

# THERMAL SYSTEM GLOSSARY

**Absolute Zero**—The lowest theoretical temperature. At absolute zero, a body would have no molecular motion of heat energy. Absolute zero is the zero point on the Rankine and Kelvin scale. (-273.15°C or -459.67°F)

**AC**—Alternating Current; an electric current that reverses direction at regularly occurring intervals.

## Accuracy

Calibration Accuracy—the potential error of a device compared to a physical constant or agency standard.

Control Accuracy—maintaining a process at the desired setting. The errors or combination of errors in the entire system including the sensor, control, power, load and design inefficiencies affect control accuracy.

Display Accuracy—the amount of potential error between a measured value and the control's displayed value.

Set Point Accuracy—the potential error between a measured value and the control setting

**Alarm**—a control condition or function, indicating that the process is a predetermined amount above or below the set point.

**Ambient Compensation**—the ability of an instrument to compensate for changes in the ambient temperature so that the changes do not affect control accuracy.

**Ambient Temperature**—the temperature of the immediate surroundings in which equipment is to operate.

**Ampere (amp)**—the rate of flow of current in a circuit.

**Analog Indication**—a meter with graduated scale and a pointer that moves to indicate process condition.

**Analog Output**—a voltage or current signal that is a continuous function of the measure parameter.

**Analog Set Point**—potentiometer adjustment of the control setting

**Anneal**—To relieve stress in a metal or glass material by heating to just below its melting point, then gradually cooling to ambient temperature. Annealing lowers tensile strength while increasing flexibility. Tubular heaters are annealed prior to forming.

**ANSI**—American National Standards Institute

**Anti-reset Windup**—a feature in 3 mode (PID) controls which prevents the integral (automatic rest) circuit from functioning when the temperature is outside the proportional band.

**ASME**—American Society of Mechanical Engineers.

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

**Atmospheric Pressure (Standard)**—Pressure exerted by the earth's atmosphere on the objects within. Measured at 60°F (15°C), at sea level, standard atmospheric pressure is 14.7 psia.

**Automatic Reset (Integral)**—the integral function of a control that automatically compensates for the difference between the set point and the actual process temperature. A signal moves the proportioning band up or down to correct for the droop or offset error.

**Automatic Tuning (of control parameters)**—a control that calculates the optimum PID parameters with a built-in software algorithm to eliminate manual tuning efforts.

**Auxiliary Output**—additional outputs for control of functions other than the primary control output, such as lights, buzzers, horns or gas purges that are triggered by the control alarm function.

**AWG**—American Wire Gauge.

**Bandwidth**—the total temperature variation measured at some point in the system, normally the process.

**Baud Rate**—In serial communications, the rate of information transfer in bits per second.

**Blackbody**—a theoretical object that radiates the maximum amount of energy at a given temperature and absorbs all energy incident upon it.

**Boiling Point**—the temperature at which a substance in the liquid

state transforms to the gaseous state. Commonly refers to the boiling point of water (100°C or 212°F at sea level).

**Btu**—British Thermal Unit; the amount of thermal energy required to raise one pound of water, 1°F.

**Bumpless Transfer**—The smooth, automatic transition from automatic control (closed loop) to manual control (open loop). The control output is maintained during the transfer.

**Burst Firing**—a fast cycling control output type (3-32VDC for Ogden products) used in conjunction with a solid state relay.

**Calibration**—the process of adjusting an instrument so that the indication is accurate compared to the actual value.

**cfm**—the volumetric flow rate of a liquid or gas in cubic feet per minute.

**Calorie**—the amount of thermal energy required to raise one gram of water 1°C at 15°C

**Cascade**—Control function where the output of one control loop provides the set point for a second loop, which determines the control action.

**CE**—A mark that designates compliance with European Union (EU) requirements for products sold in Europe

**Celsius**—(Centigrade) a temperature scale with 0°C defined as the ice point and 100°C as the boiling point of water at sea level.

**Chatter**—the rapid cycling of a relay due to too narrow a bandwidth in the control.

**Closed Loop Control**—a control system in which process temperature changes are detected by a sensor. The feedback from the sensor allows the control to make adjustments for accurate system regulation.

**Cold Junction Compensation**—a temperature sensitive device that prevents changes in the ambient temperature from affecting the cold junction of a thermocouple.

**Common Mode Line Filter**—a device to filter noise signals on both power lines with respect to ground.

**Common Mode Rejection Ratio**—the ability of an instrument to reject interference from a common voltage at the input terminals with relation to ground. Expressed in dB (decibels).

**Conduction**—the transfer of heat from one material at a given temperature to another material at a lower temperature while in direct contact with each other.

**Continuity Check**—A test that determines whether current flows throughout the length of a circuit.

**Control Loop**—the basic control loop of any automatic control system consists of:

- 1) variable (process)
- 2) sensor
- 3) error detector (of control)
- 4) control
- 5) final control element (relay, SSR, SCR)
- 6) temperature indication

**Control Mode**—the method in which the control restores the system temperature to set point. On/Off, proportioning, and PID are the most common control modes.

**Convection**—the transfer of heat from a source or higher temperature area in a gas or liquid by the movement and mixing of the masses.

**CPS**—Cycles per Second (See Hertz).

**Current Proportioning**—a 4-20 milliamp (typical) current output which provides a current proportional to the amount of control required.

**Cycle Rate**—in a time proportioning control, the period (usually in seconds) of time that is required to complete one on/off cycle once temperature has settled at the center of the proportioning band.

**DC**—direct current; an electric current flowing in one direction and constant in value.

**Data Logging**—Recording a process variable over an extended period of time.

**Dead Band**—the temperature band where no heating or cooling takes place, expressed in degrees.

**Default Parameters**—The programming instructions permanently written in microprocessor software.

**Density**—mass per unit of volume, such as lbs./cu.ft.

**Derivative**—(See Rate)

**Deviation**—the difference between the selected value and the actual value.

**Deviation Alarm**—an offset value that follows the set point. If the set point is 300°F and the Deviation Alarm value is +20°F (or 320°F), then the set point is changed to 350°F, the Deviation Value alarm would be 350°F plus 20°F (or 370°F). See Process Alarm.

**Deviation Meter**—the display of process temperature on meter that indicates temperature relative to the set point.

**Dielectric**—an electrical insulator - a material with low electrical conductivity.

**Dielectric Strength**—an amount of voltage that an insulating material can withstand before an electrical breakdown occurs.

**Differential**—in an on/off control, the temperature difference expressed in degrees between where the control switches off and the control switches on.

**Differential Mode Line Filter**—a device to filter noise signals between two power lines.

**Digital Indication**—the actual process temperature is indicated by LED.

**Digital Set Point**—the desired temperature value is set by means of a pushbutton or pushwheel switch.

**DIN**—Deutsche Industrial Norms, a German agency that sets engineering standards.

**Diode**—Device that allows current to flow in only one direction.

**Drift**—a change in a value over a long period due to changes in factors such as ambient temperature, time or line voltage.

**Droop**—in time proportioning controls, the difference in temperature between the set point and where the system temperature stabilizes. Corrected by automatic or manual reset.

**Dual Output**—the primary output will regulate the process temperature. A secondary output will be utilized for process cooling or as an alarm.

**Duty Cycle**—the time to complete one ON/OFF cycle.

**Efficiency**—the amount of useful output versus energy input.

**Electromagnetic Interference (EMI)**—electrical and magnetic “noise” than can be generated when switching AC power. EMI can interfere with the operation of microprocessor based controls.

**Emissivity**—The ratio of radiant energy emitted from a surface compared to the radiant energy emitted from a black body at the same temperature.

**Endothermic**—a process is endothermic when it absorbs heat.

**Enthalpy**—the sum of the internal energy of a body and the product of its volume multiplied by the pressure used to evaluate the energy change occurring when a vapor or gas is heated. Expressed in units of Btu/lb. or Joules/gram.

**Error**—the difference between the correct value and the reading or display value.

**Exothermic**—a process is exothermic when it generates heat.

**Event**—a programmable On/Off output used to signal peripheral equipment or a process.

**Flow Rate**—speed or velocity of fluid movement.

**Form A Relay**—Single pole, single throw relay with Normally Open (NO) and common contacts. When heat is required for a process, the contacts will close.

**Form B Relay**—Single pole, single throw relay with Normally Closed (NC) and common contacts. Contacts are open when coil is energized.

**Form C Relay**—Single pole, double throw relay with Normally Open (NO), Normally Closed (NC) and common contacts. Can be selected as Form A or Form B contact.

**fpm**—flow velocity in feet per minute.

**fps**—flow velocity in feet per second.

**Fahrenheit**—a temperature scale with 32°F defined as the ice point and 212°F as the boiling point of water at sea level.

**Frequency**—the number of event occurrences or cycles over a specified period of time.

**Freezing Point**—the temperature where a material changes from a liquid to a solid.

**Fuse**—A device that interrupts power in a circuit when an overload occurs.

**Fuzzy Logic**—An artificial intelligence technique that allows control decisions to be made upon approximate or incomplete information. Fuzzy Logic is a continuous decision making function that can prevent initial overshoot and set point differentials.

**GIGA**—the prefix for one billion (G).

**gph**—the volumetric flow rate in gallons per hour.

**gpm**—the volumetric flow rate in gallons per minute.

**Ground**—the electrical neutral line having the same potential as the surrounding earth; the negative side of a DC power supply; the reference point for an electrical system.

**Grounded Junction**—A thermocouple junction in which the sheath and conductors are welded together forming a completely sealed integrated junction.

**Heat**—thermal energy expressed in Calories, Btu's or Joules.

**Heat Balance**—proper sizing of the heat source to the requirements of the system (including heat losses) (See: “Calculating Heating Requirements” in the Engineering Section).

**Heat of Fusion**—the amount of energy required to change one pound of a material from a solid to a liquid without an increase in temperature. Expressed in Btu/lb.

**Heat of Vaporization**—the amount of energy required to change one pound of a material from a liquid to a vapor without an increase in temperature. Expressed in Btu/lb.

**Heat Sink**—heat conducting material used to dissipate heat.

**Heat Transfer**—a process of thermal energy flowing from one body to another.

1) Conduction: the transfer of heat from one particle of matter to another.

2) Convection: the transfer of heat from one part of a particle to another by the mixing of the warmer particles with the cooler.

3) Radiant: the transfer of heat from one body to another as the result of the bodies emitting and absorbing radiation energy.

**Heat Transfer Medium**—a gas, liquid or solid through which heat flows from the heat source to the work.

**Hertz**—units of expression for frequency, measured in cycles per second.

**Hi-Pot Test**—to apply a high voltage to an electrical conductor to test the surrounding insulation.

**Hysteresis**—the temperature sensitivity designed into the on/off control action between the on and off switching points. Expressed in percentage of control range.

**Ice Point**—the temperature where pure water freezes (0°C or 32°F).

**Impedance**—the total opposition in a circuit to the flow of alternating current. Measured in ohms and represented by “Z”.

**Infrared**—or radiation is the exchange of energy by electromagnetic waves. The infrared spectrum extends from the deep red end of the visible spectrum to the microwave region of the radio spectrum. The portion adjacent to the visible spectrum is of importance to heating. Radiant heat transfer can be very efficient in directing energy from the heat source to an object.

**Isolation**—Electrical Separation

**Isothermal**—a process or area that maintains a constant temperature.

**Integral**—(See Automatic Reset).

**Joule**—the basic unit of thermal energy. 1 Joule equals 1 ampere passed through a resistance of 1 ohm for 1 second.

**Junction**—A thermocouple junction is the point at which two alloys are joined. A typical thermocouple circuit would have a measuring and a reference junction.

**Kelvin**—the unit of absolute or thermodynamic temperature scale. Zero Kelvin is absolute zero, where all molecular activity stops. No ° symbol is used. 0°C = 273.15K; 100°C = 373.15K.

**Kilo**—the prefix for one thousand (K).

**Kilowatt (kw)**—1000 watts or 3412 Btu per hour.

**Kilowatt Hour**—electrical unit of energy expended by one kilowatt in one hour.

**Least Significant Digit**—The digit farthest to the right in a display.

**Linearity**—the deviation of an instrument's response from a straight line.

**Load**—the electrical demand of a process expressed as wattage, amps or resistance (ohms).

**Manual Reset**—the adjustment on a proportional control which shifts the proportioning band in relation to the set point to eliminate droop of offset errors.

**Mass Flow Rate**—weight of a substance flowing per unit of time past a specific cross-sectional area within a system.

**Mean Temperature**—the maximum and minimum temperature average of a process at equilibrium.

**Measuring Junction**—the thermocouple junction at the point of measurement in the process.

**Mega**—the prefix for one million (M) (10<sup>6</sup>).

**Mechanical Relay**—an electromechanical device that completes or breaks a circuit by opening or closing electrical contacts.

**Micro**—The prefix for one millionth (10<sup>-6</sup>).

**Microamp**—10<sup>-6</sup> amps (one millionth of an amp).

**Micron**—10<sup>-6</sup> meters (one millionth of a meter).

**Milli**—The prefix for one thousandth (10<sup>-3</sup>).

**Microprocessor**—The central processing unit (CPU) that performs the logic operations in a micro-computer system. The microprocessor in a process or instrument control decodes instructions from the stored program, performs algorithmic and logic functions, and produces signals and commands.

**Milliamp**—10<sup>-3</sup> amps (one thousandth of an amp).

**Millivolt**—10<sup>-3</sup> volts (one thousandth of a volt).

**NEC**—National Electrical Code

**NEMA**—National Electrical Manufacturer's Association

**Noise**—undesirable electrical interference on the signal wires.

**Noise Suppression**—a device used to reduce electrical interference.

**Normal Mode Rejection Ratio**—the ability of an instrument to reject interference of the line frequency (50-60Hz) across the input terminals.

**NPT**—National Pipe Thread

**Offset**—the difference in temperature between the set point and the actual process temperature.

**OHM**—The unit of electric resistance.

**On-Off**—a control whose action is full on or full off.

**Open Loop Control**—a control system with no sensing feedback.

**Overshoot**—excursion of temperature above the set point.

**Phase**—time based relationship between an intermittent function and a reference. Electrically, the expression is in angular degrees to describe the voltage or current relationship of two alternating waveforms.

**Phase Proportioning**—a temperature control form where the power supplied to the process is controlled by limiting the phase angle of the line voltage.

**PID**—three mode temperature control—proportional, integral (automatic reset), derivative (rate).

**Polarity**—having two oppositely charged poles; one positive, one negative.

**Potting**—The sealing of components with a compound such as epoxy

to protect against moisture and other contaminants.

**Process Alarm**—a fixed alarm or secondary set point value independent of the primary set point. Should a process value exceed this value, an alarm condition would register.

**Process Variable**—the parameter being controlled or measured such as temperature, relative humidity, flow, level, pressure, etc.

**Proportioning Band**—a temperature band in degrees within which a control's proportioning function is active.

**Proportioning Control Mode**—when process temperature approaches set point and enters the proportioning band, the output is switched on and off at the established cycle time. The change in power to the load provides a throttling action which results in less temperature overshoot. This cycling will continue until on and off times are equal.

**psia**—pounds per square inch absolute. Pressure reference to a vacuum.

**psig**—pound per square inch gage. Pressure reference to ambient air pressure.

**Quality of Steam**—the relative amount of liquid present in saturated steam as a percent of the total weight. The quality of steam is 100% less the percent liquid. Dry saturated steam has a quality of 100%.

**Ramp**—a programmed rise in temperature.

**Range**—an area between two limits in which a measurement or control action takes place. Typically expressed in upper and lower limits.

**Rankine**—an absolute temperature scale based upon the Fahrenheit scale with 180° between the ice point and boiling point of water. 0°F = 459.67°R.

**Rate (derivative)**—a control function that measures the rate of increase or decrease of the system temperature and brings the control into an accelerated proportioning action. This mode prevents an overshoot condition at initial heat-up and with system disturbances.

**Rate Time**—the interval over which the system temperature is sampled for the derivative function.

**Repeatability**—the ability to give the same output or measurement under repeated identical conditions.

**Resistance**—the resistance to the flow of electric current measured in ohms.

**Resolution Sensitivity**—the amount of temperature change that must occur before the control will actuate. It may be expressed in temperature or as a percentage of the control's scale.

**Response Time**—In analog instruments, the time required for a change of the measured quantity to change the indication. In sensors, the time required to reach 63.2% of the step change.

**Retransmit Output**—analog output scaled to the process or the set point value.

**RS232 or RS485 Output Signal**—A serial interface suitable for connection between a digital control and a personal computer, a host computer or printer.

**RTD**—a temperature sensing probe of finely wound platinum wire that displays a linear resistance change for a corresponding temperature change. The resistance increases as the temperature rises. A base resistance of 100 ohms at 32°F is the industry (DIN) standard.

**Saturation Temperature**—the boiling temperature of a liquid at the existing pressure.

**SCFM**—Volumetric flow rate in cubic feet per minute at 60°F (15°C) and standard atmospheric pressure.

**SCR**—Silicone Controlled Rectifier

**Sensor Breakdown Protection**—circuitry which ensures safe process shut down in the event of sensor failure.

**Serial Communications**—A method of transmitting data between devices.

**Set Point**—control setting to achieve or maintain temperature.

**Shape Factor**—in radiant applications, the amount of energy received by the target relative to heater rating and distance to the target.

**Shield**—material surrounding a conductor(s) to prevent electrostatic or EMI from external sources.

**Slide Wire Feedback**—A potentiometer that varies the resistance to control a valve position.

**Soak**—To raise the temperature of a metal object in a heated environment to produce a metallurgical change.

**Standard**—a reference point from which references or calibrations are made.

**Soft Start**—reduces voltage on initial start-up which reduces power to the heaters. If heater has accumulated moisture internally during a shut down, soft start will allow heater to dry before full voltage is applied extending heater life.

**Solid State Relay**—a solid state switching device which completes or breaks a circuit electrically with no moving parts.

**Span**—the difference between the upper and lower limits of a controller's range.

**Specific Gravity**—the ratio of mass of any material to the same volume of pure water at 4°C.

**Specific Heat**—the ratio of thermal energy required to raise the temperature of a particle 1 degree to the thermal energy required to raise an equal mass of water 1 degree.

**Speed of Response**—time needed for a temperature change occurring at the sensor to be translated into a control action.

**Stability**—the ability of an instrument or sensor to maintain a constant output when a constant input is applied.

**Standard**—a reference point from which references or calibrations are made.

**Super Heating**—the heating of a liquid above its boiling temperature without changing to a gaseous state; or the heating of a gas considerably above the boiling temperature.

**Surge Current**—a current of short duration occurring when power is initially applied to capacitive or resistive loads, usually lasting no more than several cycles.

**Temperature Gradient**—the range of temperature variations at various physical locations throughout a thermal system.

**Tera**—the prefix for one trillion(T).

**Thermal Conductivity**—the property of a material to conduct heat.

**Thermal Expansion**—an increase in size due to an increase in temperature.

**Thermal Lag**—the time delay in the distribution of heat throughout a thermal system.

**Thermal System**—a series of components arranged and designed to provide heat. The four elements or components comprising a Thermal System are:

- 1) work or load
- 2) heat source
- 3) heat transfer medium
- 4) control system

**Thermistor**—a temperature sensing probe manufactured of a mixture of metal oxides then encapsulated in epoxy or glass. A large change in resistance is exhibited proportional to a change in temperature. The resistance usually decreases as temperature rises.

**Thermocouple**—a temperature sensing probe consisting of the junction of two dissimilar metals which has a millivolt output proportional to the difference in temperature between the "hot" junction and the lead wires (cold junction).

**Thermowell**—a closed-end tube into which a temperature sensor is inserted to isolate it from the environment.

**Transducer**—a device that converts a measured variable into another form which is the transducer's output. A thermocouple transforms heat to a millivolt output.

**Transmitter**—a device used to transmit temperature data from the sensor.

**Undershoot**—excursion of temperature below set point.

**Ungrounded Junction**—A thermocouple junction fully insulated from the sheath.

**Viscosity**—the inherent resistance of a substance to flow

**Voltage**—an electrical potential which is measured in volts.

**Wattage**—a measurement of electrical power. In a resistive circuit,  $VI = W$  (See Ohms Law formulas).

**Watt Density**—the rated wattage of an element per unit of surface area. Usually expressed in watts per square inch.

**Zero Voltage Switching**—completing or breaking of a circuit when the voltage wave form crosses zero voltage.