

Guide to the use of

**Electrical apparatus
complying with BS 5501
or BS 6941 in the
presence of combustible
dusts**

Guide d'utilisation des appareils électriques
conformes aux normes BS 5501 ou BS 6941 en
présence de poussières combustibles

Leitfaden für den Einsatz von elektrischen
Betriebsmitteln nach BS 5501 oder BS 6941 in
Schlagwetteratmosphäre

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Foreword

This British Standard has been prepared under the direction of the General Electrotechnical Standards Policy Committee.

At the present time there is no other existing British, European or International Standard for this subject. In the drafting of this standard account has been taken of the work which has been done in Subcommittee 31H of the International Electrotechnical Commission (IEC), which has not so far led to any published standard. Account has also been taken of BS 6467 'Electrical apparatus with protection by enclosure for use in the presence of combustible dusts; Part 1 : Specification for apparatus and Part 2 : Guide to selection, installation and maintenance'. BS 6467 applies to apparatus with protection by enclosure in which the design features are specifically intended to make the apparatus suitable for use in a combustible dust atmosphere.

The recommendations of this guide are based on the maximum surface temperature of the enclosure and on the restriction of dust ingress to that enclosure by the use of 'dust-tight' or 'dust-protected' enclosures.

British and European Standards dealing with individual types of protection are as follows:

NOTE 1. EN 50014 to EN 50020, EN 50028 and EN 50039 (BS 5501 : Parts 1 to 9 inclusive) are referred to in EEC Directives and some United Kingdom legislation.

EN	BS ¹⁾	Type of protection	Comment
50014	5501 : Part 1	—	General requirements
50015	5501 : Part 2	'o'	Oil immersion
50016	5501 : Part 3	'p'	Pressurized apparatus
50017	5501 : Part 4	'q'	Powder filling
50018	5501 : Part 5	'd'	Flameproof enclosure
50019	5501 : Part 6	'e'	Increased safety
50020	5501 : Part 7	'i'	Intrinsically safe apparatus
50028	5501 : Part 8	'm'	Encapsulation
50039	5501 : Part 9	'i'	Intrinsically safe system
—	6941	N	Related to IEC 79-15 'n'

NOTE 2. It is currently BSI policy to implement European Standards by introducing 'BS' before the European Standard designation, e.g. future editions of BS 5501 : Part 1 will be numbered, 'BS EN 50014'.

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

Section 1. General

1.1 Scope

1.1.1 This British Standard gives guidance on using electrical apparatus and systems complying with the requirements of British Standards for electrical apparatus to be used in explosive gas atmospheres under conditions where the hazard will be from combustible dust. The guidance covers selection, installation and maintenance.

This standard is based upon the use of BS 5501 or BS 6941 apparatus and systems without modification. This is so that any claim for compliance of the apparatus or systems with those standards will not be invalidated and so that the apparatus or systems remain suitable for use, as originally intended, in an explosive gas atmosphere.

Not all such apparatus and systems will be suitable for use according to the recommendations of this standard.

The guidance in this standard takes as a criterion of acceptability that the electrical apparatus is able to operate safely under a dust layer on the external surface of the enclosure having a maximum thickness of 5 mm, which is the thickness used in the measurement of the ignition temperature of dust layers.

NOTE 1. A method for determining the ignition temperature of combustible dust in a layer (see the Draft for Public Comment in 82/24413 DC) has been approved for publication by the IEC.

NOTE 2. In the UK it is a legal requirement to minimize the release of dust and to prevent the formation of dust layers by good housekeeping. It is the responsibility of the user of this standard to ensure that the selected apparatus and the details of its installation conform to the appropriate legislation.

This standard does not apply to the use of electrical apparatus in dust from materials regarded as 'explosives', nor does it take into account any risk resulting from the emission of flammable gas or vapour from the dust. It does not apply to electrical apparatus and systems intended for or used in mines susceptible to firedamp (Group I apparatus).

This standard gives guidance on the application of apparatus constructed for use in explosive gas atmospheres and complying with BS 5501 'Electrical apparatus for potentially explosive atmospheres' or BS 6941 'Specification for electrical apparatus for explosive atmospheres with type of protection N', in situations where the hazard is only from the presence of combustible dusts.

It does not give guidance on the use of electrical apparatus in atmospheres that may simultaneously contain explosive gas and combustible dust as the Technical Committee has accepted that the technical information available from all sources is insufficient to form the basis of any recommendations.

NOTE 3. It is a requirement of BS 5501 that certification be obtained from a testing station and this is the reason for the frequent references to certification in this standard but these do not imply that there is any similar requirement related to use in a combustible dust atmosphere.

This standard does not apply to apparatus which complies with both BS 5501 and BS 6467 : Part 1, or BS 6941 and BS 6467 : Part 1 and is marked accordingly, since the use of such apparatus in a combustible dust atmosphere would be within the scope of BS 6467 : Part 2.

1.1.2 The guidance in this standard has been prepared to be as widely applied as possible without requiring modification of apparatus or systems which are likely to have been certified and without detailed assessment of the apparatus or system being required from the user. There may be particular circumstances in which the recommendations are felt to be too restrictive and suitably experienced and qualified persons may make an assessment of the circumstances and then decide either not to apply or else to modify the recommendations, taking responsibility for maintaining an adequate level of safety. In such cases, the guidance in this standard should be followed as far as is practicable.

Exceptionally the user may decide that a modification should be made, for example, to improve the degree of protection by enclosure. As this would invalidate the original claim for compliance and any certificate, the marking of the apparatus or systems and any documentation should be changed so that there can be no future misunderstanding.

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

1.2 Definitions

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

1.2.1 rating

The designed performance of an electrical apparatus.

1.2.2 degree of protection of enclosure

The measures applied to the enclosures of electrical apparatus to ensure the following:

- (a) protection of persons against contact with live or moving parts inside the enclosure and protection of the apparatus against ingress of solid foreign bodies;
- (b) protection of apparatus against ingress of liquids.

NOTE. The enclosure to give the 'degree of protection' is not necessarily identical to the apparatus enclosure for 'type of protection' and will be defined by the manufacturer.

1.2.3 terminal compartment

A separate compartment or part of a main enclosure, communicating or not with the main enclosure, and containing connection facilities.

1.2.4 connection facilities

Terminals, screws and other parts, used for the electrical connection of conductors of external circuits.

1.2.5 maximum surface temperature

The highest temperature which is attained in service under the most unfavourable conditions (but within the tolerances) by any part or surface of an electrical apparatus, which is able to produce an ignition of the surrounding atmosphere.

NOTE 1. Since this definition is from BS 5501 : Part 1, 'surrounding atmosphere' should be understood as 'surrounding explosive gas atmosphere'. The 'part' or 'surface' may therefore be inside or on the outside of any enclosure of the apparatus depending on the type of protection.

NOTE 2. The most unfavourable conditions include recognized overloads and fault conditions specified in the standard for the type of protection concerned.

1.2.6 dust

Small solid particles that settle out under their own weight but that may remain suspended for some time.

NOTE. This definition includes what are defined in BS 6069 : Part 2 as 'dust' and 'grit'.

1.2.7 combustible dust

Dust that is combustible or ignitable in mixtures with air.

NOTE 1. Most combustible dusts form explosive mixtures with air only between certain concentration limits.

NOTE 2. Although a mixture which is above the upper concentration limit is not an explosive mixture, it can become so by dilution.

NOTE 3. Combustible dusts are capable of being ignited by external ignition sources and will continue to burn at atmospheric temperatures but they will only spontaneously ignite above a certain temperature.

1.2.8 free dust

Dust that does not adhere permanently to any surface of any apparatus.

1.2.9 portable electrical apparatus

Apparatus that can either be moved while in operation or that can easily be moved from one place to another ready for use, while connected to the supply.

1.2.10 hazard (dust)¹⁾

Presence, or risk of the presence, of a combustible mixture of dust and air.

1.2.11 hazardous area (dust)¹⁾

Area in which combustible mixtures of dust, in cloud or layer form, and air are, or may be expected to be, present in quantities such as to require special precautions for the construction and use of electrical apparatus.

1.2.12 non-hazardous area (dust)¹⁾

Area in which combustible dust-air mixtures are not expected to be present so that special precautions for the construction and use of electrical apparatus are not required.

1.2.13 source of release (dust)¹⁾

Place from which combustible dust may be released into the atmosphere.

1.2.14 maximum surface temperature of the enclosure

Highest temperature that is attained under the most adverse electrical conditions (but within the specified tolerances) by any part of the external surface of the enclosure of an electrical apparatus that would be able to produce an ignition of the surrounding atmosphere.

1.2.15 ignition temperature of a dust layer/cloud

Lowest temperature at which ignition occurs under defined test conditions of a combustible dust layer/cloud.

1.2.16 area classification (dust)¹⁾

Notional division of works, plant or installation (hereinafter referred to as plant) into zones in accordance with the likelihood of the existence of a hazardous area (dust) for the purpose of selection, installation and maintenance of electrical apparatus.

1.2.17 extent of zone

Distance in any direction from a source of release to the point where the hazard associated with that zone is considered no longer to exist.

1.2.18 Zone Z

Area in which combustible dust, is, or may be, present as a cloud during normal processing, handling or cleaning operations in sufficient quantity to be capable of producing an explosive concentration of combustible or ignitable dust in a mixture with air.

NOTE. Zone Z is an area outside the dust containment.

1.2.19 Zone Y

Areas not classified as zone Z, in which accumulations or layers of combustible or ignitable dust may be present under abnormal conditions and give rise to ignitable mixtures of dust and air.

NOTE. Zone Y is an area outside the dust containment.

1.2.20 dust containment

Those parts of the process equipment inside which dust is handled, processed, transported or stored.

1.2.21 multicore cable

Cable carrying more than one intrinsically safe circuit.

1.2.22 conductive dust

A dust with electrical resistivity equal to or less than $10^3 \Omega \cdot \text{cm}$.

¹⁾ Where the word 'dust' appears in brackets it may be omitted where there is no risk of confusion with the similar term used in connection with explosive gas atmospheres

1.3 Classification of hazardous areas

This standard adopts the concept, which is internationally agreed for flammable gases and vapours, of using an area classification (see 1.2.16) to denote the risk of fire and/or explosion. As the hazard from combustible dusts, unlike that from flammable gases and vapours, will not necessarily be removed by ventilation or diffusion after the release has stopped, a common classification is not practicable. Indeed, in the case of combustible dusts, accelerated ventilation may, by the creation of dust clouds, give a greater rather than less hazardous condition. Furthermore, the formation of dust layers may be cumulative, thus increasing the hazard unless the dust is physically removed.

The definitions of Zones Z and Y are given in 1.2.18 and 1.2.19 respectively, this classification relying on an assessment of the likelihood of the existence of a hazardous area (dust). The situation where there could be the simultaneous presence of combustible dust and of flammable gas or vapour is not directly considered and it is recommended that such situations should be the subject of individual assessments based on the recommendations of this standard and of BS 5345 : Part 2. In classifying a hazardous area, account should not be taken of catastrophic failures, whether of electrical apparatus producing a source of ignition or of, for example, process equipment and pipelines which, by fracture, could become sources of release. Such catastrophic failures would be assumed to be of low probability in plants designed, constructed, tested, inspected and maintained in accordance with accepted standards and codes of practice.

By implication, an area outside the dust containment that is not classified as Zone Z or Zone Y is deemed to be a non-hazardous area for the purposes of this standard.

The procedure for area classification and an example of the designation of zones on the area classification drawings are given in appendix A.

1.4 Properties of combustible dusts

NOTE. The IEC has developed, but not yet published, agreed methods of test for the determination under specified conditions of the ignition temperature of dust in layers and in clouds. It is expected that these methods will gain popularity for the measurement of ignition temperatures required for the application of electrical apparatus in combustible dust atmospheres. Data for combustible dusts available at the date of publication of this standard will frequently not have been obtained by the application of the IEC methods or the previously used laboratory methods which served as the basis for the IEC methods.

Appendix B gives the properties of some combustible dusts. The values given in appendix B for the ignition characteristics are only typical values and, because of the complex combustion behaviour of dusts, considerable variations will occur with particle size, particle size distribution, moisture content, etc.

It is desirable for the user of this standard to obtain wherever possible measurements of these properties from samples of the dust(s) which the electrical apparatus may encounter. This applies even when the dust(s) or apparently similar dusts appear in appendix B; the desirability of having the dust sample for testing in the state in which it might be encountered in practice is stressed.

1.5 Other hazards

1.5.1 General

This standard is concerned specifically with the ignition risks associated with apparatus complying with BS 5501 or BS 6941 when used in a hazardous area. There are other hazards that exist in plants where such apparatus is used and the assessment of the risks, which is not within the scope of this standard, will involve consideration of matters such as those listed in 1.5.2 to 1.5.6 which might have implications for the electrical apparatus and which should be taken into account by the plant designer and operator.

1.5.2 Toxic risks

Even though there may be no ignition risk, there may be toxic risks associated with combustible, or other, dusts, particularly where these are deposited on heated surfaces.

1.5.3 Fire risks

Attention should be given to the installation of apparatus, particularly to any guards or covers, including those intended to reduce the deposition of combustible dust on electrical apparatus, to avoid thereby an increasing fire risk.

1.5.4 Static electricity

Reference is made in 6.3 of BS 5501 : Part 1 : 1977 to electrostatic charges on enclosures of electrical apparatus. Attention also needs to be given to the avoidance of electrostatic charges on other parts of the plant. It is recommended that reference be made to BS 5958.

1.5.5 Lightning and electromagnetic radiation

Although outside the scope of this standard, it should not be forgotten that combustible dust under certain circumstances, may be ignited by lightning and electromagnetic radiation and the implications for the electrical installation should be borne in mind. It is recommended that reference be made to BS 6651 and BS 6656.

1.5.6 Miscellaneous ignition sources

In any plant, irrespective of size, there are likely to be sources of ignition other than those represented by electrical apparatus. The possible implications of these should be taken into account when installing electrical apparatus.

Section 2. Principles for selection of apparatus and systems

2.1 General

The selection of electrical apparatus complying with BS 5501 or BS 6941 for use in any specific application in areas where a combustible dust hazard may be present should take account of all of the following:

- (a) the construction and design of the apparatus;
- (b) the maximum surface temperature;
- (c) the area classification;
- (d) the concepts of protection of the apparatus and systems;

NOTE. In a system there may be apparatus complying with BS 6467 in addition to that complying with BS 5501 or BS 6941.

- (e) the degree of ingress protection provided by the enclosure of the apparatus.

2.1.1 Selection according to apparatus construction

For any specific application, consideration should be given to the design and construction of the apparatus, and particularly to its enclosure, taking into account the points discussed in (a) to (f) as follows.

- (a) *Dust layer thickness.* The thickness of any layer of deposited dust on the external surface of the enclosure should be as small as possible and should not exceed 5 mm. In any specific application, the extent to which dust will accumulate on the enclosure will depend upon a number of factors, such as the design of the enclosure and of the apparatus; the ventilation, natural or artificial; the proximity of the apparatus to other objects; the ease of cleaning, by manual or other means; the presence of attractive forces, magnetic or electrostatic (see (c) and (d)).

In some cases, the accumulation of dust in unacceptable thicknesses may be:

- (1) avoided by the choice of attitude for the apparatus, for example by mounting it so that large flat surfaces are not horizontal; or

- (2) hindered, for example by using protective guards, although it should be remembered that these may also make cleaning more difficult and/or the presence of dust more difficult to discern.

- (b) *Degree of protection of enclosure.* (See table 1). In Zone Z, or where the dust is electrically conductive, apparatus having a degree of protection by enclosure IP 6X should be used. In Zone Y apparatus having enclosures providing a degree of protection of at least IP 5X and without permanently open breathing and draining devices may be used (but see 2.2, 2.3 and 2.4 for types of protection 'o', 'p' and 'q').

The degree of protection by the enclosure should be inherent in the design of the enclosure. It is not recommended for the user or installer to achieve IP 5X or IP 6X for the purpose of dust ingress protection by the use of additional sealing measures, for example, adhesive or tape. This does not, however, preclude their application additionally by the user or installer for weatherproofing.

- (c) *Magnetic attraction.* If ferromagnetic dust may be present, it is desirable that the apparatus should have the smallest possible external magnetic field and its enclosure should preferably be of non-magnetic material (but see (d) and (e)).

- (d) *Electrostatic attraction.* When non-metallic enclosures are used they may not have been designed and constructed to minimize the accumulation of electrostatic charges (see 6.3 of BS 5501 : Part 1 : 1977) and may bear the warning label indicating the safety measures to be applied in service. It is important that the siting and installation of the apparatus does not encourage dust accumulation due to electrostatic attraction.

NOTE. Guidance on problems associated with electrostatic charges is given in BS 5958.

Table 1. IP rating requirements and impact strength of apparatus complying with BS 5501 and BS 6941

BS No.	Type of protection	Solid ingress (first characteristic numeral)	Liquid ingress (second characteristic numeral)	Impact (J) Range 7/1 (high risk/low risk)
BS 5501 : Part 2	'o'	Not specified	Not specified	7/1
BS 5501 : Part 3	'p'	4	0	7/1
BS 5501 : Part 4	'q'	5	4	7/1
BS 5501 : Part 5	'd'	Not specified	Not specified	7/1
BS 5501 : Part 6	'e'	5/2	4/0	7/1
BS 5501 : Part 7	'i'	2/0	0	Not specified
BS 5501 : Part 8	'm'	Not specified	Not specified	7/1
BS 6941	N	5/2	4/0	3.5/0.5

(e) *Light metal construction.* Under conditions of frictional contact, the light metals, for example aluminium, magnesium and titanium, and their alloys containing more than 50 % light metal by atomic proportion, can give rise to incendive sparking. This problem is further discussed in appendix C.

(f) *Environmental conditions.* As the continued compliance of apparatus in accordance with BS 5501 or BS 6941 is often dependent on the continued integrity of its enclosure and/or the quality of its insulation, it is important that the selection process gives careful consideration to factors such as the risk of mechanical damage, chemical and solvent attack. Similarly other environmental factors which could affect the temperature classification, for example, the proximity of hot items of plant, solar gain and the presence of obstructions to cooling should be considered.

2.1.2 Selection according to surface temperature

In selecting BS 5501 or BS 6941 apparatus, attention should be given to the fact that the marked temperature class may refer to a surface inside the enclosure. The degrees of protection by enclosure referred to in this standard are assumed to prevent the entry of dangerous quantities of dust into the apparatus and the significant temperature is, therefore, taken to be that of an external surface on which dust may accumulate. Consequently the use of certain BS 5501 or BS 6941 apparatus with a given temperature classification is likely to give a safety margin. Alternatively the maximum surface temperature of the enclosure may be measured under the conditions specified in BS 5501 or BS 6941 as applicable and the apparatus selected on the basis of the measured value of temperature and the guidance in this clause.

The temperature class of apparatus is determined in accordance with the results of temperature measurements made under normal operating conditions and with recognized overloads, if any. The validity of temperature classification may be dependent upon operation within recognized tolerances of supply voltage variation; in cases of doubt the apparatus manufacturer should be consulted.

Generally, an ambient temperature of 40 °C is assumed in the rating of electrical apparatus for use in hazardous areas. Higher temperatures in exceptional cases lower temperatures, may have been taken into account in determining the rating of apparatus. In that event, the value of the maximum ambient temperature should be clearly marked on the apparatus and/or stated on the

certificate. It should be noted that a certificate¹⁾ will be invalidated if the apparatus is used at an ambient temperature higher than that for which the certification applies. The principle to be observed is that the maximum surface temperature should be less than the ignition temperatures of the dust(s) concerned, in cloud and layer form, with a suitable safety margin.

Appendix B contains data for a range of combustible dusts but it is emphasized that the list is not complete and the data for those quoted depend on the physical properties of the dust. In case of doubt it is recommended that the samples of actual dust(s) are submitted to a suitable test laboratory for the determination of the ignition temperatures (cloud and layer).

It is recommended that the safety margin is obtained by selecting apparatus having a temperature class or a maximum surface temperature less than the following:

- (a) two thirds of the minimum ignition temperature of the combustible dust/air mixture(s) (cloud(s)) concerned; and
- (b) 75 K less than the minimum ignition temperature of a 5 mm layer of the combustible dust(s) concerned.

NOTE. Group II apparatus complying with BS 5501 or BS 6941 is normally temperature classified as follows:

Temperature class	Maximum surface temperature °C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

2.1.3 Selection for use within the dust containment

2.1.3.1 The selection of BS 5501 apparatus for use within the dust containment requires special consideration because the effect on the apparatus of thick dust layers, or immersion in dust cannot be predicted. It is considered, however, that non-heat dissipating apparatus, part of whose enclosure forms part of the dust containment and whose electrical parts may thus be considered to be outside the dust containment is permissible. For the purposes of this standard, non-heat dissipating apparatus is considered to be apparatus whose surface temperature at the hottest point of the external surface of the enclosure after thermal stability has been reached does not exceed 5 K above ambient temperature when measured in free air under the conditions specified for the allocation of the temperature classification in the standard for the method of protection. This may be

¹⁾ BS 5501 requires a certificate from a testing station.

determined by test, from a declaration by the certificate holder for the apparatus or by a declaration from the certifying body. Such apparatus includes, but is not necessarily limited to the following:

- (a) measuring devices operating via a pocket or thermowell which forms part of the dust containment;
- (b) apparatus having only mechanical parts within the dust containment;
- (c) apparatus which has access to the inside of the dust containment only through a solid window, or other solid boundary of the dust containment. In this case the general recommendations given in 2.1.1 and 2.1.2 and the specific recommendations in 2.2 to 2.9 inclusive should be followed on the basis of the area classification outside the dust containment;
- (d) capacitance probes.

2.1.3.2 Where intrinsically safe apparatus and systems are considered for use within the dust containment they should be of category ia, Group IIc, in accordance with BS 5501 : Parts 7 and 9, and the apparatus intended for use therein should have an IP 6X enclosure. The installation should be accepted as suitable only if consideration of potential causes of ignition demonstrates that the apparatus will not ignite the dust under the fault conditions specified in BS 5501 : Parts 7 and 9. The potential causes of ignition which should be considered include, but are not necessarily limited to the following:

- (a) the thick layer ignition temperature of the dust;
- (b) the surface temperature of the enclosure of the apparatus under a thick layer of the dust;
- (c) accumulation of electrostatic charge on the enclosure of the apparatus or parts thereof;
- (d) sparking between the enclosure of the apparatus and its surroundings;
- (e) ohmic heating of the dust.

2.2 Selection of apparatus complying with BS 5501 : Part 2 (oil immersion 'o')

Oil immersed apparatus may be used in Zone Y provided that the degree of protection by enclosure is at least IP 5X. In Zone Z, or where the dust is electrically conductive an IP 6X enclosure should be used.

An IP 6X enclosure may be required if the dust ingress allowed by an IP 5X enclosure would change the properties of the oil.

If the oil immersed apparatus incorporates a terminal compartment protected by another method of protection of BS 5501, the suitability of any terminal compartment should be separately assessed in accordance with the appropriate clauses of this standard.

2.3 Selection of apparatus complying with BS 5501 : Part 3 (pressurized apparatus 'p')

Pressurized apparatus may be used in Zone Y provided the degree of protection by enclosure is at least IP 5X. In Zone Z, or where the dust is electrically conductive an IP 6X enclosure should be used.

The pressurized enclosure should have one or more inlet apertures and one or more outlet apertures for the connection of the inlet and outlet ducts for the protective gas. These apertures are excluded from the degree of protection recommendations in 2.1.1(b). However outlet apertures discharging into the hazardous area should be so constructed that they are closed at the end of the purging period in the case of leakage compensation systems, or on cessation of pressurization in the case of continuous circulation systems.

2.4 Selection of apparatus complying with BS 5501 : Part 4 (powder filling 'q')

Powder filled apparatus may be used in Zone Y provided that the degree of protection by enclosure is at least IP 5X. In Zone Z or where the dust is electrically conductive an IP 6X enclosure should be used.

If the powder filled apparatus incorporates a terminal compartment protected by another method of protection of BS 5501, the suitability of any terminal compartment should be separately assessed in accordance with the appropriate clause of this standard.

2.5 Selection of apparatus complying with BS 5501 : Part 5 (flameproof enclosure 'd')

Apparatus with flameproof enclosures may be used in Zone Y or Zone Z and should have a degree of protection by enclosure of at least IP 5X for Zone Y and IP 6X for Zone Z. Where the dust is electrically conductive, apparatus having a degree of protection by enclosure of IP 6X should always be selected.

2.6 Selection of apparatus complying with BS 5501 : Part 6 (increased safety 'e')

Increased safety apparatus may be used in Zone Y provided the degree of protection by enclosure is at least IP 5X. In Zone Z or where the dust is electrically conductive, increased safety apparatus having a degree of protection by enclosure of IP 6X should always be selected. Additional considerations for cage motors and protection devices are given in appendix F.

2.7 Selection of apparatus and systems in accordance with BS 5501 : Parts 7 and 9 respectively (intrinsically safe apparatus and systems 'i')

Intrinsically safe apparatus, having enclosures providing a degree of protection of at least IP 5X, and systems may be used in Zone Y. Intrinsically safe apparatus, having enclosures providing a degree of protection of IP 6X, and systems may be used in Zone Z. Uncertified parts of intrinsically safe systems such as simple devices, junction boxes etc., should have a degree of protection by enclosure of at least IP 5X for Zone Y and IP 6X for Zone Z. Where the dust is electrically conductive, apparatus having a degree of protection by enclosure of IP 6X should always be selected.

In circumstances where the BS 5501 : Part 7 intrinsically safe apparatus does not have the IP 5X or IP 6X enclosure recommended, an assessment of suitability should be carried out by examination and, where necessary, testing to show that the required integrity of the intrinsically safe circuit is maintained despite a layer of dust.

For this purpose all exposed clearance and creepage distances should be assumed to have failed to the most onerous conditions. The normal criteria for acceptable energy release are those for group IIC gases and vapours specified in BS 5501 : Part 7. The category of intrinsic safety chosen should be 'ia' for Zone Z applications and at least 'ib' for Zone Y applications.

It is necessary to reassess the temperature classification of the apparatus taking into account the additional possibility of failure of exposed clearance and creepage distances. In particular the temperature classification of any exposed small components should be reconsidered. In the design, advantage may have been taken of the small component relaxation on surface temperature requirements and these may achieve a temperature higher than the marked temperature classification. Temperature excursions of small components under conditions of test may exceed the ignition temperature of the dust (in cloud or layer form) provided that the dust(s) in question is (are) not ignited or charred by the component.

The additional assessment and any necessary testing should be documented and carried out by a competent body using techniques and facilities similar to those normally used by a national certifying authority for intrinsically safe apparatus.

Each piece of apparatus or its immediate location should be marked or identified so that the particular application can readily be traced back to the related safety documentation.

If there is any doubt about the suitability of the apparatus, then enclosures having the recommended IP ratings should be used.

2.8 Selection of apparatus complying with BS 5501 : Part 8 (encapsulation 'm')

Encapsulated apparatus may be used in Zone Y or Zone Z.

2.9 Selection of apparatus complying with BS 6941 with type of protection (N)

Type of protection N apparatus having enclosures providing a degree of protection of IP 5X may be used in Zone Y. Where the dust is electrically conducting an IP 6X enclosure should always be used.

Section 3. Installation of apparatus and systems

3.1 General

3.1.1 Installation procedure

In addition to the requirements for installation in non-hazardous areas, the further requirements that are recommended for installations in hazardous areas as a consequence of the nature of the environment and that are generally applicable to all types of protection are described below. The recommended installation Procedures that apply to particular types of protection are described in later clauses of this standard.

3.1.2 Access for inspection

Installations should be designed and the apparatus and systems installed so as to ensure ease of access for inspection and maintenance.

3.1.3 Plans and records

Plans of each site showing the extent of hazardous areas together with records of explosion protected apparatus and of the type and route of underground cables in those areas should be made and kept up-to-date.

3.1.4 Electrical ratings

Electrical apparatus and systems should be installed, used and maintained for use within their electrical ratings for power, voltage, current, frequency, duty and other characteristics where non-compliance might jeopardize the safety of the installation.

Where the electrical apparatus has not been manufactured in the United Kingdom, care should be especially taken to ensure the following:

- (a) the rated voltage and frequency are appropriate to the supply system on which the apparatus is to be used; and
- (b) the temperature classification has been established having regard to (a)

3.1.5 Installation of apparatus

All apparatus should be installed with due regard to the possibility of external mechanical damage. Where adequate protection cannot be ensured (for example, by location), reference should be made to the impact test requirements for the apparatus before deciding what additional measures, if any, may be necessary. These measures may include, for example, the provision of guards for transparent parts. However, care should be taken to ensure that such additional measures do not impair the integrity of the protective features inherent in the design of the apparatus when this is used for the originally intended conditions of service.

No alterations should be made to any installation without due consideration of the necessity to maintain the integrity of the type or types of protection involved. Alterations to apparatus or systems may invalidate any certificate or other documentation relating to that apparatus or system.

The use of electric surface heating necessitates particular considerations and techniques to achieve a safe installation (see also BS 6351 for general guidance).

3.1.6 Interconnection of apparatus (systems)

The safety of individual pieces of apparatus may be influenced by other interconnected apparatus. Such system considerations are dealt with in the clauses which deal with individual protection concepts.

3.1.7 Integrity of circuits and insulation

Care should be taken during installation to maintain good, low-resistance connections in all electrical circuits, including bonding circuits, and to avoid damage to electrical insulation or reduction of clearances and creepage distances.

Care should be taken during installation to maintain the integrity of electrical insulation provided during the design and manufacture of the apparatus so that the possibility of accidental sparking or arcing is avoided.

3.1.8 Automatic electrical protection

All circuits and apparatus in hazardous areas should be provided with means to ensure disconnection quickly in the event of overcurrent, overload or earth fault conditions. Suitable protection should be fitted where there is a danger that three-phase apparatus may be subject to excess current during single-phasing operation.

NOTE. This clause does not apply to apparatus and systems with type of protection 'i', for which guidance is given in 3.7.

3.1.9 Earthing

3.1.9.1 Earthing of power systems

Generally earthing of power systems should be in accordance with BS 7430.

High voltage apparatus should have earth fault protection in addition to overcurrent protection.

For low voltage systems, earth fault protection should be applied in all cases where the earth loop impedance is higher than the values required by appropriate regulations.

The maximum permitted impedance values should be halved in all cases where, on initial installation, it is anticipated that environmental conditions could lead to accelerated degradation of earth loop impedance paths.

3.1.9.2 Intrinsic safety earthing

Detailed information on the particular recommendations is given in 3.7.4.

3.1.9.3 Lightning protection

Recommendations for protection of structures against lightning are given in BS 6651.

3.1.9.4 Electrostatic phenomena

Recommendations for the avoidance of static electricity risks due to static electricity are given in BS 5958.

3.1.9.5 Cathodic protection

Recommendations for cathodic protection systems are given in BS 7361 : Part 1.

3.1.9.6 Protective multiple earthing (PME)

Where the power supply is directly from a system that is protected by PME, special precautions may be required within the hazardous area and specialist advice should be sought.

3.1.9.7 Interconnection of earthing systems

The power, lightning and static earthing systems, where they exist in the same area, should be bonded together¹⁾ to ensure as far as possible that all metal work in a particular area is at the same potential under all conditions (see 3.7 for particular recommendations for intrinsic safety).

3.1.10 Isolation

Except where otherwise permitted in this standard the integrity of the enclosure should not be disturbed until the apparatus has been disconnected from all sources of supply and effective measures have been taken to avoid the risk of it being re-energized before the integrity of the enclosure is restored.

If the apparatus contains stored energy, whether 'permanent', for example storage batteries, or 'temporary' such as flywheel energy or charged capacitors, special precautions will be necessary. In the case of the permanent source of energy, inspection, testing and maintenance should be undertaken in non-hazardous areas or controlled procedures established. In the case of the temporary stored energy, it will normally be sufficient to allow an adequate time, for example for rotors to come to rest or for capacitors to discharge through the discharge resistor normally fitted.

3.1.10.1 All electrical circuits should be provided with an effective means of complete circuit isolation, including the neutral. Such means of isolation should be provided for each item of electrical apparatus and/or each subcircuit. Adequate labelling should be provided immediately adjacent to each isolator to permit rapid identification of the apparatus or subcircuit that is thereby controlled. A master isolator or isolators may also be provided that will permit disconnection of large areas of plant in the event of serious emergency.

3.1.10.2 The means of isolation when located in a hazardous area should be a switch that breaks all poles, including the neutral, and that is provided with an appropriate type of protection. This applies equally to single-phase subcircuits. When the means of isolation is located in a non-hazardous area, the switch should break all poles, including the neutral, or alternatively may break only the

live poles, the neutral being isolated by removing a link. The means of isolation should be capable of being locked in the 'off' position.

3.1.10.3 Where the means of isolation is not immediately adjacent to the associated apparatus, effective measures should be taken to prevent the restoration of supply to the apparatus as long as there is a risk of live conductors being exposed to combustible dust.

3.1.11 Emergency supplies

Consideration should be given to the provision of emergency supplies to electrical apparatus (for example, emergency lighting, critical instruments, valves) that may be required to operate during periods of power failure.

3.1.12 Wiring systems

The types of wiring that in principle may be used for installations in hazardous areas are described in (a) and (b). The detailed requirements for permitted types of cable and their accessories are described in the subclauses dealing with individual types of protection. All cables, conduit and accessories should be in accordance with the appropriate British Standards.

The temperature of 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 should be specified and marked on the apparatus, or the marking should refer to the certification documents.

NOTE. Requirements for the installation of power systems may not apply to the installation of apparatus and systems with type of protection 'i'. For guidance on the latter see 3.7.3.

Types of wiring and systems that may be used for installations in hazardous areas are as follows:

- (a) cables drawn into screwed, solid drawn or seam welded steel conduit; and
- (b) cables that are otherwise suitably protected against mechanical damage; the following types of cable may in principle be used in Zones Y and Z:
 - (1) lead sheathed cable;
 - (2) armoured cable;
 - (3) thermoplastic or elastomer insulated, screened or armoured cable with a polyvinyl chloride (PVC), polychloroprene (PCP), chlorosulphonated polyethylene (CSP) or similar sheath;
 - (4) cables enclosed in a seamless aluminium sheath with or without armour, with an outer protective sheath (see also appendix C);

¹⁾ Subject to the approval of the supply authority.

(5) mineral insulated metal sheathed cable (see also appendix C);

(6) thermoplastic or elastomer insulated flexible cable or cord with a flexible metallic screen or armour and with a PVC, PCP or similar sheath overall;

(7) thermoplastic or elastomeric insulated cable with a semi-rigid sheath.

NOTE. The sheath of a metal sheathed cable should not be used as the neutral conductor.

In Zone Y only, other cables may be used (see the clauses dealing with the relevant types of protection suitable only for use in Zone Y).

3.1.12.1 Electrical continuity between metallic enclosures and conduit, armour, or cable sheaths and armour, or across any joints in the conduit or armour, should be ensured by the integrity of the joint itself. If external bonding is in certain circumstances necessary, it should preferably be connected directly across the joint.

3.1.12.2 Where circuits traverse a hazardous area (dust) in passing from one non-hazardous area to another, the wiring in the hazardous area should conform with the recommendations of this standard.

3.1.12.3 Except for electric trace heating, fortuitous contact between conduit or the metallic armouring sheathing of cables and pipework or equipment containing combustible dust should be avoided. The insulation provided by a non-metallic outer sheath on a cable will usually be sufficient to avoid this.

3.1.12.4 Wiring should be installed, so far as is practicable, in positions that will prevent its being exposed to mechanical damage and (with the exception of electric trace heating cables) to the effects of heat and to corrosive or solvent agencies. Where exposure of this nature is unavoidable, appropriate protective measures should be taken.

3.1.12.5 For terminal connections to fixed apparatus that may be required from time to time to be moved a small distance (for example, motors on sliderails), cables arranged to permit the necessary movement without detriment to the cable, or one of the types of cable suitable for transportable apparatus may be used. Suitably protected terminal boxes for the junction with the fixed wiring and apparatus respectively should be provided where the fixed wiring is not itself of a type that will permit the necessary movement. If flexible metallic conduit is used, it and its fittings should be constructed and assembled so that damage to the cable consequent upon its use is avoided. Adequate earthing or bonding should be maintained.

3.1.12.6 Where cables or conduit pass through a floor, wall, partition or ceiling that forms a dust or fire barrier, the hole provided for them should be made good with cement or similar incombustible material to the full thickness of the floor, wall, partition or ceiling. Alternatively, cable glands or cable transits may be used.

3.1.12.7 Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions should be taken to prevent the collection of combustible dust. Such precautions may involve the sealing of trunking, ducts and pipes or the sand filling of trenches.

3.1.12.8 All apparatus, connections and wiring whose functions are not apparent should be clearly marked to enable their relation to any associated apparatus, connections and wiring to be clearly recognized.

3.1.12.9 When an overhead line is used for either power or telecommunication circuits, it should be terminated to a cable outside the hazardous area with an effective surge diverter at or near the terminal pole. The armouring or metal sheathing of the cable should be electrically continuous, and the end adjacent to the point of connection with the overhead line should be bonded to the earth electrode of the surge diverter. In addition, the armouring or metal sheathing should be independently earthed as near as possible to the junction of the cable with the installation and bonded to the lightning protection system, if any, associated with the hazardous area subject to agreement with the supply authority (see also BS 6651).

3.1.12.10 The wiring entry to the apparatus should maintain the integrity of the type of protection of the apparatus.

3.1.12.11 Unused cable entries in electrical apparatus should be closed with plugs suitable for the type of protection of the apparatus.

3.1.12.12 Where accessories (for example, junction boxes) are used for the interconnection of cables, only those accessories that are suitable for the zone in which they are located should be used.

Where the apparatus includes a specific type of cable entry or is intended to be used only with a specific type of cable entry, no unauthorized alteration should be made in installing the apparatus.

Where the cables are terminated in apparatus or accessories with type of protection 'e', the cable lugs or other connections should be so arranged as to ensure maintenance of the distances and clearance and creepage specified in BS 5501 : Part 6.

3.1.12.13 Consideration should be given to the treatment or protection of cables and conduit against fire and fire transmission where high process integrity is required.

3.1.13 Factors affecting choice of wiring system

In regard to the choice of system the following environmental factors should be considered in addition to those indicated in **3.1.12**.

3.1.13.1 When the choice of wiring system and its component parts is being considered, due account should be taken of the nature of the hazardous environment, including chemical and thermal factors, particularly corrosive and solvent agents. It should be noted that certain sheath materials are vulnerable to attack by certain organic chemicals. Where contact with such liquids is likely to be sufficiently long to cause deterioration of certain sheath materials (as may occur with buried cables in contaminated areas), consideration should be given to the use of metal sheathed cables or alternative insulants or sheaths.

3.1.13.2 A screwed steel conduit system is satisfactory for many situations but should not be used where vibration may cause fracture or loosening of joints or where excessive stress may result from its rigidity or where corrosion or excessive internal condensation of moisture is likely to occur.

3.1.13.3 Mineral insulated metal sheathed cable may be used where it is not subject to flexing or vibration. Special considerations are necessary for installations of apparatus with type of protection 'e' (see the appropriate subclause of this standard).

Where electrolytic corrosion of the copper sheath may result from contact with walls or other surfaces to which the cable is attached, it should be kept clear of such surfaces or covered with a protective sheath.

3.1.13.4 Cables to electrical apparatus should preferably, be arranged vertically to prevent the undue accumulation of dust and they should be clipped, cleated or otherwise attached to suitable supports, care being taken to avoid excessive pressure on the cable. All cables should be adequately supported, avoiding arrangements which would lead to dust accumulations.

3.1.14 Conduit systems

3.1.14.1 Conduit should be screwed heavy gauge steel, solid drawn or seam welded complying with BS 31 or BS 4568.

NOTE. The use of plastics conduit with apparatus having specific types of protection is discussed in the appropriate subclauses of this standard.

3.1.14.2 Elbows of the solid type may be used for the immediate connection of conduit to apparatus.

3.1.14.3 Where a run of conduit, irrespective of size, passes from a hazardous area to a non-hazardous area, a stopper box or sealing device should be inserted at the hazardous area boundary or, failing this, on the side remote from the hazardous area.

NOTE. The use of a sealing device is essential to the maintenance of certain types of protection (see the appropriate subclauses of this standard).

3.1.14.4 Surface mounted conduit should be supported by spacing saddles.

3.1.14.5 All joints in an assembly of conduit should be painted with moisture resistant paint after assembly to inhibit the development of rust.

3.1.14.6 All bends in conduit should be machine made and radiused so as to facilitate the easy drawing in of cables.

3.1.14.7 For additional requirements for conduit systems that are relevant to particular types of protection, see the appropriate clauses of this standard.

3.1.15 Cable systems

Conductors may be of copper or aluminium, but plain aluminium should not be used for conductors with cross-sectional areas less than 16 mm² (see also **3.5** for precautions on the use of aluminium in, for example, flameproof enclosures 'd').

Cable runs should, where practicable, be uninterrupted. Where discontinuities cannot be avoided, the joint should either be encapsulated or made in a compound filled joint box or be protected in accordance with the recommendations for the zone.

Certain methods of explosion protection require specific types of cable glands; reference should be made to other clauses of this standard for details.

All cables should be provided with adequate mechanical protection. Cables should be adequately supported throughout their length, care being taken to avoid excessive pressure when cleats are used. Horizontal cables may be carried on supports or cable trays or through protective troughs or tubes. Rising cables should be clipped, cleated or otherwise attached to suitable supports that provide adequate mechanical protection and support.

Where single core metal sheathed or armoured cables are used, precautions should be taken to avoid dangerous sheath voltages or currents.

3.1.15.1 PVC covered and/or insulated cables

Attention is drawn to the fact that as the temperature decreases, PVC compounds become increasingly stiff and brittle with the result that if most PVC cables are bent too sharply, or are struck at temperatures of about 0 °C or lower, there is a risk of shattering the PVC. Therefore it is advisable to store PVC cable at a temperature above 0 °C for at least 24 h prior to installation (see also **3.1.13** for the effect of organic chemicals on PVC).

3.1.15.2 Paper insulated cables

Where paper insulated armoured cables are used, and particularly where such cables may be exposed to high temperature, preference should be given to non-draining cables complying with the test requirements of **10.2** of BS 6480 : 1988. In the case of other types of paper insulated armoured cables, vertical runs should be avoided (but see also **3.1.13.4**).

Cable boxes should, if necessary, be arranged for sealing the cable insulation and should be provided as necessary with adequate means for ensuring the earth continuity of metallic sheath and/or armour. Adequate arrangements should be made to ensure that cable boxes can be completely filled with the necessary compound resin or insulating oil in accordance with their design.

3.1.15.3 Mineral insulated metal sheathed cables

Cable fittings should be of a type approved for use with the apparatus to which they are to be attached and should be arranged for sealing the cable insulation and be provided with means for ensuring adequate earth continuity.

Fittings in which compound is used should not be exposed to temperatures that may, in the course of normal working, affect the satisfactory functioning of such compound.

Where there is a risk of mineral insulated cables being exposed to excessive voltages such as inductive surges, surge suppressors should be fitted. Where surge diverters are installed in hazardous areas, they should be suitably explosion protected.

3.1.15.4 Aluminium sheathed cables

Aluminium sheathed cables, unless sheathed with a protective covering, should not be installed in contact with walls or floor. Consideration should be given to the avoidance of frictional contact with such cables (see appendix C).

3.1.16 Portable and transportable apparatus and its connections

3.1.16.1 Portable and transportable electrical apparatus should have a type of protection appropriate to the zone(s) of use. In use the apparatus should not be transferred from the lower to the higher zone of risk unless it is suitably protected for the higher risk. Additionally the temperature class should be appropriate to all of the combustible dusts in which the apparatus may be used.

3.1.16.2 Account should be taken of the electric shock risk with mains-supplied portable or transportable apparatus. The precautions required (which may include double insulation, earth leakage protection, earth monitoring, extra low voltages, etc or a combination of these) are outside the scope of this standard.

3.1.16.3 Should plugs and sockets be in a hazardous area they should be suitable for use in the particular zone of risk and should have mechanical and/or electrical interlocking to avoid danger during insertion or removal of the plug.

3.1.16.4 In many cases the type of cable to be used will be specified on the apparatus certificate. In cases where this is not so, the cable should be suitable for rough usage and other adverse environmental conditions (e.g. elevated temperatures, presence of solvents). It should also be suitable for the circuit protective arrangements, (e.g. where earth monitoring is used, the required number of conductors should be included). Where the apparatus needs to be earthed, the cable may include an annular earthed flexible metallic screen in addition to the earth conductor.

3.2 Installation of apparatus complying with BS 5501 : Part 2 (oil immersion 'o')

Because of the nature of this type of protection the terminal compartment is normally protected by another type of protection and the installation recommendations for that type should be applied (e.g. for increased safety 'e' refer to **3.6**). Exceptionally the terminal chamber itself may be oil immersed and thus require filling with oil after installation. In these cases care is required to ensure the correct oil is used and that the cable entry arrangements prevent transmission of the oil down cable interstices.

3.3 Installation of apparatus complying with BS 5501 : Part 3 (pressurized apparatus 'p')**3.3.1 General**

Purging the enclosure may not remove dust which has accumulated within the enclosure. Before the pressurized apparatus is energized any accumulation of dust within the enclosure or ducting should be removed by cleaning. The certification of the apparatus will specify a purge flow and duration but these can be reduced as convenient where the only hazard is combustible dust.

NOTE. If the pressurized apparatus incorporates cells or batteries then the specified purge time should be implemented.

3.3.2 Ducts

3.3.2.1 Ducts should have adequate mechanical strength and be located where they are unlikely to suffer accidental damage. They should be adequately protected against corrosion throughout their length.