IEC 60519-12

Edition 1.0 2013-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Safety in electroheating installations –
Part 12: Particular requirements for infrared electroheating installations

Sécurité dans les installations électrothermiques –
Partie 12: Exigences particulières pour les installations électrothermiques par rayonnement infrarouge

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX W

ICS 25.180.10

ISBN 978-2-83220-742-0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY IN ELECTROHEATING INSTALLATIONS –

Part 12: Particular requirements for infrared electroheating installations

FOREWORD

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International Standard IEC 60519-12 has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing.

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

FDIS	Report on voting
27/894/FDIS	27/905/RVD

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.

A list of all parts in the IEC 60519 series, published under the general title *Safety in electroheating installations*, can be found on the IEC website.

The clauses of parts of the IEC 60519 series (hereinafter called Particular requirements) supplement or modify the corresponding clauses of IEC 60519-1:2010 (*General requirements* hereinafter called Part 1).

This part of IEC 60519 is to be read in conjunction with Part 1. It supplements or modifies the corresponding clauses of Part 1. Where the text indicates an "addition" to or a "replacement" of the relevant provision of Part 1, these changes are made to the relevant text of Part 1. Where no change is necessary, the words "This clause of Part 1 is applicable" are used. When a particular subclause of Part 1 is not mentioned in this part, that subclause applies as far as is reasonable.

Additional specific provisions to those in Part 1, given as individual clauses or subclauses, are numbered starting from 101.

NOTE The following numbering system is used:

– subclauses, tables and figures that are numbered starting from 101 are additional to those in Part 1;

– unless notes are in a new subclause or involve notes in Part 1, they are numbered starting from 101, including those in a replaced clause or subclause;

– additional annexes are lettered AA, BB, etc.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The scope of this standard covers very different types and designs of infrared equipment used for many different purposes by the industry. This standard is intended to cover all industrial infrared equipment types, with some few exceptions described in Clause 1.

As many different types of electroheating equipment emit infrared radiation of hazardous levels, the scope of this Part 12 of the IEC 60519 series addresses these infrared radiation aspects for other parts of the series as well. Especially and with reference to IEC 60519-2:2006 [3][1] it has been agreed in TC 27 that this standard covers all kinds of infrared emission hazards of industrial electroheating installations.

The discussion of infrared radiation has become quite detailed in this standard, as for the industry there is not any single useful source available for simple, versatile, easy to use and cost effective measurement methods.

Provisions of this standard relating to hazards by infrared emission from the equipment as such and from hot workloads can be used as a complement to IEC 60519-2:2006, since such aspects are not dealt with in that standard.

This standard provides guidance on the assessment and avoidance of hazards caused by infrared radiation emitted to accessible locations by hot workloads, electrodes, or other thermal sources belonging to electroheating equipment.

The other principles for covering the risks caused by infrared radiation were:

– Neither the manufacturer nor the user of electroheating equipment usually employs an expert in optical radiation measurement or has access to an optical laboratory with all the necessary equipment needed for elaborate measurements.

– Operating staff with limited experience in radiation measurement is usually responsible for the task of performing the necessary measurements and will appreciate a simple and easy to follow guide.

– EN 14255-2:2005 is defined for and useful for lamps only [8].

– EN 12198 series is not very detailed on measurement methods. It gives good guidance on procedures to improve the safety of equipment. Some material from this source has been adapted [9 – 11].

– The scope of IEC 62471:2006 is limited to lamps but that standard can be used for other light sources. Therefore, core aspects were adapted and if possible simplified for this standard. Content that is essential for safety of electroheating equipment is included in this standard.

– Figures illustrating the classes defined in IEC 62471:2006 are included to provide a more understandable and useful standard (IEC 62471:2006 provides data only in the tables).

– Relevant documents of American National Standard Institute / Illuminating Engineering Society of North America, the ANSI/IESNA RP 27 series [12 – 14], are based on the ICNIRP recommendations [1, 2] as well. They provide no extra material with regard to this standard and its references.

A new infrared warning sign shown in Annex GG has been defined in liaison with IEC/SC 3C.

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1 Numbers in square brackets refer to the Bibliography.

SAFETY IN ELECTROHEATING INSTALLATIONS –

Part 12: Particular requirements for infrared electroheating installations

1 Scope and object

This clause of Part 1 is replaced by the following.

Replacement:

This part of IEC 60519 specifies safety requirements for industrial electroheating equipment and installations in which infrared radiation, usually generated by infrared emitters, is significantly dominating over heat convection or heat conduction as means of energy transfer to the material to be treated. A further limitation of the scope 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 defines infrared as 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.

Since substantial emission of e.g. blackbody thermal emitters may extend beyond 780 nm or 3 000 nm, the safety aspects of emitted visible light and emission at wavelengths longer than 3 000 nm are also considered in this standard.

This standard is not applicable to:

– infrared installations with lasers or light-emitting diodes (LEDs) as main sources – they are covered by IEC 62471:2006, IEC 60825-1:2007 [4] and IEC/TR 60825-9:1999 [5];
– appliances for use by the general public;
– appliances for laboratory use – they are covered by IEC 61010-1:2010 [6];
– electroheating installations where resistance heated bare wires, tubes or bars are used as heating elements, and infrared radiation is not a dominant side effect of the intended use, covered by IEC 60519-2:2006 [3];
– infrared heating equipment with a nominal combined electrical power of the infrared emitters of less than 250 W;
– handheld infrared equipment.

Industrial infrared electroheating equipment under the scope of this standard typically uses the Joule effect for the conversion of electric energy into infrared radiation by one or several sources. Radiation is then emitted from one or several elements onto the material to be treated. Such infrared heating elements are in particular:

– 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, graphite, iron-chromium-aluminium alloys like Kanthal™ or comparable materials;
– wide-spectrum arc lamps.

2 Normative references

This clause of Part 1 is applicable except as follows.

Additions:

IEC 60519-1:2010, *Safety in electroheating installations – Part 1: General requirements*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

ISO 12100:2010, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13577-1, *Industrial furnaces and associated processing equipment – Safety – Part 1: General requirements*

ISO 14159, *Safety of machinery – Hygiene requirements for the design of machinery*

3 Terms and definitions

This clause of Part 1 is applicable except as follows.

Additions:

3.101
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.

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 62471:2006, 3.14, modified – Note 1 has been modified and Note 2 added]

3.102
infrared heating
heating consisting in absorption of thermal and optical radiation, mostly infrared radiation, emitted by especially constructed equipment

[SOURCE: IEC 60050-841:2004, 841-24-05, modified – the definition has been editorially improved]

3.103
infrared installation
infrared electroheating installation
electroheating installation, where processing of the workload is achieved by infrared heating

[SOURCE: IEC 60050-841:2004, 841-24-09, modified – the synonym has been added; the definition has been shortened]

3.104
infrared emitter
component from which infrared radiation is emitted

Note 1 to entry: This component is usually replaceable.

3.105
infrared source
part of the infrared emitter, where electric energy is converted by the Joule effect into heat or radiation

3.106
filament
conductive wire or thread of an infrared emitter, in which electric energy is converted into heat by the Joule effect

[SOURCE: IEC 60050-841:2004, 841-24-27, modified – the definition has been clarified]

3.107
infrared ceramic heater
infrared emitter made of or covered with ceramic material

[SOURCE: IEC 60050-841:2004, 841-24-13, modified – the definition has been shortened]

3.108
tubular infrared emitter
infrared emitter in which one of the basic dimensions is dominant

Note 1 to entry: The emitter can include reflecting means and be straight or bent.

[SOURCE: IEC 60050-841:2004, 841-24-24, modified – the definition has been shortened; Note 1 has been added]

3.109
infrared plate emitter
infrared emitter in which two of the basic dimensions are dominant

Note 1 to entry: The emitter can include reflecting means and may be flat or curved.

[SOURCE: IEC 60050-841:2004, 841-24-25, modified – the definition has been shortened; Note 1 has been added]

3.110
infrared quartz emitter
infrared emitter in which the source is inside a quartz glass envelope

Note 1 to entry: Glass envelopes made from hard glasses like Vycor™ are included.

[SOURCE: IEC 60050-841:2004, 841-24-26, modified – the definition has been shortened; Note 1 has been added]

3.111
halogen lamp emitter
infrared emitter with a tungsten filament placed inside a gas tight glass envelope with halogen, containing atmosphere where the halogen actively transports tungsten from the glass wall to the tungsten filament

Note 1 to entry: Halogen lamp emitters are typically infrared quartz emitters.

[SOURCE: IEC 60050-841:2004, 841-24-22, modified – the definition has been clarified; Note 1 has been added]

3.112
infrared reflector
passive, non transmitting component which reflects and directs infrared radiation

Note 1 to entry: The reflector can be part of an infrared emitter and can reflect specularly or diffusely.

3.113
infrared refractor
passive, transmitting component that focuses and directs infrared radiation

Note 1 to entry: The refractor can be part of an infrared emitter.

3.114
infrared wavelength converter
element inside the infrared installation that is heated up by infrared radiation during normal operation to a temperature, where its own emitted radiation participates in heating up the workload

Note 1 to entry: The spectrum of a wavelength converter has a substantially longer wavelength than the wavelength of major emission of the infrared emitters.

3.115
infrared module
component housing one or more infrared emitters

Note 1 to entry: The module can include reflectors, refractors, filters, or other means for protecting the emitter as well as cooling devices.

3.116
infrared shield
opaque component designed to stop infrared radiation from being transmitted through it

3.117
protection shield
shield used for the radiation protection of people or equipment

3.118
filter
partially transparent, partially absorbing or reflecting component, designed to reduce transmission at selected wavelength

3.119
infrared barrier
physical barrier, which limits access to areas of potentially hazardous irradiation, and can only be removed with the aid of a tool

3.120
infrared enclosure
structure intended to confine the infrared radiation to a defined region

EXAMPLE Closed treatment chamber, infrared shield, infrared reflector.

Note 1 to entry: Infrared barriers mounted outside the infrared enclosure are not considered as part of it.

3.121
rated temperature
maximum surface temperature of the infrared filament or infrared emitter at rated voltage

Note 1 to entry: This temperature is used for the determination of the spectral emission of thermal infrared emitters.

Note 2 to entry: The temperature applies under conditions of normal operation.

4 Classification of electroheating equipment

This clause of Part 1 is applicable.

5 General requirements

This clause of Part 1 is applicable except as follows.

5.1.5

Addition:

Bare conductors shall be placed in such a way that they cannot come into contact with persons, the workload, or the workload handling equipment under normal operating conditions or single fault conditions. Exception may be made for bare conductors supplied from sources which comply with the requirements for safety of extra-low voltage (SELV) supplied in accordance with IEC 60364-4-41.

Bare conductors may be used to contact infrared emitters in hot environments, or they may be the infrared source as such.

5.2.1

Addition:

In case of parts of infrared equipment inside a vacuum, the voltage applied to all such parts subjected to subatmospheric pressure shall be chosen in such a way that no flashover or breakdown occurs.

In most cases this limits the voltage difference inside the vacuum to about 80 V.

5.2.5

Addition:

Precautions shall be taken to ensure that the workload or auxiliary equipment for example handling, transport and charging devices do not constitute a source of damage to the infrared emitters or modules. Special care is needed to avoid damage to infrared quartz emitters and halogen lamp emitters.

Additional subclauses:

5.3.101 If the filament material or the infrared source has a substantially higher specific electric resistivity at rated temperature than at ambient – exceeding 130 % of ambient resistivity at rated temperature – this inrush current effect shall be taken into account in the

design and specification of conductors and other associated components as fuses as well as with regard to voltage fluctuations and flicker.

The exact value of the inrush current and its duration depend inter alia on the material, the electric impedance of the complete feeding circuit, the temperature of the source or filament in the cold state, and the equilibrium temperature of the filaments at applied voltage.

This effect is very pronounced with filaments made from refractory metals such as tungsten.

5.5.101 Hazards from infrared radiation

Infrared equipment and installations shall be so designed and constructed that emission of infrared radiation is limited to the extent necessary for their operation and that their effects on exposed persons are non-existent or reduced to non-hazardous proportions.

The safety limits of hazardous exposure are defined in Annex AA (which is in accordance with IEC 62471:2006). It shall be taken into account, if not otherwise required by national regulations.

The following conditions can lead to hazardous exposure:

– Emission of radiation through the entrance and exit ports of continuously operating equipment;
– Emission of radiation when door(s) of batch equipment are opened during process or stay open and the equipment, the workload or infrared emitters have not cooled down in advance;
– Emission of radiation by a very hot workload after leaving the infrared installation;
– Emission of radiation caused by insufficient precautions during maintenance or commissioning;
– If infrared emitters or modules are operated outside the infrared equipment;
– If infrared reflectors or refractors or reflective walls inside the infrared installation cause zones of intense irradiation outside the installation;
– If hot walls and wavelength converters inside the infrared equipment cause zones of intense irradiation outside the installation.

Different phases of the life cycle of the equipment can cause different levels of radiation emission.

5.5.102 Procedure for reducing risk from infrared radiation

If the equipment can cause hazardous emission of infrared radiation during some stages of its life cycle, the procedure given in Table 101 shall be used for risk assessment and risk reduction.

Some steps of the procedure for assessing and reducing radiation exposure of persons from the equipment through technical means depend on the product being a unique installation made to order or being manufactured repetitively. Repetitively manufactured equipment and made to order equipment usually vary in the design process. Manufacturers and users usually agree jointly on the design only in the design process for made to order equipment. Therefore, in this case responsibility for design decisions can be shared between the manufacturer and user.

Table 101 – Procedure for assessment and reduction of radiation exposure through design

<table>
<tr><th></th><th>Made to purpose industrial equipment</th><th>Repetitively manufactured industrial equipment</th></tr>
<tr><td></td><td>This is an individual process, to be undertaken for each installation individually.
The process takes place during the design, construction and commissioning phases of the product.</td><td>This process is type testing and done once and before placing the product on the market.
The procedure shall be repeated, if design changes can affect the emission of infrared radiation from the product.</td></tr>
<tr><td>a)</td><td>Specify the design target of risk groups according to intended purpose, environment, and national regulations for all phases of the life cycle. The manufacturer can involve the user during this process.
Annex AA shall be used if no national regulations apply for the definition of design targets.</td><td>Specify the design target of risk groups according to intended purpose, environment, and national regulations for all phases of the life cycle.
Annex AA shall be used if no national regulations apply for the definition of design targets.</td></tr>
<tr><td>b)</td><td colspan="2">Characterize all infrared emission caused by the equipment, direct and indirect for all stages of operation, considering
– the number of sources;
– the geometry of the emitters for example point source, tubular infrared emitter, infrared plate emitter;
– the emitted spectrum of the emitters – which depends on rated temperature, emissivity of the surfaces as well as on the conditions during normal operation;
– the surface area of emitting sources or surfaces and emitted power from there depending on operation conditions;
– the direction of emission of all emitting surfaces;
– the temporal reaction of the sources.</td></tr>
<tr><td>c)</td><td>Define intended directions of irradiation, intensity of intended irradiation and access to the irradiated area.
The point of use and possible interference with other equipment or processes shall be retrieved from the user, if possible.</td><td>Define intended directions of irradiation, intensity of intended irradiation and access to the irradiated area for the equipment.</td></tr>
<tr><td>d)</td><td colspan="2">Review available materials for infrared shields, protection shields, infrared barriers, enclosures or filters. The materials shall be able to withstand all environmental conditions and the effects of all conditions of irradiation caused during the intended purpose of the equipment and for expected failure modes.</td></tr>
<tr><td>e)</td><td>The manufacturer shall involve the user when making the necessary design decisions. Design decisions shall be based on Annex DD.</td><td>The manufacturer makes design decisions. They shall be based on Annex DD.</td></tr>
<tr><td>f)</td><td colspan="2">Either proceed to step h) or calculate emission and exposure of the equipment according to Annex CC and compare the results with the specified levels set in step a).</td></tr>
<tr><td>g)</td><td colspan="2">If calculated results show discrepancy with the specified levels as set in step a), make changes in the design by repeating steps e) and f).</td></tr>
<tr><td>h)</td><td>Manufacture and install the equipment at the user's site.
Measure in accordance with Annex BB in the following cases:
– no calculation regarding step f) has been undertaken;
– calculations regarding step f) or the design need verification.</td><td>Manufacture the equipment.
Measure in accordance with Annex BB in the following cases:
– no calculation regarding step f) has been undertaken;
– calculations regarding step f) or the design need verification.</td></tr>
<tr><td>i)</td><td>If the measured results show discrepancy with the specified levels set in step a), decide on necessary measures: design improvements, shields, barriers, or organisational means.
If agreed on, make changes in the design and repeat steps e), h) and i).</td><td>If measured results show discrepancy with the specified levels set in a), make changes in the design and repeat steps e), h) and i).</td></tr>
<tr><td>j)</td><td colspan="2">Prepare the documentation and instructions for commissioning and maintenance, list the necessary organisational means.</td></tr>
</table>