

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Systèmes de traçage par résistance électrique pour applications industrielles et commerciales –
Partie 1: Exigences générales et d'essai**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2013 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Systèmes de traçage par résistance électrique pour applications industrielles et commerciales –
Partie 1: Exigences générales et d'essai**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX



ICS 25.180.10

ISBN 978-2-8322-1079-6

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	8
3 Terms and definitions	8
4 General requirements	13
4.1 General	13
4.2 Electrically conductive covering.....	13
4.3 Electrical circuit protection requirements for branch circuits	13
4.4 Temperature requirements	14
4.4.1 General	14
4.4.2 Stabilized design	14
4.4.3 Controlled design	14
5 Testing	14
5.1 Type tests – General	14
5.2 Type tests – All applications	14
5.2.1 Dielectric test	14
5.2.2 Electrical insulation resistance test.....	15
5.2.3 Flammability test	16
5.2.4 Room temperature impact test.....	17
5.2.5 Minimum temperature impact test.....	19
5.2.6 Deformation test.....	20
5.2.7 Cold bend test.....	21
5.2.8 Water resistance test.....	22
5.2.9 Integral components resistance to water test	22
5.2.10 Verification of rated output.....	23
5.2.11 Thermal stability of electrical insulating material	25
5.2.12 Thermal performance test for parallel trace heaters	26
5.2.13 Determination of maximum sheath temperature	27
5.2.14 Verification of start-up current	34
5.2.15 Verification of the electrical resistance of the electrically conductive covering	34
5.2.16 Strain relief test for connections (terminations)	34
5.3 Type tests – Additional tests for outdoor exposed surface heating installations without thermal insulation	35
5.3.1 Verification of rated output.....	35
5.3.2 Determination of maximum sheath temperature	35
5.3.3 Increased moisture resistance test	35
5.3.4 UV test	35
5.3.5 Resistance to cutting test	35
5.3.6 Abrasion test	35
5.3.7 Tension test.....	36
5.3.8 Rail system voltage spike test	36
5.3.9 Rail system over-voltage test.....	37
5.4 Type tests – Additional tests and test modifications for embedded heating applications.....	37
5.4.1 Verification of rated output.....	37

5.4.2	Determination of maximum sheath temperature	37
5.4.3	Resistance to cutting test	37
5.4.4	Flammability test	37
5.5	Type tests – Additional tests for applications of trace heating internal to conduit and piping	37
5.5.1	Verification of rated output.....	37
5.5.2	Determination of maximum sheath temperature	37
5.5.3	Increased moisture resistance test	37
5.5.4	Pull-strength test	38
5.6	Type tests – Additional requirements for sprinkler systems.....	38
5.6.1	Normal and abnormal operation test	38
5.6.2	Normal operation test	38
5.6.3	Abnormal operation test.....	41
5.7	Routine tests	41
5.7.1	Dielectric test	41
5.7.2	Verification of rated output.....	41
6	Marking	41
6.1	General	41
6.2	Product markings	42
7	Installation instructions	42
Bibliography.....		44
<p style="text-align: center;">iTeh STANDARD PREVIEW (standards.iteh.ai)</p>		
Figure 1 – Flammability test.....		17
Figure 2 – Room temperature impact test.....		18
Figure 3 – Example of room temperature impact test apparatus.....		19
Figure 4 – Example of minimum temperature impact test apparatus.....		20
Figure 5 – Cold bend test.....		22
Figure 6 – Moisture resistance test		23
Figure 7 – Verification of rated output		25
Figure 8 – Pipe fixture.....		29
Figure 9 – Plate fixture.....		30
Figure 10 – Plate fixture when trace heaters are allowed to touch.....		31
Figure 11 – Maximum sheath temperature using the product approach		34
Figure 12 – Abrasion test.....		36
Figure 13 – Sprinkler system temperature control test – branch line arrangement		39
Figure 14 – Sprinkler system temperature control test – branch line – alternative arrangement		40
Figure 15 – Sprinkler system temperature control test – supply pipe arrangement		40
Table 1 – Test voltages for the dielectric test.....		15
Table 2 – Product marking		42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

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

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

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

¹ Under consideration.

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

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

FDIS	Report on voting
27/926/FDIS	27/935/RVD

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

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

A list of all parts in the IEC 62395 series, published under the general title *Electrical resistance trace heating systems for industrial and commercial applications*, can be found on the IEC website.

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

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

ITeh STANDARD PREVIEW
(standards.iteh.ai)

IEC 62395-1:2013

IMPORTANT – The colour inside logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

IEC 62395-1:2013

<https://standards.iteh.ai/catalog/standards/sist/a61d5de2-dd92-4095-b0e4-a547a21de673/iec-62395-1-2013>

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.

<https://standards.iteh.ai/catalog/standards/sist/a61d5de2-dd92-4095-b0e4-a517a31d-6772/iec-62395-1-2013>

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

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

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

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

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

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

2 Normative references

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

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

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

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

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

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

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

3 Terms and definitions

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

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

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

3.1

ambient temperature

temperature surrounding the object under consideration

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

3.1.1

maximum ambient temperature

the highest specified ambient temperature

3.1.2

minimum ambient temperature

the lowest specified ambient temperature

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

3.2

branch circuit

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

3.3

cold lead

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

3.4

connection

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

3.5

dead leg

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

3.6

design loading

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

3.7

electrically conductive covering

metallic sheath, metallic braid, or electrically conductive material

3.8

end termination

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

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

3.9

factory-fabricated unit

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

3.10

field-assembled unit

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

3.11

heat loss

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

3.12

heat sink

part that conducts and dissipates heat away from a workpiece

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

3.13

heat transfer aids

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

3.14

heater pad

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

3.15

heater panel

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

3.16

high limit temperature

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

<https://standards.iteh.ai/catalog/standards/sist/a61d5de2-dd92-4095-b0e4-a547a21de673/iec-62395-1-2013>

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

[IEC 62395-1:2013](https://standards.iteh.ai/catalog/standards/sist/a61d5de2-dd92-4095-b0e4-a547a21de673/iec-62395-1-2013)

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