Materials, used for **Sensing elements** or **Transduction elements**, whose resistivity falls between that of conductors and insulators (e.g.: germanium, silicon, etc.). Examples of useful phenomena associated with these materials are: Hall effect, temperature coefficient of resistance, photo-resistivity, photovoltaic effect, piezoresistance, etc.

Servo (a contraction of servomechanism): A **Transducer** type in which the **Output** of the **Transduction element** is amplified and fed back so as to balance the forces applied to the **Sensing element** or its displacements. The **Output** is a function of the feedback signal.

Turbine: A bladed rotor which turns at a speed nominally proportional to the volume rate of flow.

Ultrasonic: Using frequencies above the audio-frequency range, i.e., above 20k Hz.

Unbonded: Stretched and unsupported between ends (usually refers to strain-sensitive wire).

4 Terminology

When a term is not defined and is referenced to other terms, one of the terms referred to should be used instead.

All terms appearing in bold type in definitions are defined in this document.

Definitions, or portions thereof, intended for use only in specifications (and their verification by testing) are preceded by "(S)."

Acceleration error: The maximum difference, at any **Measurand** value within the specified Range, between **Output** readings taken with and without the application of specified constant acceleration along specified axes.

> **NOTE:** See **Transverse Sensitivity** when applied to Acceleration **Transducer**.

Accuracy: The ratio of the **Error** to the **Full-scale output** or the ratio of the **Error** to the **Output**, as specified, expressed in percent.

> **NOTE 1:** Accuracy may be expressed in terms of units of **Measurand**, or as within ±_____ per cent of **Full scale output**.
>
> **NOTE 2:** Use of the term **Accuracy** should be limited to generalized descriptions of characteristics. It should not be used in specifications. The term **Error** is preferred in specifications and other specific descriptions of transducer performance.

Altitude: The vertical distance above a stated reference level.

> **NOTE:** Unless otherwise specified, this reference is mean sea level.

Ambient conditions: The conditions (pressure, temperature, etc.) of the medium surrounding the case of the **Transducer**.

Ambient pressure error: The maximum change in **Output**, at any **Measurand** value within the specified **Range**, when the ambient pressure is changed between specified values.

Analog output: **Transducer output** which is a continuous function of the **Measurand**, except as modified by the **Resolution** of the **Transducer**.

Attitude error: The **Error** due to the orientation of the **Transducer** relative to the direction in which gravity acts upon the **Transducer** (see **Acceleration error**)**.**

"Best straight line": A line midway between the two parallel straight lines closest together and enclosing all **Output** vs. **Measurand** values on a **Calibration Curve**.

Breakdown voltage rating: (S) The dc or sinusoidal ac voltage which can be applied across specified insulated portions of a **Transducer** without causing arcing or conduction above a specified current value across the insulating material.

> **NOTE:** Time duration of application, **Ambient conditions**, and ac frequency must be specified.

Bridge resistance: (See **Input impedance** and **Output impedance**).

Burst pressure rating: (S) The pressure which may be applied to the **Sensing element** or the case (as specified) of a **Transducer** without rupture of either the **Sensing element** or **Transducer** case as specified.

> **NOTE:** (1) Minimum number of applications and time duration of each application must be specified, (2) In the case of **Transducers** intended to measure a property of a pressurized fluid, **Burst pressure** is applied to the portion subjected to the fluid.

Calibration: A test during which known values of **Measurand** are applied to the **Transducer** and corresponding **Output** reading are recorded under specified conditions.

Calibration curve: A graphical representation of the **Calibration record**.

Calibration cycle: The application of known values of **Measurand**, and recording of corresponding **Output** readings, over the full (or specified portion of the) **Range** of a **Transducer** in an ascending and descending direction.

Calibration record: A record (e.g., table or graph) of the measured relationship of the **Transducer output** to the applied **Measurand** over the **Transducer range**.

> **NOTE:** Calibration records may contain additional calculated points so identified.

Calibration simulation provisions: Electrical connections or circuitry, contained within a **Transducer**, designed to permit the calibration of the associated measuring system by causing **Output** changes of known magnitude without varying the applied **Measurand**.

Calibration traceability: The relation of a **Transducer calibration**, through a specified step-by-step process, to an instrument or group of instruments calibrated by the National Bureau of Standards.

> **NOTE:** The estimated **Error** incurred in each step must be known.

Calibration uncertainty: The maximum calculated **Error** in the **Output** values, shown in a **Calibration record**, due to causes not attributable to the **Transducer**.

Case pressure: (See **Burst pressure rating, Proof pressure,** or **Reference pressure**).

Center of seismic mass: The point within an acceleration **Transducer** where acceleration forces are considered to be summed.

Compensation: Provision of a supplemental device, circuit, or special materials to counteract known sources of **Error**.

Conduction error: The **Error** in a temperature **Transducer** due to heat conduction between the **Sensing element** and the mounting of the **Transducer**.

Conformance: (See **Accuracy** and **Error band**).

Continuous rating: The rating applicable to specified operation for a specified uninterrupted length of time.

Creep: A change in **Output** occurring over a specific time period while the **Measurand** and all **Environmental conditions** are held constant.

Critical damping: (This term is defined under **"Damping"**).

Cross-axis acceleration: (See **Transverse acceleration**).

Cross sensitivity, Cross-axis sensitivity: (See **Transverse sensitivity**).

Damping: The energy dissipating characteristic which, together with **Natural frequency**, determines the limit of **Frequency response** and the **Response-time** characteristics of a **Transducer**.

> **NOTE 1:** In response to a step change of **Measurand**, an underdamped (periodic) system oscillates about its final steady value before coming to rest at that value; and overdamped (aperiodic) system comes to rest without overshoot; and a critically damped system is at the point of change between the underdamped and overdamped conditions.
>
> **NOTE 2:** Viscous **Damping** uses the viscosity of fluids (liquids or gases) to effect **Damping**.
>
> **NOTE 3:** Magnetic **Damping** uses the current induced in electrical conductors by changes in magnetic flux to effect **Damping**.

Damping ratio: The ratio of the actual **Damping** to the **Damping** required for **Critical damping**.

Dead volume: The total volume of the pressure port cavity of a **Transducer** with room barometric pressure applied.

Detector: (See **Transducer**).

Dielectric strength: (**See Breakdown voltage rating** and **Insulation resistance**).

Digital output: **Transducer output** that represents the magnitude of the **Measurand** in the form of a series of discrete quantities coded in a system of notation.

> **NOTE:** Distinguished from **Analog output**.

Directivity: The solid angle, or the angle in a specified plane, over which sound or radiant energy incident on a **Transducer** is measured within specified tolerances in a specified band of **Measurand** frequencies.

Distortion: (See **Harmonic content**).

Dithering: The application of intermittent or oscillatory forces just sufficient to minimize static friction within the **Transducer**.

Double amplitude: The peak-to-peak value.

Drift: An undesired change in **Output** over a period of time, which change is not a function of the **Measurand**.

Dynamic characteristics: Those characteristics of a **Transducer** which relate to its response to variations of the **Measurand** with time.

End device, end instrument: (See **Transducer**).

End points: The **Outputs** at the specified upper and lower limits of the **Range**.

NOTE: (S) Unless otherwise specified, **End points** are averaged during any one **Calibration**.

End-point line: The straight line between the **End points**.

Environmental conditions : Specified external conditions (shock, vibration, temperature, etc.) to which a **Transducer** may be exposed during shipping, storage, handling, and operation.

Environmental conditions, operating: **Environmental conditions** during exposure to which a **Transducer** must perform in some specified manner.

Error: The algebraic difference between the indicated value and the true value of the **Measurand**.

NOTE 1: (S) It is usually expressed in percent of the **Full scale output**, sometimes expressed in percent of the **Output** reading of the **Transducer**.

NOTE 2: (S) A theoretical value may be specified as true value.

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**.

NOTE 1: (S) The band of allowable deviations is usually expressed as "±____ per cent of **Full scale output**," whereas in test and calibration reports the band of maximum actual deviations is expressed as "+____ per cent, -____ per cent of **Full scale output**."

NOTE 2: (S) The **Error band** should be specified as applicable over at least two **Calibration cycles**, so as to include **Repeatability**, and verified accordingly.

Error curve: A graphical representation of **Errors** obtained from a specified number of **Calibration cycles**.

Excitation: The external electrical voltage and/or current applied to a **Transducer** for its proper operation.

NOTE 1: In the sense of a physical quantity to be measured by a **Transducer**, use **Measurand**.

NOTE 2: (S) Usually expressed as range(s) of voltage and/or current values.

NOTE 3: Also see **Maximum excitation**.

Field of view: The solid angle, or the angle in a specified plane, over which radiant energy incident on a **Transducer** is measured within specified tolerances.

Frequency-modulated output: An **Output** in the form of frequency deviations from a center frequency, where the deviation is a function of the applied **Measurand**.

Frequency output: An **Output** in the form of frequency which varies as a function of the applied **Measurand** (e.g., angular speed and flow rate).

Frequency, natural: The frequency of free (not forced) oscillations of the **Sensing element** of a fully assembled **Transducer**.

NOTE 1: It is also defined as the frequency of a sinusoidally applied **Measurand** at which the **Transducer output** lags the **Measurand** by 90 degrees.

NOTE 2: (S) Applicable at **Room temperature** unless otherwise specified.

NOTE 3: Also see **Frequency, resonant** and **Frequency, ringing** which are considered of more practical value than **Natural frequency**.

Frequency, resonant: The **Measurand** frequency at which a **Transducer** responds with maximum **Output** amplitude.

NOTE 1: (S) When major amplitude peaks occur at more than one frequency, the lowest of the frequencies is the **Resonant frequency**.

NOTE 2: (S) A peak is considered major when it has an amplitude at least 1.3 times the amplitude of the frequency to which specified **Frequency response** is referred.

NOTE 3: For subsidiary resonance peaks see **Resonances**.

Frequency, ringing: The frequency of the oscillatory transient occurring in the **Transducer output** as a result of a step change in **Measurand**.

Frequency response: The change with frequency of the **Output/Measurand** amplitude ratio (and of the phase difference between **Output** and **Measurand**), for a sinusoidally varying **Measurand** applied to a **Transducer** within a stated range of **Measurand** frequencies.

NOTE 1: (S) It is usually specified as "within ±____ percent (or ±____ db) from ___ to ___ Hertz."

NOTE 2: (S) **Frequency response** should be referred to a frequency within the specified **Measurand** frequency range and to a specific **Measurand** value.

Frequency response, calculated: The **Frequency response** of a **Transducer** calculated from its **Transient response**, its mechanical properties, or its geometry, and so identified.

Friction: (See **Friction error.**)

Friction error: The maximum change in **Output**, at any **Measurand** value within the specified **Range**, before and after minimizing friction within the **Transducer** by **Dithering**.

Friction-free error band: The **Error band** applicable at **Room conditions** and with frictions within the **Transducer** minimized by **Dithering**.

Full Scale: (See **Range**).

Full scale output: The algebraic difference between the **End points**.

NOTE: (S) Sometimes expressed as "±(half the algebraic difference)" e.g., "±2.5 volts."

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

Harmonic content: The distortion in a **Transducer's** sinusoidal **Output**, in the form of harmonics other than the fundamental component.

NOTE: (S) It is usually expressed as a percentage of rms **Output**.

Hysteresis: The maximum difference in **Output**, at any **Measurand** value within the specified **Range**, when the value is approached first with increasing and then with decreasing **Measurand**.

NOTE: (S) **Hysteresis** is expressed in percent of **Full scale output**, during any one **Calibration cycle**. **Friction error** is included with **Hysteresis** unless **Dithering** is specified.

Inaccuracy: (See **Error**).

Input: (See **Excitation** or **Measurand**).

Input impedance: The impedance (presented to the **Excitation** source) measured across the **Excitation** terminals of a **Transducer**.

NOTE: (S) Unless otherwise specified, **Input impedance** is measured at **Room conditions**, with no **Measurand** applied, and with the **Output** terminals open-circuited.

Instability: (See **Stability**).

Insulation resistance: (S) The resistance measured between specified insulated portions of a **Transducer** when a specified dc voltage is applied at **Room conditions** unless otherwise stated.

Intermittent rating: The rating applicable to specified operation over a specified number of time intervals of specified duration; the length of time between these time intervals must also be specified.

Internal pressure: (See **Burst pressure, Proof pressure,** or **Reference pressure**).

Leakage rate: The maximum rate at which a fluid is permitted or determined to leak through a seal.

> **NOTE:** (S) The type of fluid, the differential pressure across the seal, the direction of leakage and the location of the seal must be specified.

Least-squares line: The straight line for which the sum of the squares of the residuals (deviations) is minimized.

Life, cycling: (S) The specified minimum number of full **Range** excursions or specified partial **Range** excursions over which a **Transducer** will operate as specified without changing its performance beyond specified tolerances.

Life, operating: (S) The specified minimum length of time over which the specified **Continuous** and **Intermittent rating** of a **Transducer** applies without change in **Transducer** performance beyond specified tolerances.

Life, storage: (S) The specified minimum length of time over which a **Transducer** can be exposed to specified **Storage conditions** without changing its performance beyond specified tolerances.

Linearity: The closeness of a **Calibration curve** to a specified straight line.

> **NOTE:** (S) **Linearity** is expressed as the maximum deviation of any **Calibration** point on a specified straight line, during any one **Calibration cycle**. It is expressed as "within ±____ percent of **Full scale output**."

Linearity, end point: **Linearity** referred to the **End point line**.

Linearity, independent: **Linearity** referred to the **"Best straight line."**

Linearity, least squares: **Linearity** referred to the **Least squares line**.

Linearity, terminal: **Linearity** referred to the **Terminal line**.

Linearity, theoretical slope: **Linearity** referred to the **Theoretical slope**.

Line pressure: (See **Reference pressure**).

Load: (See **Load impedance**).

Load impedance: The impedance presented to the **Output** terminals of a **Transducer** by the associated external circuitry.

Loading error: An **Error** due to the effect of the **Load impedance** on the **Transducer output**.

> **NOTE:** In the case of force **Transducers** the term "loading" has been applied to application of force.

Maximum (minimum) ambient temperature: The value of the highest (lowest) ambient temperature that a **Transducer** can be exposed to, with or without **Excitation** applied, without being damaged or subsequently showing a performance degradation beyond specified tolerances.

Maximum excitation: (S) The maximum value of **Excitation** voltage or current that can be applied to the **Transducer** at **Room conditions** without causing damage or performance degradation beyond specified tolerances.

Maximum (minimum) fluid temperature: (S) The value of the highest (lowest) **Measured-fluid** temperature that a **Transducer** can be exposed to, with or without **Excitation** applied, without being damaged or subsequently showing a performance degradation beyond specified tolerances.

> **NOTE:** (S) When a **Maximum** or **Minimum fluid temperature** is not separately specified it is intended to be the same as any specified **Maximum** or **Minimum ambient temperature**.

Mean output curve: The curve through the mean values of **Output** during any one **Calibration cycle** or a different specified number of **Calibration cycles**.

Measurand: A physical quantity, property or condition which is measured.

> **NOTE:** The term "**Measurand**" is preferred to "input," "parameter to be measured," "physical phenomenon," "stimulus," and "variable."

Measured fluid: The fluid which comes in contact with the **Sensing element**.

> **NOTE:** The chemical and/or physical properties of this fluid may be specified to insure proper **Transducer** operation.

Mounting error: The **Error** resulting from mechanical deformation of the **Transducer** caused by mounting the **Transducer** and making all **Measurand** and electrical connections.

Natural frequency: (See **Frequency, natural**. See also **Frequency, resonant**.)

Non-linearity: (See **Linearity**).

Non-operating conditions: (See **Environmental conditions, non-operating**).

Non-repeatability: (See **Repeatability**).

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

Operating conditions: (See **Environmental condition**).

Output: The electrical quantity, produced by a **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, peak, or peak-to-peak (as specified) ac component of a **Transducer's** dc **Output** in the absence of **Measurand** variations.

> **NOTE:** (s) Unless otherwise specified, **Output impedance** is measured at **Room conditions** with the **Excitation** terminals open/circuited, except that nominal **Excitation** and **Measurand** between 80 and 100 percent-of-**Span** is applied when the **Transducer** contains integral active output-conditioning circuitry.

Output regulation: The change in **Output** due to a change in **Excitation**.

> **NOTE:** (S) Unless otherwise specified, **Output regulation** is measured at **Room conditions** and with the **Measurand** applied at its upper **Range** limit.

Overload: The maximum magnitude of **Measurand** that can be applied to a **Transducer** without causing a change in performance beyond specified tolerance.

Overrange: (See **Overload**).

Overshoot: The amount of **Output** measured beyond the final steady **Output** value, in response to a step change in the **Measurand**.

NOTE: (S) Expressed in percent of the equivalent step change in **Output**.

Parameter (to be measured): (See **Measurand**).

Peak-to-peak: (See **Double amplitude**).

Physical input: (See **Measurand**).

Pickup: (See **Transducer**).

Power input: (See **Excitation.**)

Precision: (See **Repeatability** and **Stability**).

Primary element, primary detector: (See **Sensing element**).

Proof pressure: The maximum pressure which may be applied to the **Sensing element** of a **Transducer** without changing the **Transducer** performance beyond specified tolerances.

NOTE 1: In the case of **Transducers** intended to measure a property of pressurized fluid, proof pressure is applied to the portion subject to the fluid.

NOTE 2: (S) **Differential-pressure transducer** specifications should indicate whether the specified differential **Proof pressure** is applicable at ambient or maximum specified **Reference pressure**, or both, and whether a reverse-differential **Proof pressure**, at ambient or maximum specified **Reference pressure**, or both, is additionally applicable.

Range: The **Measurand** values, over which a **Transducer** is intended to measure, specified by their upper and lower limits.

Recovery time: The time interval, after a specified event (e.g., **Overload, Excitation** transients, **Output** shortcircuiting) after which a **Transducer** again performs within its specified tolerances.

Reference pressure: The pressure relative to which a **Differential-pressure transducer** measures pressure.

Reference pressure error: The **Error** resulting from variations of a **Differential-pressure transducer's reference pressure** within the applicable **Reference pressure range**.

NOTE: (S) It is usually specified as the maximum change in **Output**, at any **Measurand** value within the specified **Range**, when the **Reference pressure** is changed from **Ambient pressure** to the upper limit of the specified **Reference pressure range**.

Reference pressure range: (S) The range of **Reference pressures** which can be applied without changing the **Differential-pressure transducer's** performance beyond specified tolerances for **Reference pressure error**. When no such error 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.

Reference-pressure zero shift: The change in the **Zero-measurand output** of a **Differential-pressure transducer** resulting from variations of **Reference pressure** (applied simultaneously to both pressure ports) within its specific limits.

Repeatability: The ability of a **Transducer** to reproduce **Output** readings when the same **Measurand** value is applied to it consecutively, under the same conditions, and in the same direction.

NOTE: (S) **Repeatability** is expressed as the maximum difference between **Output** readings; it is expressed as "within _____ percent of **Full scale output**." Two **Calibration cycles** are used to determine **Repeatability** unless otherwise specified.

Reproducibility: (See **Repeatability**).

Resolution: The magnitude of **Output** step changes as the **Measurand** is continuously varied over the range.

NOTE 1: This term relates primarily to **Potentiometric transducers**.

NOTE 2: (S) **Resolution** is best specified as **Average** and **Maximum resolution**; it is usually expressed in percent of **Full scale output**.

NOTE 3: In the sense of the smallest detectable change in **Measurand** use **Threshold**.

Resolution, average: (S) The reciprocal of the total number of **Output** steps over the **Range**, multiplied by 100 and expressed in percent voltage-ratio (for a **Potentiometric transducer**) or in percent of **Full-scale output.**

Resolution, maximum: (S) The magnitude of the largest of all **Output** steps over the **Range**, expressed as percent voltage-ratio (for a **Potentiometric transducer**) or in percent of **Full-scale output**.

Resonances: Amplified vibrations of **Transducer** components, within narrow frequency bands, observable in the **Output**, as vibration is applied along specified **Transducer** axes.

Resonant frequency: (See **Frequency, resonant**).

Response time: The length of time required for the **Output** of a **Transducer** to rise to a specified percentage of its final value as a result of a step change of **Measurand**.

NOTE 1: (S) To indicate this percentage it can be worded so as to precede the main term, e.g., "98%-Response Time: _____ milliseconds, max."

NOTE 2: Also see **Time constant** and **Rise time**.

Ringing period: The period of time during which the amplitude of **Output** oscillations, excited by a step change in **Measurand**, exceeds the steady-state **Output** value.

NOTE: (S) Unless otherwise specified, the **Ringing period** is considered terminated when the **Output** oscillations no longer exceed ten percent of the subsequent steady-state **Output** value.

Rise time: The length of time for the **Output** of a **Transducer** to rise from a small specified percentage of its final value to a large specified percentage of its final value as a result of a step-change of **Measurand**.

NOTE 1: (S) Unless otherwise specified, these percentages are assumed to be 10 and 90 percent of the final value.

NOTE 2: Also see **Time constant**.

Room conditions: Ambient **Environmental conditions**, under which transducers must commonly operate, which have been established as follows:

a) Temperature: 25 ± 10°C (77 ± 18°F).

b) Relative Humidity: 90 percent or less.

c) Barometric Pressure: 26 to 32 inches Hg.

NOTE: Tolerances closer than shown above are frequently specified for transducer calibration and test environments.

Self-heating: Internal heating resulting from electrical energy dissipated within the **Transducer**.

Sensing element: The part of the **Transducer** which responds directly to the **Measurand**.

NOTE: This term is preferred to "Primary element," "Primary detector," "Primary detecting element."

Sensitivity: The ratio of the change in **Transducer output** to a change in the value of the **Measurand**.

NOTE: In the sense of the smallest detectable change in **Measurand** use **Threshold**.

Sensitivity shift: A change in the slope of the **Calibration curve** due to a change in **Sensitivity**.

Sensor: (See **Transducer**).

Source impedance: The impedance of the **Excitation** supply presented to the **Excitation** terminals of the **Transducer**.

Span: The algebraic difference between the limits of the **Range**.

Speed of response: (See **Response time, Time constant**).

Stability: The ability of a **Transducer** to retain its performance characteristics for a relatively long period of time.

NOTE: (S) Unless otherwise stated, **Stability** is the ability of a **Transducer** to reproduce **Output** readings obtained during its original **Calibration**, at **Room conditions**, for a specified period of time; it is then typically expressed as "within ___ percent of **Full scale output** for a period of ___ months."

Static calibration: A **Calibration** performed under **Room conditions** and in the absence of any vibration, shock, or acceleration (unless one of these is the **Measurand**).

Stimulus: (See **Measurand**).

Strain error: The **Error** resulting from a strain imposed on a surface to which the **Transducer** is mounted.

NOTE 1: This term is not intended to relate to **Strain transducers** (strain gages).

NOTE 2: Also see **Mounting error**.

Tapping: (See **Dithering**).

Temperature error: The maximum change in **Output**, at any **Measurand** value within the specified **Range**, when the **Transducer** temperature is changed from **Room temperature** to specified temperature extremes.

Temperature error band: The **Error band** applicable over stated environmental temperature limits.

Temperature gradient error: The transient deviation in **Output** of a **Transducer** at a given **Measurand** value when the ambient temperature or the **Measured fluid** temperature changes at a specified rate between specified magnitudes.

Temperature range, compensated: (See **Temperature range, operating**).

Temperature range, fluid: The range of temperature of the **Measured fluid**, when it is not the ambient fluid, within which operation of the **Transducer** is intended.

NOTE 1: (S) Within this range of fluid temperature all tolerances specified for **Temperature error, Temperature error band, Temperature gradient error, Thermal zero shift** and **Thermal sensitivity shift** are applicable.

NOTE 2: (S) When a **Fluid temperature range** is not separately specified, it is intended to be the same as the **Operating temperature range**.

Temperature range, operating: The range of ambient temperatures, given by their extremes, within which the **Transducer** is intended to operate; (S) within this range of ambient temperature all tolerances specified for **Temperature error, Temperature error band, Temperature gradient error, Thermal zero shift** and **Thermal sensitivity shift** are applicable.

Terminal line: A **Theoretical slope** for which the **Theoretical end points** are 0 and 100% of both **Measurand** and **Output**.

Theoretical curve: The specified relationship (table, graph, or equation) of the **Transducer output** to the applied **Measurand** over the **Range**.

Theoretical end points: The specified points between which the **Theoretical curve** is established and to which no **End point** tolerances apply.

> **NOTE:** The points can be other than 0 and 100% of both **Measurand** and **Output**.

Theoretical slope: The straight line between the **Theoretical end points.**

Thermal coefficient of resistance: The relative change in resistance of a conductor or semi-conductor per unit change in temperature over a stated range of temperature.

> **NOTE:** (S) Expressed in ohms per ohm per degree F or C.

Thermal compensation: (See **Compensation**).

Thermal sensitivity shift: (S) The **Sensitivity shift** due to changes of the ambient temperature from **Room temperature** to the specified limits of the **Operating temperature range**.

Thermal zero shift: (S) The **Zero shift** due to changes of the ambient temperature from **Room temperature** to the specified limits of the **Operating temperature range**.

Threshold: The smallest change in the **Measurand** that will result in a measurable change in **Transducer output**.

> **NOTE:** When the **Threshold** is influenced by the **Measurand** values, these values must be specified.

Time constant: The length of time required for the **Output** of a **Transducer** to rise to 63% of its final value as a result of a step change of **Measurand**.

Total error band: (See **Error band**).

Torque error: (See **Mounting error**).

Transducer: A device which provides a usable **Output** in response to a specified **Measurand**.

> **NOTE:** The term **Transducer** is usually preferred to "Sensor" and "Detector" and to such terms as "Flowmeter," "Accelerometer" and "Tachometer"; it is always preferred to "Pickup," "Gage" (when not equipped with a dial-indicator), "Transmitter" (which has an entirely different meaning in telemetry technology), "Cell," and "End Instrument."

Transduction element: The electrical portion of a **Transducer** in which the **Output** originates. (Refer to Table 1, Third Modifier.)

Transient response: The response of a **Transducer** to a step-change in **Measurand**.

> **NOTE:** (S) **Transient response**, as such, is not shown in a specification except as a general heading, but is defined by such characteristics as **Time constant, Response time, Ringing period,** etc.

Transverse response: (See **Transverse sensitivity**).

Transverse acceleration: An acceleration perpendicular to the sensitive axis of the **Transducer**.

Transverse sensitivity: The **Sensitivity** of a **Transducer** to **Transverse acceleration** or other transverse **Measurand**.

NOTE: (S) It is specified as maximum **Transverse sensitivity** when a specified value of **Measurand** is applied along the transverse plane in any direction, and is usually expressed in percent of the **Sensitivity** of the **Transducer** in its sensitive axis.

Variable: (See **Measurand**).

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**).

Voltage ratio: For potentiometric **Transducers**, the ratio of **Output** voltage to **Excitation** voltage, usually expressed in percent.

Warm-up period: The period of time, starting with the application of excitation to the **Transducer**, required to assure that the **Transducer** will perform within all specified tolerances.

Zero-measurand output: The **Output** of a **Transducer**, under **Room conditions** unless otherwise specified, with nominal excitation and zero **Measurand** applied.

Zero shift: A change in the **Zero-measurand output** over a specified period of time and at **Room conditions**.

NOTE: This **Error** is characterized by a parallel displacement of the entire **Calibration curve**.

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