

Glossary of Basic Thermography Terms

Absolute Zero - The temperature that is zero on the Kelvin or Rankine temperature scales, also the temperature at which a material is at its lowest energy state.

Absorptivity, a [Absorptance] - The proportion (as a fraction of 1) of the radiant energy impinging on a material's surface that is absorbed into the material. For a blackbody, this is unity (1.0). Technically, absorptivity is the internal absorptance per unit path length. In thermography, the two terms are often used interchangeably.

Accuracy [of Measurement] - The maximum deviation, expressed in % of scale or in degrees Celsius or Fahrenheit, that the reading of an instrument will deviate from an acceptable standard reference.

Ambient Operating Range - Range of ambient temperatures at which an instrument is designed to operate within published performance specifications.

Ambient Temperature - Temperature of the air in the vicinity of the target (target ambient) or the instrument (instrument ambient).

Ambient Temperature Compensation - Correction built into an instrument to provide automatic compensation in the measurement for variations in instrument ambient temperature.

Anomaly - Any irregularity, such as a thermal anomaly on an otherwise isothermal surface. Any indication that deviates from what is expected.

Apparent Temperature - The target surface temperature indicated by an infrared point sensor, line scanner or imager before temperature corrections are made.

Artifact - A product of artificial character due to extraneous agency; an error caused by an uncompensated anomaly. In thermography, an emissivity artifact simulates a change in surface temperature but is not a real change. A hot solar reflection or a cold reflection due to narcissus would be examples of artifacts.

Atmospheric Windows [Infrared] - The spectral intervals within the infrared spectrum in which the atmosphere transmits radiant energy well (atmospheric absorption is a minimum.). These are roughly defined as 3-5 μm and 8-14 μm .

Background Temperature, Instrument - The apparent temperature of the radiant energy impinging on an object that is reflected off the object and enters the instrument. Originates from the scene behind and surrounding the instrument, as viewed from the target. The reflection of this background appears in the image and affects temperature measurements. Good quality quantitative thermal sensing and imaging instruments provide a means for correcting measurements for this reflection.

Background Temperature, Target - Apparent ambient temperature of the scene behind and surrounding the target, as viewed from the instrument. When the FOV of a point sensing instrument is larger than the target, the target background temperature will affect the instrument reading. Also called surroundings temperature or foreground temperature.

Blackbody, Blackbody Radiator - A perfect radiator, one that radiates the maximum number of photons in a unit time from a unit area in a specified spectral interval into a hemisphere that any body in thermodynamic equilibrium at the same temperature can radiate. It follows that a blackbody absorbs all radiant energy impinging on it and reflects and transmits none; thus a surface with emissivity of unity (1.0).

[More information on blackbody radiation.](#)

[More information on blackbody types and emissivity.](#)

Blackbody Curves - Plots of radiant power spectral exitance ($W/m^2/mm$) vs. wavelength for various temperatures according to the Planck equation. These curves show the maximum amount of energy at any given wavelength that can be radiated by an object due solely to its temperature. Also called Planck curves.

Bolometer, Infrared [Micro-Bolometer] - A type of thermal detector commonly used in uncooled radiometers.

Calibration - Checking and/or adjusting an instrument such that its readings agree with a standard. Calibration removes instrument systematic error and quantifies the instrument random error.

Calibration Check - A routine check of an instrument against a reference to ensure that the instrument has not deviated from calibration since its last use.

Calibration Accuracy - The accuracy, to which a calibration is performed, usually based on the accuracy and sensitivity of the instruments and references used in the calibration.

Calibration Source, Infrared - A blackbody or other target of known temperature and effective emissivity used as a calibration reference.

Capacitance, Thermal - This term is used to describe heat capacity in terms of an electrical analog, where loss of heat in analogous to loss of charge on a capacitor. Structures with high thermal capacitance lose heat more slowly than those structures with low thermal capacitance.

Capacity, Heat - The heat capacity of a material or structure describes its ability to store heat. It is the product of the specific heat (c_p) and the density (ρ) of the material. This means that denser materials generally will have higher heat capacities than porous materials.

Celsius [Centigrade] - A temperature scale based on $0^\circ C$ as the freezing point of water and $100^\circ C$ as the boiling point of water at standard atmospheric pressure; a relative scale related to the Kelvin scale [$0^\circ C = 273.12 K$. $1 C^\circ (DT) = 1 K. (DT)$]

Color - A term sometimes used to define wavelength or spectral interval, as in two-color radiometry (meaning a method that measures in two spectral intervals); also used conventionally (visual color) as a means of displaying a thermal image, as in color thermogram.

Colored Body - See non-graybody.

Conductance, Thermal - A measure of the ability of a material of defined thickness and cross-sectional area to conduct heat. Related to the material property, thermal conductivity. The inverse of thermal resistance ($C = 1/R$).

Conduction, Thermal - The only mode of heat flow in solids, but can also take place in liquids and gases. It occurs as the result of atomic vibrations (in solids) and molecular collisions (in liquids and gases) whereby energy is transferred from locations of higher temperature to locations of lower temperature.

Conductivity, Thermal, [K] - A material property defining the relative capability to carry heat by conduction in a static temperature gradient. Conductivity varies slightly with temperature in solids and liquids and with temperature and pressure in gases. It is high for metals (copper has a K of 380 W/m-°C) and low for porous materials (concrete has a K of 1.0) and gases.

Convection - The form of heat transfer that takes place in a moving medium and is almost always associated with transfer between a solid (surface) and a moving fluid (such as air), whereby energy is transferred from higher temperature sites to lower temperature sites.

Delta T - The temperature difference between two targets usually of comparable targets under comparable conditions.

Detector, Infrared - A transducer element that converts incoming infrared radiant energy impinging on its sensitive surface into a useful electrical signal.

Diffuse Reflector - A surface that reflects a portion of the incident radiation in such a manner that the reflected radiation is equal in all directions. A mirror is not a diffuse reflector.

Diffusivity, Thermal, [a] - (Note: same symbol as absorptivity, may be confusing.) The ratio of conductivity (k) to the product of density (ρ) and specific heat (Cp) [$a = k/\rho C_p$ cm² sec⁻¹]. The ability of a material to distribute thermal energy after a change in heat input. A body with a high diffusivity will reach a uniform temperature distribution faster than a body with lower diffusivity.

D* [Detectivity Star] - Sensitivity figure of merit of an infrared detector—detectivity expressed inversely so that higher D*s indicate better performance; taken at specific test conditions of chopping frequency and information bandwidth and displayed as a function of spectral wavelength.

Direct Thermography - Thermal imaging and measurement of a surface whose thermal signature is, or is directly affected by the target of concern. That is, the target of concern has little or no thermal insulation between it and the surface measured.

Display Resolution, Thermal – The precision with which an instrument displays its assigned measurement parameter (temperature), usually expressed in degrees, tenths of degrees, hundredths of degrees, etc.

Effective Emissivity [e] (*also called emittance, but emittance is a less preferable term because it was formerly used to describe radiant exitance*). - The measured emissive value of a particular surface under existing measurement conditions (rather than the generic tabulated value for the surface material) that can be used to correct a specific measuring instrument to provide a correct temperature measurement.

Effusivity, Thermal [e] - A measure of the resistance of a material to temperature change

$$E = \sqrt{k\rho C_p} \text{ cal Cm}^{-2} \text{ } ^\circ\text{C}^{-1} \text{ sec}^{1/2}$$

where:

K = thermal conductivity

r = bulk density

Cp = specific heat

Emissivity [e] - The ratio of a target surface's radiance to that of a blackbody at the same temperature, viewed from the same angle and over the same spectral interval; a generic look-up value for a material. Values range from 0 to 1.0. Alternatively, the ratio of a flat, optically polished, opaque target surface radiance to that of a blackbody at the same temperature, viewed from the same angle and over the same spectral interval. The latter definition characterizes the property of the material. When used this way, emittance is used to characterize the material when it is other than flat, optically polished and opaque.

[More Emissivity information.](#)

Emittance [e] - The ratio of a target surface's radiance to that of a blackbody at the same temperature, viewed from the same angle over the same spectral interval; a generic look-up value for a material. Values range from 0 to 1.0.

EMI/RFI Noise - Disturbances to electrical signals caused by electromagnetic interference (EMI) or radio frequency interference (RFI). In thermography, this may cause noise patterns to appear on the display.

Environmental Rating - A rating given an operating unit (typically an electrical or mechanical enclosure) to indicate the limits of the environmental conditions under which the unit will function reliably and within published performance specifications.

Exitance, Radiant [Also Called Radiosity] - Total infrared energy (radiant flux) leaving a target surface. This is composed of radiated, reflected and transmitted components. Only the radiated component is related to target surface temperature.

Fahrenheit - A temperature scale based on 32°F as the freezing point of water and 212°F as the boiling point of water at standard atmospheric pressure; a relative scale related to the Rankine scale [$0^{\circ}\text{F} = 459.67\text{.R}$; $1\text{ F}^{\circ} (\text{DT}) = 1\text{ R} (\text{DT})$].

Field of View [FOV] - The angular subtense (expressed in angular degrees or radians per side if rectangular, and angular degrees or radians if circular) over which an instrument will integrate all incoming radiant energy. In a radiation thermometer this defines the target spot size; in a scanner or imager this defines the scan angle or picture size or total field of view (TFOV).

[Information on Measuring Field of View.](#)

Fiber Optic, Infrared - A flexible fiber made of a material that transmits infrared energy, used for making non-contact temperature measurements when there is not a direct line of sight between the instrument and the target.

Filter, Spectral - An optical element, usually transmissive, used to restrict the spectral band of energy received by an instrument's detector.

Flame Filter - A filter of a specific waveband used to minimize the effects of flame, enabling the IR camera to "see" through the flame. The specific waveband is a region where the transmittance of flame approaches unity. Center wavelengths are typically 3.9 mm for shortwave instruments and 10.6 mm for longwave.

Focal Plane Array [FPA] - A linear or two-dimensional matrix of detector elements, typically used at the focal plane of an instrument. In thermography, rectangular FPAs are used in “staring” (non-scanning) infrared imagers. These are called IRFPA imagers.

Focal Point - The point at which the instruments optics image the infrared detector at the target plane. In a radiation thermometer, this is where the spot size is the smallest. In a scanner or imager, this is where the instantaneous field of view (IFOV) is smallest.

Foreground Temperature [See Instrument Ambient Background] - Temperature of the scene behind and surrounding the instrument as viewed from the target.

Frame Repetition Rate - The time it takes an infrared imager to scan (update) every thermogram picture element (pixel); in frames per second.

Full Scale - The span between the minimum value and the maximum value that any instrument is capable of measuring. In a thermometer, this would be the span between the highest and lowest temperature that can be measured.

Graybody - A radiating object whose emissivity is a constant value less than unity (1.0). over a specific spectral range.

Heat Transfer - The movement of heat from one point to another by conduction, convection and/or radiation.

Hertz [Hz] - A unit of measurement of signal frequency; 1 Hz = cycle per second.

Herschel, Sir William - Discovered infrared waves in 1800.

Imager, Infrared - An infrared instrument that collects the infrared radiant energy from a target surface and produces an image in monochrome (black and white) or color, where the gray shades or color hues correspond respectively to target exitance.

Image Display Tone - Gray shade or color hue on a thermogram.

Image Processing, Thermal - Analysis of thermal images, usually by computer; enhancing the image to prepare it for computer or visual analysis. In the case of an infrared image or thermogram, this could include temperature scaling, spot temperature measurements, thermal profiles, image manipulation, subtraction and storage.

Imaging Radiometer - An infrared thermal imager that provides quantitative thermal images.

Indirect Thermography - Thermal imaging and measurement of a surface which is indirectly affected by the target of concern. That is, the target of concern is thermally decoupled from the surface due to thermal insulation, such as an air gap or a radiant barrier.

Indium Antimonide [InSb] - A material from which fast, sensitive photo-detectors used in infrared scanners and imagers are made. Such detectors usually require cooling while in operation.

Inertia, Thermal - See thermal effusivity.

Infrared [IR] - The infrared spectrum is loosely defined as that portion of the electromagnetic continuum extending from the red visible (0.75 mm to about 1,000 mm) . Because of instrument design considerations and the infrared transmission characteristics of the atmosphere, however, most infrared measurements are made between 0.75 and 20 mm.

Infrared Focal Plane Array [IRFPA] - A linear or two-dimensional matrix of individual infrared detector elements, typically used as a detector in an infrared imaging instrument.

IRFPA Imager or Camera - An infrared imaging instrument that incorporates a two-dimensional IRFPA (focal plane array) and produces a thermogram without mechanical scanning.

Infrared Radiation Thermometer - An instrument that converts incoming infrared radiant energy from a spot on a target surface to a measurement value that can be related to the temperature of that spot.

Infrared Thermal Imager - An Instrument or system that converts incoming infrared radiant energy from a target surface to a thermal map, or thermogram, on which color hues or gray shades can be related to the temperature distribution on that surface.

Instantaneous Field of View [IFOV] - The angular subtense (expressed in angular degrees or radians per side if rectangular and angular degrees or radians if round) found by the ratio of the detector dimension divided by the instrument focal length; the projection of the detector at the target plane. In a radiation thermometer this defines the target spot size; in a line scanner or imager it represents one resolution element in a scan line or thermogram and is a measure of spatial resolution.

Isotherm - A pattern superimposed on a thermogram or on a line scan that includes or highlights all points that have the same apparent temperature.

Kelvin - Absolute temperature scale related to the Celsius (or Centigrade) relative scale. The Kelvin unit is equal to 1 C°; 0 Kelvin = -273.16°C; the degree sign and the word “degrees” are not used in describing Kelvin temperatures.

Kirchoff's Law - In thermal equilibrium the absorbtivity of an opaque surface equals its emissivity ($a = e$).

Laser Pyrometer - An infrared radiation thermometer that projects a laser beam to the target, uses the reflected laser energy to compute target effective emissivity and automatically computes target temperature (assuming that the target is a diffuse reflector)—not to be confused with laser-aided aiming devices on some radiation thermometers.

Latent Heat - Also called “hidden heat” as heat is added or removed without changing the temperature. The amount of heat required (or released) for a change of phase from solid to liquid and liquid to gas (or vice versa). The latent heat of vaporization is the amount of heat required to change one gram of liquid to vapor without change of temperature. The latent heat of fusion is the amount of heat to melt one gram of solid to liquid with no temperature change.

Line Scan Rate - The number of target lines scanned by an infrared scanner or imager in one second.

Line Scanner, Infrared - An instrument that scans an field of view along a straight line at the target plane in order to collect infrared radiant energy from a line on the target surface, usually done by incorporating one scanning element within the instrument. If the target (such as a sheet or web process) moves at a fixed rate normal to the line scan direction, the result can be displayed as a thermogram..

Measurement Spatial Resolution, IFOV_{meas} - The smallest target spot size on which an infrared imager can produce a measurement, expressed in terms of angular subtense (mrad per side). The slit response function (SRF) test is used to measure IFOV_{meas}.

Medium, Transmitting Medium - The composition of the measurement path between a target surface and the measuring instrument through which the radiant energy propagates. This can be vacuum, gaseous (such as air), solid, liquid or any combination of these.

Mercury Cadmium Telluride MCT [HgCdTe] - A material used for fast, sensitive infrared photo-detectors used in infrared sensors, scanners and imagers that requires cooled operation.

Micro-Cooler - A small, palm size cooler based on the Stirling cycle that cools an infrared detector or focal plane array to liquid nitrogen temperature (77K).

Micron [Micrometer] [m or, mm] - One millionth of a meter; a unit used to express wavelength in the infrared.

Milliradian [MRAD] - One thousandth of a radian (1 radian = 180°/π); a unit used to express instrument angular field of view; an angle whose tangent is equal to 0.001; 1 mrad = 0.05729578°

Minimum Resolvable Temperature [Difference], MRT(D) - Thermal resolution; thermal sensitivity – the smallest temperature difference that an instrument can clearly distinguish out of the noise, taking into account target size and characteristics of the display and the subjective interpretation of the operator. The limit of MRTD is MDTD (minimum detectable temperature difference). MDTD is the MRTD of an extended source target, that is, a target large enough to be fully resolved by the instrument.

Modulation - In general, the changes in one wave train caused by another; in thermal scanning and imaging, image luminant contrast; $(L_{max} - L_{min}) / (L_{max} + L_{min})$.

Modulation Transfer Function [MTF] - A measure of the ability of an imaging system to reproduce the image of a target. A formalized procedure is used to measure MTF. It assesses the spatial frequency resolution of a scanning or imaging system as a function of distance to the target.

Night Vision - [Click Here for Information](#)

Noise Equivalent Temperature [Difference], NET[D] - The temperature difference that is just equal to the rms noise signal; a measure of thermal resolution; (thermal sensitivity), but not taking into account target size, characteristics of the display and the subjective interpretation of the operator.

NIST, NIST Traceability - The National Institute of Standards and Technology (formerly NBS). Traceability to NIST is a means of ensuring that reference standards remain valid and their calibration remains current.

Non-Gray body - An object whose emissivity varies with wavelength over the wavelength interval of interest. A radiating object that does not have a spectral radiation distribution similar to a blackbody; also called a “colored body” or “realbody”. Glass and plastic films are examples of non-graybodies. An object can be a graybody over one wavelength interval and a non-gray body over another.

Objective, Objective Lens - The primary lens of an optical system, on an infrared instrument, usually the interchangeable lens that defines the total field of view.

Opaque - In thermography, an opaque material is one that does not transmit thermal infrared energy, ($t = 0$).

Optical Element, Infrared - Any element that collects, transmits, restricts or reflects infrared energy as part of an infrared sensing or imaging instrument.

Oversampling - Collecting samples at a rate higher than the Nyquist critical frequency, $f_c = 1/(2D)$, where D is the sampling interval. Applies to both time and spatial domains.

Peak - Hold - A feature of an instrument whereby an output signal is maintained at the peak instantaneous measurement for a specified duration.

Photo-Detector [Photon Detector] - A type of infrared detector that has fast response, (on the order of microseconds), limited spectral response and usually requires cooled operation; photo-detectors are used in infrared radiation thermometers, scanners and imagers.

Pixel - Abbreviation for picture element. In infrared technology a pixel is a focal plane array element, for scanning systems is defined by the IFOV, for spot radiometers by FOV.

Planck, Max Karl Ernst Ludwig - German physicist who incorporated quantum physics into the blackbody spectral radiance equation, giving rise to blackbody curves.

Pyroelectric Detector - A type of thermal infrared detector that acts as a current source with its output proportional to the rate of change of its temperature.

Pyroelectric Vidicon [PEV], Also Called Pyrovidicon - A video camera tube with its receiving element fabricated of pyroelectric material and sensitive to wavelengths from about 2 to 20 μm ; used in infrared thermal viewers.

Pyrometer - Any instrument used for temperature measurement. A radiation or brightness pyrometer measures visible energy and relates it to brightness or color temperature. An infrared pyrometer measures infrared radiation and relates it to target surface temperature.

Qualitative Measurement - the process of obtaining and interpreting thermal images based on thermal contrast in order to identify anomalies; the purpose is more to determine where a temperature difference exists than what the temperature difference is between the target and its surroundings.

Quantitative Measurement - the process of obtaining thermal images with correct temperature readings. Especially useful in situations when the exact temperature or temperature difference of the target determines whether it falls in or out of a determined criteria or range of acceptability. Also important to R & D and process control situations.

Radian - An angular measurement equal to the ratio of the arc length of a circle to its radius. The circumference of a circle is 2π times the radius. Thus π radians = 180 degrees, and 1 radian = 57.29578 degrees.

Radiation, Thermal - The mode of heat flow that occurs by emission and absorption of electromagnetic radiation, propagating at the speed of light. Unlike conductive and convective heat flow, it is capable of propagating across a vacuum. The form of heat transfer that allows infrared thermography to work since infrared energy travels from the target to the detector by radiation.