

# Electric surface heating —

## Part 1: Specification for electric surface heating devices

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- Health and Safety Executive
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- Lighting Industry Federation Ltd.

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## Foreword

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

It is intended that this standard will comprise the following Parts.

- *Part 1: Specification for electric surface heating devices;*
- *Part 2: Guide to the design of electric surface heating systems;*
- *Part 3: Code of practice for the installation, testing and maintenance of electric surface heating systems.*

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### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## Section 1. General

### 0 Introduction

Electric surface heating can be an efficient, economical and safe method of providing heat energy where this is required to enable a process, system or apparatus to function correctly, for applications such as the following.

Industrial temperature maintenance and process heating, including:

- frost protection of water pipelines;
- temperature maintenance of pipelines, fittings and vessels to ensure fluid flow;
- process heating to provide a heat energy input for chemical reactions or changes of state.

Anti-condensation heating.

De-icing and ice prevention.

Evaporation of liquefied gases.

Drying and solvent evaporation and recovery.

Processing of thermoplastic and thermosetting materials.

Vulcanizing and curing processes.

Heating of transport containers.

Laboratory applications, for example constant temperature baths and enclosures, extraction and distillation apparatus and filtration apparatus.

Baking and out-gassing of vacuum components.

### 1 Scope

This Part of BS 6351 specifies requirements for the construction and testing of electric surface heating (ESH) devices when applied to metal surfaces.

NOTE 1 For other materials, special consideration should be given to their thermal properties.

It does not cover devices which operate by induction heating, immersion heating, skin effect heating or direct pipeline heating, nor those intended for stress relieving.

Requirements are given for use both in non-hazardous areas and in those hazardous areas (other than marine applications, mining applications or explosive processing and manufacture) classified as Zone 1 or Zone 2 in accordance with BS 5345. The scope of this standard does not include areas classified as Zone 0 nor the heating parts of vessels, etc. when they may have an internal Zone 0 classification.

The additional requirements relating to hazardous area applications are given in section three of this Part.

An appendix is included giving guidance regarding certification.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

### 2 Definitions

For the purposes of this standard the definitions given in BS 5345 apply, together with the following.

#### 2.1

#### **electric surface heating (ESH)**

the heating of the surface of a body by electrical means in order to raise or maintain its temperature

#### 2.2

#### **cold lead**

an electrically insulated conductor used to connect a heating conductor to a source of electrical energy and designed so as to produce no apparent heat

#### 2.3

#### **corrosion resistant covering**

a layer of non-conducting material applied outside a metallic covering (or metallic flexible carrier) to provide protection against corrosion

#### 2.4

#### **design loading**

the minimum power which will meet the design requirements of the system under the most onerous environmental conditions, after considerations of voltage and resistance tolerances and adjustment for reserve power

#### 2.5

#### **electric surface heating device (ESH device)**

a heating cable, heating tape, surface heater, heating cable/tape unit or surface heater unit for electric surface heating

#### 2.6

#### **electric surface heating temperature controller (ESH temperature controller)**

a device or combination of devices incorporating a means of sensing temperature and of switching the power to the ESH device

#### 2.7

#### **flexible carrier**

a non-rigid material which supports the heating conductor(s)

#### 2.8

#### **flexible surface heater**

a surface heater having sufficient flexibility to conform to the shape of the surface to be heated

**2.9****grading**

the classification of ESH devices according to their degree of water resistance and their ability to withstand mechanical forces during and after their installation

**2.10****hazardous area**

an area as defined in BS 5345-1 in which explosive gas-air mixtures are, or may be expected to be, present in quantities such as to require special precautions for the construction and use of electrical apparatus, and which has been classified as Zone 1 or Zone 2

**2.11****heating cable**

a cable with one or more electrically insulated heating conductors

**2.12****heating cable unit**

a terminated heating cable designed to produce a particular heat output at a designated voltage and temperature, with or without cold leads

**2.13****heating conductor**

a conductor used to transform electrical energy into heat

**2.14****heating tape**

an electrically insulated flat tape with one or more heating conductors

**2.15****heating tape unit**

a terminated heating tape designed to produce a particular heat output at a designated voltage and temperature, with or without cold leads

**2.16****heating zone**

a part of an ESH system in which the ESH devices are controlled by one means and may be isolated independently from the remainder of the system

**2.17****installed load**

the load to be installed after consideration of design loading and selection of ESH device for the operating temperature

**2.18****maximum temperature of the surface to be heated**

the temperature above which a specific ESH device would exceed either its maximum withstand temperature or temperature class (T1 to T6)

**2.19****maximum withstand temperature**

the maximum temperature which can be withstood by an ESH device without deterioration of any of the constructional materials

**2.20****metallic covering**

a metal sheath or braid used to provide mechanical and/or electrical protection for the insulated heating conductor(s)

**2.21****minimum installation temperature**

the minimum temperature at which an ESH device may be installed without deterioration of any of the constructional materials

**2.22****non-hazardous area**

an area, as defined in BS 5345-1, in which explosive gas-air mixtures are not expected to be present so that special precautions for the construction and use of electrical apparatus are not required

**2.23****non-metallic covering**

a non-metallic sheath or braid used to provide mechanical and/or electrical protection for the insulated heating conductor(s)

**2.24****power density**

the power output in watts per linear metre for heating cables, tapes, cable units and tape units and in watts per square metre for all other ESH devices

**2.25****residual current operated circuit-breaker (r.c.c.b.)**

a device for making and breaking a circuit, and for breaking a circuit automatically when the residual current exceeds a predetermined amount

**2.26****rigid surface heater**

a non-flexible surface heater fabricated to the general shape of the surface to be heated

### 2.27 self-limiting characteristic

that characteristic exhibited by an ESH device in which the thermal, output generated at its operating voltage decreases as the temperature of its environment increases. Further, there exists a temperature at which the thermal output of the device is reduced to an insignificant amount. At this point the sheath temperature is substantially that of its environment. Also at this temperature all parts of the device will have stabilized below the maximum withstand temperature

### 2.28 service category

a two-digit code which describes the degree of exposure to moisture and mechanical damage

### 2.29 stabilized design

a design of a heating system such that it will stabilize, under all conditions that may be reasonably foreseen including empty pipe and no-flow conditions, at a temperature below both the maximum withstand temperature of the ESH device and the hazardous area temperature classification, if any

### 2.30 surface heater

an unterminated, electrically insulated heating surface with one or more heating conductors

### 2.31 surface heater unit

a terminated surface heater designed to produce a particular heat output at a designated voltage and temperature, with or without cold leads

### 2.32 system documentation

information provided by the supplier to allow satisfactory understanding, installation and use of the ESH system

### 2.33 workpiece

an item of plant or equipment to which an ESH device is fitted to maintain its temperature or provide process heating

## Section 2. Requirements for all ESH devices

### 3 General

All ESH devices for use at a maximum operating voltage above 50 V but not exceeding 300 V to earth or 500 V between phases shall comply with the requirements of this section.

NOTE 1 Additional requirements for ESH devices for use in hazardous areas are specified in section 3.

ESH devices shall be constructed so as to give electrical, thermal and mechanical durability and so that, when incorporated in ESH systems designed in accordance with Part 2 of this standard and when installed in accordance with Part 3<sup>1)</sup> of this standard, their performance is reliable and without danger to the user or surroundings.

NOTE 2 No particular materials are specified in this standard, the use of any suitable material being acceptable provided the ESH device and its component parts satisfy the requirements in clause 7.

### 4 Grading

The grade of an ESH device, as determined by the appropriate type tests, shall be denoted by two characteristic numerals, the first characteristic numeral designating the degree of water resistance (see Table 1) and the second characteristic numeral designating the ability to withstand mechanical damage (see Table 2).

NOTE The grades correspond with the service categories described in 3.2 of BS 6351-2:1983.

**Table 1 — Degree of water resistance**

| First characteristic numeral                                                    | Degree of water resistance | Type test requirements |
|---------------------------------------------------------------------------------|----------------------------|------------------------|
| 0                                                                               | Low                        | None                   |
| 1                                                                               | Medium                     | see 8.1.5 and 8.1.6    |
| 2                                                                               | High                       | see 8.1.5 and 8.1.6    |
| NOTE High water resistance does not imply suitability for continuous immersion. |                            |                        |

**Table 2 — Degree of mechanical strength**

| Second characteristic numeral | Degree of mechanical strength | Type test requirements      |
|-------------------------------|-------------------------------|-----------------------------|
| 0                             | Low                           | see 8.1.8, 8.1.9 and 8.1.10 |
| 1                             | Medium                        | see 8.1.8, 8.1.9 and 8.1.10 |
| 2                             | High                          | see 8.1.8, 8.1.9 and 8.1.10 |

*Example.* Grade 01 denotes equipment having a low degree of water resistance and a medium degree of mechanical strength.

<sup>1)</sup> In course of preparation.

## 5 Construction

**5.1 Heating cables and tapes.** Heating cables and tapes shall consist of one or more electrically insulated heating conductors which shall consist of a metal or alloy in the annealed condition or other electrically conducting material with defined characteristics.

NOTE 1 The conductors may be arranged for series and/or parallel connection to the electricity supply.

NOTE 2 In order to suit particular operating conditions, heating cables and tapes may have additional protective layers comprising one or more of the following:

- a) non-metallic covering;
- b) metallic covering;
- c) corrosion resistant covering.

**5.2 Heating cable units and tape units.** Heating cable and tape units shall consist of a suitable length of heating cable or tape (which may or may not be blanked off at one end) terminated in a manner suitable for connection to the electricity supply.

Units shall be designed to produce a stated wattage at a declared operating voltage and temperature.

NOTE In order to suit particular operating conditions, the heating cable or tape may be jointed, at one or both ends, to a cold lead terminated at the supply end.

In the case of units with a metallic covering and/or a metallic flexible carrier, the terminations shall incorporate means for earthing the metallic covering and/or carrier.

**5.3 Surface heaters.** Surface heaters shall comprise a heating surface consisting of one or more electrically insulated heating conductors arranged for series and/or parallel connection to the electricity supply and supported by a carrier.

Surface heaters shall be fabricated into surface heater units before connection to the electricity supply.

Units shall be designed to produce a stated wattage at a declared operating voltage and temperature.

NOTE In order to suit particular applications, the surface heater unit may be provided with one or more of the following:

- a) cold leads;
- b) integral thermal insulation;
- c) outer cladding;
- d) a terminal box and controls.

The termination shall incorporate means for earthing any metallic coverings, carriers and claddings.

Surface heater units may be either rigid or flexible.

## 6 Terminations

Terminations of heating cable/tape units and surface heater units shall comply with the requirements of either BS 6081 or BS 6121, if applicable, or be of equivalent suitability.

## 7 Tests

**7.1 Heating conductors.** For series connected heating conductors the d.c. linear resistance of the conductors at 20 °C shall be within the declared tolerance. Compliance shall be checked by the type test specified in 8.1.2.

For parallel circuit heating conductors without self-limiting characteristics the d.c. linear conductance shall be within the declared tolerance. Compliance shall be checked by the type test specified in 8.1.3.

For parallel circuit heating conductors with self-limiting characteristics, the values of inrush current at various conductor temperatures and of power output over the operating temperature range shall be within the declared tolerances.

NOTE This information is required for sizing of over-current protection, supply cables, etc.

Compliance shall be checked by the type test specified in 8.1.4.

**7.2 Maximum withstand temperature.** The component parts of an ESH device shall be suitable for continuous use up to the declared maximum withstand temperature. Compliance shall be checked by the high temperature and electrical type tests specified in 8.1.5, 8.1.6 and 8.1.7.

After testing in accordance with 8.1.5, the sample shall show no sign of melting, splitting or cracking. Discoloration of the sample shall not be deemed reason for failure.

When tested in accordance with 8.1.6 no breakdown shall occur during the voltage test and, in the case of ESH devices having a high or medium degree of water resistance, as indicated in the grade by the first characteristic numeral 1 or 2, the measured value of insulation resistance shall be not less than 0.5 MΩ km (i.e. not less than 100 MΩ on a 5 m sample).

When tested in accordance with 8.1.7, no breakdown shall occur during the high temperature voltage test.

**7.3 Mechanical strength.** The nature and thickness of the component parts shall be such that the ESH device possesses a degree of mechanical strength appropriate to its grade. Compliance shall be checked by the mechanical type tests specified in 8.1.8, 8.1.9 and 8.1.10.

When tested in accordance with 8.1.8, the recorded breaking load shall be not less than the minimum value appropriate to the degree of mechanical strength indicated by the grade of the device, as detailed in Table 3.