

Specification for
**Metal-sheathed heating
elements for industrial
use**

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Foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee.

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

Specification

1 Scope

This British Standard specifies general requirements together with performance and constructional requirements and tests for individual metal-sheathed heating elements for industrial use.

This British Standard does not apply to elements designed for household use.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

2.1 metal sheathed heating element

(hereinafter called an element)

An assembly comprising a resistance alloy within, and insulated from, a tubular metal sheath which is particularly resistant to mechanical stress.

2.2 rated voltage

The voltage assigned to the element by the manufacturer.

2.3 rated voltage range

The range of voltage assigned to the element by the manufacturer, expressed by its lower and upper limits.

2.4 design voltage

The voltage at which the stated characteristics are obtained. In the case of a rated voltage range, design voltage is the mean of the upper and lower voltage limits.

2.5 rated power

The wattage assigned to the element by the manufacturer at rated or design voltage.

2.6 operating temperature

The temperature at which the element sheath operates under service conditions.

2.7 maximum sheath temperature

The maximum temperature attained by any part of the element sheath.

2.8 maximum permissible temperature

The maximum temperature that any part is permitted to attain under service conditions.

2.9 basic insulation

The insulation contained within the element to provide basic protection against electric shock.

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

2.10 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.

2.11 clearance

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

3 General requirements

Elements shall be so designed and constructed that, in normal use, they function safely so as to cause no danger to persons or surroundings.

TESTS. In general, compliance shall be checked by carrying out all the tests specified.

4 General notes on tests

4.1 Tests made in accordance with this standard are type tests, except for those made in accordance with clause 10, which are routine tests.

4.2 Unless otherwise specified, the test shall be made on a normal sample which shall withstand all the relevant tests.

4.3 The tests shall be carried out in the order of the clauses of this standard.

NOTE 1. Before testing is started, the element should be operated at rated voltage in order to verify that it is in working order.

NOTE 2. It is important to ensure that the tests are carried out in such a manner that the maximum permissible sheath temperature is not exceeded.

4.4 If the test results are influenced by the temperature of the ambient air, the room temperature shall be maintained at 20 ± 5 °C.

5 Rating

The maximum rated voltage shall be 440 V.

TEST. Compliance shall be checked by inspection of the marking.

6 Marking

6.1 Elements shall be durably and legibly marked with the following:

- (a) rated voltage, in volts (V);
- (b) rated power, in watts (W);
- (c) manufacturer's name, identification, trade mark or responsible vendor;
- (d) manufacturer's model or type reference;
- (e) manufacturer's date code.

TEST. Compliance shall be checked by inspection.

NOTE 1. Additional markings are allowed, provided that they do not give rise to misunderstanding.

NOTE 2. It is recommended that the following additional information be made available by the manufacturer:

- (a) maximum permissible temperature, in degrees Celsius (°C);
- (b) environmental conditions which may adversely affect safety;
- (c) operating position/application limitations;
- (d) requirements for storage including the method of restoring the insulation should the element be subject to ingress of moisture;
- (e) maximum permissible sheath temperature, in degrees Celsius (°C);
- (f) details of unheated and heated zones on a particular design of element;
- (g) recommended method of forming, where applicable;
- (h) the K value for calculating resistance, where K is a conversion factor for a change in resistance at operating temperature.

6.2 When symbols are used they shall be as follows:

V	volts
A	amperes
W	watts
h	hours
min	minutes
N	newtons
s	seconds

TEST. Compliance shall be checked by inspection.

7 Rated power

Permissible variations in rated power shall not differ from the rated wattage by more than $\pm 7.5\%$ or 10 W, whichever is the greater, when measured at rated voltage.

Compliance shall be checked by calculating the resistance of the element in cold condition R (in Ω) from the following equation:

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

where

- K is a conversion factor for the change in resistance at operating temperature;
- V is the rated voltage as given in 6.1 (in V);
- W is the rated wattage as given in 6.1 (in W).

8 Electrical insulation and leakage current at operating temperature

8.1 The electrical insulation of elements at operating temperature shall be checked by the tests specified in 8.2 and 8.3.

8.2 TEST. Leakage. The test shall be carried out with the element connected to the design voltage and at no less than its operating temperature. Having reached a steady state temperature a voltage equal to 1.06 times the design voltage is

applied and the leakage current is measured between each pole of the supply and metal element sheathing within 5 s.

The measuring circuit shall be as shown in figure 1. The resistance of the measuring circuit shall be $2000 \pm 100 \Omega$. The test shall be made with a.c. The leakage current from the element shall not exceed 0.75 mA or 0.75 mA per 1000 W rated power, whichever is the greater, with a maximum of 5 mA.

8.3 TEST. Insulation. The insulation shall be subjected for 1 min to a voltage of substantially sine-wave form, having a frequency of 50 Hz or 60 Hz. The connections shall be as shown in figure 2 under the following conditions.

The test voltage shall be applied between parts intended for connection to the supply mains and the metal sheath enclosing the element and metal fittings.

The value of the test voltage shall be 1000 V at the maximum operating temperature as specified in 8.2.

Initially not more than half of the specified voltage shall be applied, and then it shall be raised rapidly to the full value.

No flashover or breakdown shall occur.

9 Electrical insulation and leakage current in humid conditions

9.1 Where the element is to be used in humid conditions, the cold element shall be tested as specified in 9.2 to 9.4.

9.2 TEST. Set-up. The humidity treatment shall be carried out in a humidity cabinet containing air with a relative humidity of $93 \pm 2\%$. The temperature of the air is maintained within 1 °C of any convenient value between 20 °C and 30 °C.

The sample shall be kept in a cabinet for 48 h.

NOTE 1. The sample may be brought to the specified temperature and maintained in a steady state condition for a period of 4 h prior to the humidity test.

NOTE 2. A relative humidity of $93 \pm 2\%$ can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water, having a sufficiently large contact surface with the air.

NOTE 3. In order to achieve the specified conditions it is necessary to ensure constant circulation of the air within the cabinet and to use a cabinet which is thermally insulated.

9.3 TEST. Leakage. The element is removed from the humidity cabinet and connected to a supply voltage equal to 1.06 times the design voltage and the earth leakage current is measured within 5 s of connecting to the supply.

The leakage current shall not exceed 0.75 mA or 0.75 mA per kilowatt rated power, whichever is the greater, with a maximum of 5 mA. The measuring circuit shall be as shown in figure 1.

9.4 TEST. Insulation. Immediately after the test specified in 9.3 the insulation shall be subjected for 1 min to a voltage of substantially sine-wave form of 50 Hz or 60 Hz. This voltage shall be applied between terminals and the element sheath.

The value of the voltage shall be twice the line to earth voltage plus 1000 V.

Initially not more than half the prescribed voltage shall be applied, and then it is raised rapidly to full value.

No flashover or breakdown shall occur during the test.

10 Routine tests

NOTE 1. Routine tests are tests that are carried out after manufacture and prior to dispatch.

NOTE 2. Insulation resistance of an element should be checked in the cold condition using a 500 V d.c. insulation resistance tester. After manufacture the insulation resistance should not be less than 100 M Ω .

10.1 Electrical strength

An electrical strength test on the insulation shall be carried out for 2 s with a voltage of substantially sine-wave form of 50 Hz to 60 Hz. This voltage shall be applied between one terminal and the element sheath. The value of the voltage shall be twice the line to earth voltage plus 1000 V. No flashover or breakdown shall occur.

10.2 Cold element resistance

Cold element resistance in the cold condition shall be calculated using the equation given in clause 7. Permissible variations in rated power shall not differ from the rated wattage by more than $\pm 7.5\%$ or 10 W, whichever is the greater.

11 Construction

11.1 Electrical connectors and their insulation shall withstand the maximum temperatures as specified by the manufacturer.

11.2 The element shall be so constructed that unless otherwise specified a uniform heat dissipation is attained over the heated length.

11.3 When the element is supplied in an annealed condition it shall be capable of being formed cold around a former (see table 1).

Forming shall not take place within 15 mm of either side of the cold junction.

TEST. The element is formed through a 180° hairpin around a former with a diameter of circular cross section as given in table 1, at ambient temperature between 15 °C and 30 °C.

The element shall be formed as many times as possible at 150 mm intervals within the permitted forming length.

After forming there shall be no visible evidence of fracture or deformation of the metal sheath and the element shall comply with clause 8.

NOTE. When other materials are used for sheath construction, the manufacturer's guidance should be obtained.

12 Supply connections

12.1 Elements shall be provided with means of termination for connection to an incoming supply.

12.2 TEST. Compliance shall be checked by inspection.

13 Screws and connections

13.1 Screwed connections shall withstand the mechanical stresses occurring in normal use.

TEST. Compliance shall be checked by inspection. Screws and nuts that transmit contact pressure shall be tightened and loosened five times. The test shall be made by means of a suitable test screwdriver, spanner or key, applying a torque as given in table 2.

13.2 Connecting leads (tails) and terminations shall be securely attached to the element.

TEST. The connecting leads shall withstand a sudden longitudinal pull of 80 N.

14 Creepage distances, clearances and distances through insulation

Creepage distances and clearances shall be not less than the values given in table 3.

Table 1. Relationship of sheath diameter of element to circular cross section of the former

Sheath diameter of element	Diameter of circular cross section of former
mm	mm
6.5	19
8	21
9.5	23
11	25
12.5	32

NOTE. This table is for materials in general use, such as copper, mild steel, stainless steel and nickel alloy to BS 3072, BS 3073, BS 3074, BS 3075 and BS 3076.

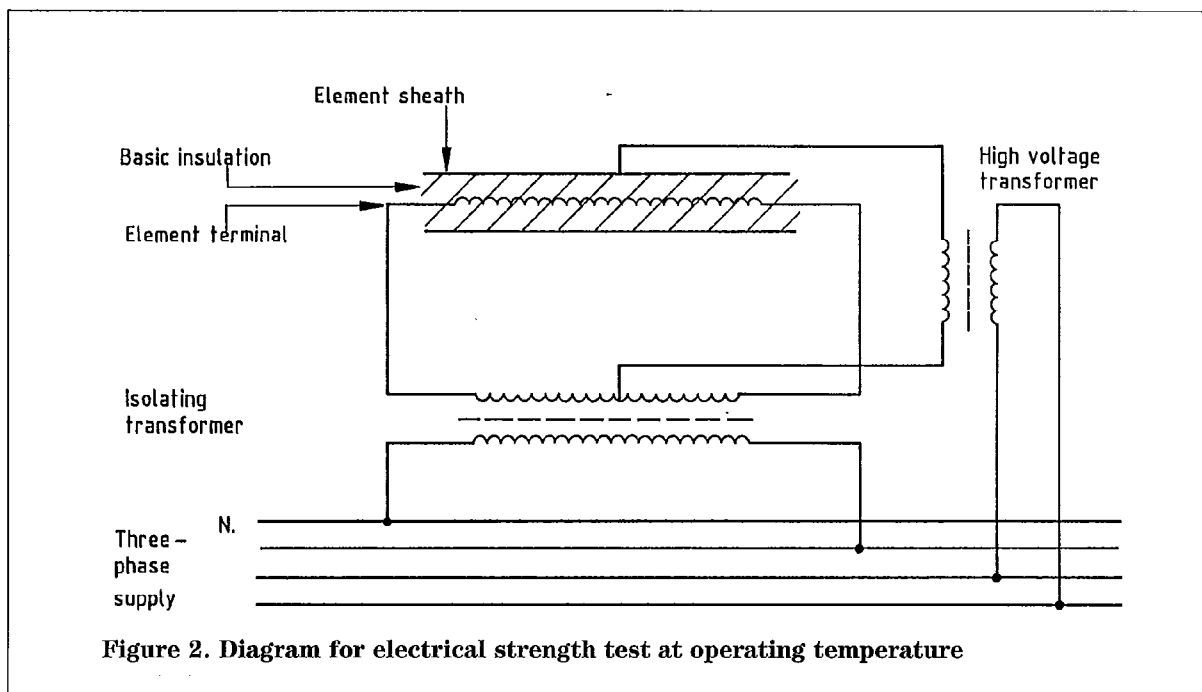
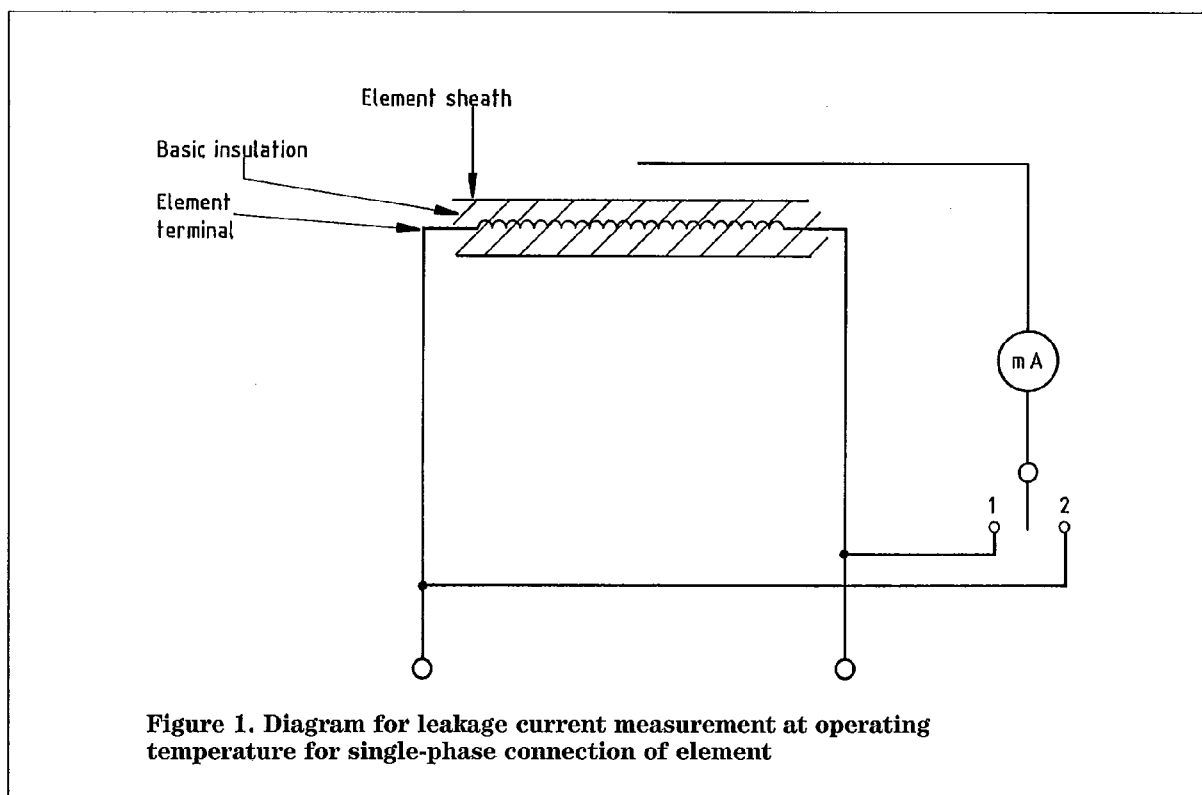
Table 2. Torque values for screwed connections

Nominal diameter of screw	Torque
mm	N·m
Up to and including 2.8	0.4
Over 2.8 up to and including 3.0	0.5
Over 3.0 up to and including 3.2	0.6
Over 3.2 up to and including 3.6	0.8
Over 3.6 up to and including 4.1	1.2
Over 4.1 up to and including 4.7	1.8
Over 4.7 up to and including 5.3	2.0
Over 5.3 up to and including 6.0	2.5

NOTE. The screws and nuts are to be tightened uniformly.

Table 3. Creepage distances and clearances

Point of measurement	Creepage distance and clearance			
	Working voltage over 130 V up to 250 V		Working voltage over 250 V up to 440 V	
	Creepage distance	Clearance	Creepage distance	Clearance
	mm	mm	mm	mm
Between live parts of different polarity:				
if protected against deposition of dirt	2.0	2.0	2.0	2.0
if not protected against deposition of dirt	3.0	2.5	4.0	3.0
Between live part and other metal parts over basic insulation:				
if protected against deposition of dirt				
and of ceramic material or pure mica or similar material	2.5	2.5	3.0	3.0
or other material	3.0	2.5	3.0	3.0
if not protected against deposition of dirt	4.0	3.0	5.0	4.0



Publication(s) referred to

- BS 3072 Specification for nickel and nickel alloys: sheet and plate
BS 3073 Specification for nickel and nickel alloys: strip
BS 3074 Specification for nickel and nickel alloys: seamless tube
BS 3075 Specification for nickel and nickel alloys: wire
BS 3076 Specification for nickel and nickel alloys: bar

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BSI
2 Park Street
London
W1A 2BS

BSI
Linford Wood
Milton Keynes
MK14 6LE