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Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods —

Part 1: General procedures

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IMPORTANT — Please use this updated version dated 2020-09-18, and discard any previous version of this DIS. Note that the project is now being processed as ISO/CEN parallel processing.

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 163, *Thermal Performance and Energy Use in the Built Environment*, Subcommittee SC1, *Test and measurement methods*, Working Group 15, Thermography of buildings and industrial installations.

ISO 6781-1 cancels and replaces the first edition of ISO 6781:1983 which was a single-part document.

ISO 6781 consists of the following parts, (some of which are presently in development as indicated) under the general title Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods:

— ***Part 1****: General procedures*

— ***Part 2****: Equipment requirements (Under development)*

— ***Part 3****: Qualifications of equipment operators, data analysts and report writers (Under development)*

— ***Part 4****: Conducting Thermographic Inspections and Reporting of Results - Residential and small buildings (Under development)*

— ***Part 5****: Conducting Thermographic Inspections and Reporting of Results – Commercial Buildings (Under development)*

— ***Part 6****: Conducting Thermographic Inspections and Reporting of Results – Institutional and special purpose buildings (Under development)*

Introduction

Infrared building thermography provides a tool to qualitatively identify the presence of energy-wasting defects and anomalies within building structures. These defects and anomalies can include, for example, thermal insulation defects, moisture content, and / or unwanted air movement or leakage within the building enclosure.

Building thermography is carried out by means of an infrared thermography camera, which produces an image based on the apparent radiance temperature of the target surface area. The thermal radiation (infrared radiation density) from the target area is converted by the infrared thermography camera to produce a thermal image (thermogram). This image (thermogram) represents the relative intensity of thermal radiation from different parts of the surface. The radiation intensity indicated by the image is related directly to (i) the surface temperature and distribution, (ii) the characteristics of the surface, (iii) the ambient conditions, and (iv) the sensor itself.

As a result, surface temperature distribution can be a key parameter for monitoring the performance of building components, building enclosure and the diagnostics of problems. In use, via analysis of surface temperature distributions, irregularities in the heat and moisture properties of building enclosures and components, and air movement within the building enclosure, can be indicated. These irregularities can be due to, for example, thermal insulation defects, moisture content, air leakage within components or through assemblies, or incorrect installation of components which comprise the construction of the building.

To realize its full utility as an initial qualitative screening technique, or in-depth diagnostic technique, thermography must often be supported and/or validated by other methods. These methods include, but are not limited to, infrared photosensitive tracer gas methods, fan pressurization of the building enclosure, heat-flow meters, smoke diffusion, anemometry, moisture metres, relative humidity sensors, etc.

Infrared building thermography inspection methodologies can be used for either new-construction quality control applications, or in existing buildings as ongoing condition monitoring for periodic or specific building-condition reporting. The latter applications may be accompanied with visual fault symptoms, while the former may not necessarily present symptoms via visual faults.

Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods —

Part 1: General procedures

1 Scope

This document specifies requirements and methodologies for infrared thermographic services for detection of heat, air and moisture irregularities in buildings that help users to specify and understand (i) the extent of thermographic services required, (ii) the type and condition of equipment that must be used, (iii) the qualifications of equipment operators, image analysts, and report authors and those making recommendations (iv) the requirements for reporting results, and (v) have a guide to understanding and utilizing the final results stemming from provision of the thermographic services

This part of ISO 6781 is applicable to the general procedures for infrared thermographic methods as may be applied to residential, commercial, and institutional & special use buildings.

2 Normative references

The following documents, in whole or part, are indispensable for the application of this international standard.. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Member Bodies of ISO and IEC maintain registers of currently valid International Standards.

ISO 6781-3, *Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods — Part 3: Qualifications of equipment operators, data analysts and report writers*

ISO/DIS 9972, *Thermal performance of buildings — Determination of air permeability of buildings — Fan pressurization method*

ISO/FDIS 10878, *Nondestructive testing – Infrared thermography – Vocabulary*

ISO/FDIS 12569, *Thermal performance of buildings and materials — Determination of specific airflow rate in buildings — Tracer gas dilution method*

ISO 9869-1, *Thermal insulation — Building elements — In-situ measurement of thermal resistance and thermal transmittance — Part 1: Heat flow meter method*

ISO 7345, *Thermal performance of buildings and building components — Physical quantities and definitions*

ISO 9288, *Thermal insulation — Heat transfer by radiation — Physical quantities and definitions*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9288 and the following apply:

3.1 General terms

3.1.1
system
regularly interacting or interdependent group of associated entities (components, factors, members, parts, etc) forming an integrated whole and delineated by its spatial and temporal boundaries

Note 1 to entry: One or more of the associated entities define the boundary of the system.

3.1.2
analysis
careful scrutiny of constituent parts of a *system* (3.1.1) in order to thoroughly understand the whole

3.1.3
function
functional purpose of the building, building component or building *system* (3.1.1)

Note 1 to entry: The function is the activity assigned to, required of, or expected of the system.

3.1.4
small / residential building
building meeting the parameters defined in local building codes as small / residential building and as agreed with customer receiving thermographic services

3.1.5
parameter
numerical or other measurable factor forming one of a set that sets the conditions for measurement, or defines the system and its operation

3.1.6
performance
behaviour, characteristics and efficiency of a building, building component or building *system* (3.1.1)

3.1.7
sign
characteristic parameter of a signal, which shows information about a state

3.1.8
symptom
perception, made by means of human observations and measurements (descriptors), which may indicate the presence of one or more *faults* (3.1.12) with a certain probability

3.1.9
syndrome
group of *signs* (3.1.7) or *symptoms* (3.1.8) that collectively indicate or characterize an abnormal condition

3.1.10
anomaly
something that deviates from what is standard, normal or expected, and irregularity or *abnormality* (3.1.11) in a *system* (3.1.1)

3.1.11
abnormality
deviation from a standard condition

3.1.12
Irregularity
a condition which significantly departs from the operational norm

3.1.13
fault
a condition that occurs when a building or one of its components or assemblies degrades or exhibits abnormal behaviour, which may lead to the *failure* (3.1.14) to perform in accordance with its design intent.

Note 1 to entry: A fault may be the result of a failure, but can exist without a failure.

Note 2 to entry: Planned actions or lack of external resources are not a fault.

3.1.14
fault progression
characterization of the change in severity of a *fault* (3.1.12) over time

3.1.15
failure
termination of the ability of an item to perform a required *function* (3.1.4)

Note 1 to entry: Failure is an event as distinguished from *fault* (3.1.12), which is a state.

3.1.16
failure mode
effect by which a *failure* (3.1.14) is observed

3.1.17
diagnostics
examination of *symptoms* (3.1.8) and *syndromes* (3.1.9) to determine the nature of *faults* (3.1.12) or *failures* (3.1.14) (i.e.: kind, situation, extent)

3.1.18
root cause
set of conditions and/or actions that occur at the beginning of a sequence of events and result in the initiation of a *failure mode* (3.1.15)

3.1.19
root cause failure analysis - RCFA
after a failure, the logical systematic examination of an item, its construction, application and documentation in order to identify the *failure mode* (3.1.15) and determine the failure mechanism and its basic cause

Note 1 to entry: Root cause failure analysis is often used to provide a solution to chronic problems.

3.1.20
risk assessment
process of balancing risk with cost, schedule and other management considerations

Note 1 to entry: Risk assessment consists of identifying risks, assessing those risks, determining a course of action and tracking the effectiveness of the decision.

3.1.21
prognostics
analysis of the symptoms of *faults* (3.1.12) to predict a future condition and remaining useful life

3.1.22
prognosis
result of the prognostics process

3.1.23
qualitative
relating to measuring, or measured by the quality of something, rather than its quantity

3.1.24
quantitative
relating to measuring, or measured by the quantity of something, rather than its general qualities

3.2 Thermography terms

3.2.1
Infrared
IR
that portion of the electromagnetic spectrum extending from the red visible wavelength, 0,75 µm to 1 mm

Note 1 to entry: Because of instrument design and infrared transmission characteristics of the atmosphere, most infrared measurements are made between 0,75 µm and 15 µm wavelengths.

3.2.2
thermography
representation of the temperature distribution of a surface , in a thermal image

3.2.3
Thermographic analysis
interpretation and determination of the casual mechanisms producing variations and irregularities in the thermal image

3.2.4
quantitative thermographic examination
examination of whole buildings, structures or components using thermographic methods with the objective of providing quantitative (3.1.22) output

Note 1 to entry: Reporting requirements for both qualitative and quantitative examinations are specified in clause 19 of this document.

3.2.5
infrared thermography camera
IRT camera
instrument that collects the infrared radiant energy from a target surface and produces a monochrome (black and white) or colour image, where the grey shades (monochrome) or colour hues are related to the target surface apparent temperature

3.2.6
thermal image
image which is produced by an infrared thermography camera and which represents the apparent radiance temperature distribution over the target surfaces

Note 1 to entry: Such images are sometimes called *infrared thermograms*.

3.2.7
Isotherm
<temperature> enhancement feature applied to an image, which marks an interval of equal apparent temperature

3.2.8
Isotherm
<radiation density> region on an IR display consisting of points, lines or areas having the same infrared radiation density

3.2.9
isotherm image
output from a infrared thermography camera showing isotherms (3.2.7 & 3.2.8)

3.2.10
ironbow image
image comprising a colour palette running from black through blue, magenta, orange, yellow to white that creates best contrast, in particular in regard to edges and shapes

3.2.11
image processing
converting an image to digital form and enhancing the image to prepare it for computer or visual analysis

Note 1 to entry: In the case of a thermal image or thermogram this could include temperature scaling, spot temperature measurements, thermal profiles, image manipulation, subtraction and storage.

3.2.12
apparent temperature
uncompensated reading from an infrared thermography camera containing all radiation incident on the detector, regardless of its source

3.2.13
attenuating media
windows, filters, atmospheres, external optics, materials or other media that attenuate the infrared radiation emitted from a source

3.2.14
black body
ideal perfect emitter and absorber of thermal radiation at all wavelengths. The **emissivity** 3.2.14 of a black body is 1… ε = 1

Note 1 to entry: This is described by Planck's law.

3.2.15
emissivity
ε
ratio of a target surface's radiance to that of a black body at the same temperature and over the same spectral Interval

3.2.16
total radiance
radiant heat flow rate divided by the solid angle around the direction Δ and the projected area normal to this direction.

Note 1 to entry: Radiance includes emitted radiation from a surface as well as reflected and transmitted radiation.

3.2.17
apparent radiance temperature
temperature determined from the measured total radiance

Note 1 to entry: This temperature is the equivalent black body temperature which would produce the same total radiance.

3.2.18
reflectivity
ρ − the ratio of the total reflected energy from a surface to total incident energy on that surface

Note 1 to entry: ρ = 1 − ε - τ ; for a mirror, reflectivity approaches 1.0; for a black body, ρ = 0.

Note 2 to entry: 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. In IRT, the two terms are often used interchangeably.

3.2.19
reflected apparent temperature
***T*refl**
apparent temperature of other objects that are reflected by the target into the thermography camera

3.2.20
repeatability
capability of an instrument to repeat exactly a reading on a fixed target over a short or long-term interval

Note 1 to entry: Repeatability is expressed in ± degrees or a percentage of full scale.

3.2.21
signal processing
manipulation of a temperature signal or image data for the purposes of enhancing or controlling a process

EXAMPLE 1 For infrared radiation thermometers: peak hold, valley hold, sample hold and averaging.

EXAMPLE 2 For scanners, cameras and imagers: isotherm enhancement, image averaging, alignment, image subtraction and image filtering.

3.2.22
spatial measurement resolution – instantaneous field of view
IFOV
measurement-spot size in terms of working distance

Note 1 to entry: In an infrared radiation thermometer this 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 it is most often expressed in milliradian.

3.2.23
target
object surface to be measured

3.2.24
working distance
distance from the target to the instrument, usually to the primary optic

3.2.25
diffuse surface
a surface from which light or other electromagnetic radiation is scattered, rather than reflected

3.2.26
specular surface
a surface from which light or other electromagnetic radiation is strongly reflected, rather than randomly scattered

3.3 Definitions used in thermography

3.3.1
transmissivity / transmittance
τ
proportion of infrared radiant energy impinging on an object surface, for any given spectral interval, that is transmitted through the object

Note 1 to entry: Transmissivity: $\tau = 1 - \varepsilon - \rho$, where:

τ is transmissivity;

ε is emissivity;

ρ is reflectivity.

Note 2 to entry: For a black body, τ = 0. Transmissivity is that fraction of incident radiation transmitted by matter.

3.3.2
thermal index (TI)
the ratio of temperature drop across the building enclosure, to the total temperature drop between inside and outside environmental temperatures

Note 1 to entry: Thermal index is calculated as follows: TI= $[(T_{surface}-T_{out}) / (T_{in}-T_{out})] \times 100\%$, where:

T surface = The surface temperature of a part of the building enclosure.

Tout = The localized outside air temperature measured by the user.

Tin = The air temperature inside the structure measured by the user.

Note 2 to entry: Example: Tsurface=60ºC; Tin=70 ºC; Tout=30 ºC; Therefore TI = [(60 - 30) / (70-30)] x 100 = 75%.

4 Symbols (and abbreviated terms)

FOV	Field of view
Hz	Hertz
IFOV	Instantaneous field of view for detection (Note: thermographic terms 3.2.22)
IRT	Infrared Thermography
MDT	Minimum detectable temperature
MRTD	Minimum resolvable temperature difference
NETD	Noise equivalent temperature difference
NUC	Non-uniformity correction
MIFOV	Instantaneous field of view for measurement
Mrad	milliradian
TI	Temperature index
L_e	Radiance
ε(λ)	Spectral emissivity
ρ(λ)	Spectral reflectivity
τ(λ)	Spectral transmissivity
α(λ)	Spectral absorptivity
ΔT	Differential temperature

5 Example applications of use of thermography in building assessments

The following list gives examples of where thermography may be applied as a screening or initial analysis too in the context of building examinations. These examinations can be conducted from inside or outside of the building. The list given below is not limiting:

a) surface temperature variations

