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Non-destructive testing — Infrared thermography — Vocabulary

National foreword

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Contents

Page

Foreword

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The committee responsible for this document is ISO/TC 135, *Non-destructive testing*, Subcommittee SC 8, *Infrared thermography for non-destructive testing*.

Introduction

This International Standard is a compilation of terms and definitions to provide a precise understanding or interpretation of infrared thermography and thermal/infrared non-destructive testing. These serve to secure the foundation of infrared thermography technology growth within the academic and industrial communities.

Non-destructive testing — Infrared thermography — Vocabulary

Scope

This International Standard defines terms used in infrared thermography for non-destructive testing and forms a common basis for standard general use.

1 Terms and definitions

1.1
absorptivity
α
absorptance
absorptance coefficient
proportion (as a fraction of 1) of the radiant energy impinging on a material's surface that is absorbed by the material

NOTE 1 Absorptivity is dimensionless.

NOTE 2 For a blackbody, this is unity (1,0). Technically, absorptivity is the internal absorptance per path length. In thermography, the two terms, absorptivity and absorptance, are often used interchangeably.

NOTE 3 Absorptance is the ratio between the radiation energy absorbed by a body and the total radiation incident on the body.

NOTE 4 Absorptivity can vary with wavelength and be quoted for a specified band width or a specific wavelength. See 1.136, Spectral absorption coefficient.

1.2
active thermography
infrared thermographic examination of materials and objects which requires additional thermal stimulation

NOTE The thermal stimulation can be optical, sonic (ultrasonic), inductive, microwave or use any other form of energy.

1.3
ambient operating range
range of ambient temperatures over which an instrument is designed to operate within reported performance specifications

1.4
ambient temperature
temperature of the air in the vicinity of a test object (target)

NOTE "Ambient temperature" is not to be confused with "reflected ambient temperature", which is a term often used to mean "reflected apparent temperature".

1.5
ambient temperature compensation
correction built into infrared instruments to provide automatic compensation of temperature readings affected by the ambient temperature

1.6
angular subtense
angular diameter of an optical system or subsystem

NOTE 1 Angular subtense is expressed in angular degrees or milliradians.

NOTE 2 In infrared thermography, the angle over which a sensing instrument collects radiant energy.

1.7
anomalous thermal image
observed thermal pattern of a structure that is not in accordance with the expected (reference) thermal pattern

1.8
anomaly
irregularity or abnormality in a system

EXAMPLE An irregularity, such as an anomalous thermal pattern or any indication that deviates from what is normally expected in the absence of any anomaly.

1.9
anti-reflectance coating
coating of infrared optical elements (lenses, windows) used to increase the sensitivity of a specified wavelength range through minimization or suppression of reflections causing signal loss

1.10
apparent temperature
uncompensated reading from an infrared thermography camera containing all radiation incident on the detector, regardless of its source

[ISO 18434-1:2008[6], 3.1]

1.11
area effect
change in infrared radiometer output depending on the area of the measuring target

1.12
artefact
⟨1⟩ product of artificial character due to an extraneous agency
⟨2⟩ error caused by an uncompensated anomaly

EXAMPLE In thermography, an emissivity artefact simulates apparent variation of surface temperature.

1.13
atmospheric absorption
absorption of specific wavelengths of solar radiation, due largely to moisture, atmospheric gases and pollutants

1.14
atmospheric temperature
temperature of the atmosphere between the infrared camera and the object

1.15
atmospheric window
⟨infrared⟩ any spectral interval within the infrared spectrum in which the atmosphere transmits radiant energy well (atmospheric absorption is minimal)

EXAMPLE Atmospheric windows are roughly defined to lie in the wavelength ranges:

a) 0,78 µm to 2,0 µm in the near infrared (NIR);

b) 2,0 µm to 5,5 µm in the mid-wave infrared (MWIR);

c) 7,5 µm to 14,0 µm in the long-wave infrared (LWIR).

1.16
attenuating medium
material or other medium that attenuates infrared radiation emitted from a source

EXAMPLE Attenuating media include windows, filters, atmospheres, external optics.

1.17
blackbody
ideal perfect emitter and absorber of thermal radiation at all wavelengths

NOTE A blackbody is described by Planck's law. In its classical form, Planck’s law describes the spectral distribution of the radiant energy emitted by a blackbody.

1.17.1
blackbody equivalent temperature
apparent temperature of a test object that is equal to the temperature of a blackbody emitting the same amount of radiant energy

1.17.2
blackbody radiator
radiator with the effective emissivity ε close to unity ($\varepsilon \geq 0{,}98$ across all relevant wavelengths)

1.17.3
blackbody reference
calibrated, traceable device used to check the calibration of infrared imaging radiometers or infrared thermometers

1.17.4
blackbody simulator
device whose radiation is close to that of a blackbody at the same temperature

EXAMPLE A cavity or a flat plate with a structured or coated surface characterized by a stable and uniform temperature and with emissivity close to 1.

1.18
centre wavelength
wavelength in the middle of the spectral sensitivity band of an infrared detector

1.19
cooled sensor
sensor that needs cooling to improve sensitivity to infrared radiant energy by reducing thermal noise influence

1.20
detecting element
sensitive part of a detector which is directly affected by the quantity to be measured

EXAMPLE For temperature-sensing devices: a thermocouple junction; resistive element; photoelectric, pyroelectric or quantum sensor.

1.21
differential blackbody
device for establishing two parallel isothermal planar zones of different temperatures and with effective emissivities close to 1,0

1.22
diffraction limit
limit of geometric diffraction of optical systems

1.23
diffuse reflector
lambertian reflector
surface that reflects incident radiation equally in all directions

NOTE 1 A lambertian diffuser is a surface that reflects a portion of the incident radiation in such a manner that the reflected radiation is equal in all directions, such as a gold perfect sphere.

NOTE 2 A mirror is not a diffuse reflector.

1.24
edge effect
(1) effect caused by measurement error mainly at the edge due to solid displacement or deformation by variable loading in thermoelastic stress measurement
(2) change in thermal properties at the edge of a target object as a result of different thermal conduction and convection properties

EXAMPLE Effect caused by measurement error at an edge due to solid displacement or deformation by variable loading in thermoelastic stress measurement.

1.25
effective emissivity
ε^*
measured emissivity value of a particular target surface under existing measurement conditions (rather than the generic tabulated value for the same material) that can be used to correct specific temperature readings

NOTE 1 Effective emissivity is also called emittance; however, the latter term is not preferred because it has been used to describe radiant exitance.

NOTE 2 Effective emissivity is context dependent, and is not purely a property of a material.

1.26
effective number of pixels
spatial resolution of a measured infrared image

NOTE The effective number of pixels is determined for a scanning infrared thermographic instrument according to the scanning pitch, and for an infrared thermographic instrument with an array sensor according to the number of pixels of the detector.

1.27
EMI/RFI noise
disturbance to electrical signals caused by electromagnetic interference (EMI) or radio frequency interference (RFI)

NOTE In infrared thermography, EMI/RFI noise can cause patterns to appear on the display and is sometimes due to poor grounding or earthing.

1.28
emissivity
ε
ratio of the radiance of a target surface to that of a blackbody at the same temperature and over the same spectral interval

1.29
emittance
ratio of the radiant flux emitted by a real target and that emitted by a blackbody at the same temperature and under the same conditions

NOTE 1 The total radiance, R^0, is obtained by an integration of the monochromatic radiance between wavelengths zero and infinity.

$$R^0 = \int_0^\infty \frac{2\pi hc^2\lambda^{-5}}{\exp(\frac{hc}{k\lambda T})-1}\,\mathrm{d}\lambda = \frac{\sigma}{\pi}T^4$$

where

c is the speed of light in a vacuum;

h is the Planck constant;

k is the Boltzmann constant;

T is the thermodynamic temperature;

σ is the Stefan-Boltzmann constant, in watts per square metre per kelvin to the power four, given by

$$\sigma = \frac{2\pi k^4}{15c^2h^3} = 5{,}67 \times 10^{-8}$$

Radiance and emittance being connected, the total emittance, M^0, is given by

$$M^0 = \pi\, R^0 = \sigma\, T^4$$

NOTE 2 In thermography, the terms “radiance” and “emittance” are technically often used interchangeably.

NOTE 3 Refer to ISO 80000-7

1.30
environmental rating
rating assigned to an operating unit (typically an electrical or mechanical enclosure) to indicate the limits of the environmental conditions under which the unit functions reliably and within reported performance specifications

1.31
extended source
source of infrared radiation whose image fills completely or a larger part of the field of view of the infrared camera

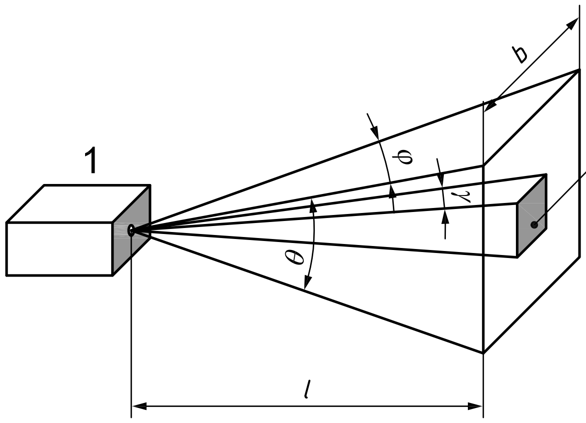
1.32
field of view
field of vision
FOV
angular subtense over which an instrument integrates total incoming radiant energy

NOTE 1 Angular subtense is expressed in angular degrees or radians per side if rectangular or square and in angular degrees or radians if circular.

NOTE 2 In infrared thermometers, field of view defines the target spot size; in a scanning/staring imager, it defines the scan angle or picture size or a total field of view (TFOV).

NOTE 3 The field of view is the angular extent of the observable world that is seen at any given moment.

See Figure 1.



Key

1 detector

A minimum detecting size

b view

l working distance

γ instantaneous view angle (scanning type); spatial resolution (2D sensor type)

θ vertical view angle

φ horizontal view angle

Figure 1 — Field of view

1.33
fill factor
⟨focal plane arrays⟩ ratio of the total surface of sensitive detector elements to the total area of the detector

1.34
filter
⟨infrared thermography⟩ optical element, usually transmissive, which is used to limit spectral sensitivity of infrared detectors

1.35
fixed pattern noise
FPN
non-temporal variations between pixels that are exposed to the same scene radiation

NOTE These variations can be caused by non-linearities in the detector, non-perfections in gain and offset maps, and slow temporal changes that are too slow for the eye or brain to interpret as a temporal change. In uncooled detectors, the slow temporal term is, most of the time, the dominant term of the spatial noise equivalent temperature difference.

1.36
focal plane array
FPA
type of infrared detector which involves a one- or two-dimensional array consisting of many individual sensing elements (called "pixels")

NOTE Detector arrays are typically placed at the focal plane of an instrument. In thermography, rectangular or square FPAs are used in "staring" (non-scanning) infrared imagers. These are called IRFPA imagers.

1.37
focal point
⟨infrared thermography⟩ image point conjugate to an infinitely distant object point on the optical axis

NOTE In infrared thermometers, this is where the spot size is the smallest. In scanning or staring imagers, this point corresponds to the minimum instantaneous field of view (IFOV).

1.38
foreground temperature
temperature of the scene behind and surrounding the instrument, as viewed from the target

NOTE 1 This is often referred to as 'Instrument background temperature' or as 'Observer background temperature'

NOTE 2 See ambient temperature.

1.39
frame averaging
addition of images and the division of their total for signal to noise ratio (signal level to noise level) improvement

1.40
frame repetition rate
number of full fields of view scanned per second

1.41
frame time
time needed to obtain signal information in all field elements, or pixels)

1.42
grey body
object whose emissivity is constant (less than 1) in a particular spectral range

1.43
image display tone
grey shade or colour hue on a thermogram

1.44
image processing
converting an image to digital form and further enhancing the image to prepare it for computer or visual analysis

NOTE For an infrared image or thermogram, image processing can include temperature scaling, spot temperature measurements, thermal profiles, image manipulation, subtraction, and storage.

1.45
imaging line scanner
line scanner
line-scanning (one-dimensional) device which images perpendicularly to a scan direction to produce a two-dimensional image of a scene

1.46
imaging radiometer
infrared thermal imager or point infrared sensor that can provide thermal images from which quantitative temperature measurements are possible

1.46.1
infrared camera
infrared thermography camera
IRT camera
instrument that collects the infrared radiant energy from a target and produces an image in monochrome (black and white) or colour, where the grey shades or colour hues are related to target apparent temperature distribution.

NOTE Such images are sometimes called infrared thermograms.

1.46.2
infrared imaging system
infrared thermal imager
instrument that converts spatial variations of surface infrared radiation to grey tones or colours corresponding to radiation power (temperature)

NOTE See infrared camera.

1.46.3
infrared thermographic instrument
instrument that converts infrared radiant energy to a temperature and displays a thermogram

1.47
indium antimonide
InSb
InSb is a narrow-gap semiconductor with an energy band gap of 0,17 eV at 300 K and spectral sensitivity in the range of 1 μm to 5 μm; it is widely used as the sensor in infrared thermal imaging systems

NOTE Such detectors typically require cooling while in operation.

1.48
infrared
infrared radiation
IR
optical radiation for which the wavelengths are longer than those for visible radiation

NOTE 1 For infrared radiation, the range between 780 nm and 1 mm is commonly subdivided into:

— IR-A: 780 nm to 1 400 nm;

— IR-B: 1,4 μm to 3 μm;

— IR-C: 3 μm to 1 mm.

[IEC 60050-845:1987[7]]

NOTE 2 The range of infrared emitted by the source and which reaches the lens should be considered in the design of an infrared-absorbing material.

1.49
infrared bolometer
sensor that provides a signal; it employs an electrical conductance

1.49.1
infrared thermistor bolometer
thermistor configured so as to collect radiant infrared energy

1.49.2
infrared thermister bolometer
type of thermal infrared detector

1.50
infrared calibration source
blackbody simulator or other target of known temperature and effective emissivity used as a calibration reference

1.51
infrared detector
sensor which converts absorbed infrared radiation into an electrical signal

1.52
infrared fibre optic
flexible fibre made of a material that transmits infrared energy, used for non-contact temperature measurements in cases where there is no direct sight between the instrument and the target

1.53
infrared fibre optics
fibre optics which transmit infrared radiation

1.54
infrared focal plane array
IRFPA
one- or two-dimensional array of individual infrared sensing elements, typically used as a detector in infrared imaging instruments

1.55
infrared image
image that shows distribution of infrared radiant energy with colour hues or grey shades

1.56
infrared-imaging line scanner
infrared (one-dimensional) line-scanning device which images perpendicularly to a scan direction to produce a two-dimensional thermogram of a scene

1.57
infrared optical element
element that collects, transmits, restricts, refracts or reflects infrared energy as part of an infrared sensing or imaging instrument

1.58
infrared radiant energy
energy that is radiated and propagated as infrared, an electromagnetic wave whose wavelength is longer than visible light and shorter than 1 mm

1.59
infrared radiation thermometer
infrared non-imaging device allowing non-contact temperature measurement by sensing thermal radiation emitted by a target (target emissivity is to be known for measuring the “true” temperature)

1.60
infrared radiometer
equipment that measures infrared radiant energy

NOTE An infrared camera is a type of infrared radiometer.

1.61
infrared reflector
material with an excellent reflectance in the infrared region, close to 1,00

EXAMPLE Polished gold is an excellent infrared reflector commonly used in first surface mirrors.

1.62
infrared sensing device
instrument intended for the analysis of objects by the capture of their infrared radiation

EXAMPLE Infrared cameras, both imaging and staring, and infrared thermometers are the most typical infrared sensing devices.

1.63
infrared thermal detector
detector that absorbs infrared radiation and produces an electrical signal following changes of its temperature

EXAMPLE Measuring signals are changed to electrical resistance (bolometer), the thermal voltage (thermal element) and electrical polarization.

1.64
infrared thermographic testing
thermographic testing
inspection of materials and products using infrared thermography

1.65
infrared thermography
thermography infrared
IR thermography
technique allowing imaging of objects by sensing their emitted infrared (thermal) radiation

1.66
instantaneous field of view
IFOV
angular subtense energy or the angular projection of the detector element at the target plane

NOTE 1 The angular subtense is expressed in angular degrees or radians per side if rectangular, and angular degrees or radians if round.

NOTE 2 In infrared thermometers, instantaneous field of view defines the target spot size; in a line scanner or imager it represents a single resolution element in a scan line or a thermogram being a measure of spatial resolution.

NOTE 3 The instantaneous field of view is equivalent to the horizontal and vertical fields of view of an individual detector. For small detectors, the detector angular subtenses or projections α and β are defined by $\alpha = a/f$ and $\beta = b/f$, where a and b are horizontal and vertical dimensions of the detector, and f is the effective focal length of the optics.

NOTE 4 Instantaneous field of view can be expressed as a solid angle in units of π.

NOTE 5 IFOVs may be different in the vertical (VIFOV) and horizontal (HIFOV) directions.

1.67
irradiance
radiant flux (power) per area incident on a given surface

NOTE Irradiance is expressed in watts per metre squared.

1.68
isotherm
zone marking an interval of equal apparent temperature in a thermogram

NOTE As an image enhancement feature, it replaces certain colours in the scale with a contrasting colour.

1.69
laser pyrometer
infrared radiation thermometer that projects a laser beam on to a target and uses the reflected laser energy to calculate the target effective emissivity and automatically correct the target temperature (assuming that the target is a diffuse reflector)

NOTE Laser pyrometers are not to be confused with laser-aiming infrared thermometers, where the laser is used to indicate a measured area.

1.70
limiting resolution
highest spatial frequency of a target that an imaging sensor is able to resolve

1.71
line scan rate
number of target lines scanned by an infrared scanner or imager in 1 s

1.72
load frequency range
range of load frequencies used in elastic stress measurement

1.73
lock-in technique
technique allowing for the extraction of a signal of known carrier wave from an extremely noisy environment. This signal can be, but should not be, restricted to temperature.

NOTE A common application is for non-destructive evaluation.

1.74
long-wave infrared
LWIR
wavelength range 7 µm to 14 µm, in which certain infrared instruments operate

1.75
measurement spatial resolution
$IFOV_{meas}$
MFOV
smallest target spot size on which an infrared camera can fulfil measurement, expressed in terms of angular subtense

NOTE 1 The angular subtense is expressed in milliradians.

NOTE 2 The slit response function (SRF) test and the hole response function (HRF) are used to measure $IFOV_{meas}$

1.76
mercury cadmium telluride
MCT
HgCdTe
material sensitive to infrared radiation in the spectral range of 1,5 µm to 14 µm and widely used as a detector in infrared imagers, especially in the 8-14 µm range.)

NOTE Such detectors typically require cooling while in operation.

1.77
mid-wave infrared
middle-wave infrared
MWIR
wavelength range 3 µm to 5 µm, in which certain infrared instruments operate

1.78
minimum detectable dimension
MDD
dimension or length of the smallest object that can be measured

1.79
minimum detectable temperature difference
MDTD
measure of the combined ability of an infrared imaging system and a human observer to detect a target at a particular temperature of unknown location against a vast uniform background having another temperature, the target being displayed on a monitor for a limited time

NOTE For a given target size, the MDTD is the minimum temperature difference between the target and its background at which the observer can detect the target. The standard target is a circle whose size is given by its angular subtense, and both the target and the background are isothermal black bodies.

1.80
minimum resolvable temperature difference
MRTD
measure of the ability of an infrared imaging system and the human observer to recognize periodic bar targets on a display

See Figure 2.

NOTE The MRTD is the minimum temperature difference between a standard periodic test pattern (7:1 aspect ratio, four bars) and the blackbody background at which an observer can resolve the pattern as the four-bar pattern.

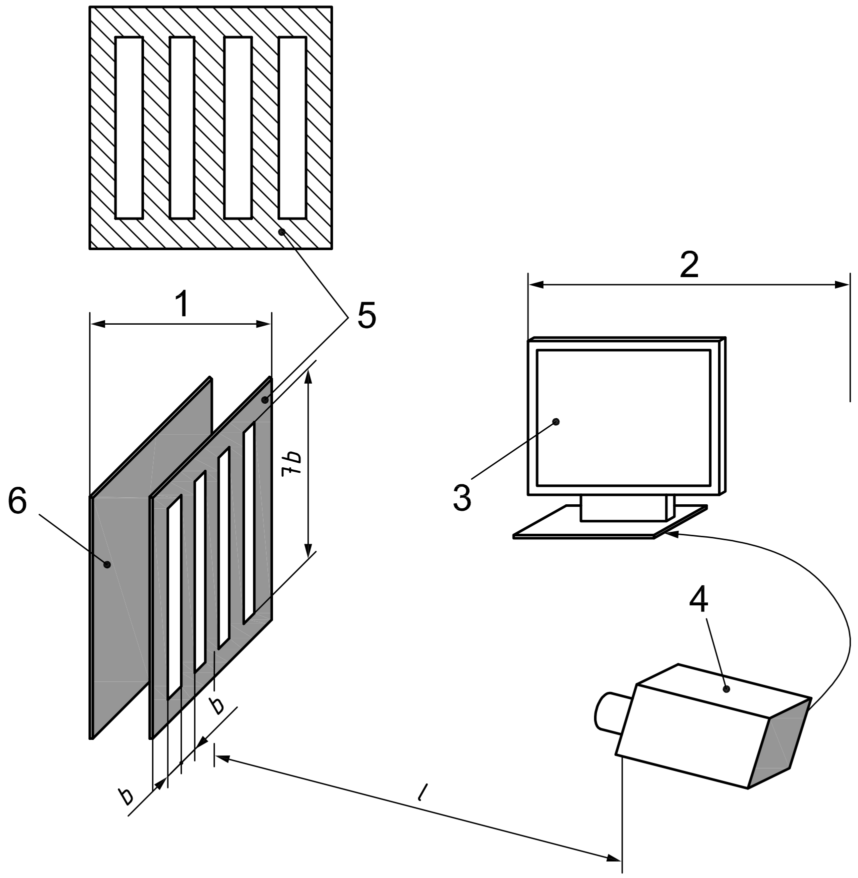
1.81
modulation transfer function
MTF
measure of the ability of an imaging system to reproduce an image of a target

NOTE A formalized procedure is used to measure the modulation transfer function. It assesses the spatial resolution of a scanning or imaging system as a function of distance to the target.

1.82
motion compensation
correction of the measurement error caused by displacement or transformation of the measuring object

1.83
multi-element sensor
sensor that arranges infrared detectors in one dimension or two dimensions

1.84
near infrared
NIR
wavelength range 0,75 µm to 1,9 µm, in which certain infrared instruments operate



Key

1 test target

2 infrared imaging system

3 display

4 detector

5 near plate with rectangular slot

6 far plate

b slot width

l working distance

Figure 2 — Minimum resolvable temperature difference

1.85
noise equivalent temperature difference
NETD
target-to-background temperature difference between a blackbody target and its blackbody background at which the signal-to-noise ratio for a particular infrared instrument is equal to unity

NOTE Noise equivalent temperature difference is the result of both temporal and spatial noise, expressed in equivalence of temperature.

1.86
non-contact style
method for measuring temperature without a contact between the object and the sensor, typically, by object thermal radiation

1.87
non-grey body
object whose spectral radiation is not constant at all wavelengths unlike a grey body and a blackbody

NOTE 1 Such an object can be partially transparent to infrared radiation; also called a “coloured body” or “real body”.

NOTE 2 Almost all real objects are non-grey bodies in that their emissivity properties vary with temperature and wavelength; most have zero transmissivity. A non-grey body is also known as a “selective radiator”.

EXAMPLE Glass and plastics films.

1.88
non-uniformity correction
NUC
camera software-initiated picture correction for compensation of various sensitivities of individual sensing elements in array detectors (FPA-cameras), as well as other disturbances of an optical or geometric nature

NOTE Some cameras perform a “manual non-uniformity correction” where the lens cap is put in front of the lens while the NUC is performed.

1.89
number of pixels
number of units of picture elements (pixel) that compose a thermal image or infrared image displayed on a monitor

1.90
object plane resolution
dimension in the object plane that corresponds to the product of the system instantaneous field of view and the specified distance between the infrared instrument and the object

1.91
observer background radiation
total radiation emitted by background objects and reflected from a target

1.92
opaque
impervious to radiant energy

NOTE In thermography, opaque materials do not transmit thermal infrared energy ($\tau = 0$).

1.93
passive thermography
thermographic technique for inspecting objects or installations by measuring their emitted thermal radiation, without using any additional energy source for thermal stimulation

1.94
peak hold
feature of an instrument whereby an output signal is maintained at the peak instantaneous measurement for a specified duration

1.95
permissible uncertainty
uncertainty value specified in the technical documentation, at which the blackbody radiator is considered fit for its intended use

NOTE Degrees Celsius or kelvin are used as temperature units.

1.96
phase adjustment
⟨infrared thermography⟩ adjustment of the phase of a “signal that is synchronized to heat or load to the measuring object” and “actual temperature change”

1.97
photodetector
photonic detector
quantum detector
infrared detector whose operating principle is based on using the internal or external photoeffect (in the capture of incoming photons)

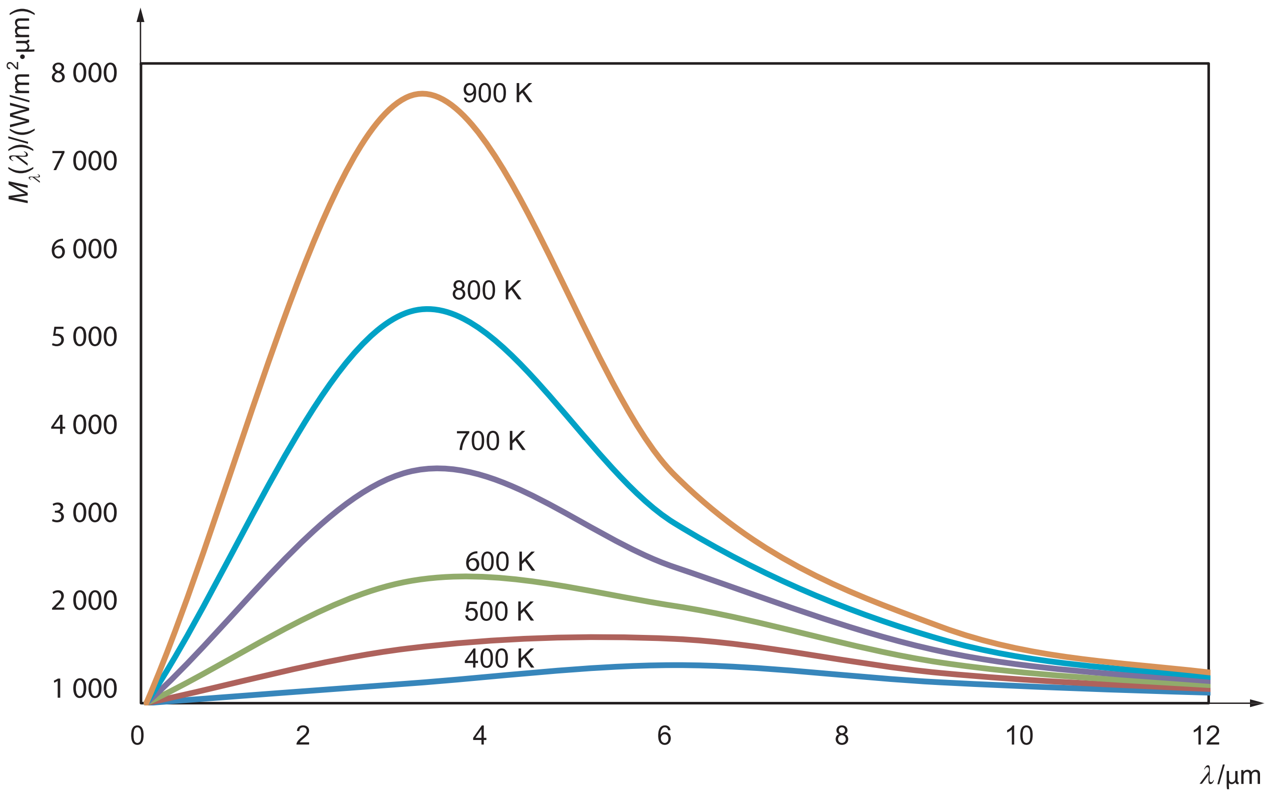
NOTE These detectors are characterized by fast response (of the order of microseconds), a limited spectral response, and usually their need for cooling while in operation. They are widely used in infrared imagers and thermometers.

1.98
Planck's law
law establishing the spectral radiance of unpolarised electromagnetic radiation at all wavelengths emitted by a black bod, at an absolute temperature *T*(K)

See Figure 3.

NOTE This law was formulated by Max Planck in 1900.

EXAMPLE For the purposes of thermography, Planck's law is best shown by a set of curves of spectral radiant exitance against wavelength.



Key
$M_\lambda(\lambda)$ spectral radiant exitance
λ wavelength

Figure 3 — Blackbody curves at various temperatures

1.99
point source
source whose linear dimensions are very small compared to the distance between the source and the infrared instrument

NOTE The irradiance varies inversely with the square of the distance, a unique property of point sources.

1.100
pulsed phase thermography
PPT
processing technique used in pulsed thermography and in which data are analysed in the frequency domain rather than in the time domain

NOTE Phase data are often of particular interest.

1.101
pulsed thermography
active infrared thermographic inspection technique, in which a test sample is stimulated with a pulse of energy and recorded infrared image sequences are analysed to enhance defect “visibility” and to characterize defect parameters

1.102
pyroelectric detector
type of thermal infrared detector that operates as a current source, with its output being proportional to the rate of a detector temperature change

1.103
pyroelectric vidicon
PEV
pyrovidicon
video camera tube whose receiving element is fabricated of a pyroelectric material and which is sensitive to wavelengths from about 2 μm to 20 μm; used in infrared thermal viewers

NOTE At the time of publication, these devices are becoming obsolete.

1.104
pyrometer
instrument used to infrared thermometer

EXAMPLE Radiation or brightness pyrometers measure visible energy and relate it to brightness or colour temperature. Infrared pyrometers measure infrared radiation and relate it to the target surface temperature.

1.105
qualitative infrared examination
qualitative thermography
technique which relies on the analysis of thermal patterns to reveal the existence and locate the position of anomalies

1.106
quantitative infrared examination
quantitative thermography
technique which uses quantitative temperature measurement to determine the seriousness of an anomaly, in order to establish repair priorities

1.107
quantum well infrared photodetector
QWIP detector
special type of infrared detector which uses the effect of photo-excitation of electrons (holes) between the base and the first excitation levels in the conduction (valence) band of so-called quantum wells

NOTE Special cases are QWIPs.

1.108
radiance
L
thermal flux per projected area per solid angle leaving a source or, in general, any reference surface

NOTE At a point on a surface of a source and in a given direction.

$$L = \frac{\mathrm{d}I}{\mathrm{d}A} \frac{1}{\cos \alpha}$$

where

$\mathrm{d}I$ is the radiant intensity emitted from an element of the surface with area $\mathrm{d}A$;

α is the angle between the normal to the surface and the given direction.

[ISO 80000-7:2008[5], 7.15]

1.109
radiant exitance
radiosity
M
total infrared energy (radiant flux) leaving a target surface

NOTE 1 Radiant exitance includes radiated, reflected and transmitted components. Only the radiated component is related to the target surface temperature.

NOTE 2 At a point on a surface,

$$M = \frac{\mathrm{d}\Phi}{\mathrm{d}A}$$

where $\mathrm{d}\Phi$ is the radiant flux leaving the element of the surface with area $\mathrm{d}A$.

[ISO 80000-7:2008[5], 7.18]

1.110
radiation reference source
blackbody-like or other target of a known temperature and effective emissivity used as a reference to obtain optimum measurement accuracy, ideally, traceable to relevant national or International Standards

1.111
radiation thermometer
radiometer
instrument for non-contact temperature measurement by object thermal radiation

NOTE Instrument calibration and material emissivity values are required to convert apparent temperatures into “true” temperatures

1.112
radiometric temperature measurement
measurement made by using an infrared system which converts radiant energy into temperature

NOTE Radiometric data should be corrected for emissivity, atmosphere transmission, and reflected apparent temperature.

1.113
ratio pyrometer
bi-colour pyrometer
infrared thermometer that uses the ratio of incoming infrared radiant energy in two separated wavelengths in order to determine target temperature independently of its emissivity

NOTE A ratio pyrometer assumes “grey body” conditions and is normally limited to relatively hot targets (above 300 °C).

1.114
recognition
ability to differentiate between different types of thermal patterns such as board-stock, picture-framed and amorphous

NOTE Recognition of thermal anomalies can be accomplished when their dimensions are at least several times greater than a pixel size on a test object.

1.115
reflected apparent temperature
T_{refl}
apparent temperature of other objects that are reflected by the target into the infrared thermography camera

[ISO 18434-1:2008[6], 3.12]

NOTE 1 This is one of the most important definitions in thermography because it is the temperature of the sink for the thermal energy radiated by the target. Making an erroneous assumption about this leads to considerable errors in estimation of the target temperature.

NOTE 2 Reflected apparent temperature was previously known as “reflected ambient temperature”, “reflected temperature” or sometimes just “ambient temperature”.

1.116
reflection coefficient
ρ
⟨infrared thermography⟩ ratio of reflected radiation energy from a body to the total radiation incident on the body

NOTE The reflection coefficient is dimensionless and quantifies the reflection capability of a body.

1.116.1
reflectivity
reflectance
ratio of the total reflected energy from a surface to total incident energy on that surface

NOTE 1 $\rho = 1 - \varepsilon - \tau$ [where ε is emissivity; τ is transmittance]; for a [perfect] mirror, reflectivity approaches 1,0; for a blackbody, $\rho = 0$.

NOTE 2 Technically, reflectivity is the ratio of the intensity of the reflected radiation to the total radiation; reflectance is the ratio of the reflected flux to the incident flux.

[ISO 18434-1:2008[6], 3.11]

NOTE 3 “Reflectivity”, “reflectance”, and “reflection coefficient” are often used interchangeably.

NOTE 4 [Expressed mathematically]:

$$\rho = \frac{\Phi_r}{\Phi_m}$$

where

Φ_r is the reflected radiant flux or the reflected luminous flux;
Φ_m is the radiant flux or luminous flux of the incident radiation.

[ISO 80000-7:2008[5], 7-22.2]

1.117
short-wave infrared
SWIR
wavelength range 1 µm to 3 µm, in which certain infrared instruments operate

1.118
single element sensor
sensor that consists of one infrared detector

1.119
slit response function
SRF
measure of the measurement spatial resolution ($IFOV_{meas}$ or MFOV) of a scanning infrared

1.120
spatial frequency
measure of details in terms of equivalent, uniformly spaced, cyclical patterns

NOTE 1 In an object or image plane, spatial frequency can be expressed in cycles per millimetre or line pairs per millimetre.

NOTE 2 In an imaging system, spatial frequency can be expressed in terms of cycles per milliradian or line pairs per milliradian.

1.121
spatial measurement resolution
measurement-spot size in terms of working distance which Is connected to SRF, HRF, etc.

NOTE 1 In an infrared radiation thermometer, spatial measurement resolution is expressed in milliradians or as a ratio of the target-spot size (containing 95 % of the radiant energy, according to common usage) to the working distance. In scanners, cameras, and imagers, spatial measurement resolution is most often expressed in milliradians.

NOTE 2 Adapted from ISO 18434-1:2008[6], 3.14.

1.122
spectral absorption coefficient
α_λ
wavelength-dependent absorption coefficient

NOTE Linear absorption coefficient:

$$\alpha(\lambda) = \frac{1}{\Phi_\lambda(\lambda)} \frac{\mathrm{d}\Phi_\lambda(\lambda)}{\mathrm{d}l}$$

where $\mathrm{d}\Phi/\Phi$ is the relative decrease, caused by absorption, in the spectral radiant flux Φ of a collimated beam of electromagnetic radiation corresponding to the wavelength λ during traversal of an infinitesimal layer of a medium and $\mathrm{d}l$ is the length traversed.

[ISO 80000-7:2008[5], 7-25.2]

1.123
spectral emissivity
ε_λ
wavelength-dependent emissivity

NOTE [Expressed mathematically]:

$$\varepsilon(\lambda) = \frac{M_\lambda(\lambda)}{M_{\mathrm{b},\lambda}(\lambda)}$$

where

$M_\lambda(\lambda)$ is the spectral radiant exitance of a thermal radiator;
$M_{\mathrm{b},\lambda}(\lambda)$ is the spectral radiant exitance of a blackbody at the same temperature.

[ISO 80000-7:2008[5], 7-21.2]

1.124
spectral reflection coefficient
ρ_λ
wavelength-dependent reflection coefficient

1.125
spectral response
spectral wavelength interval over which an instrument or sensor responds to infrared radiant energy

NOTE 1 Spectral response is expressed in micrometres.

NOTE 2 Spectral response can be plotted on a spectral response curve of a particular infrared detector (infrared camera).

1.126
spectral transmission coefficient
τ_λ
wavelength-dependent transmission coefficient

1.127
specular reflector
smooth surface that reflects most (total) incident radiant energy at an angle complementary (equal about the normal) to the angle of incidence

EXAMPLE A mirror.

1.128
spherical aberration
lens geometry-dependent display fault of a lens

EXAMPLE For lenses whose surfaces can be described by spherical segments, axis far boundary radiation is not displayed exactly at the focal point or a point in the picture level.

1.129
spot
instantaneous area (quantified by its diameter, unless otherwise specified) at the target plane that is being measured by an instrument

NOTE In infrared thermometry, a spot is specified by most manufacturers to contain 95 % of the radiant energy emitted by an infinitely large target of the same temperature and emissivity.

1.130
spot radiometer
non-imaging device that senses infrared radiation and that can be calibrated in temperature of thermal flux power density

1.131
standard large aperture radiator
standard (reference) radiator, with angular dimensions several times greater than the elementary field of view of a given thermographic instrument

1.132
standard radiator
radiator which simulates a blackbody

1.133
standard slit pattern
slit pattern introduced into a standard specimen used for the estimation of minimum resolvable temperature difference

1.134
storage operating range
temperature extremes over which an instrument can be stored and, subsequently, operated within reported performance specifications

1.135
stress resolution
resolution of stress achieved by measuring thermoelastic stresses

NOTE Stress resolution is applied to temperature resolution of an infrared instrument.

1.136
surface-modifying material
tape, spray or paint used to modify (enhance) emissivity of test samples

1.137
target background
set of objects and the atmosphere in the vicinity of a test object that is observed by an infrared camera and which can affect the thermal pattern of the test object

1.138
target plane
plane perpendicular to the sight direction of a radiation thermometer that is in focus for that instrument

1.139
target size
diameter of a circle in the target plane of a radiation thermometer that is centred on its sight direction and which contains 99 % of the input radiant power received by that instrument

1.140
temperature difference imaging technique
signal-processing method to obtain a picture of the change of the sum of principal stresses, consisting of measuring temperature distribution images during the maximum temperature period and the minimum temperature period, and making an overall “temperature range image” from the images

NOTE Range means the total amplitude.

1.141
temperature drift
reading change (error) in time when observing a target with non-varying temperature, which can be caused by a combination of ambient factors and variation in voltage and instrument characteristics

1.142
temperature maintenance instability
instability of a blackbody radiator temperature, i.e. standard deviation of blackbody radiator temperature values measured every 10 s to 15 s during 15 min to 20 min with reference to their arithmetic mean value during the same period

1.143
temperature resolution
minimum simulated or actual change in the target temperature that produces a temperature signal identified by an observer (typically, at the signal-to-noise ratio equal to unity)

NOTE This is equivalent to NETD. See NETD.

1.144
thermal anomaly
surface thermal pattern which deviates from a reference (expected) thermal pattern

1.145
thermal contrast
degree of detectable temperature difference between adjacent areas or objects having unequal temperatures at a particular moment

NOTE Thermal contrast is a processing technique used to enhance target visibility. In its simplest form, a thermal contrast is computed by calculating the difference between the temperature of the target and the temperature of a (sound) reference area.

1.146
thermal diffusivity
α
ratio of conductivity, χ, to the product of density, ρ, and specific heat, c_p

$$\alpha = \frac{\chi}{\rho c_p}$$

NOTE 1 Thermal diffusivity is expressed in metres squared per second.

NOTE 2 Thermal diffusivity is the ability of a material to diffuse thermal energy after a change in heat input. A body with a high diffusivity reaches a uniform temperature distribution faster than a body with a lower diffusivity.

1.147
thermal effusivity
thermal inertia
e
measure of the resistance of a material to a temperature change

NOTE 1 Expressed mathematically

$$e = \left(\chi \rho c_p\right)^{1/2}$$

where

χ is the thermal conductivity;
ρ is the bulk density;
c_p is the specific heat capacity.

NOTE 2 Thermal effusivity is expressed in watts squared root second per square metre kelvin.

1.148
thermal pattern
area on an infrared thermogram of a particular shape and amplitude

NOTE A thermal pattern is often used to identify thermal anomalies.

1.149
thermal radiation
mode of energy flow that occurs by emission and absorption of electromagnetic radiation, propagating at the speed of light

NOTE Unlike conductive and convective heat flow, thermal radiation is capable of propagating across a vacuum, a form of heat transfer which allows IRT to work since infrared energy travels from the target to the detector by radiation.

1.150
thermal resolution
smallest apparent temperature difference between two blackbodies that can be measured by an infrared sensing device

1.151
thermal test object
device producing a special thermal pattern of a specific spatial frequency, shape or temperature on a uniformly radiating background with known temperature and emissivity of both the object and the background

1.152
thermal tomography
processing technique used in pulsed thermography and in which data are analysed by reference to a particular instant of interest such as the time of maximum thermal contrast

1.153
thermal wave imaging
active infrared thermographic inspection technique, in which a test sample is stimulated with periodical pulses of thermal energy and recorded infrared image sequences are analysed to enhance defect “visibility” and characterize defect parameters

NOTE Sometimes this term is applied to pulsed infrared thermographic non-destructive testing.

1.154
thermistor
temperature detector, usually a semiconductor, whose resistivity changes predictably with increasing temperature

1.155
thermoelastic coefficient
proportional coefficient of “temperature change” and “product of object temperature and change of the sum of principal stresses by thermoelastic effect”

NOTE The thermoelastic coefficient, k_t, in reciprocal pascals, is material constant and is given by the equation.

$$k_\mathrm{t} = \frac{\alpha_\mathrm{l}}{\rho c_p}$$

where

α_l is the coefficient of linear thermal expansion, in reciprocal kelvins;
ρ is the material density, in kilograms per metre cubed;
c_p is the specific heat at constant pressure, in joules per kilogram per kelvin.

1.156
thermoelastic effect
phenomenon in which temperature changes with adiabatic elastic deformation of an object

NOTE Temperature generally decreases with tension and increases with compression. Temperature change, ΔT, in kelvins, is proportional to the change in the sum of principal stresses:

$$\Delta T = -k_\mathrm{t}\, T\, \Delta\sigma$$

where

k_t is the thermoelastic coefficient, in reciprocal pascals;
T is the object temperature, in kelvins;
$\Delta\sigma$ is the change in the sum of principal stresses, in pascals.

1.157
thermoelastic apparatus (stress measuring)
instrument that measures stress distribution in a measuring object based on the thermoelastic effect

1.158
thermoelastic method (stress measuring)
method that measures distribution of surface temperature change in a measurement object using the thermoelastic effect with an infrared thermography instrument and converts and displays the distribution of the sum of principal stress change

1.159
thermogram
thermal map or image of a target where the grey tones or colour hues represent the distribution of infrared thermal radiant energy over the surface of the target

[ISO 18434-1:2008[6], 3.17]

1.160
thermographic signal reconstruction
TSR
signal-processing technique for reconstructing and improving time-resolved thermal images, used in pulsed thermography material testing and based on polynomial fitting of the temperature decay

1.161
thermology
⟨medical applications⟩ thermography

1.162
thermometer
device used to measure temperature

1.163
thermopile
device constructed from thermocouples in series to add the thermoelectric voltage

NOTE A radiation thermopile has junctions arranged so as to collect infrared radiant energy from a target, i.e. it is a type of thermal infrared detector.

1.164
total field of view
TFOV
total solid angle scanned view, usually rectangular in cross-section, in imagers

1.165
transfer calibration
technique for correcting a temperature measurement or a thermogram for various errors by placing a radiation reference adjacent to the target

1.166
transfer standard
precision radiometric measurement instrument whose calibration is traceable to national or international standards which is used to calibrate radiation reference sources

1.167
transmission coefficient
ratio of the radiation energy transmitted through a body to the total incident radiation

1.168
transmissivity
τ
transmittance
proportion of infrared radiant energy impinging on an object surface, for any given spectral interval, that is transmitted through the object

NOTE 1

$$\tau = 1 - \varepsilon - \rho$$

where

τ is transmissivity;
ε is emissivity;
ρ is reflectivity.

[ISO 18434-1:2008[6], 3.18]

NOTE 2 “Transmissivity” and “reflectance” are often used interchangeably.

NOTE 3 Transmissivity is that fraction of incident radiation transmitted by matter.

$$\tau = \frac{\Phi_t}{\Phi_m}$$

where

Φ_t is the transmitted radiant flux or luminous flux;
Φ_m is the radiant flux or luminous flux of the incident radiation.

(Adapted from ISO 80000-7:2008[5], 7-47.3.)

EXAMPLE For a blackbody, $\tau = 0$.

1.169
transmitting medium
composition of the measurement path between a target and a measuring instrument through which radiant energy propagates

NOTE The transmitting medium can be a vacuum, gaseous (such as air), solid, liquid or any combination of these.

1.170
vibrothermography
thermographic technique for examining an object where temperature differences are produced by mechanical vibrations

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