

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Electrical resistance trace heating systems for industrial and commercial applications –

Part 1: General and testing requirements

Systèmes de traçage par résistance électrique pour applications industrielles et commerciales –

Partie 1: Exigences générales et d'essai



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**Electrical resistance trace heating systems for industrial and commercial applications –
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**Systèmes de traçage par résistance électrique pour applications industrielles et commerciales –
Partie 1: Exigences générales et d'essai**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL RESISTANCE TRACE HEATING SYSTEMS
FOR INDUSTRIAL AND COMMERCIAL APPLICATIONS –****Part 1: General and testing requirements**

FOREWORD

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International Standard IEC 62395-1 has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing.

This second edition cancels and replaces the previous edition published in 2006 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Tests have been added for trace heating on sprinkler systems;
- The flammability test has been changed to align with the latest draft of future IEC/IEEE 60079-30-1¹;

¹ Under consideration.

- A supplementary test has been added for the verification of sheath temperature using trace heating mounted on a plate fixture.

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

FDIS	Report on voting
27/926/FDIS	27/935/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 62395 series, published under the general title *Electrical resistance trace heating systems for industrial and commercial applications*, can be found on the IEC website.

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- withdrawn,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.

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INTRODUCTION

IEC 62395-1 provides the essential requirements and testing appropriate to electrical resistance trace heating equipment used in industrial and commercial applications. While some of this work already exists in national or international standards, this standard has collated much of this existing work and added considerably to it.

IEC 62395-2 provides detailed recommendations for the system design, installation and maintenance of electric trace heating systems in industrial and commercial applications.

It is the objective of IEC 62395 that, when in normal use, electrical trace heating systems operate safely under their defined conditions of use, by

- a) employing heaters of the appropriate construction and meeting the test criteria detailed in IEC 62395-1. The construction includes a metallic sheath, braid, screen or equivalent electrically conductive covering;
- b) operating at safe temperatures when designed, installed, and maintained in accordance with IEC 62395-2.
- c) having at least the minimum levels of overcurrent and earth-fault protection required in IEC 62395-1 and IEC 62395-2.

ELECTRICAL RESISTANCE TRACE HEATING SYSTEMS FOR INDUSTRIAL AND COMMERCIAL APPLICATIONS –

Part 1: General and testing requirements

1 Scope

This part of IEC 62395 specifies requirements for electrical resistance trace heating systems and includes general test requirements.

This standard pertains to trace heating systems that may comprise either factory-fabricated or field-assembled (work-site) units, and which may be series and parallel trace heaters or surface heaters (heater pads and heater panels) that have been assembled and/or terminated in accordance with the manufacturer's instructions.

This standard also includes requirements for termination assemblies and control methods used with trace heating systems.

This standard provides the essential requirements and testing appropriate to electrical resistance trace heating equipment used in industrial and commercial applications. The products certified according to this standard are intended to be installed by persons who are suitably trained in the techniques required and that only trained personnel carry out especially critical work, such as the installation of connections and terminations. Installations are intended to be carried out under the supervision of a qualified person who has undergone supplementary training in electric trace heating systems.

This standard does not include or provide for any applications in potentially explosive atmospheres.

This standard does not cover induction, impedance or skin effect heating.

Trace heating systems can be grouped into different types of applications and the different conditions found during and after installation necessitate different requirements for testing. Trace heating systems are usually certified for a specific type of installation or application. Typical applications for the different types of installation include, but are not limited to:

- a) installations of trace heating for surface heating on pipes, vessels and associated equipment – applications include:
 - freeze protection and temperature maintenance;
 - hot water lines;
 - oil and chemical lines;
 - sprinkler system mains and supply piping;
- b) outdoor exposed area installations of trace heating – applications include:
 - roof de-icing;
 - gutter and down-spout de-icing;
 - catch basins and drains;
 - rail heating²;

² Further evaluation may be required to address application specific conditions such as fluctuations in impressed voltage and voltage spikes.

- c) installation with embedded trace heating – applications include:
 - snow melting;
 - frost heave protection;
 - floor warming;
 - energy storage systems;
 - door frames;
- d) installations of trace heating internal to conduit and piping – applications include:
 - snow melting – in conduit;
 - frost heave protection – in conduit;
 - floor warming – in conduit;
 - energy storage systems – in conduit;
 - internal trace heating for freeze protection of potable water lines;
 - enclosed drains and culverts.

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 60068-2-5, *Environmental testing – Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing*

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

IEC 60519-10, *Safety in electroheating installations – Part 10: Particular requirements for electrical resistance trace heating systems for industrial and commercial applications*

IEC 62395-2:2013, *Electrical resistance trace heating systems for industrial and commercial applications – Part 2: Application guide for system design, installation and maintenance*

ASTM D 5025-05, *Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*

ASTM D 5207-09, *Standard Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60519-10 and the following apply.

NOTE 1 General definitions are given in the International Electrotechnical Vocabulary, IEC 60050. Terms relating to industrial electroheat are defined in IEC 60050-841.

NOTE 2 The terms defined in this clause are used both in IEC 62395-1 and IEC 62395-2.

3.1

ambient temperature

temperature surrounding the object under consideration

Note 1 to entry: Where trace heaters or surface heaters are enclosed in thermal insulation, the ambient temperature is the temperature exterior to such thermal insulation.

3.1.1

maximum ambient temperature

the highest specified ambient temperature

3.1.2

minimum ambient temperature

the lowest specified ambient temperature

Note 1 to entry: Heat-loss calculations in IEC 62395-2 are based on the minimum ambient temperature.

3.2

branch circuit

portion of the wiring installation between the overcurrent device protecting the circuit and the trace heater(s) or surface heater(s)

3.3

cold lead

electrically insulated conductor or conductors used to connect a trace heater or surface heater to the branch circuit and designed so that it does not produce significant heat

3.4

connection

termination or splice used to attach trace heaters or surface heaters to power wiring or to connect sections of these devices

3.5

dead leg

segment of process piping segregated from the normal flow pattern for the purpose of providing a heat loss reference

3.6

design loading

minimum power that will meet the design requirements, in the worst conditions, after voltage and resistance tolerances and appropriate safety factors have been considered

3.7

electrically conductive covering

metallic sheath, metallic braid, or electrically conductive material

3.8

end termination

termination, which may be heat producing, applied to a trace heater at the end opposite to that where the power is supplied

[SOURCE: IEC 60050-426:2008, 426-20-04]

3.9

factory-fabricated unit

trace heater unit or set or surface heater unit or set, including the necessary terminations and connections, assembled by the manufacturer

3.10

field-assembled unit

trace heaters or surface heaters supplied unterminated with terminating components to be assembled at the work site

3.11

heat loss

energy flow from a pipe, vessel or equipment to its surroundings

3.12

heat sink

part that conducts and dissipates heat away from a workpiece

Note 1 to entry: Typical heat sinks are pipe shoes, pipe supports and items of large mass such as valve actuators or pump bodies.

3.13

heat transfer aids

thermally conductive materials, such as metallic foils or heat transfer compounds used to increase the heat-transfer efficiency from trace heaters or surface heaters to the workpiece

3.14

heater pad

surface heater, comprising series or parallel connected elements having sufficient flexibility to conform to the shape of the surface to be heated

3.15

heater panel

non-flexible surface heater, comprising series or parallel connected elements fabricated to conform to the general shape of the surface to be heated

3.16

high limit temperature

maximum allowable temperature of the system, including piping, fluid and trace heating system

3.17

integral component

component such as a heat shrink termination, a cold lead connection, a moulded end seal or a splice, which conforms to the general shape of the trace heater or surface heater and is exposed to the same environment as the trace heater or surface heater, which may be factory-fabricated or field-assembled, and which is not intended to be re-used in the event of a repair or modification

3.18

low risk of mechanical damage

installations and applications where only lower levels of impact and deformation are expected to occur

3.19

maximum sheath temperature

maximum temperature of the outermost continuous covering of the trace heater or surface heater

3.20

maximum withstand temperature

maximum operating or exposure temperature that does not adversely affect the thermal stability of the trace heater or surface heater and its component parts

3.21

operating voltage

actual voltage applied to the trace heater or surface heater when in service

3.22**overjacket**

continuous layer of material applied outside the electrically conductive covering to protect against corrosion

3.23**parallel trace heater**

heating elements electrically connected in parallel, with the heating element either continuous or in discrete units or zones, such that the watt density per unit length is not significantly changed with any change in circuit length

3.24**power density**

power output in watts per linear metre for trace heaters, and in watts per square metre for surface heaters

3.25**power termination**

termination applied to the end of a trace heater or surface heater at which the power is supplied

3.26**rated output**

total power or power per unit length or unit surface area of the trace heater or surface heater, at rated voltage and temperature, which is normally expressed in watts, watts per metre or watts per square metre

3.27**rated voltage**

voltage assigned by the manufacturer to which operating and performance characteristics of trace heaters or surface heaters are referred

3.28**routine test**

test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.29**series trace heater**

heating elements electrically connected in series with a single current path and with a specific resistance at a given temperature for a given length

3.30**sheath**

uniform and continuous covering(s), metallic or non-metallic, enclosing the insulated conductor(s), used to protect the trace heater or surface heater against mechanical damage and influences from the surroundings (corrosion, moisture, etc.), which may provide an electrical path to enable an electrical protection device to operate as intended

Note 1 to entry: See overjacket (3.22).

3.31**stabilized design**

concept where the temperature of the trace heater or surface heater will, by design and use, stabilize below the limiting temperature, under the most unfavourable conditions, without the need for a protective system to limit the temperature

3.32

start-up current

current of a trace heater or surface heater immediately upon energizing

3.33

surface heater

heater pad or panel intended to provide heat over a relatively large area, typically constructed of one or more metallic conductors that may also include one or more discrete or continuous electric heating elements, suitably insulated and protected

3.34

surface heater unit

surface heater suitably terminated in conformity with the manufacturer's instructions

3.35

system documentation

information typically provided by the supplier to allow satisfactory understanding, installation and safe use of the trace heating system

3.36

tee

electrical connection of trace heaters or surface heaters, in series or in parallel, to accommodate a branch in the circuit and resembling the shape of a capital T

3.37

temperature controller

device or combination of devices incorporating a means of sensing temperature and of controlling the power supplied to the trace heater or surface heater

3.38

temperature sensor

device designed to respond to temperature providing an electrical signal or mechanical operation

3.39

thermal insulation

material having air- or gas-filled pockets, void spaces, or heat-reflecting surfaces that, when properly applied, retard the transfer of heat

3.40

trace heater

device of linear geometry designed for the purpose of producing heat on the principle of electrical resistance

3.41

trace heater unit

trace heater suitably terminated in conformity with the manufacturer's instructions

3.42

trace heating

utilization of trace heaters and surface heaters as well as support components, designed for the purpose of producing heat through heating elements electrically connected in series or in parallel, used to maintain or raise temperatures of piping, tanks and other surfaces

3.43

type test

conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.44

weather barrier

material that, when installed on the outer surface of thermal insulation, protects the thermal insulation from water or other liquids, from physical damage caused by sleet, wind or mechanical abuse, and from deterioration caused by solar radiation or atmospheric contamination

3.45

workpiece

object to which a trace heater is applied

4 General requirements

4.1 General

Electrical resistance trace heating systems within the scope of this standard shall be designed and constructed so as to ensure electrical, thermal and mechanical durability and reliable performance such that, in normal use, they pose no danger to the user or the surroundings.

Trace heaters which are identified for use only in areas with a low risk of mechanical damage are subjected to a reduced load in the impact tests in 5.2.4 and 5.2.5 and a reduced force in the deformation test in 5.2.6, and shall be clearly marked as specified in Clause 7.

Trace heaters and surface heaters may be supplied with additional mechanical protection to meet the requirements of this standard if they are supplied as an integral assembly (prefabricated), and shall be marked as required by Clause 7, item g).

Trace heating equipment intended for use in contact with potable water shall be constructed of materials that meet relevant toxicity requirements.

The manufacturer shall declare the maximum withstand temperature in degrees Celsius. The materials used in the trace heater or surface heater shall withstand a temperature 20 K greater than its maximum withstand temperature, when tested in accordance with 5.2.11.

4.2 Electrically conductive covering

Trace heaters and surface heaters shall be provided with an evenly distributed electrically conductive covering which shall cover at least 70 % of the surface. Surface heating units shall be constructed such that the electrically conductive covering shall be opposite the surface to be heated.

4.3 Electrical circuit protection requirements for branch circuits

The minimum requirements for trace heating systems are:

- a) a means of isolating all line conductors from the supply;
- b) over-current protection provided for each branch circuit;
- c) Earth-fault protection for each branch circuit.

The trace heater or surface heater branch circuit electrical protection shall be capable of interrupting earth faults, as well as short-circuit faults. An earth-fault protective device or a controller with earth-fault interruption capability shall be used. A nominal 30 mA trip rating is recommended except where capacitive leakage may lead to nuisance tripping, in which case devices having a trip current not greater than 300 mA may be used. These devices are intended for use in conjunction with circuit overcurrent protection. Where conditions of maintenance and supervision ensure that only qualified persons will service the installed

systems and continued circuit operation is necessary for the safe operation of the equipment or processes, earth-fault detection without interruption is acceptable if alarmed in a manner assuring an acknowledged response.

4.4 Temperature requirements

4.4.1 General

A trace heating system shall be designed so that under all conditions that may reasonably be foreseen, the surface temperature of the trace heater or surface heater does not exceed its maximum withstand temperature or any maximum system temperature ratings. This shall be achieved by a stabilized design or controlled design.

4.4.2 Stabilized design

Stabilized design applications, in which the maximum surface temperature of the trace heater or surface heater is determined without thermostatic control, shall employ either the systems approach specified in 5.2.13.2 or the product approach specified in 5.2.13.3.

4.4.3 Controlled design

The surface temperature obtained through controlled design is based on energy limitation by temperature controllers or limiting devices.

5 Testing

5.1 Type tests – General

All trace heaters and surface heaters shall meet the requirements of the type tests given in 5.2. Trace heaters and surface heaters intended for applications described in Clause 1, items b), c) and d) shall also meet the requirements of 5.3, 5.4 and 5.5, respectively.

Samples of trace heaters selected for testing shall be at least 3 m in length, unless otherwise specified.

Integral components shall be subjected to the same type test as the trace heater or surface heater unless otherwise noted. System components, other than those identified as integral, shall be evaluated in accordance with standards relevant to their construction and use.

Tests shall be conducted at a room temperature between 10 °C and 40 °C unless otherwise specified.

Separate samples shall be used for each test unless otherwise specified. These shall be prepared in accordance with the manufacturer's recommendations.

5.2 Type tests – All applications

5.2.1 Dielectric test

The dielectric test shall be performed on trace heaters or surface heaters in accordance with Table 1.

Table 1 – Test voltages for the dielectric test

Rated voltage U	Test voltage V a.c. (r.m.s.)
< 30 V a.c. (r.m.s.)	500
< 60 V d.c.	500
≥ 30 V a.c. (r.m.s.)	$2U + 1\,000$
≥ 60 V d.c.	$\sqrt{2}U + 1\,000$

For single conductor series trace heaters or surface heaters the voltage shall be applied between the conductor and the metallic sheath, braid, screen or equivalent electrically conductive covering.

For multi-conductor series trace heaters or surface heaters the voltage shall be applied between the conductors connected together and the metallic sheath, braid, screen or equivalent electrically conductive covering, and also between each conductor in turn with the remaining conductor(s) connected together.

For parallel trace heaters or surface heaters the voltage shall be applied between the conductors connected together and the metallic sheath, braid, screen or equivalent electrically conductive covering.

Alternatively the dielectric test may be conducted by submerging the trace heaters or surface heaters in tap water at room temperature (resistivity typically $50\,000\ \Omega\cdot\text{cm}$). The test voltage shall be applied between the heating conductors and the water.

The rate of rise shall be neither less than 100 V/s nor more than 200 V/s and maintained for 1 min at the specified test voltage without dielectric breakdown. The test voltage waveform shall be essentially sinusoidal, with a frequency of 45 Hz to 65 Hz.

For type tests 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.2.11, 5.3.3, 5.3.8, 5.3.9, 5.5.3.2, 5.5.4 and 5.7.1, for MI trace heaters, the required test voltage in 5.2.1 is reduced to $2U + 500$ V a.c. for MI trace heaters rated at or over 30 V a.c. and to $\sqrt{2}U + 500$ V d.c. for MI trace heaters rated at or over 60 V d.c.

When determining U , the correct use of phase-to-phase or phase-to-neutral voltage levels shall be considered.

5.2.2 Electrical insulation resistance test

The electrical insulation resistance shall be measured on the test sample(s) prepared in accordance with 5.1 after the dielectric test specified in 5.2.1.

For single conductor series trace heaters or surface heaters the resistance of the electrical insulation shall be measured between the conductor and the metallic sheath, braid, screen or equivalent electrically conductive covering.

For multi-conductor series trace heaters or surface heaters where the conductors are electrically insulated from each other, the resistance of the electrical insulation shall be measured between the conductors connected together and the metallic sheath, braid, screen or equivalent electrically conductive covering, and also between each conductor in turn with the remaining conductor(s) connected together.

For parallel trace heaters or surface heaters the resistance of the electrical insulation shall be measured between the conductors connected together and the metallic sheath, braid, screen or equivalent electrically conductive covering.

The insulation resistance shall be measured by means of a d.c. voltage of at least 500 V. The measured value shall be not less than 50 M Ω .

5.2.3 Flammability test

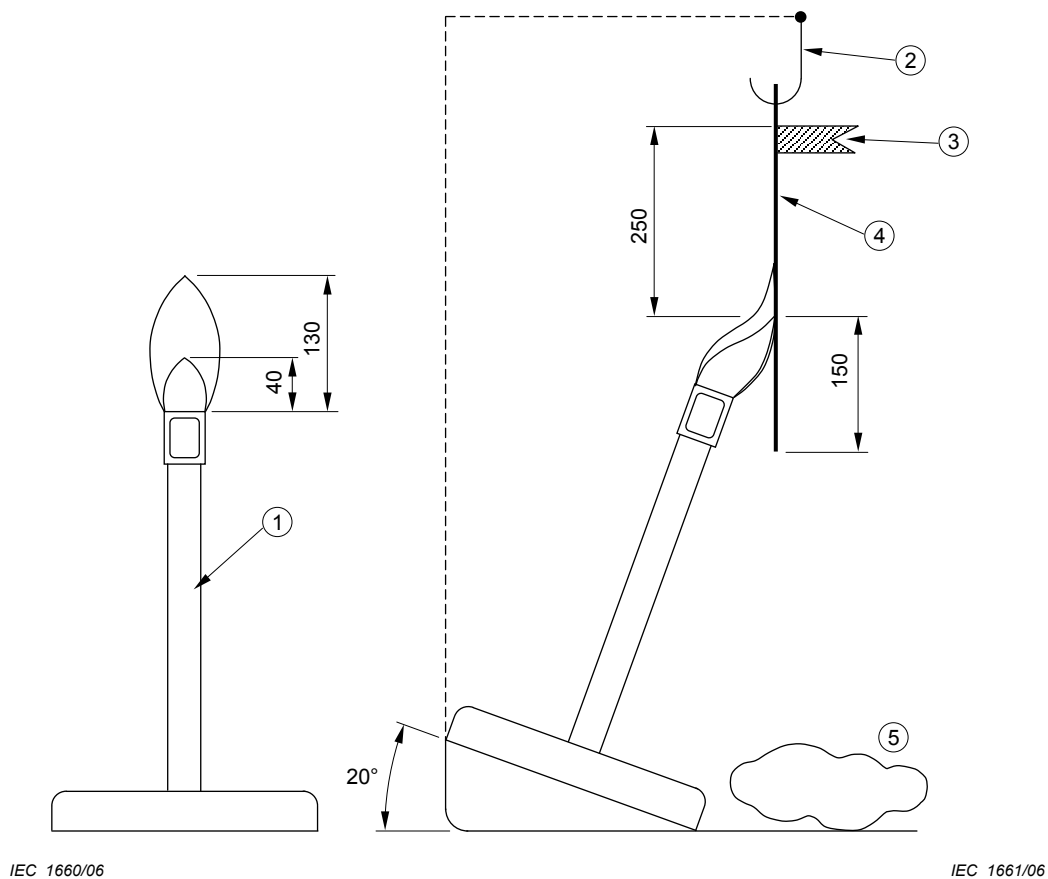
A flammability test shall be performed on trace heaters and surface heaters and also on trace heaters and surface heaters with integral components. The full range of sizes shall be capable of complying with the test. The test shall be made in a room free from draughts and carried out in a minimum volume of 0,5 cubic meters flame chamber or fume hood. For trace heaters, the sample shall be at least 450 mm in length, and shall be supported in a vertical position. For surface heaters the sample shall be as above with a maximum width of 80 mm.

A gummed unbleached paper indicator shall be wrapped once around the sample so that it projects 20 mm from the sample. The paper indicator shall be positioned 250 mm above the point at which the inner blue cone of the flame contacts the sample. A layer of dry, pure surgical cotton not more than 6 mm in depth shall be placed underneath the sample so that the distance from the cotton to the point of the flame application is 250 mm.

A laboratory burner described in ASTM D 5025-05 shall be used for the test. The gas flame produced by the burner is to be calibrated as described in ASTM D 5207-09. The fuel shall be methane, propane, or natural gas, and shall be of a grade suitable for calibration to the ASTM D 5207-09 procedure. As shown in Figure 1, the flame shall be adjusted to a 130 mm height with a 40 mm inner blue cone. The burner shall be tilted to an angle of 20° from the vertical and the flame applied to the heating device so that the tip of inner blue cone of the flame touches the specimen at a point 250 mm below the unbleached paper indicator and approximately 150 mm from the bottom of the sample. For termination assemblies, the flame shall be set such that it will contact the material at the most vulnerable point. Clamps used to support the sample shall be above the paper indicator and at least 80 mm below the point of flame application.

The flame shall be brought up to the sample in such a manner that the vertical plane containing the major axis of the burner tube shall be at right angles to the sample. For surface heaters, the flame is applied at the horizontal mid-point of the surface heater, with the unbleached paper indicator vertically above the flame using dimensions as shown in Figure 1. The flame shall be applied for 15 s and then removed for 15 s, until five such applications have been made.

The test results shall be considered satisfactory if the sample does not support combustion for more than 1 min after the fifth application of the flame, does not burn more than 25 % of the extended unbleached paper indicator, and does not ignite the cotton from burning falling particles.



IEC 1660/06

IEC 1661/06

Dimensions in mm

Figure 1a – Height of natural gas flames

Figure 1b – Vertical plane at right angles
to sample under test**Key**

- | | |
|-------------------------|----------------------------|
| 1 Burner | 4 Test sample |
| 2 Support | 5 Dry pure surgical cotton |
| 3 Unbleached paper flag | |

Figure 1 – Flammability test**5.2.4 Room temperature impact test**

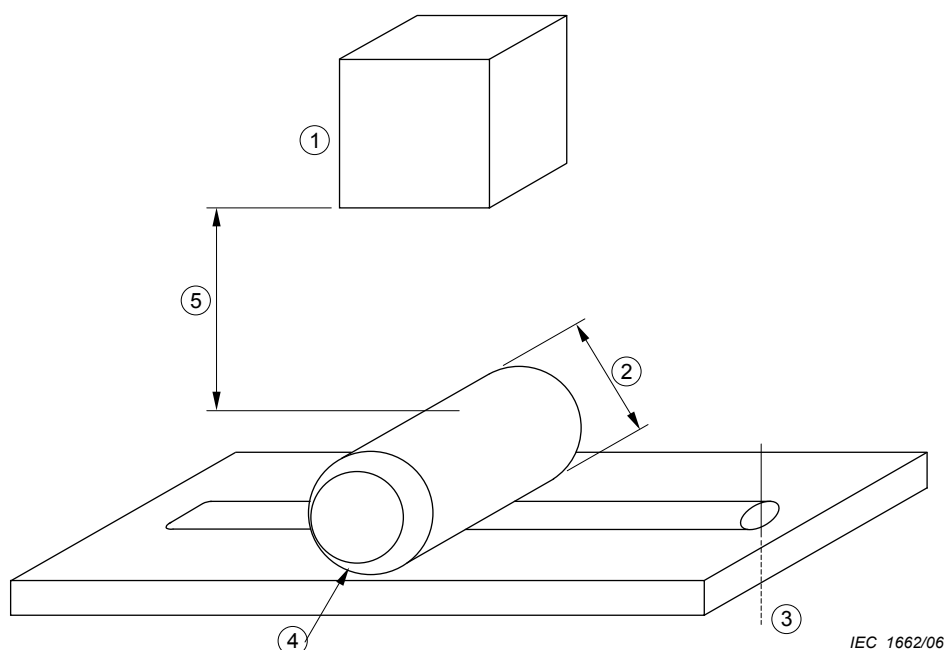
NOTE Electric trace heaters and surface heaters are, in the majority of applications, covered by thermal insulation and therefore afforded some mechanical protection. In some situations, however, trace heaters and surface heaters are not mechanically protected by thermal insulation. For example, during installation before the thermal insulation is applied or where the trace heater exits from the thermal insulation into a junction box or outdoor exposed area installations.

A sample approximately 200 mm in length is placed on a rigid flat steel plate (approximately 21 kg, 195 mm × 195 mm × 70 mm) on a rigid substrate such that the impact energy absorbed by the substrate is negligible. The sample is positioned underneath an intermediate piece of hardened steel in the shape of a horizontal cylinder with a diameter of 25 mm. This cylinder is required to have a length of 25 mm with smoothly rounded edges to a radius of approximately 5 mm when used to test surface heaters (see Figures 2 and 3). For the test, the cylinder is laid horizontally on the sample and, in the case of a trace heater, its axis is placed across the sample. A trace heater having a non-circular cross-section shall be so positioned that the impact is applied along the minor axis (that is to say the sample is positioned flat on the steel plate).

Other than in tests on electrical trace heaters intended for use in applications with low risk of mechanical damage, a hammer with a mass of 1 kg shall be allowed to fall once onto the horizontal cylinder from a height of 700 mm (nominal impact energy of 7 J).

For trace heaters and surface heaters intended for use in applications with low risk of mechanical damage, the height may be reduced to 400 mm (nominal impact load of 4 J). Trace heaters or surface heaters submitted to such a test shall be examined by the testing body to verify that the manufacturer's installation instructions adequately caution the user regarding the use of a trace heater or surface heater with reduced mechanical capability.

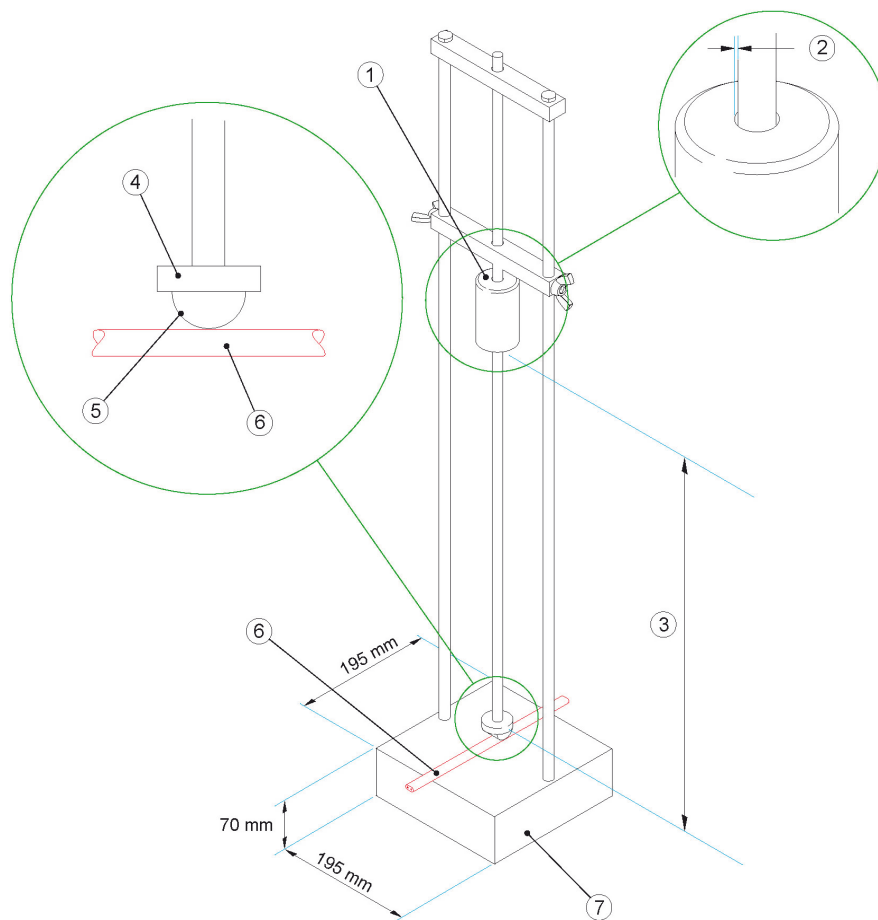
Conformity is verified by testing the electrical insulation in accordance with 5.2.1 and 5.2.2 while the steel cylinder and hammer are still in place on the sample.



Key

- | | |
|---|---|
| 1 Hammer with mass of 1 kg | 4 Cylinder with 25 mm overall length and 5 mm radius rounding when used to test heater pads and heater panels |
| 2 Cylinder with diameter of 25 mm | |
| 3 Minor axis of non-circular trace heater | 5 Height of fall of hammer: 700 mm or 400 mm |

Figure 2 – Room temperature impact test



IEC 2220/13

Key

- 1 Steel hammer with a mass of 1,0 kg
- 2 1,5 mm clearance between steel hammer and guide rod
- 3 Drop height measured from bottom surface of steel hammer to top surface of intermediate piece: 700 mm (or 400 mm for reduced impact energy test)
- 4 Hardened steel intermediate piece
- 5 Intermediate piece has a length of 25 mm, a diameter of 25 mm and both ends of the cylindrical shape have 5 mm radius (relevant only when testing samples wider than 25 mm)
- 6 Sample under test. Impact flatter side of non-circular samples
- 7 Rigid flat steel plate

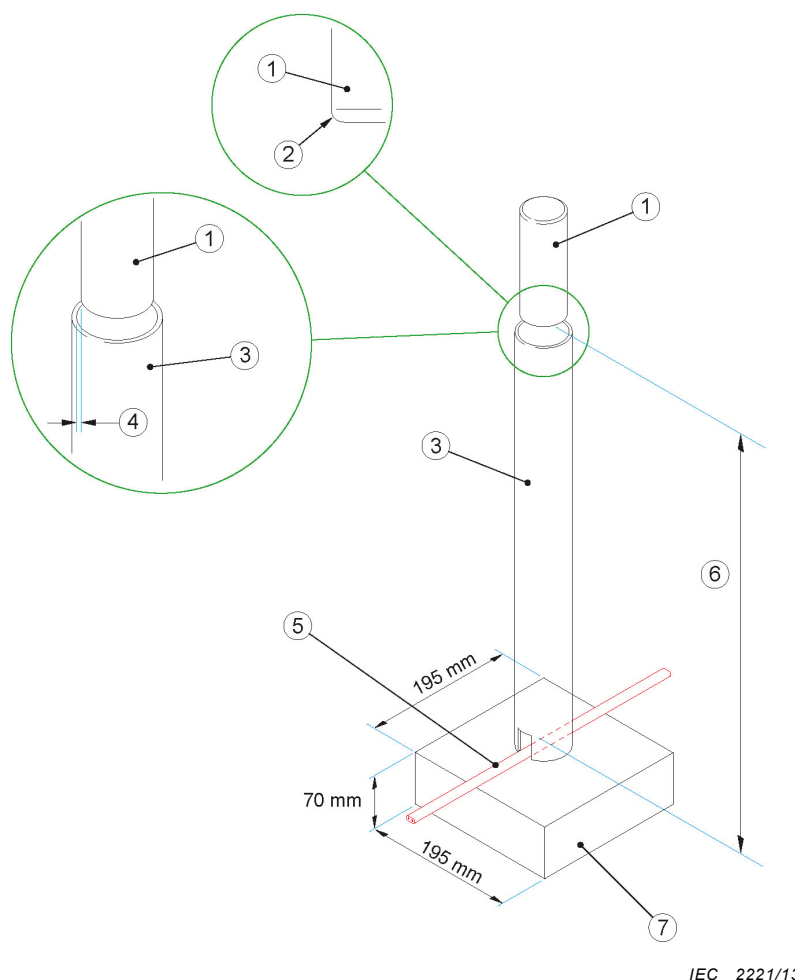
Figure 3 – Example of room temperature impact test apparatus**5.2.5 Minimum temperature impact test**

A sample approximately 450 mm in length positioned on a hardened steel plate (with a mass equal to or greater than 20 kg, 195 mm × 195 mm × 70 mm). The plate is positioned on a rigid substrate such that the impact energy absorbed by the substrate is negligible. The assembly is then conditioned for a minimum of 4 h at the manufacturer's minimum recommended installation temperature. (See Figure 4).

After conditioning, and other than in tests on trace heaters intended for use in applications with low risk of mechanical damage, a sample, whilst still at the minimum recommended installation temperature, shall be subjected to a 50,8 mm diameter cylindrical steel plunger with a smoothly rounded edge (with a radius of approximately 5 mm) around the bottom flat impacting surface, having a mass of 1,8 kg and allowed to free fall from a height of 762 mm, resulting in a nominal impact energy of 13,6 J.

For trace heaters intended for use in applications with a low risk of mechanical damage in accordance with 4.1, the height shall be reduced to 420 mm (i.e. a nominal impact energy of 7,5 J). Trace heaters submitted to such a test shall have information in the installation instructions that adequately caution the user regarding the use of a trace heater with reduced mechanical capability. See Clause 7.

The impacted portion of the sample shall then be immersed in tap water at 10 °C to 25 °C for 5 min, and the dielectric test 5.2.1 and insulation resistance test 5.2.2 shall be successfully completed. For surface heaters, both the heating region and cold leads shall be impacted.



IEC 2221/13

Key

- | | |
|--|---|
| 1 Steel hammer with a mass of 1,8 kg and a diameter of 50,8 mm | 5 Sample under test. Impact flatter side of non-circular samples |
| 2 5 mm radius around the bottom edge of the cylindrical steel hammer | 6 Drop height measured from bottom surface of steel hammer to top surface of sample under test: 762 mm (or 420 mm for reduced impact energy test) |
| 3 Guide tube | 7 Rigid flat steel plate |
| 4 2 mm clearance between steel hammer and guide tube | |

Figure 4 – Example of minimum temperature impact test apparatus

5.2.6 Deformation test

A sample approximately 200 mm in length is placed on a rigid flat steel plate. A crushing force of 1 500 N is then applied for 30 s, without shock, by means of a 6 mm diameter steel rod with hemispherical ends and a total length of 25 mm. For the test, the rod is laid flat on the sample and in the case of a trace heater it is placed across a specimen at right angles. In the case of a surface heater, it is necessary to ensure that the cylinder rests across an active element.

For trace heaters and surface heaters intended for use in applications with low risk of mechanical damage, the crushing force may be reduced to 800 N. Trace heaters or surface heaters submitted to such a test shall be examined by the testing body to verify that the manufacturer's installation instructions adequately caution the user regarding the use of a trace heater or surface heater with reduced mechanical capability.

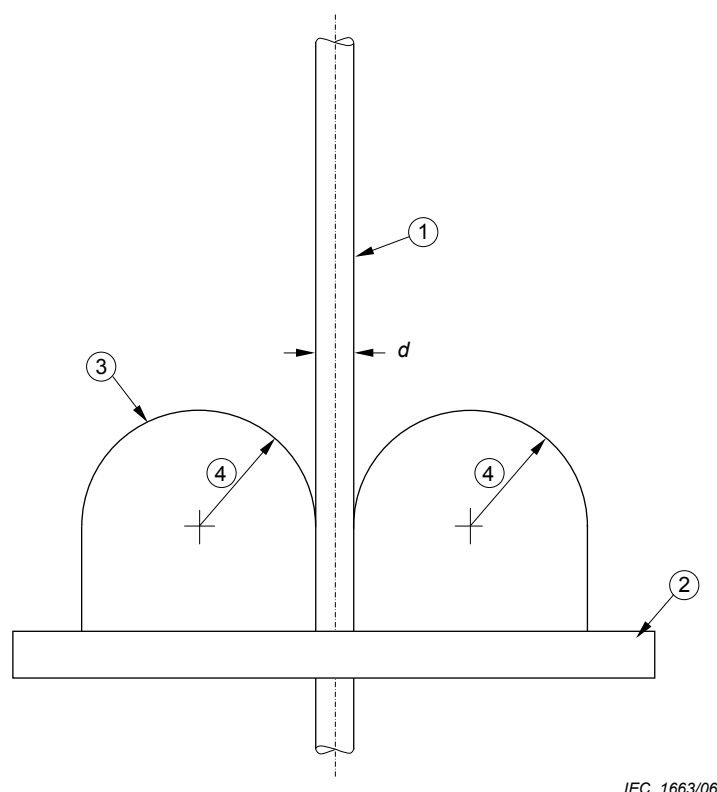
Conformity is verified by testing the electrical insulation in accordance with 5.2.1 and 5.2.2 while the horizontal steel rod is still in place on the sample and the load applied.

5.2.7 Cold bend test

This test applies only to trace heaters or surface heaters that have a stated minimum bending radius less than 300 mm.

The apparatus used for the cold bend test is shown in Figure 5, with the radius of the metal mandrel equal to the manufacturer's stated minimum bend radius. A sample of trace heater or surface heater, without integral components, shall be fixed in the apparatus as shown. The apparatus and sample shall be placed in a refrigerated compartment and maintained at the manufacturer's minimum recommended installation temperature for a period not less than 4 h. At the end of this period, and with the sample maintained at the minimum recommended installation temperature, the sample shall be bent through 90° around one of the mandrels, then bent through 180° in the opposite direction over the second mandrel and then straightened to its original position. All the bending operations shall be carried out in the same plane. This cycle of operations shall be performed three times and the rate of bend shall not be faster than 5 s per cycle.

Conformity is verified by testing the electrical insulation in accordance with 5.2.1 and 5.2.2 and the sample shall have no visible cracks when examined with normal vision.



Key

- | | |
|---|--|
| 1 Sample trace heater or surface heater | 3 Metal mandrel |
| 2 Metal base | d Trace heater diameter or primary bending plane |
| | 4 Manufacturer's stated minimum bend radius |

Figure 5 – Cold bend test

5.2.8 Water resistance test

A sample of trace heater at least 3 m in length without integral components, or a sample of surface heater, shall be immersed under at least 50 mm of tap water at 10 °C to 25 °C for a period of 336 h (14 days). After this period, the sample shall be tested using the dielectric voltage test, 5.2.1, and shall withstand this for 1 min without dielectric breakdown. The same sample shall then be tested using the electrical insulation resistance test, 5.2.2, and the measured value shall not be less than 50 MΩ.

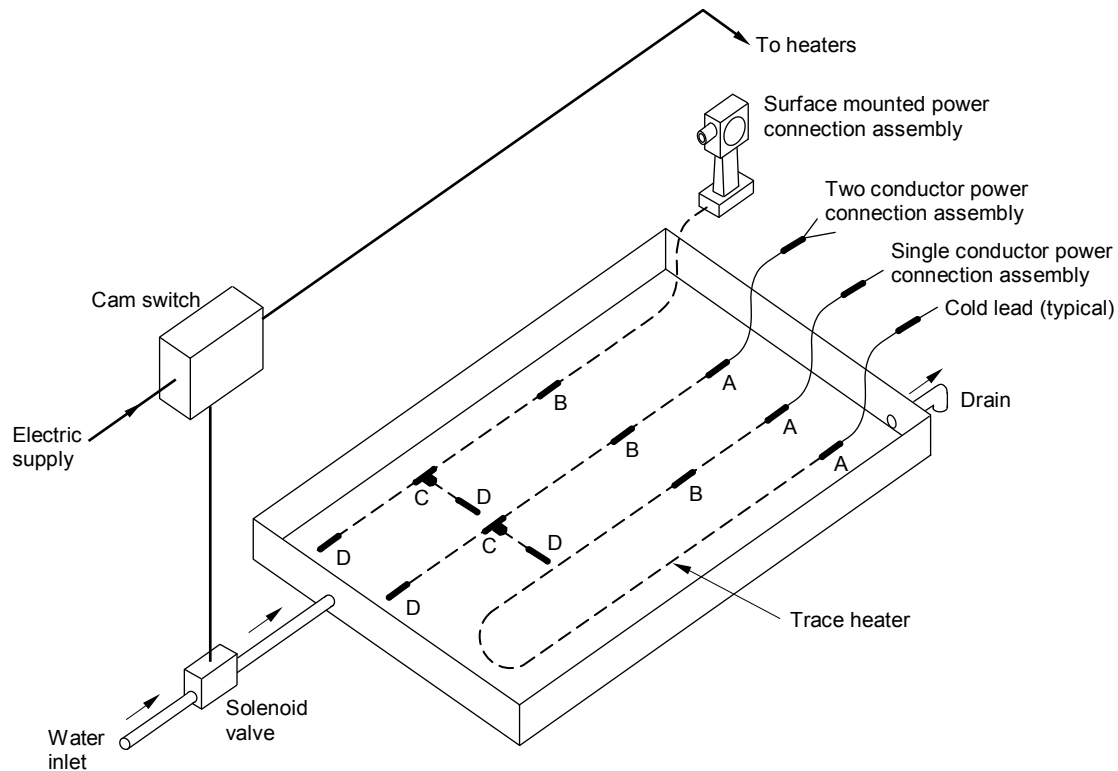
For samples supplied with overjackets, a section of the overjacket shall be removed prior to testing.

5.2.9 Integral components resistance to water test

A sample of trace heater at least 3 m in length, or a sample of surface heater, including integral terminations, shall be placed in a water flow and drain apparatus as shown in Figure 6. The rate of water flow shall be regulated to cover the sample and terminations completely for a period of at least 30 s every 5 min, after which it is drained off.

The voltage to the water flow solenoid and the voltage applied to the sample shall be controlled by a cam switch or equivalent means. The timing sequences shall be such that the sample shall be energized for 30 s after the water has been drained. The test shall be continued for a period of 24 h.

At the end of the test period, the sample shall be tested in accordance with 5.2.1. All immersed connections and immersed terminations shall be inspected to verify that no water ingress has occurred.



IEC 1664/06

Key

- | | |
|------------------------------|----------------------------|
| A Integral power connection | C Integral in-line tee |
| B Integral splice connection | D Integral end termination |

Figure 6 – Moisture resistance test

5.2.10 Verification of rated output

5.2.10.1 Verification methods

The rated output of the trace heater or surface heater shall be verified by one of the following methods described in 5.2.10.2 and 5.2.10.3.

5.2.10.2 Resistance method

The measured d.c. resistance per unit length at a specified temperature shall be within the manufacturer's declared tolerance.

5.2.10.3 Thermal methods

5.2.10.3.1 General

The thermal output of trace heaters or surface heaters shall be evaluated on a fixture representative of the intended application. The following procedures are appropriate for specific applications. For applications other than these, the testing body and the manufacturer shall determine an appropriate test.

In each of the following procedures, the trace heater or surface heater shall be powered at rated voltage and allowed to reach equilibrium. The voltage, current, workpiece temperatures and sample length or size shall be recorded at each test temperature.

For routine testing requirements, power output values for the methods in 5.2.10.3.3, 5.2.10.3.4, and 5.2.10.3.5 may be correlated to the method in 5.2.10.3.2.

5.2.10.3.2 Insulated surface applications

The thermal output of a trace heater is measured by installation of a single sample, 3 m to 6 m in length, on a carbon steel pipe of 50 mm diameter or greater, as shown in Figure 7. The sample is installed in accordance with the manufacturer's instructions. The test apparatus is completely covered with thermal insulation of 25 mm thickness.

For surface heaters, the test is conducted on a liquid-cooled flat metal plate with 25 mm of thermal insulation installed over the surface.

A suitable heat transfer liquid is circulated through the pipe at a sufficient rate to establish turbulent flow such that there is a negligible temperature difference between the fluid and the pipe. The heat transfer fluid is maintained at a constant temperature. These parameters are verified by thermocouples placed at the entry and exit ends of the pipe. Flow velocity shall be such that the fluid temperature does not differ by more than 2 K from end to end.

The thermal output of the trace heater or surface heater is measured at three pipe (or plate) temperatures representative of the full operating range. The trace heater or surface heater is powered at its rated voltage and allowed to attain equilibrium. The voltage, current and liquid temperatures (or plate temperatures), and sample length or size are recorded at each test temperature. Three separate determinations are made on separate samples. The resulting values shall be within the manufacturer's declared tolerance.

5.2.10.3.3 Outdoor exposed surface heating applications without thermal insulation

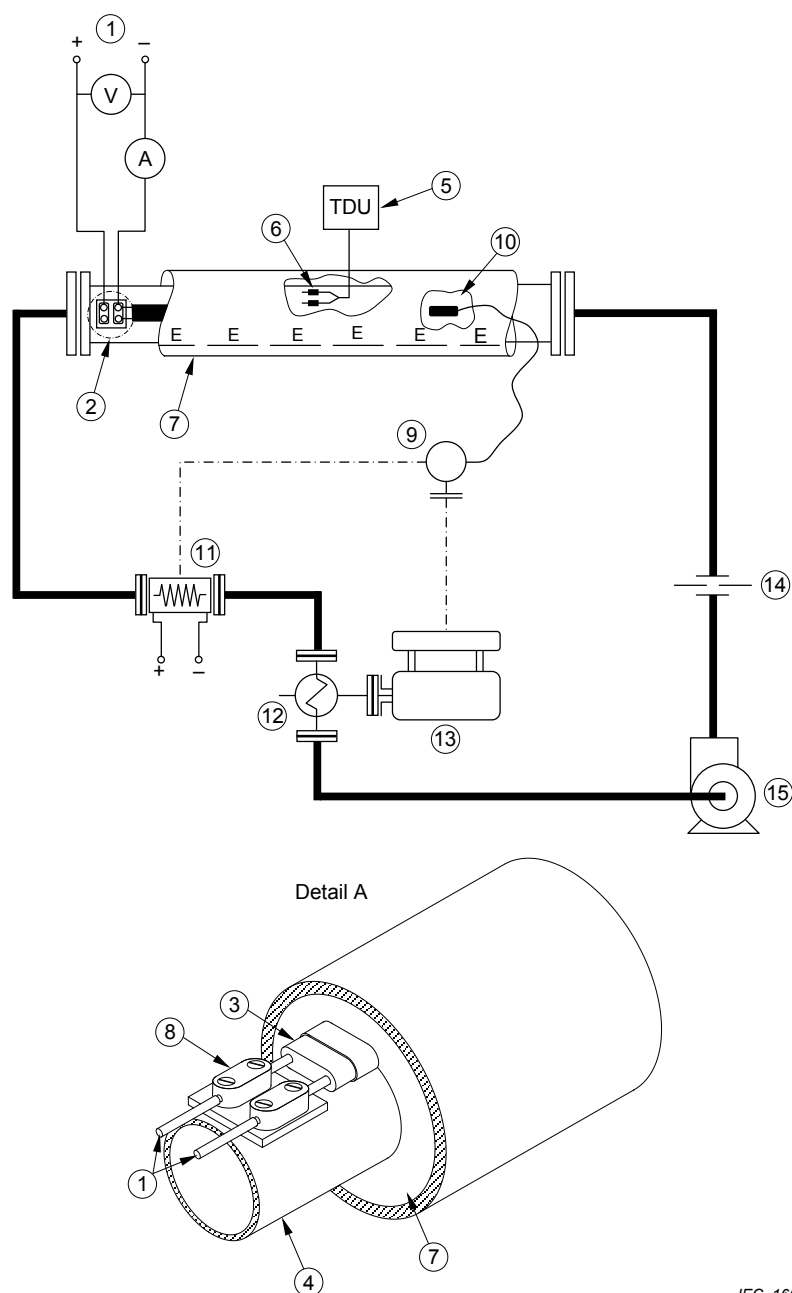
For trace heaters or surface heaters intended for outdoor exposed surface heating applications without thermal insulation, the test apparatus described in 5.2.13.2.4 shall be utilized, but with the trace heater installation not including any cross-over point. If the application is for roof and gutter heating, the trace heater shall additionally be tested in an ice bath to determine thermal output in ice conditions. Three separate determinations are made on separate samples. The resulting values shall be within the manufacturer's declared tolerance.

5.2.10.3.4 Embedded heating applications

For trace heaters intended for embedded heating, the test apparatus described in 5.2.13.2.5 shall be utilized, but with the trace heater installation not including any control/expansion joint or cross-over point. The resulting values shall be within the manufacturer's declared tolerance.

5.2.10.3.5 Applications of trace heating internal to conduit and piping

For trace heaters or surface heaters intended for installation internal to conduit and piping, the test apparatus described in 5.2.13.2.6 shall be utilized, but with the trace heater or surface heater installation not including any cross-over point. In addition, it is not necessary to include the vertical section of pipe or conduit. The resulting values shall be within the manufacturer's declared tolerance.



IEC 1665/06

Key

- | | | | |
|---|---|----|------------------------|
| 1 | Controlled voltage source | 8 | Electrical terminals |
| 2 | See detail A | 9 | Temperature controller |
| 3 | Trace heater or surface heater | 10 | Temperature sensor |
| 4 | Test pipe, outside diameter ≥ 50 mm | 11 | In-line heater |
| 5 | Temperature display unit | 12 | Heat exchanger |
| 6 | Thermocouple | 13 | Chiller |
| 7 | Fibre glass insulation, min. 25 mm thickness, approximate density of 3,25 kg/m ³ | 14 | Flow meter |
| | | 15 | Pump |

Figure 7 – Verification of rated output**5.2.11 Thermal stability of electrical insulating material**

The thermal stability of the electrical insulating materials of trace heaters and surface heaters shall be verified on a sample or prototype after it has been conditioned at 20 K greater than the manufacturer's declared maximum withstand temperature, for 28 days (with tolerance of +2/-0 days).

The sample shall be removed from the air oven and cooled to room temperature.

Flexible trace heater samples shall be wound six close turns around a mandrel having a radius equal to six times the diameter of a circular trace heater or six times the minor dimension of a non-circular trace heater. Integral components shall not be wound around the mandrel.

Surface heaters shall be wrapped on a mandrel with a radius equivalent to the manufacturer's minimum recommended bending radius.

While still on the mandrel the sample, except at terminations or ends where the conductor is exposed shall be submerged in tap water for 5 min. While still in the tap water, the dielectric test 5.2.1 and the insulation resistance test 5.2.2 shall be successfully completed.

Non-flexible trace heaters shall not be wrapped around a mandrel but shall also be submerged in tap water and tested.

Upon completion of the test, the sample shall have no visible cracks when examined with normal vision.

5.2.12 Thermal performance test for parallel trace heaters

The test apparatus shall consist of a metal platen(s) with the ability to change temperature within specified levels. The platen(s) shall be sized to expose all parts of the trace heater or surface heater samples, which would be exposed under normal installation conditions, to the temperature levels required by this procedure. The test apparatus shall ensure that the trace heater or surface heater samples are in intimate contact with the platen. The test apparatus may be supplied with a sample mounting fixture. Offsets may be built into the fixture or platen(s) to accommodate end termination/power transition fittings/boots, if provided, where their size profile exceeds the trace heater or surface heater profile. The apparatus shall allow energizing of the trace heater or surface heater samples as required during the test procedure.

The samples shall be thermally insulated on the side not facing the platen so as to assure effective heat transfer from the platen to the trace heater or surface heater samples.

The temperature of the platen(s) shall be uniformly controlled to a maximum tolerance of $\pm 5\text{ }^{\circ}\text{C}$ for platen temperatures less than $100\text{ }^{\circ}\text{C}$ or 5 % of the maximum continuous operating temperature if above $100\text{ }^{\circ}\text{C}$.

The platen described above may be a flat metal plate, a metal pipe, or a metal surface typical of the majority of applications for the trace heater or surface heater being tested.

The trace heater or surface heater samples shall be randomly selected and shall be a minimum of 0,3 m in length. Where the sample is irregular in shape, such as a surface heater, the sample shall consist of at least one heating unit.

If the trace heater or surface heater are part of a product range, with common materials (with materials having the same performance ratings) and construction, which have different levels of rated voltages and power outputs, then three samples each shall be selected that represent:

- the lowest rated voltage level and the maximum rated power output;
- the highest rated voltage and the minimum rated power output.

The trace heater or surface heater samples may be conditioned, at the maximum rated voltage for up to 150 h at the manufacturer's declared maximum continuous operating temperature prior to starting the test.

The trace heater or surface heater samples shall be installed on the sample mounting fixture or directly applied to the platen. The samples shall be powered at the maximum rated voltage. The temperature of the platen shall be 23 ± 5 °C. The initial power output of the samples shall be determined by measuring voltage and current after the device has reached equilibrium.

Samples of continuous parallel construction, while still installed on the sample mounting fixture or platen and energized at the maximum rated voltage, shall be temperature cycled by alternately exposing the samples to platen(s) temperatures corresponding to 23 ± 5 °C and the maximum continuous operating temperature. The samples are permitted to be de-energized during the cool down period.

Samples of zone type parallel construction shall be temperature cycled in the same manner with the exception that the samples shall be de-energized when not being held at the maximum continuous operating temperature.

If the cycle temperature range exceeds 350 °C, the lower temperature may be set at 350 °C below the maximum continuous operating temperature.

The energized samples shall be exposed to each of these temperature extremes for a minimum of 15 min and a transition time between extremes shall not exceed 15 min with a cycle being one complete exposure at both temperature extremes.

The heating device samples shall be subjected to a pre-conditioning period of 5 continuous temperature cycles. A minimum of 1 500 cycles shall then be performed.

Following the temperature cycling, the temperature of the platen(s) shall be raised to the maximum continuous exposure temperature or the maximum intermittent exposure temperature if higher, declared by the manufacturer and held for a period of no less than 250 h.

Where the maximum intermittent exposure temperature is declared as “power on”, the samples shall be energized at the maximum rated voltage.

The power output of the samples shall be measured during the final 300 seconds of every cold cycle, using the same method and platen temperature as used during the initial measurements. In the case of samples having a zone type parallel construction, the power output shall be measured during the final 300 seconds of every hot cycle.

After completion of the maximum exposure testing, the power output measurements of the samples shall be reviewed. The samples shall have maintained a power level within plus 20 % or minus 25 % of the initial measured output.

5.2.13 Determination of maximum sheath temperature

5.2.13.1 General

Maximum sheath temperatures of trace heaters and surface heater shall be determined to ensure the safe use of the heater(s). These sheath temperatures shall not exceed the maximum declared withstand temperature of the trace heater or surface heater.

The maximum allowable power density and sheath temperatures declared by the manufacturer shall be tested by at least one of the following methods.

- A systems approach (see 5.2.13.2), used to validate a manufacturer's design methodology and calculations, in which the trace heater or surface heater is subjected to a test condition where the manufacturer demonstrates ability to design and predict sheath temperatures by conducting specific tests with or without control. Testing for the systems approach may be omitted if test results from the product approach are used exclusively.