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Specification for

Industrial duct heaters using metal-sheathed elements

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Committees responsible for this British Standard

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Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)
British Glass Manufacturers' Confederation
British Industrial Furnace Constructors Association
British Lighting Association for the Preparation of Standards (BRITLAPS)
British National Committee for Electroheat
British Steel plc
Committee for Electrical Equipment for Use in Flammable Atmosphere (BEAMA Ltd.)
Electric Trace Heating Industry Council (ETHIC)
Electricity Association
Energy Industries Council
Engineering Equipment and Materials Users' Association
Engineering Industries Association
Health and Safety Executive
Induction and Dielectric Heating Manufacturers' Association
Institution of Electrical Engineers
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Contents

Foreword

This British Standard has been prepared by Technical Committee PEL/27.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

Specification

1 Scope

This British Standard specifies requirements for industrial electric heaters with a rated voltage of up to 440 V, using metal-sheathed elements and installed in a duct run, for heating in forced air systems or for heating of non-flammable gases.

The heaters may have fixed, replaceable or removable elements.

2 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies: any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

3 Definitions

For the purposes of this British Standard, the following definitions apply.

3.1 (metal-sheathed heating) element

A heating assembly comprising a resistance alloy within, and insulated from, a tubular metal sheath.

3.2 duct heater

An assembly of metal-sheathed heating element(s), associated controls and wiring, installed in a duct run.

3.3 terminal enclosure

The enclosure in which the elements are terminated.

NOTE. Other electrical equipment can be contained within the enclosure; for example, thermostats, pressure switches, contactors, transformers, fuses.

3.4 fixed element

An element which is permanently attached to its supporting body by adhesive bonding, soldering, brazing or welding.

3.5 replaceable element

An element which can only be removed with the aid of a tool, normally after removal of the element bundle from its containment ducting.

3.6 removable element

An element which can be removed without the need for removing the element bundle from its containment ducting.

3.7 ducting

The sheet-metal fabrication through which the air or non-flammable gases pass, and into which the element bundle is inserted.

3.8 mounting plate

The plate to which the element bundle or containment pocket is attached.

3.9 rated voltage

The voltage assigned to the heater by the manufacturer.

3.10 rated power

The wattage, at rated voltage, assigned to the heater by the manufacturer.

3.11 thermal insulation

A material or system that has the property of resisting the transfer of heat.

3.12 thermostat

A temperature-sensing device, the operating temperature of which may be either fixed or adjustable and which, during normal operation, keeps the temperature of the air or gases between certain limits by opening or closing a heater circuit.

3.13 temperature limiter

A temperature-sensing device, the operating temperature of which may be either fixed or adjustable and which, during normal operation, operates by opening or closing a heater circuit when the temperature reaches a predetermined value.

NOTE. A temperature limiter does not make the reverse operation during the normal duty cycle of the heater. It may or may not require manual resetting.

3.14 thermal cut-out

A device which, during abnormal operation, limits the temperature of a heater, or of parts of it, by opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user.

3.15 basic insulation

Insulation applied to live parts to provide basic protection against electric shock.

NOTE. Basic insulation does not necessarily include insulation used exclusively for functional purposes.

3.16 supplementary insulation

Independent insulation applied in addition to basic insulation, for protection against electric shock in the event of a failure of the basic insulation.

3.17 double insulation

Insulation comprising both basic insulation and supplementary insulation.

3.18 reinforced insulation

A single insulation system applied to live parts that provides a degree of protection against electric shock equivalent to double insulation.

NOTE. The term 'insulation system' does not imply that the insulation is one homogeneous piece. It may comprise several layers that cannot be tested singly.

3.19 stud terminal

Screw-type terminal in which the conductor is clamped under one or two nuts. The clamping pressure may be applied directly by a suitably shaped nut or through an intermediate part, such as a washer, clamping plate or anti-spread device.

3.20 pillar terminal

Screw-type terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of a screw or screws. The clamping pressure may be applied directly by the shank of the screw or through an intermediate part to which pressure is applied by the shank of the screw.

3.21 screw terminal

Screw-type terminal in which the conductor is clamped under a bolt and washer, the bolt passing through a fixed nut or threaded bush.

3.22 creepage distance

The path between two conductive parts, or between a conductive part and the bounding surface of the element, measured across the surface of the insulating material.

3.23 clearance

The distance between two conductive parts, or between a conductive part and the bounding surface of the element, measured through air.

4 Heating elements

All the heating elements shall conform to BS 7351 : 1990.

5 Rating

5.1 Rated voltage

Heaters shall be rated for a line voltage not greater than 440 V.

NOTE. The requirements of this standard are based on the assumption that, in normal use, the voltage between the supply lines and neutral does not exceed 254 V.

5.2 Rated power

The actual power output from the heater at the operating temperature, on application of the rated voltage, shall not vary from the rated power output by more than the tolerances given in table 1, when verified in accordance with **A.1**.

Table 1. Power output

Rated power kW	**Tolerance** %
0 to 50	± 7.5
≥ 51	± 5.5

6 Degree of protection

The minimum degree of protection provided by heater enclosures shall be in accordance with IP 20 of BS EN 60529 : 1992.

7 Electrical insulation

7.1 The mounting of electrically insulating parts shall be designed so as to prevent breakage or damage due to expansion and contraction.

7.2 Electrically insulating washers, bushings and the like, which are integral parts of the heater, and bases or supports of the mounting of current-carrying parts shall be of a moisture-resistant material which will not be damaged by the temperatures to which they will be subjected under conditions of actual use.

7.3 The insulation between any parts operating at extra-low voltage and other live parts, and between the core of the isolating transformer and other metal parts, shall be as specified in BS 3535 : Part 1 and Part 2.

7.4 Parts which serve as supplementary insulation or reinforced insulation shall either:

a) be fixed in such a way that they cannot be removed without being seriously damaged; or

b) be designed so that they cannot be replaced in an incorrect position, and so that, if they are omitted, the appliance is rendered inoperable or manifestly incomplete.

NOTE 1. Sleeving may be used as supplementary insulation on internal wiring, if it can only be removed by breaking or cutting, or if it is clamped at both ends.

NOTE 2. Lining metal enclosures with a coating of lacquer, or with other material in the form of a coating which can be easily removed by scraping, is not deemed to meet this requirement.

7.5 Inside the terminal enclosure, the sheath of a flexible cable or cord shall only be used as supplementary insulation where it is not subject to undue mechanical or thermal stresses and if its insulating properties are not less than those specified for the sheaths of flexible cables and cords in BS 6004, BS 6007, or BS 6500.

8 Thermal insulation

8.1 Thermal insulation materials shall not make contact with the heating element.

8.2 Where terminal enclosures are stood off from the mounting plate to give cooling via natural convection, the stand-off areas shall not be thermally insulated.

9 Construction

NOTE. Heaters should be so constructed that they operate in all positions to be expected in normal use. Any limitations of use should be specified by the manufacturer.

9.1 Heaters shall be constructed so that, after being removed for servicing or maintenance, they can be refitted correctly with normal tools.

9.2 A thermal cut-out or temperature limiter shall be provided. The sensor shall be mounted so as to protect the complete heater unit.

9.3 If element surface temperature monitors are fitted, they shall be attached to the element sheath by brazing, welding or mechanical clamping.

9.4 Heaters shall be provided with an enclosure.

9.5 The minimum thickness of metallic enclosures shall be as stated in table 2.

9.6 Non-metallic enclosures shall conform to the appropriate glow-wire test requirements of BS 6458 : Section 2.1.

NOTE. Special consideration should be given to any non-metallic enclosure to ensure that it has sufficient physical strength, and that it has adequate resistance to impact, moisture absorption, corrosion and to distortion with respect to thermal ageing.

9.7 All parts of the heater in contact with air or gases shall be manufactured from materials resistant to service corrosion or protected by a corrosion-resistant finish.

Details of any protective finish, including its method of application and recommended intervals for recoating, shall be specified in the maintenance instructions.

9.8 All external parts open to the atmosphere shall be manufactured from materials resistant to the atmosphere or protected by a corrosion-resistant finish.

NOTE. Particular care should be taken in the selection of the materials used within the terminal enclosures, where airborne vapours or corrosive gases may exist.

Details of any protective finish, including its method of application and recommended intervals for recoating, shall be specified in the maintenance instructions.

9.9 Internal surfaces shall be smooth and free from sharp edges, burrs, flashes and the like, which might abrade the insulation of the wiring.

9.10 Where terminal enclosures are stood off from the flange plate to allow cooling by natural convection, suitable safety guards shall be fitted.

9.11 Spacers intended to prevent the element from overheating the duct walls shall be so fixed that it is not possible to remove them from the outside of the heater by means of a screwdriver or spanner.

9.12 The heaters shall be so constructed that the setting of thermostats or other control devices cannot be accidentally altered.

9.13 The location and mounting of any integral controls shall be such as to protect them from damage when in use and when the heater is removed for servicing.

9.14 Handles, knobs, grips and levers shall be securely fixed so that they will not work loose in normal use. If handles or knobs are used to indicate the position of switches or similar components, it shall not be possible to fix them in an incorrect position.

9.15 Materials which support combustion shall not be used in the construction of the heaters.

9.16 Wood, cotton, silk, paper and similar fibrous or hygroscopic material shall not be used as insulation unless impregnated. Ceramic materials not fully sintered and insulating beads alone shall not be used as supplementary or reinforced insulation.

Asbestos shall not be used for any purpose.

10 Supply connections

All cables for supply connections shall conform to one of the following British Standards:

BS 5467, BS 6004, BS 6007, BS 6141, BS 6207, BS 6346.

NOTE. It is recommended that sizes be selected to suit the nominal rating of the heater plus an allowance for the increase in rating due to power factor, increase in supply voltage and the heater manufacturing tolerances.

Table 2. Minimum thickness of metallic enclosures

Material	Reinforced flat surfaces	Surfaces to which a wiring system is to be connected on site	Unreinforced flat surfaces
	mm	mm	mm
Die-cast steels	1.2	—	2.0
Cast malleable iron	1.6	—	2.4
Other cast metal	2.4	—	3.2
Uncoated sheet steel	0.66	0.81	0.66
Galvanized sheet steel	0.74	0.86	0.74
Non-ferrous sheet steel	0.91	1.14	0.91

11 Terminations for external conductors

11.1 General

11.1.1 Terminals for external connection shall be mounted in a manner that prevents self-loosening.

NOTE 1. Terminals may be secured with two screws, or with one screw in a recess such that there is no appreciable play, or by other suitable means.

NOTE 2. Covering with sealing compound without any other means of locking is not deemed to be adequate. Self-hardening resins may, however, be used to lock terminals which are not subject to torsion in normal use.

11.1.2 Terminals shall be such that proper contact is assured without deterioration of the conductors, even if multi-stranded cores are used in terminals which are intended for direct clamping of the cores.

11.1.3 Terminals shall not have sharp edges which could damage the conductors.

NOTE. Conductors are considered to be damaged if they show deep or sharp indentations.

11.1.4 Terminals shall be of a type which cannot turn, or be twisted or permanently deformed during normal tightening.

11.1.5 The terminals shall be such that the contact they apply is not impaired by the temperature changes likely in normal service. Insulating material shall not be used to transmit the contact pressure.

11.1.6 Terminals which are intended for clamping stranded cores shall include a resilient intermediate part.

NOTE. Special precautions may be necessary against vibration or mechanical shocks.

11.1.7 The minimum size of terminal used shall be for conductors of 4 mm^2 cross-section.

11.1.8 Terminals made of aluminium, or material containing aluminium, shall be protected against electrolytic corrosion.

11.1.9 For operation at an ambient temperature of 60 °C, terminals shall allow the connection of conductors having nominal cross-sectional areas as shown in table 3. The cable sizes applicable to heaters designed to operate in ambient temperatures higher than 60 °C shall be determined by applying a derating factor to the current values given in table 3.

Table 3. Terminal sizes

Rated current of heater at ambient temperature of 60 °C[1)] A	Terminal suitable for cable sizes (nominal cross-sectional area) mm^2
Up to and including 10	1 to 2.5
Over 10 up to and including 16	1.5 to 4
Over 16 up to and including 25	2.5 to 6
Over 25 up to and including 32	4 to 10
Over 32 up to and including 40	6 to 16
Over 40 up to and including 63	10 to 25

[1)] For temperatures higher than 60 °C, a derating factor shall be applied.

11.1.10 Terminals shall not require special preparation of the conductor in order to effect correct connection, and they shall be so designed or placed that the conductor cannot slip out when the clamping screws or nuts are tightened.

NOTE 1. The term 'special preparation of the conductor' includes soldering of the strands, use of cable lugs, and formation of eyelets. It does not include the reshaping of the conductor before its introduction into the terminal, or the twisting of a stranded conductor to consolidate the end.

11.1.11 When fastened in the terminal, a conductor of the cross-sectional area given in table 4 shall remain secure while pulled axially for 1 min with a steady force of the corresponding value given in table 4.

Table 4. Fastening strength of terminals

Rated current of heater A	Cross-sectional area of conductor mm^2	Pulling force N
Up to and including 6	2.5	40
Over 6 up to and including 10	2.5	50
Over 10 up to and including 16	4	50
Over 16 up to and including 25	6	60
Over 25 up to and including 32	10	80
Over 32 up to and including 40	16	90
Over 40 up to and including 63	25	100

11.1.12 Where terminals are provided for the connection of external cables, each terminal shall be located adjacent to its corresponding terminal, or terminals, of different polarity, and to the earthing terminal, if any.

11.1.13 Terminal devices shall not be accessible without the aid of a tool, even if their live parts are not accessible.

11.1.14 Terminal devices shall be so located or shielded that there is no risk of accidental connection between live parts and accessible metal parts.

NOTE. Particular consideration should be given to preventing the possibility of such connection via an escaped strand of a connected conductor.

11.2 Pillar terminals

11.2.1 For operation at an ambient temperature of 60 °C, dimensions of pillar terminals shall be as given in table 5, except that the length of thread in the pillar may be shorter subject to a more stringent torque test: see **11.2.3**. For operation at ambient temperatures higher than 60 °C, the dimensions shall be determined by applying a derating factor to the current values given in table 5.

NOTE. If one or more of the dimensions are larger than the minimum specified in table 5, the other dimensions need not be correspondingly increased.

11.2.2 The length of the threaded part of the terminal screw shall not be less than the sum of the diameter of the hole for the conductor and the length of the thread in the pillar.

If the thread in the pillar is recessed, the length of a headed screw shall be increased accordingly.

11.2.3 If the length of thread in the pillar is shorter than that shown in table 5, or if the length of the extrusion is more than 80 % of the original thickness of the metal, the terminal shall conform to **15.6** when tested using the torque values specified in table A.2.

11.2.4 The surface against which the conductor is clamped shall be free from sharp indentations or projections.

NOTE. The part against which the conductor is clamped need not be in one piece with the part carrying the clamping screw.

11.2.5 Pillar terminals shall be so designed and located that the end of a conductor introduced into the hole is visible, or can pass beyond the threaded hole for a distance at least equal to half the nominal diameter of the screw, or 2.5 mm, whichever is the greater.

11.3 Screw terminals

11.3.1 Dimensions of screw terminals shall be not less than those given in table 6, except that the length of thread in the screw hole or nut and the length of thread on the screw may be shorter subject to a more stringent torque test: see **11.3.3**.

NOTE. If one or more of the dimensions are larger than specified in table 6, the other dimensions need not be correspondingly increased.

If the required length of thread in a terminal screw hole is obtained by piercing, the edge of the extrusion shall be reasonably smooth and the length of thread shall exceed the minimum value given in table 6 by at least 0.5 mm. The length of the extrusion shall be not more than 80 % of the original thickness of the metal.

If the thread in the screw hole or nut is recessed, the length of a headed screw shall be increased accordingly.

Table 5. Dimensions of pillar terminals

Rated current of heater at ambient temperature of 60 °C[1]	**Minimum nominal thread diameter**[2]	**Minimum diameter of hole for conductors**	**Minimum length of thread in pillar**[3] [4]	**Maximum difference between diameter of hole and nominal thread diameter**
A	mm	mm	mm	mm
Up to and including 10	2.8	3.0	2.0	0.6
Over 10 up to and including 16	3.5	3.5	2.5	0.6
Over 16 up to and including 25	4.0	4.0	3.0	0.6
Over 25 up to and including 32	4.0	4.5	3.0	1.0
Over 32 up to and including 40	5.0	5.5	4.0	1.3
Over 40 up to and including 63	6.0	7.0	4.0	1.5

[1] For temperatures higher than 60 °C, a derating factor shall be applied.
[2] A negative deviation of 0.15 mm is permitted, to allow for the use of non-metric screws.
[3] Measured to the point where the thread is first broken by the hole for the conductor.
[4] A shorter thread is permitted subject to a more stringent torque test: see **11.2.3**.

11.3.2 If an intermediate part, such as a pressure plate, is used between the head of the screw and the conductor, the length of thread on the screw specified in table 6 shall be increased accordingly.

NOTE 1. If an intermediate part is used, the diameter of the head of the screw relative to the shank (see table 6) may be reduced by:

1 mm for rated currents not exceeding 16 A;

2 mm for rated currents exceeding 16 A.

NOTE 2. If an intermediate part has more than one screw, screws with the following nominal thread diameter may be used:

3.5 mm for rated currents not exceeding 25 A;

4.0 mm for rated currents exceeding 25 A.

The intermediate part shall be locked against rotation.

11.3.3 If the length of thread in the screw hole or nut, or the length of thread on the screw, is smaller than that shown in table 6, or if the length of the extrusion is more than 80 % of the original thickness of the metal, the terminal shall conform to **15.6** when tested using the torque values specified in table A.2.

11.4 Stud terminals

11.4.1 Dimensions of stud terminals shall be as given in table 7.

NOTE. If one or more of the dimensions are larger than the minimum specified in table 7, the other dimensions need not be correspondingly increased.

11.4.2 Stud terminals shall be provided with washers.

12 Provision for earthing

12.1 Earthing terminal

12.1.1 Accessible metal parts, which could become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal within the heater.

The earthing terminal and earthing contacts shall not be electrically connected to the neutral terminal.

NOTE. For the purpose of this requirement, accessible metal parts that are screened from live parts by metal parts which are connected to the earthing terminal or earthing contact, are not regarded as likely to become live in the event of an insulation fault.

Table 6. Dimensions of screw terminals

Rated current of heater	Minimum nominal thread diameter[1) 2)]	Minimum length of thread on screw[4)]	Minimum length of thread in screw hole or nut[4)]	Minimum nominal difference[2)] between diameters of head[3)] and shank of screw	Minimum height of head of screw
A	mm	mm	mm	mm	mm
Up to and including 10	3.5 (3.0)	4.0 (3.5)	1.5	3.5 (3.0)	2.0 (1.8)
Over 10 up to and including 16	4.0	5.5	2.5	4.0	2.4
Over 16 up to and including 25	5.0	6.5	3.0	5.0	3.0
Over 25 up to and including 32	5.0	7.5	3.0	5.0	3.5
Over 32 up to and including 40	5.0	8.5	3.0	5.0	3.5
Over 40 up to and including 63	6.3	10.5	3.5	6.0	5.0

[1)] The nominal thread diameter may be reduced if an intermediate part is used. See **11.3.2**.
[2)] A negative deviation of 0.15 mm is permitted, to allow for the use of non-metric threads.
[3)] The screwhead diameter may be reduced if an intermediate part is used. See **11.3.2**.
[4)] A shorter thread is permitted subject to a more stringent torque test: see **11.3.3**.

NOTE. The values in parentheses apply to portable heaters only.

Table 7. Dimension of stud terminals

Rated current of heater	Minimum nominal thread diameter[1)]	Maximum difference between thread diameter and inner diameter of washers	Minimum difference between thread diameter and outer diameter of washers
A	mm	mm	mm
Up to and including 10	3.0	0.4	4.0
Over 10 up to and including 16	3.5	0.4	4.5
Over 16 up to and including 25	4.0	0.5	5.0
Over 25 up to and including 32	4.0	0.5	5.5

[1)] A negative deviation of 0.15 mm is permitted, to allow for the use of non-metric threads.

12.1.2 The earthing terminal shall conform to the requirements specified in clause **11**, with the exception of **11.1.9**.

12.1.3 External earthing terminals shall allow the connection of conductors having a minimum cross-sectional area of 2.5 mm^2.

12.1.4 The clamping devices of earthing terminals shall be locked against accidental loosening and it shall not be possible to loosen them without the aid of a tool.

NOTE. The designs commonly used for current-carrying terminals, other than some terminals of the pillar type, generally provide sufficient resilience to meet this requirement. For other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

12.1.5 All parts of the earthing terminal shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the earthing conductor, or any other metal that is in contact with these parts.

The body of the earthing terminal shall be of brass or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure. The screw or nut shall be of brass or other metal no less resistant to corrosion.

If the body of the earthing terminal is a part of a frame or enclosure made of aluminium or aluminium alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminium or its alloys.

12.1.6 When tested in accordance with **A.2**, the resistance between the earthing terminal or earthing contact and each part connected to it shall not exceed 0.1 Ω.

12.2 Bonding for earthing

12.2.1 Exposed dead metal parts, other than those described in the following note, shall be in electrical connection with the earthing means at the point of connection of the power supply wiring system.

NOTE. This requirement does not apply to:

a) a small metal part, such as an adhesive-attached foil marking label, a screw, or a handle, that is:

1) on the exterior of the enclosure and separated from all electrical components by earthed metal; or

2) positively separated from all electrical components;

b) a panel or cover that is insulated from all electrical components by a reliably secured barrier of vulcanized fibre, varnished cloth, phenolic composition, or other moisture-resistant insulating material, no less than 0.008 mm in average thickness and no less than 0.007 mm thick at any point;

c) a panel or cover that does not enclose uninsulated live parts and is positively separated from other electrical components.

12.2.2 Exposed dead metal parts, other than those noted in **12.2.1**, shall be bonded together by mechanical fasteners, or by an individual bonding conductor or strap.

12.2.3 The bonding conductor shall be of material rated for use as an electrical conductor, and protected from corrosion unless inherently resistant thereto. An individual bonding conductor or strap shall be so installed that it is protected from physical damage.

12.2.4 The bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection, brazing or welding. The bonding connection shall penetrate non-conductive coatings, such as paint.

12.2.5 The bonding connection shall withstand twice the maximum rated current for at least 2 min.

12.2.6 When tested in accordance with **A.3**, the resistance of the earthing path between a dead metal part and the heater earthing terminal or point of attachment of the wiring system shall be no more than 0.1 Ω.

13 Internal wiring

13.1 Openings in sheet metal through which insulated wires pass shall either be provided with bushings of insulating material, or shall be rounded with a radius equal to at least the material thickness.

13.2 Wiring shall be effectively prevented from coming into contact with moving parts.

13.3 Internal wiring and electrical connections between parts of heater shall be protected or enclosed.

13.4 Beads and other ceramic insulators on live wires shall be so fixed or supported that they cannot change their position. They shall not rest on sharp edges or sharp corners. If they are inside a flexible metal conduit which can move, they shall be contained within an insulating sleeve.

13.5 Internal wiring and element ends shall be either so rigid and so fixed, or so insulated, that creepage distances and clearances cannot be reduced below the values specified in clause **16**.

The insulation, if any, shall be such that it cannot be damaged in normal operation.

13.6 Conductors identified by the colour green or colour combination green and yellow shall not be connected to terminals other than earthing terminals.

13.7 The insulation of conductors which, in normal use, are subject to a temperature exceeding 50 °C shall be of heat-resisting material conforming to the appropriate standard referred to in clause **10**.

13.8 All internal wiring shall be continuous and free from splices.

13.9 Bare conductors, and conductors utilizing beads for insulation, shall not be used outside an enclosure.

13.10 Busbars shall be rigidly mounted and free from sharp edges.

14 Mounting of components

14.1 General

All electrical components shall be mechanically secured.

14.2 Prevention of turning

NOTE. More than friction between surfaces is required to prevent turning, but a lock washer is acceptable as a means for locking a small stem-mounted switch or other small device designed for single-hole fixing.

14.2.1 Fuseholders and contactors shall be prevented from turning.

14.2.2 Switches shall be prevented from turning unless all the following conditions are met.

a) The switch is of a plunger type or other type that does not tend to rotate when operated.

NOTE. A toggle switch is not considered to meet this condition.

b) The switch is not operated by direct manual contact.

c) If the switch rotates, the spacings are not reduced below the minimum values given in table 8.

14.2.3 A lampholder shall be prevented from turning unless both the following conditions are met.

a) The lampholder is of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a non-removable jewel.

b) If the lampholder rotates, the spacings are not reduced below the minimum values given in table 8.

14.2.4 Uninsulated live parts shall be secured to the base or mounting surface so that they cannot move or turn, if such motion could reduce the spacings below the minimum values given in table 8.

14.3 Spacings

14.3.1 The spacing between components shall be as given in table 8, or the components shall be separated by an insulating lining or barrier conforming to one of the following types:

a) fibre or similar insulation not less than 0.8 mm thick, which will not be adversely affected by arcing;

b) fibre insulation not less than 0.4 mm thick, in conjunction with an air spacing of not less than 50 % of the spacing specified in table 8 for air alone;

c) mica-based insulation not less than 0.25 mm thick.

14.3.2 The construction shall ensure that a minimum spacing of 1.6 mm is maintained, under all operating conditions, between an uninsulated live part and a dead metal part, either of which is not rigidly supported.

15 Screws and connections

15.1 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use.

15.2 Screws having a nominal diameter of less than 3 mm, and which transmit contact pressure or are likely to be tightened during installation, use or maintenance, shall screw into metal.

NOTE. Screws or nuts which are likely to be tightened during installation, use or maintenance include terminal screws or nuts, screws for securing covers, and screws for fixing handles and knobs.

Table 8. Minimum spacings

Situation	**Medium**	**Spacing** mm	
		Rated voltage of heater V	
		0 to 254	**255 to 440**
For parts other than terminals: Between any uninsulated live parts[1] of opposite polarity, and between any rigidly mounted uninsulated live part and metal which may be exposed to contact by persons during the operation of the heater or which may be earthed	Through air	1.6[2]	6.4
	Over surface	1.6[2]	6.4
For wiring terminals of supply connections[3]: Between a wiring terminal and metal of the enclosure	Through air	12.7	12.7
Between terminals of opposite polarity or between live terminal parts and metal, other than the enclosure, which may be earthed in service	Through air	6.4	9.5
	Over surface	9.5	12.7

[1] For the purpose of **14.3**, enamel-insulated wire is regarded as an uninsulated live part.
[2] At closed-in points only, such as the screw-and-washer construction of an insulated terminal mounted in metal, a spacing greater than 1.2 mm is acceptable.
[3] Not applicable to connecting straps or busbars which extend away from terminals.

15.3 Screws shall not be of zinc, aluminium or any other metal which is soft or liable to creep.

15.4 Screws of insulating material shall have a nominal diameter of at least 3 mm. They shall not be used for electrical connections.

15.5 Screws shall not be of insulating material if their replacement by a metal screw could impair supplementary insulation or reinforced insulation. Screws which may be removed when replacing a non-detachable flexible cable or cord, or undertaking other routine servicing, shall not be of insulating material if their replacement by a metal screw could impair functional insulation.

15.6 When tested in accordance with **A.4**, screws and nuts which transmit contact pressure, or which are likely to be tightened during installation, use or maintenance shall suffer no damage which would impair the screwed connection.

15.7 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 8 mm, or of 3 mm plus one third of the nominal screw diameter, whichever is the shorter.

15.8 The design shall ensure that screws cannot be introduced into the screw hole at an incorrect angle.

NOTE. This can be achieved, for example, by guiding the screw through a recess in the part to be fixed, by a recess in the female thread or by the use of a screw with the leading thread removed.

15.9 Contact pressure in electrical connections shall not be transmitted through insulating material other than ceramic.

15.10 Spaced-thread screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other and are provided with an effective means of locking.

Thread-cutting screws shall not be used for the connection of current-carrying parts.

NOTE 1. Thread-cutting and spaced-thread screws may be used to provide earthing continuity, provided that it is not necessary to disturb the connection in normal use and that at least two screws are used for each connection.

NOTE 2. Screws which swage a full-form standard machine screw thread are not regarded as thread-cutting screws.

15.11 Screws which secure a current-carrying connection between different parts of the heater shall be locked against loosening.

Rivets used to secure current-carrying connections shall be locked against loosening, if these connections are subject to torsion in normal use.

NOTE 1. Spring washers can provide satisfactory locking.

NOTE 2. For rivets, a non-circular shank or an appropriate notch can be sufficient to prevent loosening.

NOTE 3. Sealing compound which softens on heating can provide satisfactory locking only for screw connections not subject to torsion in normal use.

16 Creepage distances, clearances, and distances through insulation

16.1 When measured in accordance with **A.5**, creepage distances, clearances and distances through insulation shall not be less than the values shown in table 9.

NOTE 1. The values given in table 9 do not apply to a component part for which creepage distances and clearances are specified in a British Standard to which the part conforms.

NOTE 2. The contribution to the creepage distance of any groove less than 1 mm wide is limited to its width.

NOTE 3. Any air gap less than 1 mm wide is ignored in computing the total clearances.

NOTE 4. The clearances required between live parts of different polarity do not apply to the air gap between the contacts of thermostats, thermal cut-outs, and overload protection devices of micro-gap construction, nor to the air gap between the current-carrying members of such devices where the clearance varies with the movement of contacts.

NOTE 5. Uninsulated capillary tubes of thermostats are regarded as bare conductors.

NOTE 6. The interior of a dust-proof enclosure is deemed to be protected against deposition of dirt, provided that the heater does not generate dust within itself. Hermetic sealing is not required.

NOTE 7. The required distance through insulation need not be through solid insulation only; it may consist of a thickness of solid insulation plus one or more air gaps.

16.2 When terminal screws are loosened to their maximum extent, the clearance between the screwhead and any metal part which is accessible or is connected to an accessible metal part shall be not less than 50 % of the values shown in table 9.

Table 9. Creepage distances and clearances

Resonance voltage V	**Protected against deposition of dirt**		**Not protected against deposition of dirt**	
	Creepage distance mm	**Clearance** mm	**Creepage distance** mm	**Clearance** mm
Up to and including 60	0.5	0.5	2.0	1.5
Over 60 up to and including 250	2.0	2.0[1)]	3.0[2)] 4.0[3)]	2.0[2)] 3.0[3)]
Over 250 up to and including 380	2.0	2.0	4.0	3.0
Over 380 up to and including 440	3.0	3.0	5.0	4.0

[1)] Reduced to 1.5 mm for clearances between live parts of different polarity, if the design is such that the distance cannot be reduced either during manufacture or during normal use.
[2)] Applies to creepage distances or clearances between live parts of different polarity.
[3)] Applies to creepage distances or clearances between live parts and accessible metal parts, metal parts connected thereto or metal foil in contact with accessible surfaces of insulating material.

17 Controls

17.1 Control power supplies

The voltage of a power supply for the control system shall not exceed 254 V a.c. single-phase or 120 V d.c.

NOTE 1. The control power may be obtained either from the heater supply or from a separate control supply.

If the control power is derived from a three-phase three-wire system, a transformer shall be used.

NOTE 2. If the control power is derived from a three-phase and neutral supply, either a phase and neutral may be used, or a transformer.

17.2 Isolation

If the control components are fitted within an enclosure which forms part of the heater, and this enclosure is specifically for control, the cover of the enclosure shall bear a warning label, securely fixed, requiring the control system to be isolated from the power supply before the cover is removed.

NOTE. It is recommended that an interlocked isolator be fitted on the cover of the enclosure.

17.3 Components

Control components shall conform to the relevant British Standard and be suitable for the maximum anticipated temperature that they will reach during operation.

All components shall be securely fitted to the backplate or framework.

17.4 Heat-limiting and tripping devices

Devices used to limit the heat output from the heater, or to switch off the heater in the event of an over-temperature condition, shall conform to BS EN 60730-1.

Thermal cut-outs shall be fail-safe or shall indicate that a failure has occurred. If a device which is not fail-safe is used, two such devices shall be fitted in series.

Trip devices shall be calibrated with specific trip values, and be fitted with a set-point lock or mounted in such a way that the set point cannot be accidentally altered.

17.5 Voltage transformers

Transformers for controls shall be fused on the phase lines, and fused on the live output side. The other output line and the frame shall be earthed.

17.6 Power-switching devices

Power-switching devices shall be of a size capable of carrying the rated current plus 30 %, to cover variations in voltage, power factor, and manufacturing tolerances.

Thyristors shall be of the zero-voltage switching variety. Thyristor switching systems shall conform to the requirements of BS 5406 : Parts 2 and 3. Phase-angle systems shall not be used. Thyristors requiring cooling fans shall incorporate an overheat trip to prevent overheating if the cooling fan fails.

NOTE 1. Consideration should be given to thyristor heat dissipation.

NOTE 2. Types of control can be direct-switching, burst-firing or single-cycling.

18 Labels and warning notices

18.1 Where it is possible to gain access to an area containing live parts, a warning notice shall be fitted to the outside of the enclosure.

Example

'DANGER: XXX volts'

18.2 External controls, switches and indicators shall carry a clear label to identify their function.

18.3 Thermostats shall have a graduated dial showing the approximate temperature setting of the adjustable control, or a mark or label to show how the movement of the knob or handle will increase or decrease the temperature.

18.4 If the heaters isolating switch or its circuit protection is in a remote position, the following warning notice shall be displayed on the heater enclosure:

'Isolate elsewhere before removing cover'

18.5 If the terminal box, or the supply wires inside the terminal box, are expected to attain a temperature higher than 60 °C, a warning label or mark shall be provided at or near the point where the supply connections are to be made, and shall be so located that it will be readily visible during installation. The label or mark shall state the temperature in accordance with table 10.

Example

'WARNING: For supply connections, use wires suitable for at least ... °C'

Table 10. Temperature marking for supply connections

Maximum temperature (of wires) in terminal box °C	Temperature stated in marking °C
61 to 75	75
76 to 90	90

18.6 The wiring terminals shall be clearly identified.

19 Routine testing

19.1 General

All heaters shall be tested by the manufacturer in accordance with **19.2** to **19.4**.

19.2 Continuity

The continuity, phase-to-phase and phase-to-neutral, of each connected stage shall be measured and the cold resistance values recorded on the heater test report.

19.3 Insulation resistance

The insulation resistance of the heater between the live terminal on each stage and the earth shall be measured at room temperature with a voltage of not less than 500 V d.c. and with any control supplies disconnected from the power supply. The resistance shall be not less than 2 MΩ.

19.4 Dielectric strength

The heaters shall be tested in accordance with **A.6**. No flash-over or breakdown shall occur.

20 Instructions

Instructions for installation, operation and maintenance shall be supplied with the heater. The installation instructions shall indicate the wiring connections, and shall include a wiring diagram.

21 Marking

21.1 Heaters shall be marked with the following information:

a) the rated voltage(s) or rated voltage range(s), in volts;

b) the nominal power rating, in watts or kilowatts;

c) the number of phases and the frequency in hertz, if the heater has been designed for use on an a.c. supply;

d) the number of switching steps;

e) the direction of air-flow;

f) the name or trademark of the company claiming compliance with this standard;

g) the manufacturer's model or type reference;

h) the number and date of this British Standard, i.e. BS 7797 : 1998[1)].

NOTE. It is recommended that the following additional information be made available:

1) the maximum allowable working temperature, in degrees Celsius;

2) the maximum allowable working pressure, in bars (gauge);

3) the current, in amps;

4) the degree of protection, as defined in BS EN 60529 : 1992.

21.2 All markings shall be legible and permanent.

21.3 Where symbols are used they shall be as shown in table 11.

Table 11. Symbols for marking

Symbol	Meaning
V	voltage
A	amperes
Hz	hertz
W	watts
kW	kilowatts
N	newtons
Pa	pascals
h	hours
min	minutes
s	seconds
~	alternating current
3 ~	three-phase alternating current
3 ~ + n	three-phase alternating current with neutral

[1)] Marking BS 7797 : 1998 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity, which may also be desirable.

Annexes

Annex A (normative)
Methods of test

A.1 Verification of power output

A.1.1 Calculate the resistance R (in ohms) of the heater in the cold condition from the following equation:

$$R = \frac{KV^2}{W}$$

where

K is the conversion factor, stated by the manufacturer, for the change in resistance with operating temperature;

V is the rated voltage (in volts);

W is the rated wattage (in watts).

If the assembly has a large number of elements connected in parallel, calculate the cold resistance of each phase after calculating the cold resistance of each individual element.

A.1.2 Compare the cold resistance value measured in **19.2** with the value of R calculated in **A.1.1**.

A.2 Determination of resistance between earthing terminal and earthing contact

A.2.1 Between the earthing terminal or earthing contact, and each of the accessible metal parts in turn, pass a current of 25 A, derived from an a.c. source with a no-load voltage not exceeding 6 V.

A.2.2 Measure the voltage drop between the earthing terminal or earthing contact and the accessible metal part.

A.2.3 From the current and the measured voltage drop, calculate the resistance.

NOTE. Ensure that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the results.

A.3 Determination of resistance of an earthing path

A.3.1 From the heater earthing terminal, or the point of attachment of the wiring, to the dead metal part, pass a direct or alternating current equal to the maximum rated current, at a voltage of no more than 12 V.

A.3.2 Measure the voltage drop between these two points.

A.3.3 From the current and the measured voltage drop, calculate the resistance.

A.4 Screw torque test

A.4.1 When testing terminal screws and nuts, a conductor of the largest cross-sectional area given for the appropriate current rating in table 3 shall be placed in the terminal. A rigid conductor shall be used for appliances intended for permanent connection to fixed wiring. In other cases, a flexible conductor shall be used. The conductor shall be moved each time the screw or nut is loosened.

A.4.2 Using a suitable test screwdriver, spanner or key, tighten and loosen the screws and nuts as described in **A.4.3** to **A.4.6**. Do not tighten them in jerks.

A.4.3 Screws in engagement with a thread of insulating material shall be tightened and loosened ten times, being completely removed and re-inserted each time. Nuts and other screws shall be tightened and loosened five times.

A.4.4 Apply the torque shown in column I of table A.1 when tightening metal screws without heads if the screw when tightened does not protrude from the hole.

A.4.5 Apply the torque shown in column II of table A.1 when tightening nuts, metal screws other than those mentioned in **A.4.4**, and the following types of screws made of insulating material:

a) screws with a hexagonal head where the dimension across flats exceeds the overall thread diameter;

b) screws with a cylindrical head and a socket for a key, the socket having a cross-corner dimension which exceeds the overall thread diameter;

c) screws with a head having a slot or cross slots, the length of which exceeds 1.5 times the overall thread diameter.

A.4.6 Apply the torque shown in column III of table A.1 when tightening screws made of insulating material which are not included in **A.4.5**.

Table A.1 Torque values for screw torque test

Nominal diameter of screw	**Torque** N·m		
mm	I[1)]	II[2)]	III[3)]
Up to and including 2.8	0.20	0.40	0.40
Over 2.8, up to and including 3.0	0.25	0.50	0.50
Over 3.0, up to and including 3.2	0.30	0.60	0.60
Over 3.2, up to and including 3.6	0.40	0.80	0.60
Over 3.6, up to and including 4.1	0.70	1.20	0.60
Over 4.1, up to and including 4.7	0.80	1.80	0.90
Over 4.7, up to and including 5.3	0.80	2.00	1.00
Over 5.3, up to and including 6.0	—	2.50	1.25

[1)] See **A.4.4**.
[2)] See **A.4.5**.
[3)] See **A.4.6**.

A.4.7 When testing terminals as required by **11.2.3** and **11.3.3**, apply the torque given in table A.2.

Table A.2 Torque values for screw torque test, for terminals described in 11.2.3 and 11.3.3

Nominal diameter of screw	Torque N·m		
mm	I[1)]	II[2)]	III[3)]
Up to and including 2.8	0.24	0.48	0.48
Over 2.8, up to and including 3.0	0.30	0.60	0.60
Over 3.0, up to and including 3.2	0.36	0.72	0.72
Over 3.2, up to and including 3.6	0.48	0.96	0.72
Over 3.6, up to and including 4.1	0.84	1.44	0.72
Over 4.1, up to and including 4.7	0.96	2.16	1.08
Over 4.7, up to and including 5.3	0.96	2.40	1.20
Over 5.3, up to and including 6.0	—	3.00	1.50

[1)] See **A.4.4**.
[2)] See **A.4.5**.
[3)] See **A.4.6**.

A.5 Measurement of creepage distances and clearances

A.5.1 When taking measurements, place movable parts in the most unfavourable position, and tighten nuts and screws with non-circular heads so that they are in the most unfavourable position.

A.5.2 Measure distances through slots or openings in external parts of insulating material to metal foil in contact with the accessible surface. Do not press the foil into openings.

A.5.3 While taking the measurements, apply a force to any point on bare conductors and to the outside of metal enclosures, in an attempt to reduce the creepage distances and clearances. The force shall be applied by means of test probe D as specified in BS 3042 : 1992.

A.6 Dielectric test

A.6.1 The test equipment used shall include a visible indication or audible alarm on breakdown and shall be manually reset by a switch or push-button. The test shall be carried out with the heater de-energized.

A.6.2 Between one live pole or neutral on each wired stage of the heater and earth, apply for 1 min a voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz.

The minimum test voltage shall be $2\,U + 1000$ V cold for 1 min or $(2\,U + 1000\text{ V} \times 1.2)$ for 10 s, where U is the line voltage on an unearthed delta supply, i.e. line to neutral on an earthed star supply.

Annex B (informative)
Guidance for installation and maintenance of duct heaters

B.1 Terminal boxes should be positioned on the side or the underside of the installation.

B.2 Safety cut-outs should be positioned at the outlet end of the duct, near to the top element.

B.3 Units should be suitably supported and steps taken to minimize transient vibrations.

B.4 Insulated cables of the PVC type should not be used inside the terminal box. Cables should be insulated with high-temperature sheathing.

B.5 If the rating of the heaters exceeds 3 kW, it is preferable for the supply to be balanced across three phases.

B.6 The thermal cut-out on heaters which have a loading in excess of 3 kW should be connected in conjunction with a suitable contactor or relay.

B.7 The elements and assembly should be permanently and reliably connected to an earthing terminal.

B.8 The switch controlling the fan should be interlocked with the heater controls so that the heater can operate only when the fan is running.

B.9 Where possible the fan should be interlocked so that it runs for a short period of time after the elements are switched off. This will permit heat dissipation within the ducting and avoid operation of the thermal cut-out.

B.10 A check should be made on the system to verify the correct airflow.

B.11 A line check should be made on the system to confirm the accuracy of the circuit.

B.12 The heater should be inspected at least once a year for foreign bodies and element corrosion.

B.13 If the system becomes inoperable as a result of overheating, the main isolator should be switched off before the fan is checked for failure. The ducting should also be checked for air obstruction, and the heater and contactors inspected, to determine the cause of overheating, before the unit is put back into service.

B.14 Should it be necessary to replace elements, reference should be made to the manufacturer for the correct procedures.

B.15 When replacing the heater assembly into the duct, ensure that the gasket is correctly positioned and that the safety cut-out is at the outlet end of the duct.

blank

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 3042 : 1992	*Test probes to verify protection by enclosures*
BS 3535 :	*Isolating transformers and safety isolating transformers*
BS 3535 : Part 1 : 1990	*General requirements*
BS 3535 : Part 2 : 1990	*Specification for transformers for reduced system voltage*
BS 5406 :	*Disturbances in supply systems caused by household appliances and similar electrical equipment*
BS 5406 : Part 2 : 1988	*Specification of harmonics*
BS 5406 : Part 3 : 1988	*Specification of voltage fluctuations*
BS 5467 : 1989	*Specification for cables with thermosetting insulation for electricity supply for rated voltages of up to and including 600/1000 V and up to and including 1900/3300 V*
BS 6004 : 1991	*Specification for PVC-insulated cables (non-armoured) for electric power and lighting*
BS 6007 : 1993	*Specification for rubber-insulated cables for electric power and lighting*
BS 6141 : 1991	*Specification for insulated cables and flexible cords for use in high temperature zones*
BS 6207 : 1991	*Specification for mineral-insulated copper-sheathed cables with copper conductors*
BS 6346 : 1989	*Specification for PVC-insulated cables for electricity supply*
BS 6458 :	*Fire hazard testing for electrotechnical products*
BS 6458 : Part 2	*Test methods*
BS 6458 : Section 2.1	*Glow-wire test*
BS 6500 : 1994	*Specification for insulated flexible cords and cables*
BS 7351 : 1990	*Specification for metal-sheathed heating elements for industrial use*
BS EN 60439 :	*Specification for low-voltage switchgear and controlgear assemblies*
BS EN 60439-1 : 1994	*Specification for type-tested and partially type-tested assemblies*
BS EN 60529 : 1992	*Specification for degrees of protection provided by enclosures (IP code)*
BS EN 60730 :	*Specification for automatic electrical controls for household and similar use*
BS EN 60730-1 : 1992	*General requirements*

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