BS EN 62395-1:2013

BSI Standards Publication

Electrical resistance trace heating systems for industrial and commercial applications

Part 1: General and testing requirements

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National foreword

This British Standard is the UK implementation of EN 62395-1:2013. It is identical to IEC 62395-1:2013. It supersedes BS EN 62395-1:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/27, Electroheating.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Electrical resistance trace heating systems for industrial and commercial applications - Part 1: General and testing requirements

(IEC 62395-1:2013)

Systèmes de traçage par résistance électrique pour applications industrielles et commerciales - Partie 1: Exigences générales et d'essai (CEI 62395-1:2013)

Elektrische Widerstands-Begleitheizungen für industrielle und gewerbliche Zwecke - Teil 1: Allgemeine Anforderungen und Prüfanforderungen (IEC 62395-1:2013)

CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 27/926/FDIS, future edition 2 of IEC 62395-1, prepared by IEC/TC 27 "Industrial electroheating and electromagnetic processing" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62395-1:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-07-14
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-10-14

This document supersedes EN 62395-1:2006.

EN 62395-1:2013 includes the following significant technical changes with respect to EN 62395-1:2006:

- 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 60079-30-1 [1)];
- a supplementary test has been added for the verification of sheath temperature using trace heating mounted on a plate fixture.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

Endorsement notice

The text of the International Standard IEC 62395-1:2013 was approved by CENELEC as a European Standard without any modification.

1) Under consideration.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-5	-	Environmental testing - Part 2-5: Tests - Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing	EN 60068-2-5	-
IEC 60519-1	-	Safety in electroheating installations - Part 1: General requirements	EN 60519-1	-
IEC 60519-10	-	Safety in electroheating installations - Part 10: Particular requirements for electrical resistance trace heating systems for industrial and commercial applications	EN 60519-10	-
IEC 62395-2	2013	Electrical resistance trace heating systems for industrial and commercial applications - Part 2: Application guide for system design, installation and maintenance	EN 62395-2	2013
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		

CONTENTS

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 heating[2];

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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 ºC and 40 ºC 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 Ω·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 √2U + 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 MΩ.

5.2.3 Flammability test

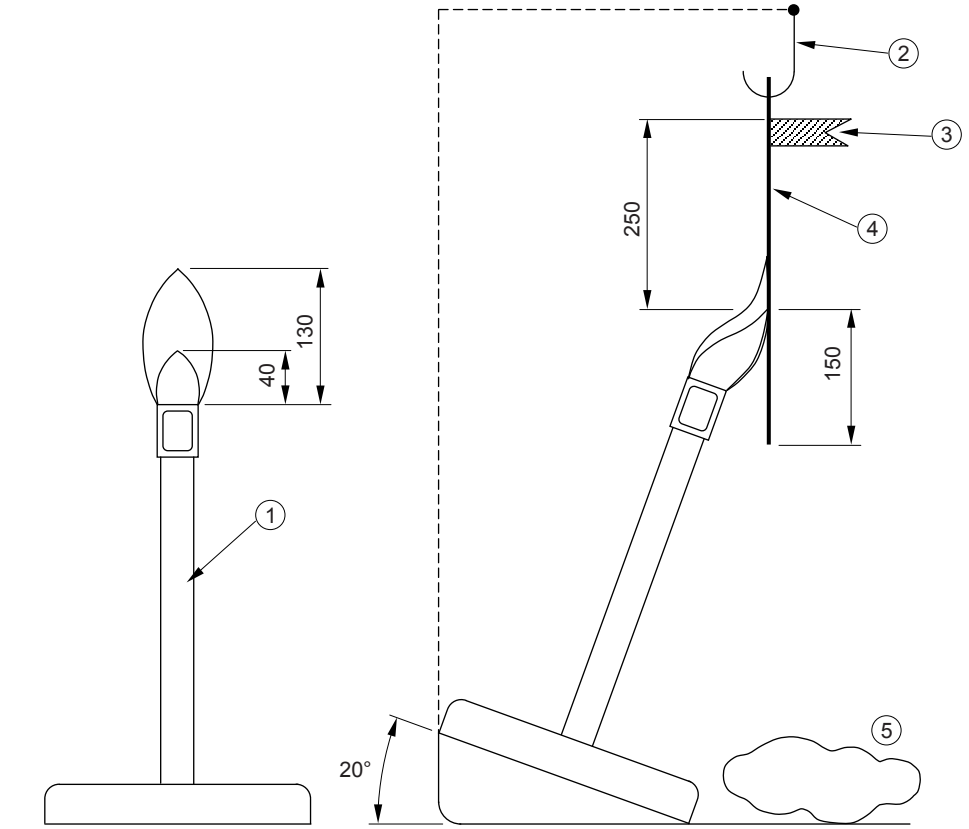
A flammability test shall be performed on trace heaters and surface heaters and also on trace heaters and surface heaters with integral components. The full range of sizes shall be capable of complying with the test. The test shall be made in a room free from draughts and carried out in a minimum volume 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.



Dimensions in mm

Figure 1a – Height of natural gas flames

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

Key

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

Figure 1 – Flammability test

5.2.4 Room temperature impact test

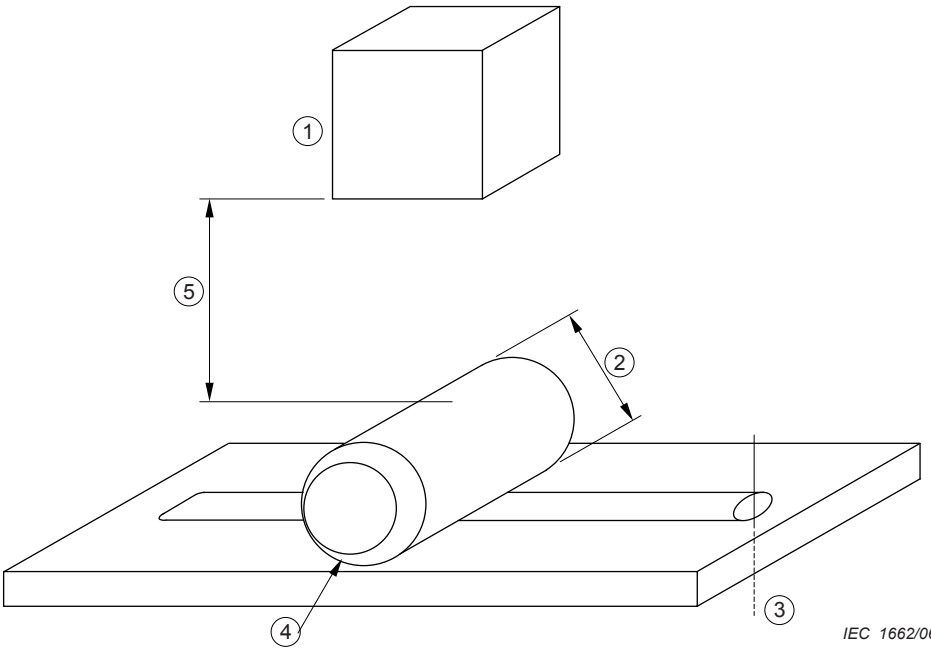
NOTE Electric trace heaters and surface heaters are, in the majority of applications, covered by thermal insulation and therefore afforded some mechanical protection. In some situations, however, trace heaters and surface heaters are not mechanically protected by thermal insulation. For example, during 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

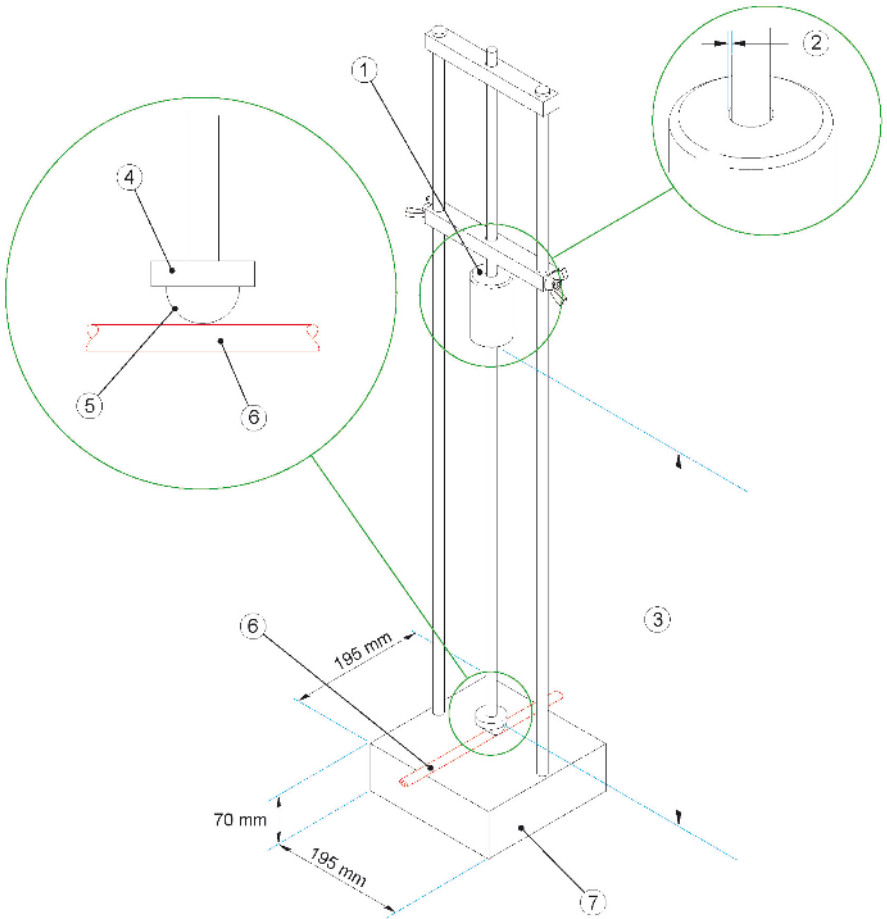
2 Cylinder with diameter of 25 mm

3 Minor axis of non-circular trace heater

4 Cylinder with 25 mm overall length and 5 mm radius rounding when used to test heater pads and heater panels

5 Height of fall of hammer: 700 mm or 400 mm

Figure 2 – Room temperature impact test



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

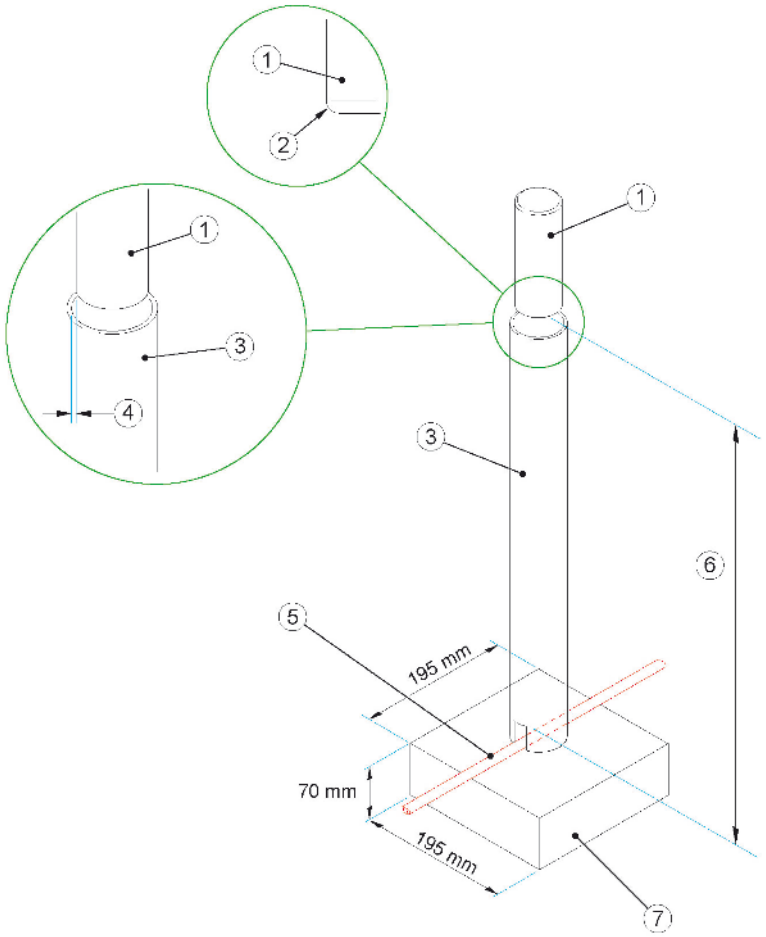
5.2.5 Minimum temperature impact test

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.



Key

1 Steel hammer with a mass of 1,8 kg and a diameter of 50,8 mm

2 5 mm radius around the bottom edge of the cylindrical steel hammer

3 Guide tube

4 2 mm clearance between steel hammer and guide tube

5 Sample under test. Impact flatter side of non-circular samples

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)

7 Rigid flat steel plate

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.

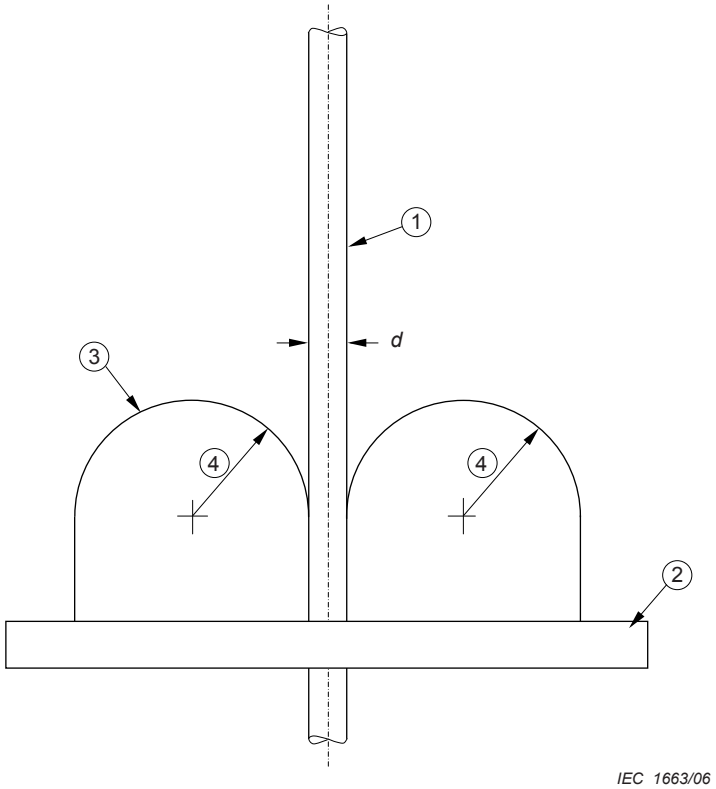
Conformity is verified by testing the electrical insulation in accordance with 5.2.1 and 5.2.2 while the horizontal steel rod is still in place on the sample and the load applied.

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 90º around one of the mandrels, then bent through 180º 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
2 Metal base
3 Metal mandrel
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 ºC to 25 ºC 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.

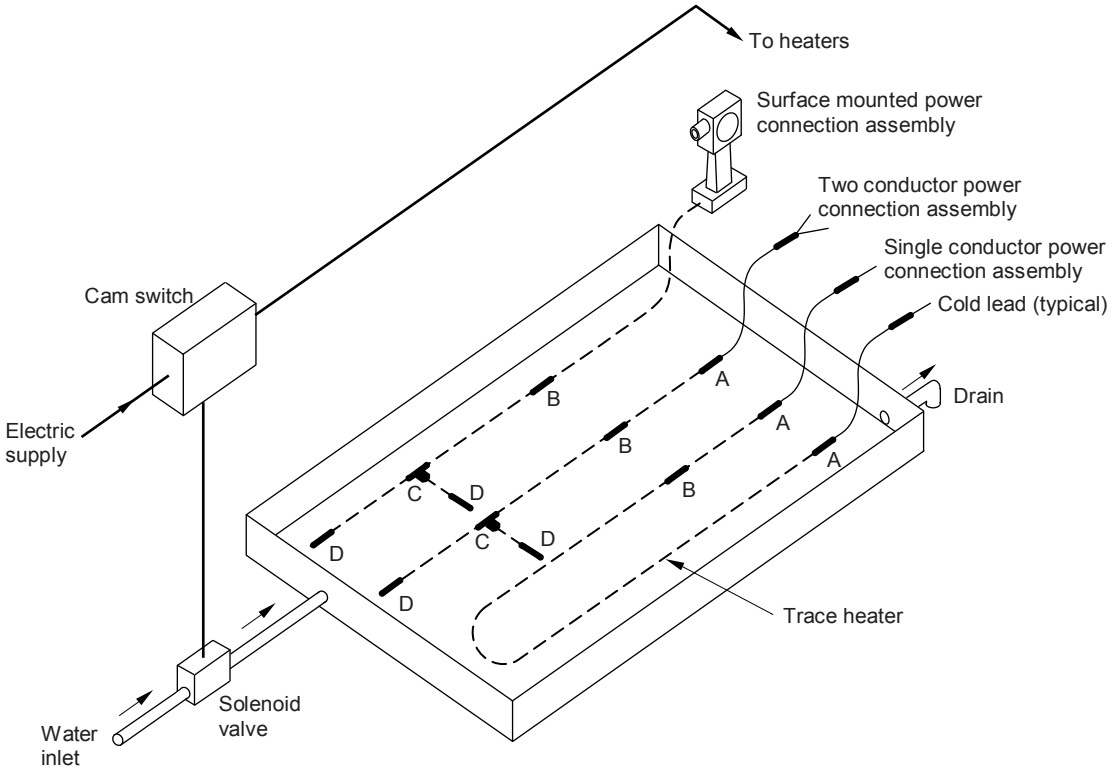
For samples supplied with overjackets, a section of the overjacket shall be removed prior to testing.

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.



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

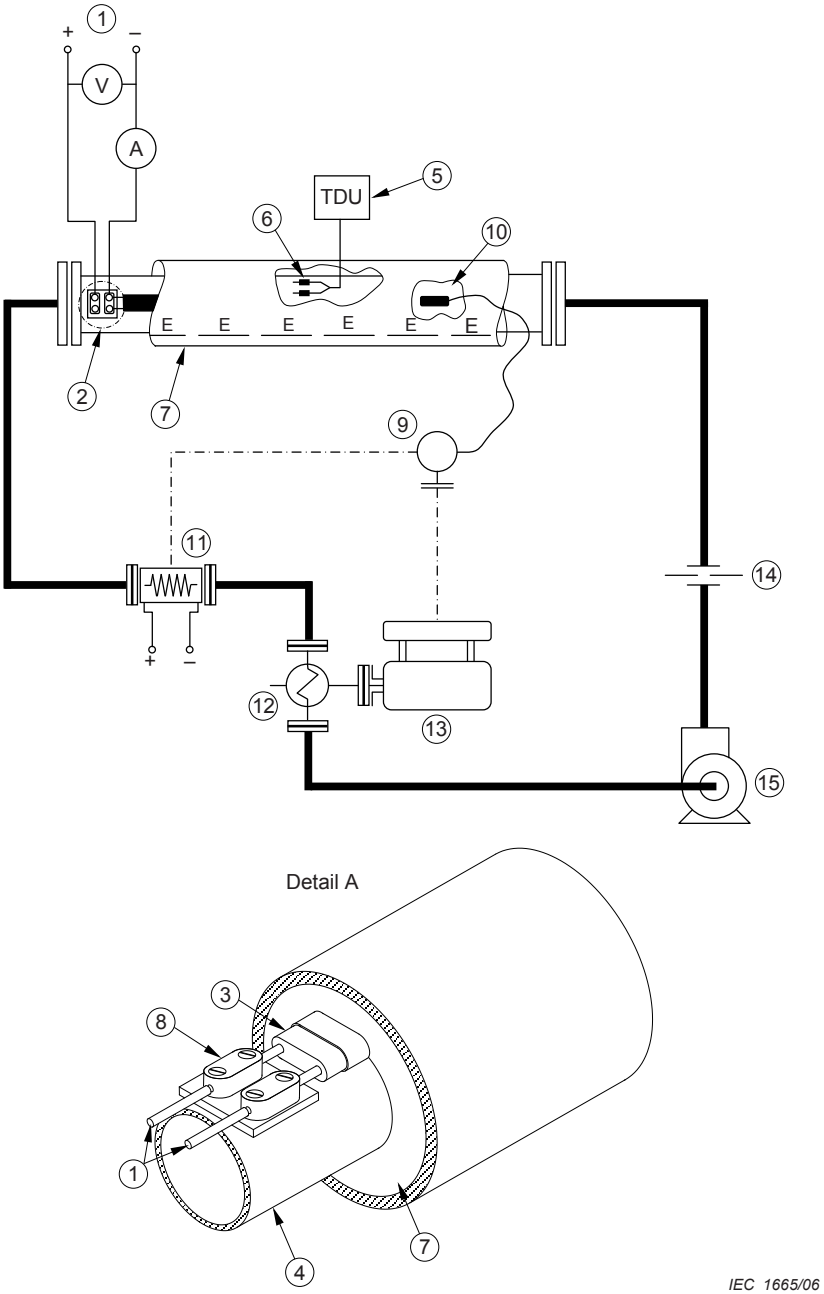
For trace heaters or surface heaters intended for outdoor exposed surface heating applications without thermal insulation, the test apparatus described in 5.2.13.2.4 shall be utilized, but with the trace heater installation not including any cross-over point. If the application is for roof and gutter 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.



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/m3	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 ± 5 °C for platen temperatures less than 100 °C or 5 % of the maximum continuous operating temperature if above 100 °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.

Once a particular application (with and/or without control) has been proven by relating power output and sheath temperature for a particular product, then additional testing for that application or other applications may be limited by analysis and by agreement between the testing body and the manufacturer.

- A product approach (see 5.2.13.3) in which the maximum sheath temperatures are determined in an artificial environment without control.

5.2.13.2 Systems approach, design verification method

5.2.13.2.1 Procedures according to installation type

The following procedures are applied according to the installation type defined in the scope and are intended to validate the manufacturer's design methodology and calculations of maximum sheath temperatures with or without control.

The measured sheath temperatures shall not exceed the manufacturer's calculated values by more than 10 K.

Alternative simulated operating conditions may be agreed between the testing body and the manufacturer.

5.2.13.2.2 Insulated surfaces with trace heaters

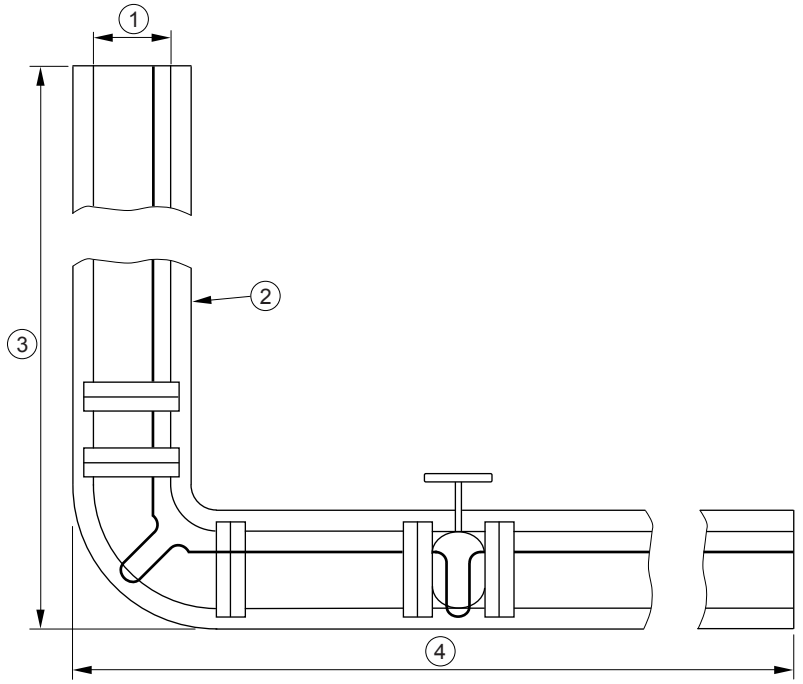
5.2.13.2.2.1 General

These tests shall be conducted three times with varied parameters such as insulation type, thickness, power output or multiple samples.

5.2.13.2.2.2 Test using pipe fixture

For trace heaters, the test apparatus (see Figure 8) shall consist of a 3 m horizontal run and a minimum 1,5 m vertical run of piping having a pipe size between 50 mm and 150 mm diameter. The pipe shall be empty. A flanged gate valve or equivalent (butterfly valve, globe valve, etc.) should be located in the centre of the horizontal run. The vertical run shall be so arranged that the flanged pipe ends are in the centre. The trace heaters shall be installed in a manner consistent with the manufacturer's installation instructions between 9 o'clock and 3 o'clock positions (upper portion of the pipe) on the pipe circumference. The sample shall be within the upper half of the heating device's thermal output tolerance or test conditions shall be considered to achieve similar results. Thermocouples shall be used to monitor the pipe, valve and flange surface temperatures and corresponding heater sheath temperatures at each of these locations. The thermocouples and the connection cables shall be selected and so arranged so they do not significantly affect the thermal behaviour of the temperature measurements, such as 0,2 mm^2 or smaller size Type J or K thermocouples as appropriate. The thermocouples should be spot welded to MI trace heater metallic sheaths and heated metallic surfaces. For metallic braid, polymeric sheaths, or nonmetallic heated surfaces the thermocouples should be attached with suitable adhesive/tape system. Additional thermocouples may be located at anticipated hotspots at the discretion of the testing body. The piping system shall be insulated with a minimum of 25 mm thickness of soft thermal insulation such as fiberglass or mineral wool, (oversized to accommodate the trace heater) and installed in accordance with the manufacturer's installation procedures. Pipe ends shall be plugged and thermally insulated. An additional length of piping may be added to the test section on either end to minimize end effects in the test section or additional trace heater may be added within the test section to achieve the same purpose.

Unless a higher temperature is specified, the ambient temperature shall not exceed 40 °C. The trace heater shall be powered at 110 % of its rated voltage. System temperatures shall be allowed to stabilize and thermocouple readings recorded. The measured sheath temperatures shall not exceed the manufacturer's calculated values or the temperature limits specified in 4.4.1.



Key

1	50 mm – 150 mm nominal pipe bore	3	1,5 m
2	Soft insulation, min. 25 mm thickness	4	3 m

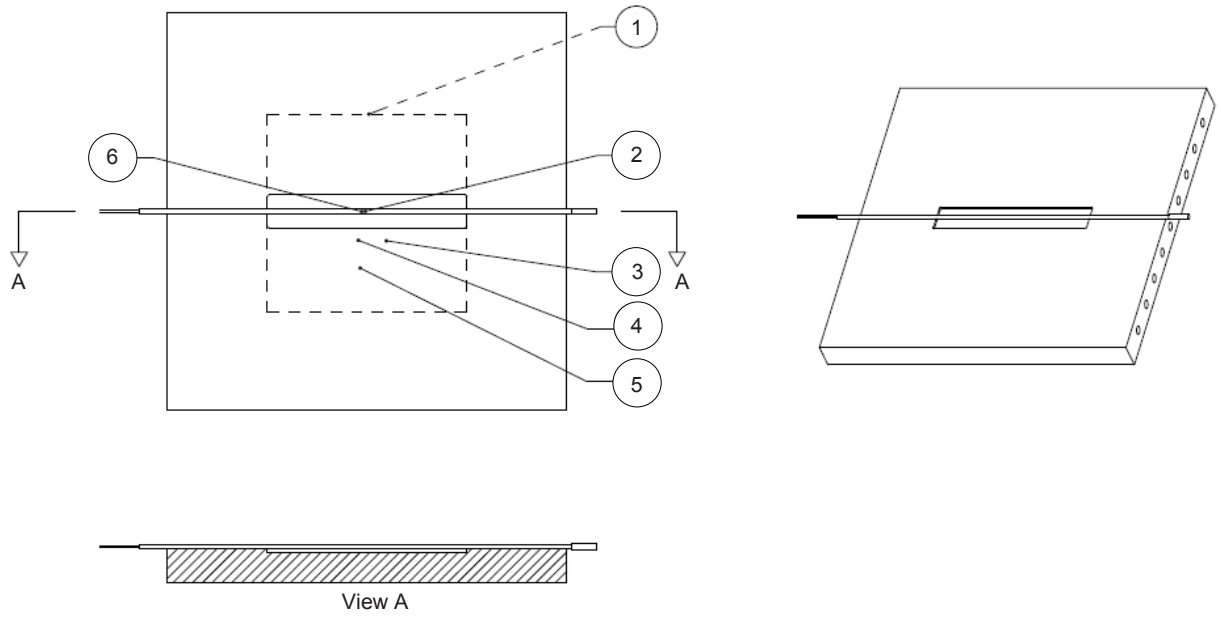
Figure 8 – Pipe fixture

5.2.13.2.2.3 Supplementary test using plate fixture

The maximum pipe temperature according to the test apparatus and procedures from 5.2.13.2.2.2 shall be used to determine the workpiece temperature that will be used as one of the plate temperatures.

The test apparatus, as shown in Figures 9 and 10, shall consist of an aluminium plate, 600 mm × 600 mm × 50 mm with cartridge heaters, temperature controller and channels for cooling. In the centre of the plate is a trough (300 mm × 50 mm × 5 mm) over which the trace heater sample is to be placed. The plate is thermally insulated with a minimum of 75 mm of calcium silicate on the bottom and 150 mm wide calcium silicate on the sides of the plate. The top of the apparatus is insulated with two layers, each consisting of three 900 mm × 300 mm × 25 mm calcium silicate sheets, or other suitable insulation as agreed upon with the testing agency. Rigid insulation should be annealed at 300 °C for 4 hours to reduce possible cracking during usage. If rigid insulation is used, the lower centre piece includes a 13 mm deep and 19 mm wide slot or larger if necessary to accommodate the trace heater size. The ends of the slot are to be filled with mineral wool and for rigid insulation a 900 mm × 900 mm × 13 mm wood board (approximately 10 kg) is placed on the top to reduce possible gaps. A thermocouple shall be located within the 300 mm × 300 mm test area which is used to control plate temperature, and three additional thermocouples shall be located on the plate as shown in Figures 9 and 10.

For trace heaters which may not be crossed over, a single thermocouple shall be attached to the top of the sample and the heater shall be centred over the trough as shown in Figure 9.



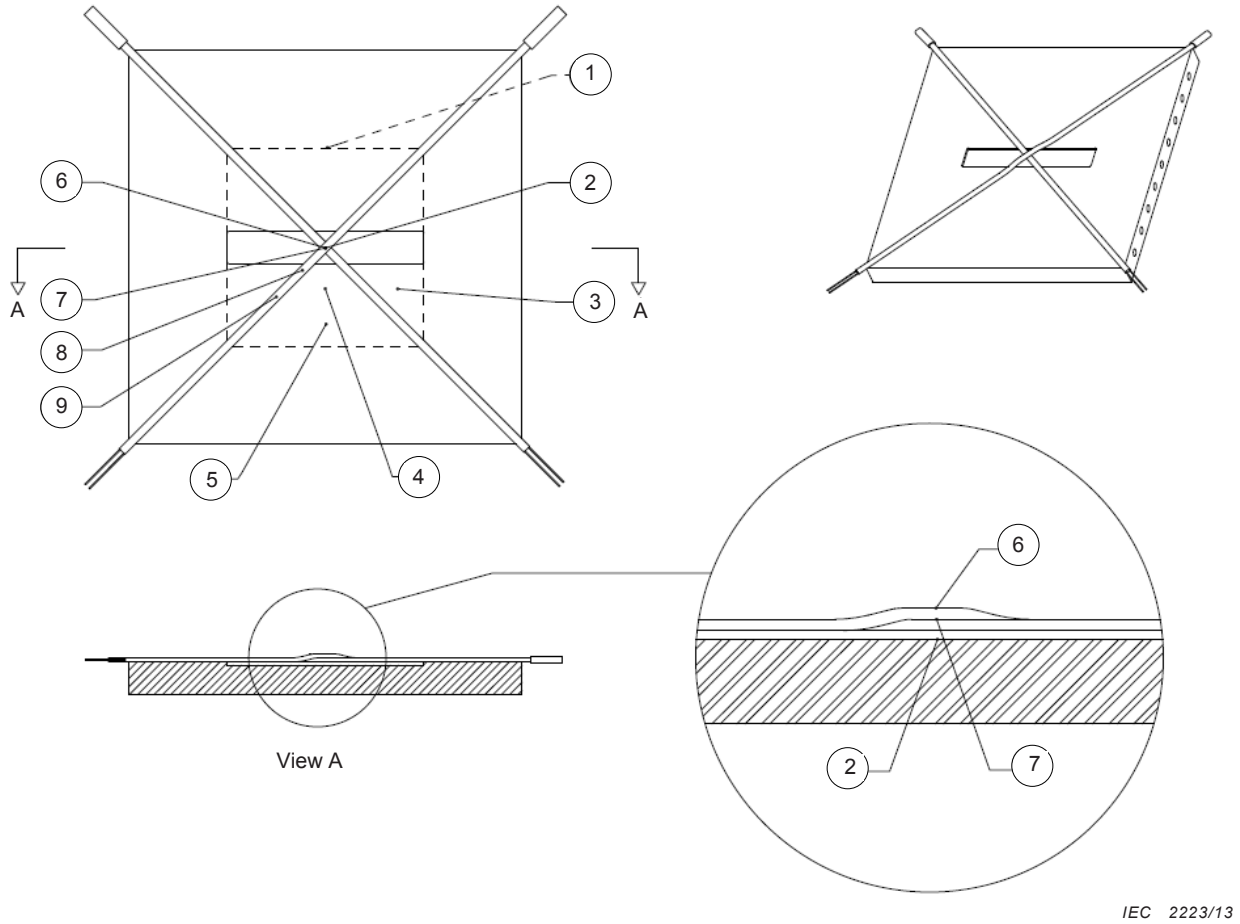
IEC 2222/13

Key

1	300 mm × 300 mm test area	4	Thermocouple 75 mm from centre of plate
2	Thermocouple on bottom surface of trough	5	Thermocouple 150 mm from centre of plate
3	Plate temperature control point 75 mm from centreline of trough	6	Thermocouple on trace heater

Figure 9 – Plate fixture

For trace heaters which are allowed to be crossed over, two trace heaters shall be installed perpendicular to each other at a 45° angle to the centreline of the trough as shown in Figure 10.



Key

1	300 mm × 300 mm test area	6	Thermocouple on trace heater
2	Thermocouple on bottom surface of trough	7	Thermocouple between trace heaters
3	Plate temperature control point 75 mm from centreline of trough	8	Thermocouple on trace heater 75 mm from centre of plate
4	Thermocouple 75 mm from centre of plate	9	Thermocouple on trace heater 150 mm from centre of plate
5	Thermocouple 150 mm from centre of plate		

Figure 10 – Plate fixture when trace heaters are allowed to touch

Four thermocouples shall be installed on the trace heaters. One thermocouple shall be attached to the top sheath of the upper cable at the crossover point. An additional thermocouple shall be placed between the crossed over samples at the centre point. Two additional thermocouples shall be attached to one of the trace heaters at 75 mm and 150 mm from the centre of the plate as shown in Figure 10.

The thermocouples and the connection cables shall be selected and so arranged so they do not significantly affect the thermal behaviour of the temperature measurements, such as 0,2 mm^2 or smaller size Type K thermocouples.

The attachment method for thermocouples to MI cables and other continuous metallic surfaces should be by welding, brazing or other suitable means. The thermocouple attachment method for metallic braid or nonmetallic sheaths should utilize suitable adhesives or tapes.

The samples shall be within the upper half of the trace heater's thermal output tolerance or test conditions shall be adjusted to achieve similar results.

The plate temperature controller shall be energized and the temperature set as desired. When the temperature has stabilized and the four thermocouples are within 2 °C of each other, the trace heater sample shall be energized and the sheath temperature rate of change shall be monitored until it is less than 1 °C in 30 min.

Measurements shall be made at three plate temperatures and at three power outputs covering the range of the manufacturer's rating, (i.e. nine sets of measurements).

The highest sheath temperature, the power output, and the plate temperature shall be recorded. The measured surface temperatures shall not exceed the manufacturer's calculated value and shall not exceed the manufacturer's declared maximum withstand temperature.

5.2.13.2.3 Insulated surfaces with surface heaters

This test shall be conducted three times with varied parameters such as insulation type, thickness, power output or multiple samples.

For surface heaters, a representative section shall be applied to a 6 mm steel plate in accordance with the manufacturer's instructions. The steel plate shall not extend more than 25 mm from any edge of the surface heater. The thermocouples shall be located at any anticipated hotspots at the discretion of the testing station. The heated side of the plate shall be insulated with a minimum of 25 mm of thermal insulation. The plate is then located in a stable room-temperature environment in a vertical orientation. The surface heater shall be powered at 110 % of rated voltage. After stabilization, the thermocouple readings shall be recorded including ambient temperature. The measured sheath temperatures shall not exceed manufacturer's calculated value and shall not exceed the manufacturer's declared maximum withstand temperature

5.2.13.2.4 Outdoor exposed surface heating

For trace heaters or surface heaters intended for roof and gutter heating, the test apparatus shall consist of a simulated roof consisting of a fir plywood panel 1,2 m × 1,8 m mounted at an angle of 45° to the horizontal. In addition, the fixture shall include a 1,8 m horizontal run of gutter and a 2 m vertical rise of downspout. The trace heater or surface heater and attachment devices shall be installed to the roof, gutter, and downspout according to the manufacturer's instructions. The trace heater or surface heater shall cross over itself on the roof if not prohibited by the manufacturer's instructions. The sheath of the trace heater or surface heater shall have thermocouples installed at the midpoints of both the vertical and horizontal runs, as well as in the midpoint of the roof run (and the crossover if applicable). The trace heater or surface heater shall be energized in no wind conditions at the maximum ambient temperature. The highest sheath temperature shall be recorded after the system reaches normal operating conditions.

For trace heaters or surface heaters intended for applications on outdoor metal structures, such as the de-icing of rails, the test apparatus shall consist of a rail, steel plate, or other fixture representative of the intended application. The heating device shall be installed on the mounting surface with expansion loops (if applicable) along with any accessories in accordance with the manufacturer's installation instructions. Thermocouples shall be used to monitor the metal surface, the heating device sheath, and anticipated hot spots to the discretion of the testing body. For maximum temperature testing, the apparatus shall be placed in an environmental chamber at the maximum ambient temperature. The highest sheath temperature shall be recorded after the system reaches normal operating conditions.

The measured sheath temperatures shall not exceed the manufacturer's calculated values and shall not exceed the manufacturer's declared maximum withstand temperature.

5.2.13.2.5 Embedded heating

For trace heaters or surface heaters intended for embedded applications, such as snow melting of concrete slabs, a test fixture consisting of formed concrete with dimensions of

1 m × 1 m × 90 mm shall be constructed. The fixture shall include one control joint across the width, and shall contain no reinforcing steel. If the intended applications do not include concrete, then a similar fixture shall be constructed using representative materials.

The trace heater or surface heater shall be installed according to the product installation instructions, using minimum allowable spacing and maximum watt density. The trace heater or surface heater shall be made to cross over itself if not prohibited by the instructions. Thermocouples shall be installed in the embedding media between two successive heating device passes, on the trace heater or surface heater sheath in the centre of the fixture, at the cross-over point if applicable, and on the sheath of the trace heater or surface heater where it exits the substrate. Thermocouples shall also be located at any other anticipated hot spots at the discretion of the testing body. If specified for the application, a covering of specified insulating material shall be placed over the substrate.

The fixture shall be placed in an environmental chamber on 50 mm of rigid thermal insulation. The environmental chamber ambient shall be raised to the maximum specified ambient temperature. The highest sheath temperature shall be recorded after the system reaches normal operating conditions.

The measured sheath temperatures shall not exceed manufacturer's calculated value and shall not exceed the manufacturer's declared maximum withstand temperature.

5.2.13.2.6 Trace heating internal to conduit and piping

For trace heaters or surface heaters intended for installation internal to conduit and piping, the test fixture shall consist of a 3 m horizontal run and a 1,5 m vertical run of conduit or pipe of a size representative for the application. The trace heater or surface heater shall be made to cross over itself if not prohibited by the instructions. Thermocouples shall be used to monitor the trace heater or surface heater sheath temperature, the cross-over point if applicable, the temperature of the connections, and the conduit or pipe temperature. Thermocouples shall also be located at any other anticipated hot spots at the discretion of the testing body.

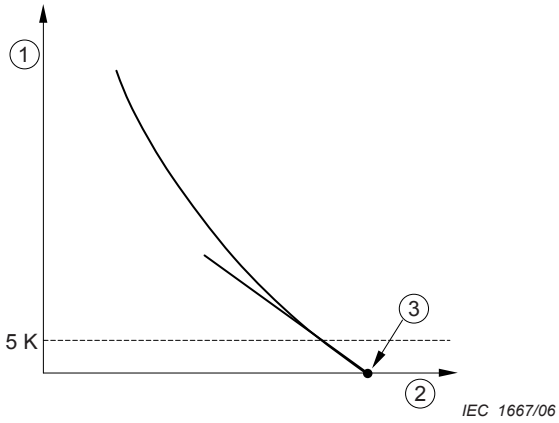
The fixture shall be placed in an environmental chamber, and the chamber ambient shall be raised to the maximum specified temperature. The highest sheath temperature shall be recorded after the system reaches normal operating conditions.

The measured sheath temperatures shall not exceed manufacturer's calculated values and shall not exceed the manufacturer's declared maximum withstand temperature.

5.2.13.3 Product approach

A sample of trace heater at least 1,5 m in length is placed loosely coiled in an oven. For surface heaters, a representative sample is placed horizontally in the oven. The sample shall be within the upper half of the trace heater's thermal output tolerance, or the data shall be adjusted to reflect the upper limit of the power output tolerance.

Representative thermocouples shall be used to monitor sample sheath temperatures and shall be placed 500 mm from each end. One additional thermocouple is used to monitor the temperature within the oven. The trace heater shall be energized at 110 % of rated voltage. The oven ambient temperature shall be raised from ambient temperature in increments no greater than 15 K. Sufficient time shall be permitted at each temperature to allow for the oven temperature and the trace heater or surface heater sheath temperature to stabilize and attain thermal equilibrium. Oven and trace heater or surface heater sheath temperatures shall be recorded at each successive level until the difference (ΔT) between the two is 5 K or less. A curve shall be drawn from the test data, and a straight line drawn tangentially to the curve at the 5 K temperature difference point and extended to 0 K. The temperature read at this intercept shall be taken as the maximum sheath temperature, as shown in Figure 11.



Key

1 Sample temperature minus oven air temperature (T_s – T_0), K

2 Oven temperature (T_0), ºC

3 Recorded value of T_s, ºC

Figure 11 – Maximum sheath temperature using the product approach

5.2.14 Verification of start-up current

The start-up current of the trace heater or surface heater shall be measured as a function of the minimum ambient temperature as designated by the manufacturer. A sample of trace heater, at least 1 m in length, shall be installed in accordance with the manufacturer's instructions on a minimum 50 mm diameter liquid-filled steel pipe or solid rod, or for surface heaters a flat metal heat sink. The data shall be adjusted to reflect the upper limit of the power output tolerance, by multiplying the test values by the ratio of the maximum output tolerance level for the sample to the actual power output for the sample.

The testing apparatus shall be completely covered with thermal insulation and conditioned at the minimum ambient temperature for at least 4 h.

NOTE The apparatus described in 5.2.10 can be used for this test.

After the conditioning period, rated voltage shall be applied and the time/r.m.s. current characteristic shall be recorded from time 0 to 300 s. The start-up current recorded shall be the highest current response of three samples. This time-current characteristic shall not be more than the value declared by the manufacturer.

5.2.15 Verification of the electrical resistance of the electrically conductive covering

The electrical resistance of the metallic braid, sheath or other electrically conductive covering shall be measured at 10 °C to 40 °C, of at least a 3 m length of trace heater or a representative sample of a surface heater. The resistance shall be equal to, or less than, the manufacturer's declared value. Additional consideration shall be applied by the testing body for evaluation of equivalent materials other than metallic braid or sheath.

5.2.16 Strain relief test for connections (terminations)

Connections designed to terminate the exposed power leads of trace heaters or surface heaters directly to exposed enclosures shall be subjected to strain relief testing. One sample of each connection that provides strain relief shall be subjected to the test. The specimens will consist of at least 300 mm of trace heater attached to the subject fitting according to the manufacturer's instructions. A steady load of 9 kg for conductors smaller than 0,81 mm^2 and 16 kg for all other cases is to be gradually applied between the trace heater or surface heater and the fitting. The load shall be maintained for a period of 1 min. As a result of this test, the power leads of the trace heater or surface heater shall not loosen or separate by more than

1 mm from the fitting when measured after removal of the load, and there shall be no visual damage to the conductors, insulation, or fitting.

5.3 Type tests – Additional tests for outdoor exposed surface heating installations without thermal insulation

5.3.1 Verification of rated output

The rated output of the trace heater or surface heater shall be verified by the procedure described in 5.2.10.3.3.

5.3.2 Determination of maximum sheath temperature

The maximum sheath temperatures of the trace heater or surface heater shall be verified by the procedure described in 5.2.13.2.4.

5.3.3 Increased moisture resistance test

A minimum 3 m sample of trace heater or a representative surface heater, complete with any integral connections and end terminations, shall be immersed in water at 10 ºC to 25 ºC for a period of 2 000 h (12 weeks).

After conditioning as above, the sample shall be tested using the dielectric 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.

5.3.4 UV test

A sample of trace heater approximately 300 mm long, or a representative sample of a surface heater, shall be exposed to a source of a xenon arc light as described in Procedure B of IEC 60068-2-5.

The samples are exposed to xenon arc radiation for 20 days. The cycle shall be set for 20 h of light and 4 h of darkness. At the end of this time, the sample(s) shall be removed from the test apparatus and tested using the cold bend test, 5.2.7.

Trace heaters or surface heaters having a continuous metal sheath with no outer jacket shall be exempt from this test.

5.3.5 Resistance to cutting test

A sample of trace heater or surface heater, at least 200 mm in long, shall be tested. The sample shall be placed on top of a rigid flat steel support. A metal cutting edge with a 0,25 mm radius shall be mounted above the sample such that the cutting edge is at a right angle to the sample. An ohmmeter shall be attached to the trace heater or surface heater conductors shorted together and to the metal cutting edge.

A proof load of 445 N is to be gradually applied to the cutting edge as it impinges on the sample. The ohmmeter shall be used to verify that the cutting edge shall not cut through the insulation and make contact with the conductors of the trace heater or surface heater.

5.3.6 Abrasion test

Six samples of trace heater, approximately 1 m in length, shall be tested. The electrical resistance of the metallic sheath, braid, screen or equivalent electrically conductive covering of each of the samples shall be measured with an ohmmeter having an accuracy of ± 1 %. The average initial resistance shall be calculated.

The samples shall be placed in the abrasion test apparatus shown in Figure 12. One end of each of the samples shall be attached to a horizontal reciprocating table and the other end of each sample shall be attached to a mass of 340 g. Each sample shall be laid over a 90 mm radius cylinder positioned at the end of the table and covered with an unused layer of grade 1/2 (medium) emery cloth, or 120 grit silicon carbide/resin bond abrasive paper. The longitudinal axis of the cylinder shall be horizontal and perpendicular to each of the samples.

The table shall commence reciprocating at a rate of approximately 30 cycles per minute. Each cycle shall consist of one complete back-and-forth motion with a stroke of approximately 160 mm. The table shall be stopped every 50 cycles and the abrasive material shall be repositioned or replaced so that all the samples shall be subject to abrasion by a fresh surface of the abrasive material in subsequent cycles. After 2 500 cycles, the test shall be stopped and the resistance of the conductive braid or sheath of each of the samples shall be measured again. The average resistance shall be calculated and compared to the initial average value. The final average resistance value shall not exceed 125 % of the initial average value. Also, if the samples are overjacketed, the underlying conductive braid or sheath shall not have become exposed.

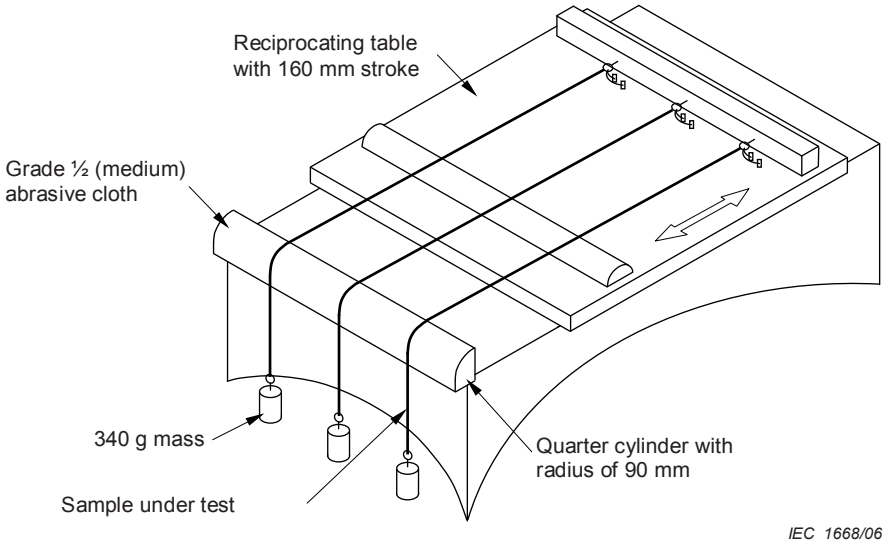


Figure 12 – Abrasion test

5.3.7 Tension test

A 30 kg mass, or a mass sufficient to impose the manufacturer's stated maximum tensile value, whichever is greater, shall be suspended from the free end of the heating section of a 1 m long sample for 1 h, with the other end of the sample secured tightly. There shall be no breakage of the conductors or braid and there shall be no visual damage to the insulation (except in the areas where the sample was secured).

5.3.8 Rail system voltage spike test

Rail heating systems are routinely subjected to voltage spikes stemming from the voltage supply. For trace heaters or surface heaters intended for applications on outdoor metal structures, such as the de-icing of rails, a sample of trace heater at least 2 m in length, or a representative surface heater, shall be subjected to 1 000 cycles of 5 000 V impulses. Each impulse should have a 1,2 μs rise time and a 50 μs fall time. The sample shall then pass the requirements of 5.2.1 and 5.2.2.

5.3.9 Rail system over-voltage test

Some rail heating systems can experience increased voltage conditions for extended periods. For trace heaters or surface heaters intended for applications on outdoor metal structures, such as the de-icing of rails, a sample of trace heater at least 2 m in length, or a representative surface heater, shall be selected. The sample shall be installed on a representative mounting surface with expansion loops (if applicable) along with any accessories in accordance with the manufacturer's installation instructions. The surrounding ambient air shall be maintained at the maximum stated ambient temperature for the system.

A voltage of 1,25 times the nominal operating voltage shall be applied for one hour. The sample shall then pass the requirements of 5.2.1 and 5.2.2.

5.4 Type tests – Additional tests and test modifications for embedded heating applications

5.4.1 Verification of rated output

The rated output of the trace heater or surface heater shall be verified by the procedure described in 5.2.10.3.4.

5.4.2 Determination of maximum sheath temperature

The maximum sheath temperatures of the trace heater or surface heater shall be verified by the procedure described in 5.2.13.2.5.

5.4.3 Resistance to cutting test

The heater's resistance to cutting shall be verified by the test described in 5.3.5.

5.4.4 Flammability test

Trace heaters, surface heaters and components intended for embedded applications, such as snow melting of concrete slabs, which are required to be fully embedded, may be exempted from the flammability test of 5.2.3.

5.5 Type tests – Additional tests for applications of trace heating internal to conduit and piping

5.5.1 Verification of rated output

The rated output of the trace heater or surface heater shall be verified by the procedure described in 5.2.10.3.5.

5.5.2 Determination of maximum sheath temperature

The maximum sheath temperatures of the trace heater or surface heater shall be verified by the procedure described in 5.2.13.2.6.

5.5.3 Increased moisture resistance test

5.5.3.1 Non-pressurized systems

Trace heaters, surface heaters and components intended for use in non-pressurized systems shall be subjected to the test described in 5.3.3.

5.5.3.2 Pressurized systems

NOTE Equipment intended to be in contact with potable water can be subject to regional and national requirements that are outside the scope of this standard.

Trace heaters, surface heaters and components intended for use in pressurized systems shall be subjected to the following increased moisture resistance test.

A sample of trace heater with integral components (at least 3 m in length for trace heaters) shall be immersed in water at 10 ºC to 25 ºC, or at the manufacturer's declared maximum maintain temperature if higher, and pressurized for a period of 2 000 h (12 weeks). The pressure shall be at the manufacturer's declared pressure rating plus 20 %.

After conditioning as above, the sample shall be subjected to the tests outlined in 5.2.1 and 5.2.2. In addition, there shall be no evidence of water ingress for any of the components.

5.5.4 Pull-strength test

A 68 kg mass, or a mass sufficient to apply the manufacturer's stated maximum conduit pull strength value, shall be suspended from the free end of a 1 m long sample for 1 min with the other end of the sample secured tightly. The mass shall then be removed, and the sample shall be tested using the dielectric test, 5.2.1, and shall withstand this for 1 min without dielectric breakdown. Also, there shall be no breakage of the conductors or braid and there shall be no visual damage to the insulation (except in the areas where the sample was secured).

5.6 Type tests – Additional requirements for sprinkler systems

5.6.1 Normal and abnormal operation test

These tests are only applicable to trace heating systems intended for use on sprinkler systems.

The trace heater or surface heater and its associated components shall meet all the applicable type tests in 5.2. In addition, they shall pass the following normal and abnormal operation tests to validate their use. Temperature control, as stipulated in 4.4.1, shall be included.

5.6.2 Normal operation test

The trace heating equipment installed onto the piping arrangement is to be powered in accordance with the manufacturer's instruction and the temperatures measured to determine that when installed as intended on a sprinkler system branch line and supply pipe configuration as specified, the trace heater or surface heater shall maintain pipe surface temperatures of not less than 4 °C nor greater than 38 °C.

The trace heater or surface heater shall be installed onto the piping arrangements shown in Figures 13 (or Figure 14) and Figure 15. Figure 14 shows an alternative arrangement to Figure 13. Instead of the test rig having 3 m of pipe with an outside diameter of 90 mm (or closest nominal size) and two sprigs (one arranged 'sprig up' and one arranged 'sprig down'), the piping arrangement shown in Figure 14 may be used. This consists of 2 m of pipe with an outside diameter of 90 mm (or closest nominal size) and a single sprig. The sprig shall be vertically down for the test conducted at the minimum ambient temperature, described in item a) below and shall be vertically up for the test as described in item b) below. Schedule 40 (or equivalent) steel piping shall be used to construct the piping arrangements. If the manufacturer references the use of the trace heater or surface heater with non-metallic piping materials such as plastic, testing using the piping arrangement described in Figure 13 (or Figure 14) shall be conducted with each piping material. Note that trace heating systems intended only for sprinkler system mains and supply lines (and not branch lines containing sprinkler heads) are only subjected to the piping arrangement referenced in Figure 15.

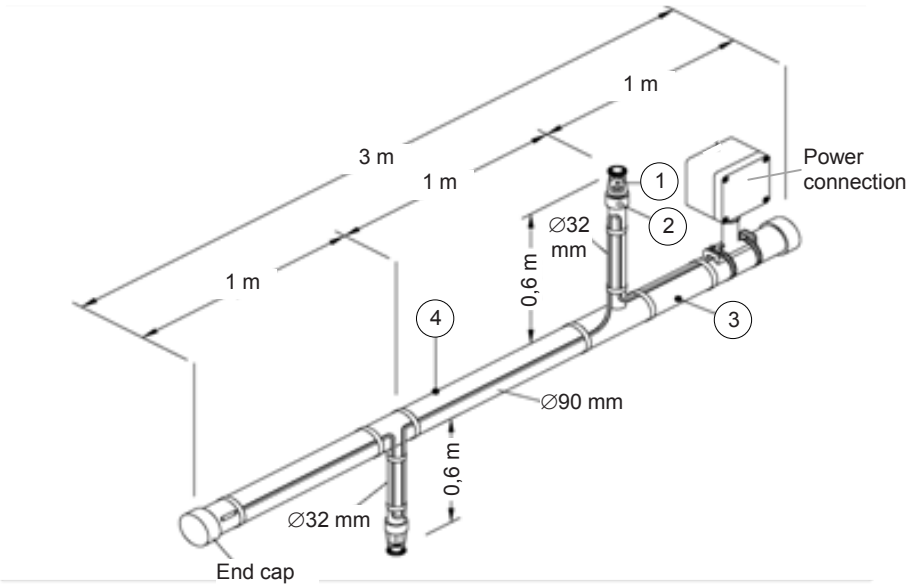
The trace heating system, including the thermal insulation, shall be installed in accordance with the manufacturer's installation instructions, including the installation of the trace heating at the closest permitted distance to the sprinklers shown in Figure 13 (or Figure 14).

Thermocouples shall be installed to measure the pipe surface temperatures at locations as shown in Figures 13 (or Figure 14) and Figure 15.

Each arrangement shall be installed in a conditioning test chamber. The sprinkler outlets shall be oriented in a vertical plane and the following test conditions shall be maintained until thermal equilibrium is reached as indicated by constant temperature readings, i.e. when three successive readings are taken at intervals of 10 % of the previously elapsed duration of the test, but not less than 15 minute intervals, there is no further increase. The test chamber temperature shall be:

a) the minimum ambient temperature referenced in the manufacturer's installation instructions, but no higher than minus 20 °C, with the sample exposed to an air movement of not more than 2 m/s;

b) an ambient temperature of 35 ± 2 °C with the sample exposed to an air movement of not more than 2 m/s.



Key Location of thermocouples

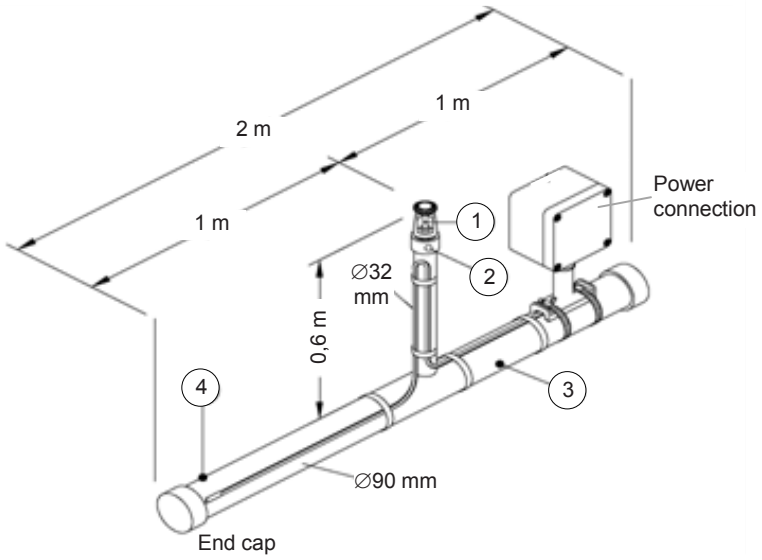
1 At sprinkler head

2 On 32 mm outside diameter sprig pipe adjacent to sprinkler head

3 On 90 mm outside diameter branch pipe approx. 0,3 m from sprig

4 On 90 mm outside diameter branch pipe approx. 0,9 m from sprig

Figure 13 – Sprinkler system temperature control test – branch line arrangement



IEC 2225/13

Key Location of thermocouples

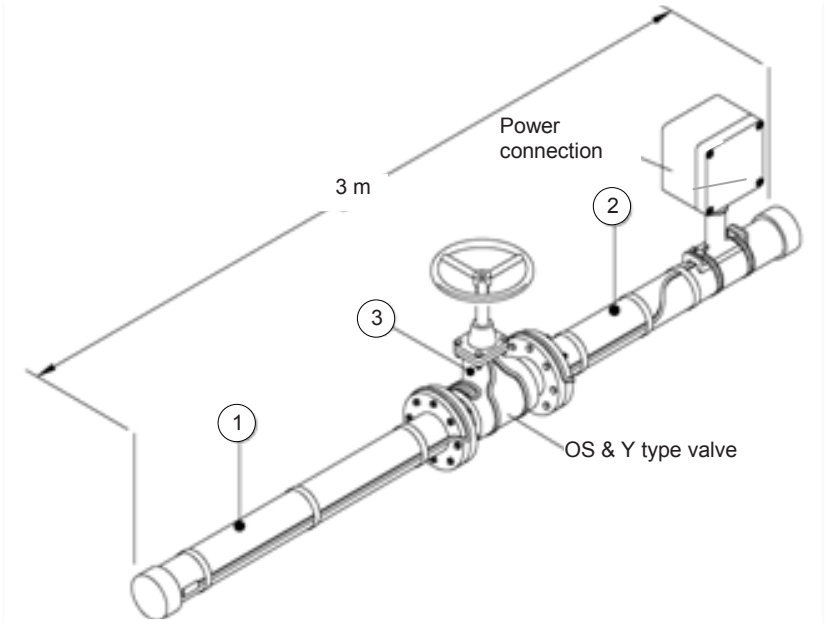
1 At sprinkler head

2 On 32 mm outside diameter sprig pipe adjacent to sprinkler head

3 On 90 mm outside diameter branch pipe approx. 0,3 m from sprig

4 On 90 mm outside diameter branch pipe approx. 0,9 m from sprig

Figure 14 – Sprinkler system temperature control test – branch line – alternative arrangement



IEC 2226/13

Key Location of thermocouples

1 On 110 mm outside diameter pipe approximately 1 m from valve flange

2 On 110 mm outside diameter pipe approximately 0,5 m from valve flange

3 On body of OS&Y (outside screw and yoke) valve, away from heater sample

Figure 15 – Sprinkler system temperature control test – supply pipe arrangement

5.6.3 Abnormal operation test

When installed as intended on a sprinkler system branch line as specified below, with the primary temperature controls disabled, pipe surface temperatures shall not exceed 55 °C, or 8 °C less than the minimum temperature rating of the sprinklers intended to be used with the system, whichever is less.

NOTE This can be achieved by the use of a separate high-temperature limit controller to de-energize the trace heater with automatic reset and annunciation.

The trace heating system including insulation shall be installed onto the sprinkler branch line as specified in Figure 13 (or Figure 14 with 'sprig up'). For spiral wrapped trace heaters use 120 % of the trace heater length specified by the manufacturer for those spiralled sections.

Thermocouples shall be installed to measure the pipe surface temperatures as specified in Figure 13 (or Figure 14). With the primary temperature control disabled and the trace heating system operated at 110 % of the rated voltage, the test arrangement is to be installed in a conditioning chamber with the sprinkler outlets in a vertical plane. The test sample is to be exposed to an ambient temperature of 35 ± 2 °C with the sample exposed to an air movement of not more than 2 m/s.

5.7 Routine tests

5.7.1 Dielectric test

The primary electrical insulation jacket of the trace heater or surface heater shall withstand a dry-spark test at a minimum of 6 000 V a.c. The dry-spark test shall have a substantially sinusoidal waveform at 2 500 Hz to 3 500 Hz. For a 3 000 Hz supply, the speed of the product in meters per second shall not be more than 3,3 times the length of the electrode in centimetres; this requirement is proportional to frequency.

As an alternative to the dry-spark test, the dielectric tests in 5.2.1 shall be conducted (except that the test voltage is to be maintained for 1 s instead of 1 min).

After the application of a metallic covering, metallic braid, or other equivalent electrically conductive material, earth plane, or continuous metal sheath, the heating device shall have the dielectric test described in 5.2.1 conducted (except that the test voltage is to be maintained for 1 s instead of 1 min). Non-metallic overjackets shall withstand an additional dry-spark test with a minimum test voltage of 3 000 V a.c. As an alternative to the dry-spark test, the dielectric tests in 5.2.1 shall be conducted (except that the test voltage is to be maintained for 1 s instead of 1 min).

5.7.2 Verification of rated output

The output rating for each manufactured length of parallel trace heater shall be verified for linearity of power output through continuous or statistical test methods. The power output rating for each length of series resistance trace heater product or fixed resistive heater shall be verified by measurement of the d.c. resistance, conductance or current at a given temperature. The test measurement criteria shall be established or correlated to the output verification test specified in 5.2.10. The measured power output shall be within the manufacturer's declared tolerances.

6 Marking

6.1 General

All the markings specified in IEC 60519-1 that are applicable to trace heating are included in the following requirements.

6.2 Product markings

Trace heaters, surface heaters and field-assembled components shall be clearly and permanently surface-marked in accordance with Table 2 or shall have a durable tag/label.

For trace heaters or surface heaters with factory-fabricated terminations, or components with small surface areas or surfaces where legible printing cannot be applied, the markings shall be placed on a durable tag/label permanently affixed within 75 mm of the power connection fitting/gland or smallest unit container instead of on the component itself.

Table 2 – Product marking

MARKING INFORMATION	PRODUCT TYPE	
	TRACE HEATING EQUIPMENT	FIELD ASSEMBLED COMPONENTS (except integral components)(1)
Manufacturer, trademark, or other recognized symbol of identification.	YES	YES
Manufacturers catalogue number, reference number or model, so that the suitable applications such as outdoor locations, wet locations, sprinkler systems and internal tracing in potable water are traceable to product installation instructions and/or data sheets.	YES	YES
Month and year of manufacture, date coding, applicable serial number, or equivalent.	YES	YES
Rated voltage.	YES	
The rated power output per unit length or unit surface area at the corresponding rated voltage (and at a stated reference temperature for devices that change output with temperature), or the resistance in ohms for unit length for series trace heater, or the operating current or total wattage as applicable.	YES	
Trace heating equipment qualified for outdoor locations , wet locations, potable water and sprinkler systems is permitted to be so marked on the trace heating equipment.	YES	YES
Applicable environmental requirements, such as IP (ingress protection) ratings, and area use requirements.		YES
(1) Other markings may apply for non-integral components.		

7 Installation instructions

The manufacturer shall provide product specific installation instructions for trace heaters, or surface heaters and components. Instructions for various components and trace heaters or surface heaters may be combined where termination and installation instructions are identical. The instructions shall be clearly identified as to the products and locations that apply, and shall include the following information, or equivalent:

a) the intended use(s) as listed in Clause 1, either by general application type or by specific listed application (or similar application);

b) the statement “Suitable for use with” (or equivalent) and a listing of applicable trace heaters or surface heater, or a listing of applicable connection fittings, as applicable;

c) the statement “Earth-fault equipment protection is required for each circuit”;

d) the statement “De-energize all power circuits before installation or servicing”;

e) the statement “Keep ends of trace heaters (or surface heaters – as applicable) and kit components dry before and during installation”;

f) for trace heaters investigated for reduced levels of impact and/or deformation, the statement “Caution: Only use in areas subject to low risk of mechanical damage”;

g) for trace heaters and surface heaters supplied with integral additional mechanical protection, (see 4.1), add the following statement in the instructions: “This mechanical covering shall not be removed and the trace heater or surface heater shall not be operated without the mechanical protection in place”;

h) for trace heaters or surface heaters, an applicable statement to indicate that the metal sheath, braid, screen or equivalent electrically conductive covering of the trace heater shall be connected to an earth terminal;

i) for pipe or vessel applications, the statement “The presence of the trace heating equipment shall be made evident by the posting of caution signs or markings at appropriate locations and/or at frequent intervals along the circuit”;

j) for outdoor de-icing and snow melting applications, the statement “The presence of the trace heating equipment shall be made evident by the posting of caution signs or marking where clearly visible”;

k) the statements “Persons involved in the installation and testing of electrical trace heating systems shall be suitably trained in all special techniques required. Installations are intended to be carried out under the supervision of a qualified person.”;

l) for use with sprinkler systems, the statement “The alarm output shall be connected to and monitored by the fire detection alarm system.”;

m) for use with sprinkler systems, the instructions shall indicate that the system installation shall comply with the obstruction requirements of local codes and standards (e.g. NFPA 13 [3]) such that thermal insulation over the trace heating does not unacceptably obstruct the sprinkler or cover the wrench boss. The instructions for upright sprinklers shall include the information in IEC 62395-2:2013, 4.6.3, items e), f) and g) including reference to Figure 7 of IEC 62395-2:2013;

n) the instructions shall indicate that sprinkler systems provided with trace heating shall be properly grounded;

o) for use with sprinkler systems, the statement “Trace heating systems for fire sprinkler systems shall be permanently connected to the power supply”.

p) for use with sprinkler systems, the statement “The design and monitoring of trace heating systems for fire sprinkler systems shall be in accordance with IEC 62395-1 and IEC 62395-2”;

q) for use with sprinkler systems, the statement “If backup power is being provided for the building electrical systems, it shall also provide backup power supply for the trace heating system”;

r) for use with sprinkler systems, the intended application(s) shall be indicated, i.e. “for supply piping only” or “for supply piping and branch lines including sprinkler heads”;

s) for use with sprinkler systems, the minimum ambient temperature rating shall be indicated.

Bibliography

[1] IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

[2] IEC/IEEE 60079-30-1[3], *Electrical apparatus for explosive atmospheres – Electrical resistance trace heating – Part 1: General and testing requirements*

[3] NFPA 13, *Standard for the installation of Sprinkler systems*

[3] Under consideration.

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