

**BS 2754:1976+A1:1977**

*Incorporating Corrigendum No. 1*



BSI Standards Publication

## MEMORANDUM

# Construction of electrical equipment for protection against electric shock

Confirmed  
November 2008

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Full document details: BS 2754:1976+A1:1977



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ISBN 978 0 580 75076 2

ICS 13.260

The following BSI references relate to the work on this standard:

Committee reference ELE/79

Draft for comment 72/29463 DC

**Publication history**

First published June 1956

First revision May 1962

Second revision January 1976

**Amendments issued since publication**

| Date        | Text affected  | Amendment no. |
|-------------|----------------|---------------|
| Feb 1977    | See tags       | A1 (AMD 2211) |
| August 2011 | Format updated | C1            |

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### Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 26, an inside back cover and a back cover.

## Foreword

When this memorandum was first issued as BS 2754:1956 its purpose was to explain the principles and requirements for the, then, new constructional method of double insulation. When the memorandum was revised in 1962 the opportunity was taken to add, for the use and guidance of BSI Committees, definitions and dimensional requirements and further details of suitable tests. A classification of equipment depending mainly on forms of construction was also introduced.

The start and finish of text introduced or altered by Amendment No.1 is indicated in the text by tags A1 A1. Minor editorial changes are not tagged.

The increase in variety of electrical equipment has made it more difficult to use the form of construction as a means of classifying the equipment with regard to protection against electric shock. A1 The IEC (International Electrotechnical Commission) has now introduced a system of classification of equipment with regard to protection against electric shock. This system of classification, which is contained in IEC Report 536, is used in the present revision of this memorandum, which also gives guidance on the forms of construction that may be considered for use for each class of equipment, having regard to the environmental conditions to which the particular equipment is likely to be subjected. A1

In order to make the memorandum complete, requirements have been added for earthed equipment and equipment operating from extra low voltage supplies.

A1 *Text deleted* A1

The memorandum is not itself a specification and it is not intended that compliance with the principles and requirements recommended should alone provide an adequate assurance of safety. Compliance in detail with a recognized British Standard specification for equipment of a particular type is of special importance.

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

**Compliance with a British Standard cannot confer immunity from legal obligations.**

# Construction of electrical equipment for protection against electric shock

## Section 1: General

### 1 Scope

Ⓐ This British Standard includes, and is based upon, the IEC Classification of electrical and electronic equipment with regard to protection against electric shock, published as IEC Report No. 536. The definitions used in this Report are reproduced in the body of the memorandum. The memorandum describes the principles of, and gives recommendations for, the design and construction of equipment within the different classes. Ⓐ Dimensional requirements and details of tests for equipment for rated voltages up to 250 V d.c. or single phase a.c. are also included. This standard is intended to be used as guidance by Technical Committees concerned with the preparation of standards for electrical equipment.

### 2 References

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

### 3 Definitions

For the purposes of this British Standard the following definitions apply. They are also recommended for use where applicable in British Standards for electrical equipment. Ⓐ The definitions marked \* are those in IEC Report 536 and are essential for the understanding of the Classification in clause 7. It is therefore important that, when the classification and the associated definitions are used in other standards, neither should be modified in any way. Ⓐ

Where the terms “voltage” and “current” are used, the r.m.s. values are implied unless otherwise stated.

Throughout this standard the term “metal part” includes parts made of metalized plastics or any other form of construction having a conducting surface.

#### 3.1 accessible metal part

any metal part which can be touched with the standard test finger I of BS 3042 or any metal which is electrically connected to such metal parts

*NOTE Some appliances which are insulation encased are provided with internal metal shields which are connected to an earthing terminal. As explained, such equipment is regarded as falling within class I (see clause 7) and these metal parts are therefore regarded as accessible metal.*

#### 3.2 functional insulation

the insulation necessary for the proper functioning of the equipment

Ⓐ *NOTE In some British Standards the term “functional insulation” has been used to describe what is defined as “basic insulation” in this memorandum.*

**3.3 \* 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. *

**3.4 basic insulated parts**

metal parts which are separated from live parts by basic insulation only

 **3.5 \* supplementary insulation**

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation 

**3.6 \* double insulation**

insulation comprising both basic insulation and supplementary insulation (see appendix A)

 **3.7 \* reinforced insulation**

a single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard

*NOTE The term “insulation system” does not imply that the insulation must be one homogeneous place. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.*

**3.8 \* safety impedance**

an impedance connected between live parts and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions in the equipment, is limited to a safe value, and which is so constructed that the reliability is maintained throughout the life of the equipment

*NOTE Details of the likely fault conditions, the safe current and the requirements for reliability are as given in the relevant standards. *

**3.9 all-insulated equipment (also known as insulation encased equipment)**

equipment in which a durable and substantially continuous enclosure of insulating material envelopes all metal parts, excepting small parts such as name plates, screws or rivets which are isolated from other metal parts by insulating material at least equivalent to reinforced insulation

*NOTE A similar exemption of such parts in earthed appliances is allowed by Regulation D4 of the 14<sup>th</sup> edition of the Regulations for the Electrical Equipment of Buildings.*

 **3.10 extra low voltage (elv)**

a voltage which does not exceed 50 V a.c. r.m.s. (see note 1) between conductors, or between any conductor and earth

*NOTE 1 The d.c. value is under consideration.*

*NOTE 2 Limitation to voltages lower than 50 V a.c. r.m.s. may be specified in the particular standard, especially when direct contact with live parts is involved.*

*NOTE 3 The voltage limit should not be exceeded either at full load or at no-load, but it is assumed, for the purpose of this definition, that any transformer or converter is operated at its rated supply voltage.*

*NOTE 4 The above definition is in accordance with that in the IEE Regulations for the Electrical Equipment of Buildings (as amended at April 1976).*

**3.11 \* safety extra low voltage (selv)**

a voltage which does not exceed 50 V a.c. r.m.s. (see note 1) between conductors, or between any conductor and earth, in a circuit which is isolated from the supply mains by means such as a safety isolating transformer or converter with separate windings

*NOTE 1 The d.c. value is under consideration.*

*NOTE 2 Limitation to voltages lower than 50 V a.c. r.m.s. may be specified in the particular standard, especially when direct contact with live parts is involved.*

*NOTE 3 The voltage limit should not be exceeded either at full load or at no-load, but it is assumed, for the purpose of this definition, that any transformer or converter is operated at its rated supply voltage.  $\langle A1 \rangle$*

**3.12 safety earthing terminal or contact (hereinafter referred to as "earthing terminal or contact")**

a terminal or contact which is provided for the purpose of connecting an earthed conductor to accessible metal parts of an equipment

**3.13 functional earthing terminal**

a terminal which is provided for the purpose of connecting a conductor to earth for functional reasons, and which is not connected to any accessible metal parts

**3.14 earth continuity terminal**

a terminal which is included to maintain the continuity of the installation earthing but which is inaccessible when the equipment is in service and is not connected to any metal part of the equipment

## 4 Methods of protection

The normal voltage of public electricity supply systems in the United Kingdom is 240 V (relative to earth potential) and a shock from this voltage can be dangerous. Hence, unless all parts of electrical equipment are made to work  $\langle A1 \rangle$  from a supply at SELV,  $\langle A1 \rangle$  it is necessary to prevent the user of the equipment from making contact with any "live" part of the system, that is to say any part the potential of which may be different from earth potential, and this is done by means of a barrier or enclosure, which provides a main line of defence against electric shock.

This may take the form of a protective screen or case either of insulating material, or of metal which is insulated from the live or current carrying parts. Such forms of construction are more or less effective according to the quality of the materials used, and the skill and experience of the designer, but in considering the degree of safety that they give, the possibility of failure of insulation should not be neglected.

If the protective case is wholly or partly of metal, a failure of the insulation might occur through breakdown of the insulating material or through some accident, such as the escape of a strand of flexible cord from under a clamping screw to bridge the gap to the case and this could raise the potential of the case to full mains voltage above earth. The result would be an extremely dangerous condition, for anyone touching the case would be likely to receive an unpleasant shock if he were making ordinary partial contact with earth, or a fatal shock if he were in good contact with earth through standing on a

wet floor or touching water pipes, gas pipes or other earthed metal. It is therefore essential in the interests of safety to provide a second line of defence, or to increase the security of the single insulation system. The second line of defence may be achieved by earthing any accessible metal parts that might become live, or by using a form of construction known as double insulation. The security of a single layer of insulation is increased by using reinforced insulation.

If the protective case is wholly of insulating material, A1 *Text deleted* A1 similar remarks apply and the use of a second line of defence, in the form of an independent layer of insulation or, according to the circumstances, the use of reinforced insulation, is equally necessary.

A1 The requirements for insulation in all cases will depend upon the environment. A1

In certain cases it is necessary to introduce a signal into a circuit which is live within an equipment through an exposed metallic contact. For this purpose such a contact should be connected to the live parts through a safety impedance.

## Section 2: Forms of construction and cation

### 5 Environmental conditions

It will be seen from clause 4 that the potential safety of an equipment may be influenced by environmental conditions.

The following situations are the main environmental conditions in which equipment is likely to be used.

- a) *Earth free situations.* Such situations exist when the walls and floors are non-conducting and there is no earthed metal within the room. In this case, as there is no earth return path, the risk of electric shock is negligible even should accessible metal become live as a result of breakdown of the basic insulation.

In such situations appliances having basic insulation only with no further protection would be safe.

*NOTE* Because of the increasing use of central heating systems, and the complication involved when appliances suitable for use only in earth free situations are used in premises having some areas which are earth free and others which are not, such situations are no longer recognized in the UK. The situation has been included in this survey because some countries still accept it [A1] Text deleted [A1].

- b) *Normal situations.* In such situations there may be earthed metal, etc., but there is not likely to be excessive deposition of moisture and the amount of dirt in the atmosphere is no more than would be found in a normal living room or office. If equipment for use in such situations has accessible metal then further precautions as mentioned in clause 6 B, F and G are necessary.
- c) *Polluting situations.* In these situations the risk of operating under damp or wet conditions is greater than for the general run of appliances, and/or the amount of conductive dust is greater than would occur in a normal situation.

In general, equipment for use in such situations is the same as that used in normal situations, so far as the precautions against electric shock are concerned, except that insulation encased equipment is required to be of double insulated construction.

There may, however, be more stringent requirements with regard to such features as creepage distances and clearances.

It is not to be expected that the ordinary layman should have to decide whether a particular item of equipment is to be used in one situation or another. Rather the designer or committee concerned with the safety standard should decide in what situation the equipment is likely to be used. Thus, for example, equipment which has to be splashproof would normally be designed to the standards for polluting situations, as would washing machines and spin dryers which are used with wet clothes.

It is true that there is always a possibility that appliances intended for use in normal situations might be taken by their owners into polluting situations, but this is to be regarded as an abnormal use for which in accordance with established practice a reduced, although still adequate, standard of safety is allowed.

## 6 Forms of construction

In order to differentiate between the various forms of construction used for protection against electric shock, it has been found convenient to identify them in the following way.

**form A.** Construction having metal parts which can be touched and which are separated from live parts by basic insulation only, but which are not provided with means for earthing.

**form B.** Constructions having metal parts which can be touched and which are separated from live parts by basic insulation only and which are, for fixed equipment connected to an earthing terminal, or for other equipment connected to the earthing conductor or a non-detachable flexible cord or to the earthing contact of an appliance inlet.

**form C.** Constructions where the accessible insulating material forms the basic insulation.

**form D.** Constructions where the accessible insulating material forms reinforced insulation.

**form E.** Constructions where the accessible insulating material forms supplementary insulation only.

*NOTE* In some specifications, basic and supplementary insulation are interchangeable. 

**form F.** Constructions having metal parts which can be touched and which are separated from live parts by reinforced insulation.

**form G.** Constructions having metal parts which can be touched and which are separated from live parts by double insulation.

**form H.** Constructions having metal parts which can be touched and which are connected to live parts by means of a safety impedance. (Requirements for safety impedance are under consideration.)

*NOTE 1* For some forms of construction, certain requirements are slightly more stringent than for others. (See Table 2 for form C construction).

*NOTE 2* The insulation between the primary and secondary windings of an elv transformer may be regarded as the equivalent of basic or of supplementary insulation. The insulation between the primary and secondary windings of a safety elv transformer may be regarded as the equivalent of double or of reinforced insulation.

## 7 Equipment classification

### 7.1 General

Some equipment has, in the past, been internationally classified with regard to the means provided for protection against electric shock as class 0, class I, class II, class III, using definitions largely orientated to methods of construction. The IEC has now adopted a system of classification, using the same class numbers and giving essentially the same result in any situation, but having regard to protection against electric shock in the event of an insulation failure. The following classifications are aligned with those in IEC Report 536 and have been co-ordinated with the definitions used in clause 3. If these