

### Glossary of Temperature Sensing Terms

**Absolute Zero** — Theoretically, the lowest possible temperature. A body at absolute zero would have no molecular motion or heat energy. It is the zero point on the Kelvin and Rankine scales, and is estimated to be  $-273.15^{\circ}\text{C}$  or  $-459.67^{\circ}\text{F}$ .

**Accuracy** — A statement that is used to define the largest allowable error in a device or system. It is an indication of how close measured values are to true values. It can be expressed in both measured units and in percentages.

**Alloy #11** — A Harrison Alloys trademark for a low-cost negative thermoelement used with copper for a compensating extension wire used with thermocouple types R and S. The EMF characteristics are similar to R and S up to approximately  $204^{\circ}\text{C}$ .

**Alpha ( $\alpha$ )** — The temperature coefficient of resistance of a material, derived from measurements at  $0^{\circ}\text{C}$  and at  $100^{\circ}\text{C}$ :  $\{R_{\text{sub}(100)} - R_{\text{sub}(0)}\}$  over  $\{100 \text{ times } R_{\text{sub}(0)}\}$ . It indicates the basic change in resistance in a material for each  $^{\circ}\text{C}$  change in temperature. It is a defining parameter for resistance temperature detectors (RTDs).

**ANSI** — An abbreviation for American National Standards Institute.

**ASTM** — An abbreviation for American Society for Testing and Materials.

**AWG** — An abbreviation for American Wire Gauge.

**Boiling Point** — The equilibrium temperature between a liquid and its vapor. It is commonly associated with water at  $100^{\circ}\text{C}$ , and 1 standard atmosphere.

**Callendar - van Dusen Equation** — An interpolation equation that provides resistance values as a function of temperature for RTDs.

**Celsius Temperature Scale** — A temperature scale with the ice point at 0 and the boiling point of water at 100. The formula for conversion to the Fahrenheit scale is  $F = 1.8C + 32$ . Formerly referred to as "Centigrade."

**Ceramic Insulation** — Crystalline compounds of both metallic and nonmetallic elements that serve as dielectric insulators. Two of the most common single oxide ceramics are alumina ( $\text{Al}_2\text{O}_3$ ) and magnesium oxide ( $\text{MgO}$ ). Ceramics are the primary insulation used to isolate sheathed thermocouple alloys.

**Compensated Connector** — A thermocouple connector that utilizes either actual thermocouple material contacts or compensating alloy contacts. By maintaining uniform circuit properties throughout the connection systems, errors due to mismatched materials are reduced.

**Compensating Alloy** — An alloy that has similar EMF characteristics to an actual thermocouple alloy. It is usually a low-cost alternative for some types of thermocouple alloy extension lead wires. An example would be the use of Alloy #11 as compensating lead wire for platinum thermocouple sensors.

**Compensating Loop** — Utilized in RTDs, a compensating loop is an extra pair of lead wires that have the same resistance as the actual lead wires, but which are not connected to the RTD element. Its purpose is to correct for lead wire resistance errors when making temperature measurement.

**Connection Head** — A housing on a sensor assembly that provides a terminal block for electrical connections and allows the attachment of protection tubes and cable or conduit hookups.

**Constantan** — The negative leg of types E, J and T thermocouples. Constantan is 55% copper and 45% nickel. The emf values can be significantly different for this material depending upon with which type of thermocouple alloy it is intended to be matched.

**Copper** — The positive leg of type T thermocouple.

**Cryogenic** — A term that usually refers to temperatures in the range of  $-183^{\circ}\text{C}$  or lower.

**Dielectric Strength** — A measure of the voltage that an insulating material can withstand before an electrical breakdown occurs. It is sometimes referred to as breakdown potential.

**DIN 43760** — German Institute for Standards document that covers nickel and platinum resistance elements. This is the most popular specification for 100 ohm platinum RTDs with a resistance vs. temperature curve specified by 0.00385 ohms/ohm $^{\circ}\text{C}$ .

**Drain Wire** — An uninsulated wire used in a cable construction as a ground connection.

**Duplex Construction** — A cable or wire constructed with two insulated conductors running parallel or twisted together.

**Exposed Junction** — A specific type of thermocouple junction where the measuring junction is exposed to the environment without any protecting sheath or outer tube. An exposed junction offers the fastest response time.

**Extension Wire** — A pair of wires connecting a thermocouple sensor to its reference junction or instrumentation. The emf characteristics of the extension wire must be similar to the thermocouple emf characteristics.

**Fahrenheit Temperature Scale** — A temperature scale with the ice point at 32 and the boiling point of water at 212. The formula for conversion to the Celsius scale is  $C = 5/9 (F - 32)$ .

**FEP** — An abbreviation for Fluorinated Ethylene Propylene. This component is commonly referred to as "Teflon®."

**Fixed Point** — A very reproducible temperature at the equilibrium point between phase changes in a material. The triple point of water ( $0.01^{\circ}\text{C}$ ) is an example of a fixed point.

**Freezing Point** — The fixed temperature point of a material that occurs during the transition from a liquid to a solid state. This is also known as the melting point for pure materials.

**Giga-** — A prefix meaning billion, or  $10^9$ . The symbol is G.

**Ground** — A conducting connection to earth or to some other large conducting object. Its purpose is to maintain an earth potential on the conductors connected to it, and to conduct the ground current to and from the earth.

**Grounded Junction** — A specific type of thermocouple junction in which the sheath and conductors are welded together, forming a completely sealed integral junction. A grounded junction is recommended for use in liquids, gas, and high pressure environments.

**Hi-Pot Test** — A test that determines the largest potential that can be applied to a conductor without breaking down the insulation (see Dielectric Strength).

**Ice Point** — The melting (and freezing) point of ice,  $0^{\circ}\text{C}$ . The ice point is frequently used as a calibration check point on resistance temperature detectors and as the reference junction for thermocouples.

**Initial Calibration Tolerances** — The allowable deviation from the theoretical emf value generated by any particular calibration thermocouple at a given temperature (previously referred to as limits of error).

**Insulation Resistance** — A ratio of the applied voltage to the total current flow between two conductors separated by insulation or any conductor and the sheath.

**Interchangeability** — A statement that describes how closely a sensor adheres to its defining equation, and the maximum variation that would exist in the readings of identical sensors mounted side-by-side under identical conditions.

**IPTS- 68, 48** — Abbreviations for the International Practical Temperature Scales of 1968 and 1948. IPTS-68 is the most recent revision of the temperature scale, which is a standard scale made up of fixed points that closely approximate thermodynamic temperatures. All temperatures between the fixed points are derived by interpolation using the assigned interpolation instrument.

**Iron** — The positive leg of a type J thermocouple.

**ISA** — An abbreviation for the Instrument Society of America.

**Junction (thermocouple)** — The point at which two thermocouple alloys are joined. In a typical thermocouple circuit there is a measuring junction and a reference junction.

**Kelvin Temperature Scale** — Also known as the thermodynamic temperature scale, the Kelvin Scale is an absolute temperature scale in which temperature differences are proportional to the amount of heat energy converted to mechanical work by a Carnot engine. The ice point on the Kelvin Scale is  $273.15\text{K}$ . A useful approximation for conversion of the Kelvin Scale to the Celsius scale is  $T(\text{K}) = T(\text{C}) + 273.15$ .

**KN** — The negative leg of a type K thermocouple. It is predominantly nickel with small added amounts of aluminum, manganese, and silicon. Company trade names are Alumel, Nial, and HAI-KN.

**KP** — The positive leg of a type K thermocouple. It is predominantly nickel with added chromium. Company trade names are Chromel, Tophel, and HAI-KP.

**Limit of Error** — The allowable error in a thermocouple, expressed as a percentage or a specific degree value throughout defined temperature ranges. See Initial Calibration Tolerances.



### Glossary of Temperature Sensing Terms (continued)

**Linearity** — An instrument or transducer's deviation in response from straight line values.

**Loop Resistance** — The total resistance of the thermocouple materials in a thermocouple circuit or heater in a heater circuit.

**Measuring Junction** — The junction in a thermocouple circuit that senses the temperature of the unknown object. It is commonly referred to as the hot junction.

**Mega-** — A prefix meaning million, or  $10^6$ . The symbol is M.

**Mica** — A silicate mineral used mainly as an electrical and heat insulator.

**Microvolt ( $\mu\text{V}$ )** — One millionth of a volt ( $10^{-6}$  volt). In thermocouple measurements, a microvolt is the smallest common increment of output.

**Millivolt (mV)** — One thousandth of a volt.

**Mineral-Insulated Thermocouple** — A thermocouple that is manufactured by loading a metal sheath with conductors and insulators, and then compacting the entire assembly.

**Negative Temperature Coefficient** — A characteristic of a material in which a decrease in resistance accompanies an exposure to increased temperatures.

**NEMA** — An abbreviation for the National Electrical Manufacturers Association.

**Nicrosil** — The positive leg of a type N thermocouple. It is predominantly nickel with added chromium and silicon.

**NISIL** — The negative leg of a type N thermocouple. It is predominantly nickel with added silicon and magnesium.

**NIST** — National Institute of Standards and Technology.

**Noise** — Unwanted electrical interference picked up on a signal cable.

**NPT** — An abbreviation for American National Standard taper pipe thread.

**OFHC** — An abbreviation for oxygen free high conductivity copper.

**Parallel Pair** — A wire construction where two single conductors are laid parallel.

**Platinel** — An Englehard Industries trade name for a platinum thermocouple alloy with thermoelectric characteristics that closely match type K thermocouples at temperatures above  $800^{\circ}\text{C}$ .

**Platinum** — The negative leg in types R and S thermocouples. A noble metal, symbol Pt, with excellent chemical and heat resistance. It is more ductile than silver, gold, or copper.

**Platinum 6% Rhodium** — The platinum-rhodium alloy that forms the negative leg on type B thermocouple.

**Platinum 10% Rhodium** — The platinum-rhodium alloy that forms the positive leg on a type S thermocouple.

**Platinum 13% Rhodium** — The platinum-rhodium alloy that forms the positive leg on a type R thermocouple.

**Platinum 30% Rhodium** — The platinum-rhodium alloy that forms the positive leg on a type B thermocouple.

**Platinum 67** — The platinum standard used by the NIST. Platinum 67 is used to interpolate the temperature scale between  $630.74$  and  $1064.43^{\circ}\text{C}$ . Previously called Platinum 27, Platinum 67 (IPTS-68) is 9 microvolts negative to Platinum 27 (IPTS-48) at  $1200^{\circ}\text{C}$ .

**Positive Temperature Coefficient** — A characteristic of a material in which an increase in resistance accompanies exposure to an increase in temperature.

**Primary Standard** — A term that applies to an instrument that meets conditions required for establishing the International Practical Temperature Scale.

**Protection Tube** — A tube that is designed to protect a sensor from any harsh environment or process conditions.

**PTFE** — An abbreviation for polytetrafluoroethylene. One of the most chemically resistant carbon based insulations.

**PVC** — An abbreviation for polyvinyl chloride, a thermoplastic with excellent dielectric strength and flexibility.

**Rankine Temperature Scale** — A temperature scale with its 0 at the absolute zero of temperature. Its degree is equal to a Fahrenheit degree, thus  $T(\text{R}) = T(\text{F}) + 459.67$ .

**Reference Junction** — The junction in a thermocouple circuit that is maintained at a constant, known temperature. It is also referred to as the cold junction and as a standard it is usually maintained at  $0^{\circ}\text{C}$ ; however, any temperature can be used.

**Refractory Metal Thermocouple** — A thermocouple made from materials that melt above  $1935^{\circ}\text{C}$ .

**Repeatability** — The ability of a sensor or system to indicate the same reading under repeated identical conditions.

**Resistance** — A property of conductors that determines the current produced by a given difference of potential. Dimensions, material and temperature all influence resistance.

**Response Time** — The time required for a sensor to reach 63.2% of the step change in temperature for a particular set of test conditions.

**Rhenium** — An elementary metal that when added to tungsten, forms an alloy with better ductility and improved high temperature strength over tungsten alone.

**Rhodium** — A platinum group metal added to pure platinum as a mild hardware and to increase high-temperature strength.

**Ro** — The resistance measurement taken on an RTD at  $0^{\circ}\text{C}$ .

**RTD** — An abbreviation for resistance temperature detector. It is a circuit element whose resistance increases with increasing temperature in a predictable manner. Platinum is the most popular material used in RTDs.

**Secondary Standard** — A measurement device that has been referenced to a primary standard.

**Seebeck Coefficient** — The rate of change of thermal emf with temperature at a given temperature.

**Seebeck emf** — The net thermal emf in a thermocouple under zero current conditions.

**Shield** — A metallic foil or braided wire layer surrounding a conductor or a group of conductors to prevent electrostatic or electromagnetic interferences from external sources.

**Stability** — The ability of an instrument or a sensor to maintain a consistent output with the application of a constant input.

**Temperature Calibration Point** — A temperature at which the output of a sensor is compared or determined by comparison against a standard.

**Tera-** — A prefix meaning trillion, or  $10^{12}$ . The symbol is T.

**Thermal Gradient** — The distribution of differential temperatures in and across an object.

**Thermistor** — A contraction for thermally sensitive resistor. A thermistor is a semiconducting circuit element that typically exhibits a high negative coefficient of resistance.

**Thermocouple** — A temperature sensor formed by joining two dissimilar metals and applying a temperature differential between the measuring junction and the reference junction.

**Thermopile** — Multiple thermocouples connected in series so that alternate junctions are at the reference and measuring points. The result of this type of arrangement is an increased output for a given temperature differential.

**Thermowell** — A closed-end tube that will accept a temperature sensor and provide a pressure-tight connection at the well's point of installation.

**Transducer** — A device that receives and transmits energy. In many instances, the energy that is received is transmitted in a different form.

**Transmitter** — An externally powered device that transmits a signal from a thermocouple or an RTD via a two-wire current loop.

**Triple Point of Water** — A thermodynamic state (of water) in which the gas, liquid, and solid phases all occur in equilibrium. For water, the triple point is  $0.01^{\circ}\text{C}$ .

**Twisted Pair** — Two insulated conductors twisted together. Twisted wires in thermocouple circuits minimize magnetic noise produced from current carrying conductors.

**Ungrounded Junction** — A thermocouple junction that is fully insulated from the capped sheath end. An ungrounded junction is often specified for applications involving frequent or rapid temperature cycling, and for protection against stray emf signals.

**Working Standard** — A measurement device that has been referenced to a secondary standard.