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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial electroheating equipment – Test methods for infrared emitters

Chauffage électrique industriel – Méthodes d'essais des émetteurs de rayonnement infrarouge

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FOREWORD

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The text of this standard is based on the following documents:

CDV	Report on voting
27/938/CDV	27/942/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The contents of the corrigendum of November 2014 have been included in this copy.

INTRODUCTION

This standard on particular test methods for infrared electroheating emitters is one of TC 27 standards that describe test methods for various types of electroheating installations.

This standard is solely concerned with tests for infrared emitters. Tests that focus on the performance of infrared equipment or installations are covered by IEC 62693, *Industrial electroheating installations – Test methods for infrared electroheating installations*. The rationale for this separation is that infrared installations are usually manufactured by other companies than infrared emitters. Still, infrared emitters are a very important and distinct part of infrared installations and a set of tests that allow for proper characterisation, comparison of different infrared emitters is valuable to manufacturers of infrared installations.

The major guiding principle for this standard is to determine

– simple tests that define the basic characteristics of all infrared emitters and can be performed with the usual test and measuring equipment available to different kinds of companies, large or small;

– more complex tests that provide valuable extra information, but need a well-equipped laboratory.

INDUSTRIAL ELECTROHEATING EQUIPMENT –

Test methods for infrared emitters

1 Scope and object

This International Standard specifies test procedures, conditions and methods according to which the main parameters and the main operational characteristics of industrial infrared emitters are established.

A limitation of the scope of this standard is that the infrared emitters have a maximum spectral emission at longer wavelengths than 780 nm in air or vacuum, and are emitting wideband continuous spectra such as by thermal radiation or high pressure arcs.

IEC 60519-1:2010 [1] [1] defines infrared as optical radiation within the frequency range between about 400 THz and 300 GHz. This corresponds to the wavelength range between 780 nm and 1 mm in vacuum. Industrial infrared heating usually uses infrared sources with rated temperatures between 500 °C and 3 000 °C; the emitted radiation from these sources dominates in the wavelength range between 780 nm and 10 μm.

Industrial infrared emitters under the scope of this standard typically use the Joule effect for the conversion of electric energy in one or several sources into infrared radiation, which is emitted from one or several elements. Such infrared emitters are especially

– thermal infrared emitters in the form of tubular, plate-like or otherwise shaped ceramics with a resistive element inside;
– infrared quartz glass tube or halogen lamp emitters with a hot filament as a source;
– non-insulated elements made from molybdenum-disilicide, silicon-carbide, iron-chromium-aluminium alloys or comparable materials;
– wide-spectrum arc lamps.

This standard is not applicable to

– infrared emitters which are lasers or light-emitting diodes (LEDs);
– infrared emitters for use by the general public;
– infrared emitters for laboratory use.

Most of the tests described, especially the destructive tests, are for type testing.

The tests specified in this standard are intended to be used for evaluating or comparing the performance of emitters belonging to the same category.

Tests related to performance of industrial infrared electroheating installations are specified in IEC 62693:2013.

Most tests specified in this standard are applicable to wide-spectrum arc lamps, but not all.

[1] Numbers in square brackets refer to the Bibliography.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

IEC 60061-2, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 2: Lampholders*

IEC 60061-3, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 3: Gauges*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-7, *Basic environmental testing procedures – Part 2-7: Tests – Test Ga and guidance: Acceleration, steady state*

IEC 60432-1:1999, *Incandescent lamps – Safety specifications – Part 1: Tungsten filament lamps for domestic and similar general lighting purposes*
IEC 60432-1:1999/AMD1:2005
IEC 60432-1:1999/AMD2:2011

IEC 60519-12, *Safety in electroheating installations – Part 12: Particular requirements for infrared electroheating installations*

IEC 60682:1980, *Standard method of measuring the pinch temperature of quartz-tungsten-halogen lamps*
IEC 60682:1980/AMD1:1987
IEC 60682:1980/AMD2:1997

IEC 62693:2013, *Industrial electroheating installations – Test methods for infrared electroheating installations*

EN 993-11, *Methods of test for dense shaped refractory products – Part 11: Determination of resistance to thermal shock*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60519-12, IEC 62693 as well as the following apply.

NOTE General definitions are given in the International Electrotechnical Vocabulary, IEC 60050 [2]. Terms relating to industrial electroheating are defined in IEC 60050-841.

3.1 General

3.1.1
infrared radiation
optical radiation for which the wavelengths are longer than those for visible radiation

Note 1 to entry: The infrared radiation range between 780 nm and 1 mm is commonly subdivided into:

IR-A 780 nm to 1 400 nm, or for a grey emitter 3 450 °C to 1 800 °C surface temperature;

IR-B 1 400 nm to 3 000 nm, or for a grey emitter 1 800 °C to 690 °C surface temperature;

IR-C 3 000 nm to 1 mm, or for a grey emitter less than 690 °C surface temperature.

The temperature corresponds to a spectrum where maximum intensity is at the wavelength of the limit.

These ranges comply with IEC 62471:2006 [3].

Note 2 to entry: In IEC 60050-841:2004 the following terms are defined:

841-24-04 – shortwave infrared radiation or near infrared radiation (780 nm to 2 µm);

841-24-03 – mediumwave infrared radiation or medium infrared radiation (2 µm to 4 µm);

841-24-02 – longwave infrared radiation or far infrared radiation (4 µm to 1 mm).

These terms are not used in this standard.

[SOURCE: IEC 60519-12:2013, 3.101]

3.1.2
emitter category
group of emitters using the same principle for applying thermal energy to the workload

3.1.3
inrush current
short term high lamp current occurring during the transient period from the moment of applying voltage to a cold emitter to steady state

3.1.4
average electrical lifetime
net operating time of infrared emitters at rated voltage under intended conditions when 50 % of all emitters are still operating

3.2 Radiation

3.2.1
radiant power
radiant flux
power emitted, transmitted or received in the form of radiation

3.2.2
irradiance
irradiation
quotient of the radiant power incident on a surface element containing the point, by the area of that element

3.2.3
radiance

quantity L defined by the formula $L = \dfrac{d\Phi}{dA \cdot \cos\theta \cdot d\Omega}$

where

$d\Phi$ is the radiant power or flux transmitted by an elementary beam passing through the given point and propagating in the solid angle containing the given direction;

$d\Omega$ is the solid angle;

dA is the area of a section of that beam containing the given point;

$\cos\theta$ is the angle between the normal to that section and the direction of the beam.

3.2.4
radiant exitance, <of a body>
quotient of the radiant flux emitted by a body into the hemispherical space (2π sr) by the surface unit area of that body

Note 1 to entry: The body can be an infrared emitter or a source of an infrared emitter.

3.2.5
spectral distribution
spectrum
quotient of a radiant quantity $dX(\lambda)$ contained in an elementary range $d\lambda$ of wavelength at the wavelength λ by that range

Note 1 to entry: The term spectral distribution is preferred when dealing with the function $X\lambda(\lambda)$ over a wide range of wavelengths, not at a particular wavelength.

3.2.6
spectral radiance
ratio of the radiant power $d\Phi(\lambda)$ passing through a point and propagating within the solid angle $d\Omega$ in the given direction, to the product of the wavelength interval $d\lambda$ and the area of a section of that beam on a plane perpendicular to this direction ($\cos\theta \cdot dA$) containing the given point and to the solid angle $d\Omega$

3.2.7
spectral radiant exitance
quotient of the radiant flux emitted by a body into the hemispherical space (2π sr) by the surface unit area of that body and by the unit wavelength interval

3.2.8
radial irradiation distribution
irradiation caused by any emitter of axial symmetry on a circumference around the axis of symmetry of the emitter on a plane perpendicular to that axis and centred at mid-length of the emitter

Note 1 to entry: Axial symmetry does not imply round.

3.2.9
rated total radiant power
radiant power emitted by the emitter at rated voltage

4 Classification of infrared emitters

The most common industrial infrared emitters under the scope of this standard emit broadband thermal spectra. Annex A provides basic definitions and concepts of thermal infrared radiation. Thermal emitters usually have a clear correlation between the maximum of the spectral radiant power and the temperature of the source of the emitter, called Wien's law; in this case the rated temperature indicates the spectrum of the emitter. Arc lamps generate a non-thermal spectrum.

The most relevant design element of infrared emitters influencing the spatial irradiation pattern is the size and dimension of the surface of the source emitting the radiation. As industrial infrared emitters are usually used in close vicinity of the workload, there are

– very small sources which act like point sources – for example small light bulbs or arc lamps with a very short arc; infrared laser and LED are point sources as well, but are outside the scope of this standard;
– near ideal line sources – for example halogen emitter, tungsten coil emitter, arc or flash lamps; their source may be bent;
– tubular or line sources with a large diameter – for example ceramic tube emitters, heating rods made from materials like graphite or silicon carbide;
– planar or two-dimensional sources – for example ceramic tile type emitters.

Radiation sources can be divided into point like sources and extended sources depending on the size of the source and observation distance. If the distance between the radiation source of the emitter and the observation point is greater than 10 to 50 times the maximum dimension of the radiation source, this source can be approximated as a point source. In most industrial installations the infrared emitters are in close vicinity to the workload and are thus extended sources. The approximate value of 10 to 50 depends on the problem and the intended accuracy of a measurement.

NOTE 1 When the observing distance is greater than 10 times the maximum dimension of the radiation source, the resulting error for calculating the irradiance is less than 1 %.

Commonly available industrial infrared emitters classified according to their spectral emission and rated temperatures are listed in Table 1.

NOTE 2 In industry a different classification than the one used in this standard and given in 3.1.1 is also known, it is provided for information in Annex B.

Table 1 – Classification of infrared emitters by spectral emission

Spectral band where maximum of emission occurs	Rated temperature of thermal emitter	Category	Comments
IR-A 780 nm to 1 400 nm	1 800 °C to 3 450 °C	– halogen emitter – tungsten quartz tube emitter – high power laser diodes[1] – light emitting diode[1] – arc lamp[1]	Other names for this spectral range used in industry are: near infrared, NIR, short-wave[2].
IR-B 1 400 nm to 3 000 nm	690 °C to 1 800 °C	– halogen emitter – tungsten quartz tube emitter – ceramic emitter – heating wire made from nickel-chromium alloys – nichrome – heating wire made from alloys of nickel-chromium, or iron-chromium-aluminium – quartz tube emitter with heating wire coil (Cr, Al, Fe) – quartz tube emitter with carbon filament – quartz tube emitter with tungsten coil – silicon carbide heating rod – graphite heating rod – molybdenum disilicide heating element – high temperature metal tube element – high temperature ceramic element	Other name for this spectral range used in industry is "medium-wave"[2].
IR-C 3 000 nm to 1 mm	< 690 °C	– metal tube element – ceramic emitter element	Not in the scope of this standard, if convection dominates.
[1] included for reference only; rated temperature is not applicable [2] short wave and medium wave can denote differing spectral ranges, see Annex B			

5 Type of tests and general conditions of their performance

5.1 General – list of tests

Table 2 summarises the tests covered by this standard and their applicability to different categories of infrared emitters. It also includes references to other standards with applicable tests. Additional tests may be covered by commissioning and operation manuals issued by the manufacturer or may be agreed on between the manufacturer and user.

Table 2 – List of tests, their applicability to different classes of infrared emitters and the number of emitters needed for the tests

Test	Subclause	Emitter category				Manufacturing[1]	
		Open heating element	Ceramic heating element	Infrared quartz	Halogen quartz	Standard, mass produced	Made to order
emitter geometry	-	test is defined between the manufacturer and user					
interchangeability of cap and holder, standard	7.2.1	not applicable		If cap and holder combinations from Parts 1, 2 and 3 of the IEC 60061 series are used, IEC 60061-3 is applicable.			
interchangeability of cap and holder, other	7.2.2	as agreed on between the manufacturer and user					
cap twist-off test	7.2.3	not applicable		IEC 60432-1 is applicable for caps covered by that standard			
rated power	7.3.1	applicable				1/100	1/100 or 1/batch
power variation with voltage	7.3.2					1/type	1/type
inrush current	7.3.3	usually not necessary		usually applicable[1]	applicable[2]		
emitter resistivity as estimate for rated power	7.3.4	may be applicable			not applicable		
rated temperature	7.4.1	applicable				IEC 60432-1 applies	1/batch
variation of source temperature with voltage	7.4.2					1/type after change in production	1/type
source temperature rise time	7.4.3						
cooling time	7.4.4, 7.4.5, 7.4.6	source cooling = surface cooling in 7.4.5			source cooling in 7.4.4 surface cooling time in 7.4.6		
temperature homogeneity	7.4.8	applicable					
surface temperature distribution	7.4.9						
distribution temperature	7.4.10						
thermal ruggedness	7.4.11	applicable		non applicable	application dependent		10/type