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Code of practice for

The selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosives processing) —

Part 6: Recommendations for type of protection "e" — Increased safety

UDC 696.6:621.3 – 7:614.83

Cooperating organizations

The General Electrotechnical Engineering Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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British Radio Equipment Manufacturers' Association
British Steel Corporation
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Rotating Electrical Machines Association (BEAMA)
Scientific Instrument Manufacturers' Association

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Contents

Foreword

Many gases, vapours, mists and dusts encountered in industry are flammable. When ignited, they may burn readily and with considerable explosive force if mixed with air in the appropriate proportions. It is often necessary to use electrical apparatus in locations where such flammable materials may be present, and appropriate precautions should therefore be taken to ensure that all such apparatus is adequately protected in order to reduce the likelihood of ignition of any external explosive atmosphere. When using electrical apparatus, potential ignition sources include electrical arcs and sparks, hot surfaces and, in certain circumstances, frictional sparks.

In general, electrical safety is ensured by implementing one of two procedures. Either the electrical apparatus should be located, whenever practicable, outside hazardous areas; or the electrical apparatus should be designed, installed and maintained in accordance with measures recommended for the area in which the apparatus is located.

Several techniques are available for the protection of electrical apparatus in hazardous areas. Some of these techniques (or "types of protection" as they are known) have been used for many years and have come to be regarded as traditional. Other types of protection have been introduced only recently.

This code of practice describes the basic safety features of these types of protection, full details of which are given in the relevant standards, and recommends the selection, installation and maintenance procedures that should be adopted to ensure the safe use of electrical apparatus in hazardous areas. This code therefore takes account of the significant developments that have taken place in area classification and in the design, manufacture and use of electrical apparatus for hazardous areas since the preparation of the earlier code of practice CP 1003.

It is important to note that this code of practice deals with *explosion* hazards due to the presence of flammable gas-air mixtures; it does not provide guidance on the extra precautions to be taken where such gases involve a *toxic* hazard.

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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.

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.

0 Introduction

This document is Part 6 of code of practice BS 5345. The code gives guidance in the selection, installation and maintenance of electrical apparatus for use in areas where flammable materials are generated, processed, handled or stored, and that are therefore potentially hazardous.

In common with the earlier code of practice for the use of electrical apparatus in hazardous areas (CP 1003-1:1964, CP 1003-2:1966 and CP 1003-3:1967), the present code is divided into a number of Parts. Each Part deals with the installation and maintenance requirements appropriate to one of the types of protection that may be used to achieve electrical safety, or with basic requirements and considerations that are fundamental to the use of electrical apparatus in hazardous areas and that therefore provide the basis for the other Parts of the code.

The full list of Parts is as follows:

— *Part 1: General recommendations;*

— *Part 2: Classification of hazardous areas*[1)]*;*

— *Part 3: Installation and maintenance requirements for electrical apparatus with type of protection "d". Flameproof enclosure*[1)]*;*

— *Part 4: Installation and maintenance requirements for electrical apparatus with type of protection "i". Intrinsically safe apparatus and systems;*

— *Part 5: Installation and maintenance requirements for electrical apparatus with type of protection "p". Pressurization and continuous dilution*[1)]*;*

— *Part 6: Recommendations for type of protection "e". Increased safety;*

— *Part 7: Installation and maintenance requirements for electrical apparatus with type of protection N*[1)]*;*

— *Part 8: Installation and maintenance requirements for electrical apparatus with type of protection "s". Special protection*[1)]*;*

— *Part 9: Installation and maintenance requirements for electrical apparatus with type of protection "o". Oil-immersed apparatus, and with type of protection "q". Sand-filled apparatus*[1)].

This Part of the code should be read in conjunction with the other Parts, particularly Parts 1 and 2 which, taken together, describe the fundamental considerations that affect the selection, installation and maintenance of all electrical apparatus used in hazardous areas.

BS 5345 is based on the concept of area classification which recognizes the differing degrees of probability with which explosive (flammable) concentrations of flammable gas or vapour may arise in installations in terms of both the frequency of occurrence and the probable duration of existence on each occasion.

The detailed considerations that should be taken into account in deciding on an area classification are described in Part 2 of the code. For completeness, and for the convenience of readers, the definitions appropriate to area classification are repeated here. It should be noted that whereas, formerly, classified areas were known as Divisions, they are now called Zones. Three Zones are recognized, i.e.:

Zone 0 In which an explosive gas-air mixture is continuously present or present for long periods.

Zone 1 In which an explosive gas-air mixture is likely to occur in normal operation.

Zone 2 In which an explosive gas-air mixture is not likely to occur in normal operation, and if it occurs it will only exist for a short time.

It should be noted that this concept of area classification deals only with risks due to flammable gases and vapours and, by implication, mists. It does not deal with flammable dusts, which may lie quiescent for long periods of time until disturbed into suspension by a suitable mechanism. An area classification concept is being developed for dusts.

By implication, an area that is not classified as Zone 0, 1 or 2 is deemed to be a non-hazardous or safe area. If doubt exists as to the classification of an area that is judged to be hazardous or potentially hazardous, guidance should be sought at an early stage from the authority having jurisdiction in the industry or area concerned (see Parts 1 and 2 of the code).

Electrical apparatus used in each of the classified Zones should be suitably protected by design and manufacture, and should also be installed and maintained in a manner to ensure its safe use.

BS 5345, in offering guidance in the selection, installation and maintenance of suitably protected apparatus, replaces CP 1003 and should be used for all new installations. It should also be used for changes to existing installations, though it is recognized that minor changes only to certain existing installations may need to be made in accordance with the recommendations of the earlier code. It is intended, however, that CP 1003-1, CP 1003-2 and CP 1003-3 will eventually be withdrawn from use.

[1)] In course of preparation.

Notwithstanding application of the installation recommendations of this code to existing installations, the recommendations for maintenance should be applied to all electrical apparatus and installations, irrespective of age and date of installation. It should also be noted that the installation and maintenance recommendations given in the code are supplementary to, and not alternative to, requirements that would apply to general industrial installations (see also Part 1 of the code).

Section 1. General principles

1 Scope

This Part of BS 5345 describes the concept of ensuring electrical safety in hazardous areas by means of type of protection "e": increased safety, and gives guidance on the selection, installation and maintenance of this type of electrical apparatus.

This code does not apply to the underground mining industry, where other precautions are necessary, though it is recognized that the code may be applied to the surface installations of mines.

Apparatus with type of protection "e": increased safety is designed for use in areas with flammable gas and vapour risks. For the use of this apparatus in areas with flammable dust risks see Part 10 of the code.

2 References

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

3 Definitions and explanation of terms

The definitions and terms generally applicable to hazardous areas and electrical apparatus used therein are included in Part 1 of the code, to which reference should be made. The definitions and terms that are particularly relevant to individual types of protection are given in the appropriate Parts of the code. For the purposes of this Part, the following definitions and terms apply.

3.1
type of protection "e": increased safety

a method of protection by which additional measures are applied to electrical apparatus to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks during the service life of the apparatus. It applies only to electrical apparatus, no parts of which produce sparks or arcs or exceed the limiting temperature in normal service

3.2
clearance

the shortest distance through air between two conducting parts

3.3
creepage distance

the shortest distance between two conducting parts along the surface of the insulating parts

3.4
dynamic current limit I_{dyn}

the peak value of the maximum alternating current the dynamic effect of which the electrical apparatus can sustain without damage

3.5
limiting temperature

the maximum permissible temperature for apparatus or parts of apparatus. It is determined by:

a) the danger of ignition of the explosive gas-air mixture;

b) the thermal stability of the materials used.

the lower temperature is the one to be taken into consideration and is the critical limiting temperature

3.6
thermal current limit I_{th}

the r.m.s. value of the current which, when it flows for 1 s, heats up the conductors to the limiting temperature

3.7
starting current I_A

the highest r.m.s. value of that current which flows in the primary part of a stalled cage rotor motor or in an alternating current magnet with a seized armature after the transient phenomena have ceased, when the apparatus is supplied at rated voltage and rated frequency. It is normally measured a few seconds after application of rated voltage

3.8
starting current ratio I_A/I_N

the ratio between starting current I_A and rated current I_N

3.9
time t_E

the time taken for a.c. windings, when carrying the starting current I_A, to be heated up from the temperature reached in rated service, and at maximum ambient temperature, to the limiting temperature

4 Description of technique

4.1 Increased safety is a technique that may be applied only to electrical apparatus that does not contain normally arcing or sparking devices, or hot surfaces that might cause ignition. Measures are applied to reduce the possibility of failure, and hence arcing or sparking of the normally non-sparking parts. These measures include:

a) the use of insulation materials with a high degree of integrity;

b) the temperature de-rating of insulation materials;

c) enhanced creepage and clearance distances;

d) particular attention to terminal design;

e) protection against the ingress of solids and liquids;

f) impact test requirements for the enclosure;

g) in some cases (e.g. motors) the control of maximum temperatures;

h) in the case of motors, requirements for air gaps and running clearances (e.g. on fans).

In addition, measures are applied to ensure that no surface (internal or external) exceeds the maximum temperature associated with the temperature class of the apparatus (see Part 1 of the code).

The concept may be applied to several different types of electrical apparatus, e.g. cage rotor motors, luminaires, hand lamps, instruments and instrument transformers.

4.2 Where necessary, the above measures are amplified as indicated in **4.2.1** to **4.2.5**.

4.2.1 The apparatus does not contain normally arcing or sparking parts. If arcing or sparking parts are essential to the operation of the apparatus, safety is assured by the use of a suitable type of protection for those parts, e.g. type of protection “d”: flameproof enclosure.

The arcing or sparking parts then comply with the requirements of the appropriate specification and should be installed and maintained accordingly (see the relevant Parts of the code).

4.2.2 The apparatus is so designed that the likelihood of arcs or sparks as a consequence of loose terminations or connections or of insulation failure is minimal. This results in specified requirements for terminations and connections, for the quality of insulation, and for creepage and clearance distances.

4.2.3 The apparatus is designed and should be installed and maintained so that the limiting temperature is not exceeded.

The limiting temperature of the apparatus is determined under conditions of maximum rating and other factors considered by the certifying authority to produce the highest values of surface temperature for the apparatus concerned. This limiting temperature will determine the temperature class of the apparatus (see Part 1 of the code) and takes account of the thermal properties of the apparatus, e.g. the winding insulation.

For some types of electrical apparatus, e.g. rotating machines, it may be necessary to use special techniques to ensure safety in respect of limiting temperatures under conditions where the duty may be onerous and variable. Such special techniques include the use of thermal protection devices which may be used, directly or indirectly, to disconnect the apparatus from the electrical supply before the limiting temperature is attained.

4.2.4 Enclosures are designed to withstand specified impact tests, so that the risk of mechanical damage to the protected electrical apparatus is reduced to an acceptable level. (See Appendix C.)

4.2.5 Enclosures are designed to provide adequate protection against the ingress of solids and liquids so that the integrity of the insulation and the creepage and clearance distances are maintained. (See also Appendix D.)

5 Relevant specifications

The British Standard specification for increased safety apparatus is BS 5501-6.

NOTE 1 The earlier specification, BS 4683-4 has been declared obsolescent.

NOTE 2 Prior to the publication of BS 4683-4, apparatus was certified to BASEEFA Certification Standard SFA 3008: Increased safety.

For the use of increased safety apparatus manufactured in accordance with other standards see Part 1 of the code.

Section 2. Selection of apparatus

6 General

The general factors affecting the selection of electrical apparatus and systems for hazardous areas are described in detail in section 2 of Part 1 of this code. The specific factors that need to be taken into account when selecting electrical apparatus and systems with type of protection “e” are described in the remaining clauses of this section.

7 Permissible Zones of use

7.1 Increased safety apparatus is not suitable for use in Zone 0.

7.2 Increased safety apparatus may be used in Zone 1 and Zone 2 provided that live bare parts and insulated parts are enclosed in accordance with degrees of protection IP54 and IP44, respectively, as minimum requirements (see Part 1 of the code).

NOTE 1 The degree of protection may be relaxed for rotating machines in certain applications (see clause **12**).

NOTE 2 The importance of satisfactory maintenance cannot be over-emphasized (see section 4).

NOTE 3 In applications where there is a likelihood of solvent or corrosive agencies entering the enclosure in quantities that could cause deterioration of the insulation, consideration should be given to the use of a higher degree of protection than that recommended above.

8 Temperature classification

8.1 Increased safety apparatus should be selected according to its temperature classification (see Part 1 of the code). The maximum temperature appropriate to the temperature class should not exceed the ignition temperature of a flammable gas or vapour expected to be present in the hazardous area, or the lowest value of ignition temperature if more than one flammable gas or vapour is present.

NOTE The temperature class of apparatus is determined according to the results of temperature measurements made under normal operating conditions and with recognized overloads, if any. For certification purposes in the UK, normal operating conditions include the rated voltage of the apparatus plus or minus 6 %.

It should be noted that for apparatus certified elsewhere than in the UK, the temperature classification may have been determined at a lower rated voltage, and without tolerance. The user should therefore take the necessary steps to ensure that the temperature class of imported apparatus is satisfactory, having regard to the supply voltage in the UK and the ignition characteristics of the flammable materials in the hazardous area.

8.2 Luminaires will generally be marked with the normal temperature classification (T class). In some cases, however, in addition to the temperature classification, the luminaire will be marked with the name of a gas or vapour that has an ignition temperature below the maximum for the temperature class. This is because measurements have established that the lowest temperatures at which ignition will occur inside luminaires are considerably higher than the ignition temperatures of gas and vapours measured in accordance with BS 4056. Thus the temperature inside a luminaire need not comply with the limiting temperature indicated in **8.1** if the maximum surface temperature of the light source is at least 50 °C below the lowest temperature at which ignition has been shown by test to take place inside the fitting under conditions most likely to cause ignition of those gases and vapours for which the fitting is intended to be used.

NOTE Some types of luminaire manufactured in accordance with standards other than IEC 79-7 or BS 4683-4 may have been certified to relaxed requirements for internal surface temperature which do not demonstrate the safety margin indicated in **8.2**. Such luminaires containing tungsten filament and/or mixed light (discharge) lamps should not be used. This does not apply to luminaires certified to IEC 79-7 or BS 4683-4 because these standards do not include any temperature relaxation.

8.3 Generally, an ambient temperature of 40 °C is assumed in the rating of electrical apparatus for use in hazardous areas. Higher temperatures should be, and in exceptional cases lower temperatures may be, taken into account in determining the rating of the apparatus. In that event, the value of the peak ambient temperature will be clearly marked on the apparatus. It should be noted that the certification will be invalidated if the apparatus is used at an ambient temperature higher than that for which the certification applies.

NOTE The choice of cables may be influenced by the peak ambient temperature (see **15.2**).

9 Apparatus subgrouping

9.1 Increased safety apparatus is not normally subject to apparatus subgrouping (see Part 1 of the code), and may therefore be used safely with all flammable gases and vapours, subject to the factors described in clauses **8** and **10**.

9.2 Notwithstanding **9.1**, apparatus may be protected by increased safety protection and by one or more additional types of protection which may require apparatus subgrouping, e.g. type of protection “d”: flameproof enclosure. Such apparatus will be marked as described in Appendix B.

In these circumstances the apparatus should be selected according to the apparatus subgroup to which the flammable materials that may be present are allocated (see Part 1 of the code).

Examples of apparatus that may be protected by multitypes of protection are as follows.

a) A switch that is an approved flameproof component is provided with increased safety terminals and mounted within an increased safety enclosure.

b) A flameproof motor that is provided with an increased safety terminal box.

The installation and maintenance requirements of the various parts of apparatus with multitypes of protection should be in accordance with the appropriate Part of this code. For example, cable entry requirements in the above two cases should be in accordance with this Part of the code.

10 Environmental conditions

When selecting apparatus, special care should be taken to ensure that the apparatus and its component parts are so constructed as to guard against electrical and mechanical failure in the intended conditions of use.

Particular attention should be given to the need for protection against the weather, the ingress of liquids and particulate matter, corrosion, the effect of solvents and the effect of heat from adjacent plant. (See Part 1, and Appendix C and Appendix D of this Part of the code.)

11 Requirements for certification of apparatus

See Part 1 of the code.

12 Rotating machines and similar apparatus

Notwithstanding the requirement for degree of protection of enclosures indicated in clause **7**, rotating machines installed in clean rooms that are classified Zone 2 need be protected only to a degree of protection not less than IP20. This does not apply to terminal boxes, which should comply with IP54.

NOTE It is normally the user's responsibility to determine that the conditions necessary for this relaxation exist. In cases of doubt, the user should consult the authority responsible for administering relevant statutory and legal requirements.

Other requirements relevant to the selection of increased safety motors and associated electrical protection apparatus are given in Appendix A.

Section 3. Installation requirements

13 General

Increased safety apparatus should be installed in accordance with the general installation requirements given in Part 1 of the code.

The specific factors that need to be taken into account when installing electrical apparatus with type of protection "e" are described in the remaining clauses in this section.

14 Automatic electrical protection

For rotating machines particularly, special attention should be given to the selection of the associated automatic electrical protection apparatus to ensure that the limiting temperature is not exceeded in service. The factors that should be considered, and the procedure for selecting the electrical protection apparatus, are described in Appendix A.

15 Wiring systems

15.1 The wiring systems for increased safety apparatus should be either cables drawn into metallic (steel) conduit or one of the types of cable described in Part 1 of the code as being suitable for use in Zone 1.

15.2 The temperature of increased safety apparatus will not normally exceed 70 °C at the cable entry point, and 80 °C at the branching point of the cores (with a reference ambient temperature of 40 °C). Higher temperatures are permissible provided that conductors are used that are suitably insulated for the operating temperature. In these cases the method or type of wiring or cabling to be used will be specified and marked on the apparatus, or the marking will refer to the certification or approval documents (see Appendix B).

16 Installation of conduit systems

Conduit systems should be installed in accordance with the recommendations given in Part 1 of the code, with the following additional requirements.

The method of connection of the conduit to the apparatus enclosure should maintain degree of protection IP54. To do this it is necessary to seal between the conduit and the enclosure (e.g. by means of a sealing washer or thread sealant) and between the conductors and the conduit (e.g. by means of a sealing device).

NOTE Where the conduit is the sole means of earth continuity the thread sealant should not reduce the effectiveness of the earth path.

17 Installation of cables

17.1 Cables should be installed in accordance with the recommendations given in Part 1 of the code, with the following additional requirements concerning cable entries.

17.2 The connection of cables to increased safety apparatus must be effected by means of glands appropriate to the type of cable used and that incorporate a suitable sealing component to maintain degree of protection IP54 of the terminal enclosure. To meet this requirement it is necessary to provide a seal between the gland and the enclosure [e.g. by means of a sealing washer or thread sealant (see note to clause **16**)] and between the cable and the gland. For plastics and elastomeric insulated cable for fixed apparatus, glands with suitable seals to the cable may be chosen from BS 4121 or BS 6121. For mineral insulated metal-sheathed cable, glands complying with the requirements of BS 4081, incorporating suitable seals between gland and sheath, must be used. In addition, with the latter type of cable it is necessary to use a special pot seal in order to meet the increased safety requirements. Such seals are subject to component approval.

For portable apparatus the packing of any gland is not regarded as a sufficient means for withstanding tensile stress, and the gland inlet device should be shaped in such a way that the cable cannot be bent near the rim at the point of entry to a degree likely to cause damage to the cable.

Metal screwed glands are recommended for cable entries. Plastics screwed glands may also be used, provided these are component approved. In some cases, plastics glands are integral with, or sealed to, the enclosure.

17.3 Unused cable entries should be closed with plugs that maintain degree of protection IP54 of the enclosure and require the use of a tool for insertion and removal.

18 Conductor terminations

18.1 The method of connection of the conductors to the apparatus terminals should be in accordance with the certification documents. This information will normally be made available by the manufacturer. Where the conductors are to be connected directly to terminals they should be clamped without reducing their cross section in such a manner that they are secured from loosening or twisting, and so that the contact pressure is maintained permanently. Alternatively, they may be connected indirectly by means of cable lugs or closed spade terminations that incorporate mechanical means for securing the conductor.

18.2 The means adopted to ensure the non-sparking features of the terminations should be maintained during installation.

Care should be taken to ensure that loose strands from stranded conductors are avoided in the installation of conductors in order that the specified creepage and clearance distances are maintained.

18.3 Where single screw saddle clamps are used with a single conductor, the latter should be U-shaped around the screw to allow for correct operation of the clamping device.

18.4 Certain terminals such as slot types may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care should be taken to ensure that each conductor is adequately clamped. Unless permitted by the certification documents, two conductors of different cross sections should not be connected into one terminal unless they are first secured within a single compression-type ferrule.

18.5 To avoid the risk of short circuits between adjacent conductors in terminal blocks the insulation of each conductor should be maintained up to the metal of the terminal.

Section 4. Inspection, maintenance and testing

19 General

The safe and satisfactory operation of increased safety apparatus is dependent on a high standard of inspection, maintenance and testing by trained and competent personnel.

General recommendations for inspection, maintenance and testing are given in detail in Part 1 of the code and apply equally to this Part. The following requirements apply particularly to increased safety apparatus.

20 Initial and periodic inspections

All electrical apparatus, systems and installations should be inspected prior to commissioning and after replacement in accordance with the “Initial” column of the inspection schedule (see Table 1).

Following any repair, adjustment or modification, those parts of the installation which have been disturbed should be checked in accordance with the relevant items in the “Initial” column of the inspection schedule.

All apparatus, systems and installations should be inspected regularly in accordance with the “Periodic” column of the inspection schedule.

If, at any time, there is a change in the area classification, or in the characteristics of the flammable material used in the area, or if the apparatus is moved from one location to another, a check should be made to ensure that the apparatus concerned has the correct apparatus group and temperature class, and that it complies with the relevant area classification.

A system should be established to record the results of all inspections and the action taken to correct defects.

21 Maintenance

21.1 No alteration that might invalidate the certificate or other document relating to the safety of the apparatus should be made to increased safety apparatus without appropriate approval.

21.2 If increased safety apparatus is rewound or refurbished by any party other than the original manufacturer or an authorized agent thereof, the approval of the manufacturer should be obtained and/or his specification should be assessed for the method of rewinding, materials, manufacturing process, etc.

Table 1 — Inspection schedule; apparatus with type of protection "e": increased safety

Check that	Inspection category[a]		Notes
	Initial	Periodic	
Apparatus is appropriate to area classification	A	B	
Surface temperature class is correct	A	B	
Apparatus subgroup (if any) if correct	A	B	
Apparatus carries the correct circuit identification	A	B	Apparatus must be positively identified with its circuit to ensure that correct isolation can be carried out.
Enclosures are satisfactory and undamaged	A	A	
There are no unauthorized modifications	A	A	
Bolts, glands and stoppers are complete and tight	A	A	
There is no undue accumulation of dust or dirt	B	B	Accumulation of dust or dirt can interfere with heat dissipation and result in surface temperatures higher than those permitted in the hazardous area.
Earthing is satisfactory	A	A	
Condition of enclosure gaskets is satisfactory	A	B	
Electrical connections are tight	A	B	
Motor air gaps and other running clearances are satisfactory	B	B	
Lamp rating and type are correct	A	B	An "initial" inspection is necessary after relamping.
Electrical protection is satisfactory	A	A	See the particular requirements for motor protection in Appendix A.
There is no deterioration of encapsulating materials	A	B	
Stopper boxes and cable boxes are correctly filled	A	B	
There is no leakage of compound from stopper or cable boxes	B	B	
There is no obvious damage to cables	A	A	
Apparatus is adequately protected against corrosion, the weather, vibration and other adverse factors	A	A	
Guards, where used, are present and correctly located	A	B	

[a] Category A inspections should be carried out in all cases and, where "periodic", at intervals not exceeding 2 years. More frequent and/or more detailed inspection will be necessary where there is a corrosive or other adverse atmosphere, a high risk of mechanical damage or vibration, or where there are other onerous circumstances. The need for more frequent inspection may also be determined by operating experience.
The need for, the method, and the frequency of category B inspections shall be at the discretion of the engineer responsible. It is not intended that periodic inspections should incur undue disturbance of apparatus unless considered necessary by the engineer responsible.

Appendix A Selection of increased safety cage motors and associated protection devices

A.1 General

Many of the factors that need to be considered in the selection of increased safety motors are dealt with in the body of this Part of the code. This appendix deals with particular requirements that need to be considered regarding control of the temperatures of various parts of the motor, and should be read in conjunction with those clauses of BS 4683-4 which deal with motors.

A.2 Frame size kW rating relationship

When selecting an increased safety motor it should be borne in mind that the output is less than that of a standard motor of the same frame size. This is because the temperature rise of an increased safety motor at rated output is reduced by 10 °C for insulation classes A, E, B and F and by 15 °C for class H compared with the temperature rises permitted on standard motors. Compliance with a minimum t_E time may necessitate an even more severe output limitation.

A.3 Critical limiting temperature, temperature class and t_E time

An increased safety motor should not, under starting, running or stalled (locked rotor) conditions, exceed the critical limiting temperature (see **3.5**). This temperature is below

a) that which will ignite any explosive gas-air mixtures in the area concerned; and

b) that which will reduce significantly the thermal stability of the materials used in the motor.

The critical limiting temperature will occur during a stall from the "hot" condition and is controlled by ensuring that the motor is switched off either by temperature detectors in the winding or by external current-dependent time lag protective devices before this temperature is exceeded. In the case of the latter devices, the motor should be switched off within a specified time known as the t_E time (see **3.9**).

Requirement a) is met by allocating a temperature classification, T1 to T6 (see clause **8**), to the motor. The temperature classification is based on the maximum temperature of any surface, inside or outside the motor, to which gas may have access. The maximum temperature (which will occur during the stalled condition) will usually, but not always, be on the rotor conductor and will depend on the length of time the starting current I_A (see **3.8**) is permitted to flow.

For example, the rotor conductors may reach a temperature of, say, 200 °C (T3) in 6 s and, say, 300 °C [2)] (T2) in 10 s, in which case, if there are no parts of the motor that would require lower temperatures during the stalled condition for thermal stability reasons, the motor would have a t_E time of 6 s for T3 and 10 s for T2. The motor protection device, if of the current-dependent type, should then be arranged to switch off the motor in the t_E time appropriate to the temperature class required. If temperature detectors in the winding are used these will be arranged by the manufacturer to operate at a particular temperature to ensure that the critical limiting temperature is not exceeded. Ignoring other considerations, temperature classes T4 (135 °C max.), T5 (100 °C max.) and T6 (85 °C max.) could also be allocated to the motor, but since these (in the example chosen) would result in t_E times less the 5 s, which is the minimum permissible (see **A.5**, and BS 4683-4), these temperature classes cannot be permitted in this particular case.

Since rotor temperatures above 300 °C [2)] are usually not acceptable during the stall condition for thermal stability reasons, a t_E time longer than 10 s would not be permitted in the example chosen; the T1 temperature class (450 °C max.) would therefore be associated with the same t_E time (10 s) as T2.

The relationship between temperature class and t_E time would therefore be:

T3: t_E time 6 s

T2: t_E time 10 s

T1: t_E time 10 s

In the example chosen, the effect, during the stall condition, of high temperatures on the thermal stability of parts of the motor other than the rotor have been ignored. BS 4683-4 specifies temperature limits for insulated windings that must not be exceeded at the end of the t_E time. These limits are given in Table 2.

[2)] In most cases 300 °C will be the maximum permissible rotor temperature during the stall condition for thermal stability reasons. However, higher temperatures for the stall condition are not excluded provided that the rotor temperature during the starting condition does not exceed 300 °C.

Table 2 — Class of insulating material and limiting temperature

	Measuring method	Class of insulating material					
		A	E	B	F	H	
Limiting temperature, °C, at end of time t_E[a]	R	160	175	185	210	235	Stalled rotor condition
Limiting temperature rise, °C, at end of time t_E[a]	R	120	135	145	170	195	

[a] These values are the sum of the temperature (or temperature rise) of the winding in rated service and the increase of temperature during the time t_E.

If, in the example chosen, the stator winding (assumed to have class B insulation) reached a temperature of 185 °C in, say, 8 s, this time would be the maximum t_E time (and not the 10 s quoted previously). In this case the relationship between temperature class and t_E time would be:

T3: t_E time 6 s

T2: t_E time 8 s

T1: t_E time 8 s

In some cases there may be parts of the motor other than the rotor conductors and stator winding insulation that impose a temperature limitation and that therefore affect the t_E time.

In order that satisfactory current-dependent motor protection devices can be provided, motor manufacturers are required to produce increased safety motors with t_E times related to the I_A/I_N current ratio in accordance with the following curve:

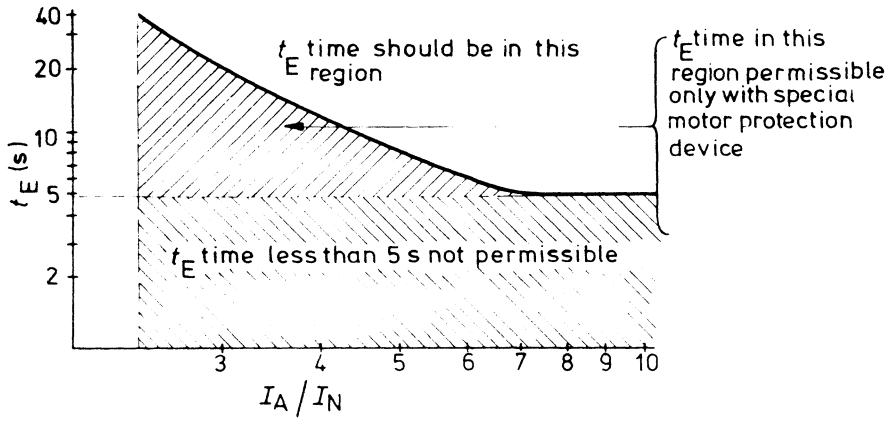

Figure 1 — Minimum t_E time for motors in relation to I_A/I_N

Summarizing:

a) The t_E times are the times taken to reach the limiting temperatures from the temperature reached in rated service and in the maximum ambient temperature (normally 40 °C) when the motor is carrying starting current (I_A) with the rotor stationary.

b) The t_E time or, when more than one t_E time is quoted, the maximum t_E time will usually be determined by the time taken to reach either a rotor conductor temperature of 300 °C[3)], or a stator winding temperature for the insulation class concerned as given in Table 2, whichever is the shorter.

[3)] In most cases 300 °C will be the maximum permissible rotor temperature during the stall condition for thermal stability reasons. However, higher temperatures for the stall condition are not excluded provided that the rotor temperature during the starting condition does not exceed 300 °C.

NOTE In some cases a rotor conductor temperature of less than 300 °C may be required for thermal stability, or there may be other parts of the motor that impose a temperature limit resulting in short t_E times.

c) A temperature class (T1 to T6) appropriate to the maximum temperature of any surface of the motor at the end of the maximum t_E time will be allocated to the motor.

d) In cases where more than one temperature class has been allocated, the appropriate t_E time(s) will be quoted, but t_E times lower than 5 s will not be permitted.

e) Where temperature detectors in the windings are used these will be tested with the motor to ensure that they will protect the motor against the critical limiting temperature being exceeded.

A.4 Selection of motor

The majority of applications of increased safety motors are for continuous running duty (duty type S1 of BS 4999-30) with infrequent direct-on-line starts. Applications involving other duty types, frequent starting, arduous starting (i.e. long starting periods) or special starting methods (e.g. star/delta) should be discussed in detail with the motor manufacturer and/or certifying authority. The following information is concerned primarily with the selection of a duty type S1, direct-on-line started motor.

It is necessary first of all to decide on the temperature class required from a knowledge of the ignition temperatures of the gases and vapours in the area of use. This will enable the t_E time to be established from the manufacturer or from his catalogue. An approximate assessment of the starting time should then be made by either the user or the motor manufacturer from a knowledge of the motor and driven equipment torque/speed curves and inertia data. It is preferable that the starting time should not exceed the t_E time in order to be quite certain that the motor protection device will not trip the motor during the starting period. In cases where this is not achievable, a starting time up to 1.7 times the t_E time may be acceptable (see BS 4683-4). This longer time is permissible because of the reduction in the starting current towards the end of the acceleration period. However, it is recommended that where the starting period exceeds the t_E time the motor manufacturer should be consulted so that the time required to reach the critical limiting temperature under the starting conditions can be established.

It has been assumed so far that rated voltage is available at the motor terminals during the starting period. This is not usually the case because of voltage drop in transformers and cables. The low voltage will have the effect of reducing the motor torque during the starting period (torque proportional to the square of the voltage) and therefore will increase the starting time.

On the other hand, the starting current will be reduced in proportion to the voltage. Since the temperature rise in the motor and in any external motor protection device is proportional to time and the square of the current the increased time and reduced current tend to compensate each other. However, where the voltage during the starting period is significantly (say, 10 % or more) below nominal, the motor manufacturer should be consulted for more accurate information regarding the starting current and time for the particular voltage conditions. The above assessment of starting time has been made on the basis of one start from the hot condition, since this is the normal assumption for increased safety motors. Generally speaking, it can be taken that the critical limiting temperature will not be exceeded with two starts in succession from the cold condition, but if this is a requirement a check should be made that any external motor protection device will not trip during the second start.

Motors complying with the requirements of BS 4999 are normally suitable for two starts in succession from the hot condition (see BS 4999-41). Where two or more starts in succession, or spaced close together in time, are required the motor manufacturer should be informed, and he should arrange for the certificate and motor nameplate to be marked with these special requirements. In cases where the starting time is short compared with the t_E time there should be no difficulty in accommodating more than one start in succession from the hot condition. Where the starting time approaches the t_E time a specified cooling period between starts will be necessary.

A.5 Motor protection devices

In order to ensure that the critical limiting temperature is not exceeded, during starting or stalling, a special motor protection device is necessary. The device will normally be a three element current sensitive relay mounted remotely (e.g. in the motor starter). The device should also provide protection (for star and/or delta wound motors, as required) against overloading and single-phasing during normal running. A delta connected motor requires special consideration with regard to protection against a single-phasing condition, resulting from the open circuiting of an internal winding phase. Unlike a star connected motor, a delta connected motor may be capable of continuing to run and also of restarting with one of its winding phases open circuit. Unless the motor is always fully loaded, the resulting unbalance in the supply line currents may not be sufficient to cause the current sensitive relay to trip on unbalance. A delta connected motor should therefore be protected either by a current sensitive relay responding to line current with unbalance protection capable of tripping the motor when running with no mechanical load and one of its winding phases open circuit, or by a current sensitive relay connected in each phase winding circuit of the delta. This latter connection will require a six core cable to the motor from the motor starter.

The remote mounted current sensitive type of device is not normally certified and therefore requires careful selection by the user. The important considerations when selecting the device are as follows.

a) The time to trip when carrying current equivalent to I_A must be less than the t_E time. A tripping time of 80 % of the t_E time is recommended to allow for tolerance and drift. It is also recommended, where the device is of the thermal type, that the "cold" tripping characteristic curve of the device should be used to cater for the motor being restarted after a short interval when it is at almost its normal running temperature but when the protective device, being of lower thermal inertia, has cooled to the "cold" condition.

b) The characteristic curve of the device should be related to an ambient temperature of 20 °C or such lower temperature as may apply to its environment.

c) The device should be of the three element type and should provide "close" overload protection during normal running and should provide single-phasing protection. It is recommended that the time/current tripping curve should be asymptotic to the current axis at 105 % I_N.

d) The device should keep to the stated values of the time delay within the limits of ± 20 %.

e) The device should be mechanically robust and suitable in all respects for its environment.

f) It is important that the user should check that the tripping time of the device (when the current is equivalent to I_A) taken from the manufacturer's time/current curves is less than the t_E time, taking account of all the above factors.

As an alternative to a current sensitive device, a temperature sensitive device, usually taking the form of at least one thermistor embedded in each phase of the stator winding, may be used with certain types of motor. Because of the relative rates of temperature rise of stator and rotor windings during the stalled condition this form of protection is not suitable for use with many types of motor. Motors certified with thermistor over-temperature protection may be subject to a limitation of the minimum ambient temperature because of differing rates of temperature rise of rotor and stator windings in the stalled condition.

The motor certificate will define the characteristics, with respect to the thermistors, of the remote relay. This will normally be in accordance with BS 4999-72. Temperature sensitive devices in the winding may be preferred for motors with duty types other than S1, or where a frequent or arduous starting duty is involved. In special cases, temperature sensitive devices may be specified in addition to current sensitive devices.

The remote relay, operated by the temperature sensitive devices, should be carefully selected so that it does not detract from the increased safety concept of the motor. For this purpose, high reliability and accuracy of operation are essential.

Appendix B Marking of apparatus

B.1 General

All electrical apparatus certified for use in hazardous areas will be marked with the particulars specified in the standard for the type of protection used. The marking enables the apparatus to be easily identified for the purposes of both initial installation and subsequent inspection and maintenance.

The marking requirements normally include general information relevant to the use of the apparatus and such additional information as is necessary to ensure its safe use in hazardous areas. Typical marking requirements are given in Part 1 of the code. For completeness, the marking requirements are included here without comment except where detailed explanation is required on account of considerations that are particularly relevant to type of protection "e".

B.2 Marking requirements

The marking requirements normally include general information relevant to the use of the apparatus and such additional information as:

a) identification of the manufacturer, trade agent's name or registered trade mark;

b) the name or type designation of the apparatus;

c) the number of the relevant British Standard, or other certification standard, e.g. BS 4683-4;

d) identification of the type of protection: apparatus certified in accordance with the concept of type of protection "e" will be marked Ex "e";

e) the apparatus group (see **B.3**);

f) the number of the certificate and the name or mark of the certifying authority;

g) the temperature class, or maximum surface temperature (see **B.4**);

h) the reference ambient temperature, if this is other than 40 °C;

i) a mark to indicate that, where appropriate, the apparatus has passed an individual test or examination (routine tests): this is applicable, for example, to individual machines that, because of their size or other characteristics, are subject to examination and, where necessary, to test at the manufacturer's premises;

j) such additional information as may be required for the correct operation of apparatus, e.g.

rated voltage and current;

starting current ratio I_A/I_N, and time t_E;

thermal current limit I_{th}, dynamic current limit I_{dyn};

maximum lamp rating and type of lamp (for luminaires);

restrictions in use, e.g. for use in clean rooms only;

special protection devices if necessary, for example, for direct temperature control of arduous starting conditions.

The apparatus may also be marked with a production or serial number, and with the date of the individual works test or final inspection. Duplicate marking may also be fixed inside the enclosure of the apparatus, particularly where the marking is normally located on a removable cover plate which could be interchanged with a similar component from an apparatus that might have dissimilar characteristics, or which may be used under alternative installation conditions, e.g. alternative load ratings.

In certain circumstances, e.g. on account of its operating temperature, apparatus may be marked with particulars of the method of wiring or cabling to be used therewith. Alternatively, reference will be made on the marking plate to the certification or approval documents, for example SEE CERTIFICATE BEFORE CONNECTING THIS APPARATUS. The suffix $/_B$ or $/_X$ after the certificate number should also be interpreted for this purpose.

In the case of plastics enclosures, in some cases a warning label may be attached to the apparatus to the effect that certain solvents may attack the plastics material.

B.3 Apparatus grouping

Apparatus with type of protection "e" will normally be marked with the symbol ‖, to indicate its suitability for use in surface industry with all flammable gases and vapours encountered therein. However, in some cases apparatus may be certified and marked for specific gases and vapours only.

B.4 Temperature class

Apparatus with type of protection "e" will normally be marked with a symbol selected from the range T1 to T6 inclusive, to indicate its temperature class (see **B.6**, and Part 1 of the code).

This symbol is indicative of the maximum temperature reached by unprotected surfaces, measured where necessary under prescribed conditions, and should be taken into account when the suitability of the apparatus for use with a particular flammable gas or vapour is being considered.

B.5 Apparatus with multitypes of protection

B.5.1 Some apparatus may incorporate two or more types of protection, one of which is type of protection "e". In such cases the marking should indicate the types of protection used. The mark Ex will be followed by the symbol for the main type of protection with the additional protective features indicated subsequently in a subordinate manner, e.g. Ex e, d; or Ex e (d).

This marking indicates certified electrical apparatus protected overall by type of protection "e", which will determine the installation requirements for the apparatus, and incorporating a component part or parts protected in accordance with type of protection "d": flameproof enclosure. Apparatus with multitypes of protection may be subject to apparatus subgrouping.

B.5.2 Apparatus protected by a type of protection other than "e" (for example "d") but having a terminal box with type of protection "e" would have the case marked in accordance with type of protection "d" standard and the terminal box marked in accordance with type of protection "e" standard.

B.5.3 Individual circuits and component parts protected other than by the main type of protection should also be marked individually with the appropriate symbol to assist in their ready identification for inspection and maintenance purposes. They should be maintained in accordance with that Part of this code appropriate to the type of protection used.

B.5.4 It may be anticipated that, increasingly in the future, apparatus will incorporate multitypes of protection. This will increase the possibility of apparatus subgrouping for apparatus with type of protection "e".

B.6 Examples of marking

B.6.1 Apparatus (other than rotating machines) protected in accordance with type of protection "e" only might be marked thus:

Ex e ‖ T5

This should be interpreted as indicating that the apparatus may be used in Zone 1 or Zone 2 with all flammable gases and vapours encountered therein, whose ignition temperatures are not less than the maximum surface temperature of 100 °C implied by the symbol T5.

A motor certified in accordance with type of protection "e" only might be marked as follows in addition to the marking required for an industrial motor:

Ex e ‖		Temperature class	T3	T2	T1
I_A/I_N	7.4	t_E time (s)	6	10	10

This should be interpreted as indicating that the apparatus may be used in Zone 1 or Zone 2 with all flammable gases and vapours encountered therein, whose ignition temperatures are not less than the maximum surface temperatures appropriate to the temperature class of the machine. The temperature class may in effect be selected according to the characteristics of the motor protection apparatus as indicated by the relationships between temperature class and t_E time in this example (see also Appendix A).

B.6.2 A single item of apparatus protected overall by type of protection "e", but incorporating additional protective features, might be marked thus:

Ex e d s ‖C T4; or Ex e (d, s) ‖C T4

This should be interpreted as indicating that the apparatus incorporates in a secondary manner components or parts protected according to types of protection "d": flameproof enclosure and "s": special protection, which should be maintained in accordance with the recommendations of the appropriate Parts of the code. The apparatus may be used in Zone 1 and Zone 2 with flammable gases and vapours requiring apparatus in subgroups IIA, IIB and IIC, whose ignition temperatures are not less than the maximum surface temperature of 135 °C implied by the symbol T4.

The component or part that is protected in accordance with type of protection "d": flameproof enclosure might, for example, be certified as complying with the constructional requirements of apparatus subgroup IIB only. In this case, the apparatus would be marked thus:

Ex e d s IIB T4; or Ex e (d, s) IIB T4

In this instance type of protection "d" limits the range of flammable gases and vapours with which the apparatus may be used.

B.6.3 Luminaires specially tested for a gas or vapour and having a light source temperature higher than the limiting temperature (see **8.2**) might be marked thus:

Ex e ‖ T4 and CS_2

This means that the luminaire is suitable for use in Zone 1 or Zone 2 with all combustible gases and vapours encountered therein, whose ignition temperatures are not less than the maximum surface temperature of 135 °C implied by the symbol T4 and also carbon disulphide for which the luminaire has been especially tested.

The certification or assessment documents would include information relating to the special test and the specified relaxation for the named gas or vapour.

Appendix C Resistance to impact

The following impact test is specified in BS 4683-4:1973 for the general assessment of enclosures for electrical apparatus certified in accordance with type of protection "e": increased safety.

A mass of 1 kg is allowed to fall through 0.7 m, using a hardened steel hemisphere of 25 mm diameter at the impinging end.

Minor denting or chipping does not prohibit certification or approval of an apparatus, unless such damage prevents compliance with any of the other certification requirements.

Appendix D Resistance to chemical attack

BS 4683-4 specifies that the chemical influence of combustible gases and vapours on certain of the mechanical and electrical properties of insulating materials such as panels, impregnants, encapsulation materials, mouldings seals and gaskets, is to be assessed by exposing the material to the vapour of the following solvents at 20 ± 2 °C, at atmospheric pressure, for 140 h to 150 h:

acetone

benzene

hexane

methanol

carbon disulphide

ethyl acetate.

After the test the average tensile strength and the average compressive strength should be more than 80 % of the initial average values, while the volume should not have changed by more than 5 % and other physical and electrical properties such as yield point, resistance to creep and resistivity should be substantially unaffected.

Publications referred to

BS 4056, *Method of test for ignition temperature of gases and vapours.*

BS 4081, *Fittings for mineral insulated cables.*

BS 4121, *Mechanical cable glands for rubber and plastics insulated cables.*

BS 4683, *Electrical apparatus for explosive atmospheres.*

BS 4683-4, *Type of protection "e".*

BS 4999, *General requirements for rotating electrical machines.*

BS 4999-30, *Duty and rating.*

BS 4999-41, *General characteristics.*

BS 4999-72, *Built-in thermal protection for electric motors rated at 660 volts a.c. and below.*

BS 5501, *Electrical apparatus for potentially explosive atmospheres.*

BS 5501-6, *Increased safety "e".*

BS 6121, *Mechanical cable glands for elastomer and plastics insulated cables.*

CP 1003, *Electrical apparatus and associated equipment for use in explosive atmospheres of gas or vapour other than mining applications.*

CP 1003-1, *Choice, installation and maintenance of flameproof and intrinsically-safe equipment.*

CP 1003-2, *Methods of meeting the explosion hazard other than by the use of flameproof or intrinsically-safe electrical equipment.*

CP 1003-3, *Division 2 areas.*

IEC 79, *Electrical apparatus for explosive gas atmospheres.*

IEC 79-7, *Construction and test of electrical apparatus, type of protection "e".*

SFA 3008, *Increased safety (BASEEFA Certification Standard).*

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