BS 6704 : 1996

Code of practice for

Selection, installation and maintenance of intrinsically safe electrical equipment in coal mines

Confirmed
January 2011

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee MRE/3, Mining electrical equipment, to Subcommittee MRE/3/3, Intrinsic safety, upon which the following bodies were represented:

Association of British Mining Equipment Companies
British Aggregate Construction Materials Industries
British Iron and Steel Producers' Association
Confederation of United Kingdom Coal Producers
Health and Safety Executive
Transmission and Distribution Association (BEAMA)

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on
15 November 1996

First published August 1987
Second edition November 1996

The following BSI references relate to the work on this standard:
Committee reference MRE/3/3
Draft for comment 94/705033 DC

ISBN 0 580 25195 0

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

Foreword

This revision of BS 6704 has been prepared by Subcommittee MRE/3/3 and reflects changes in legislation since the first edition was published in 1987. This standard provides guidance on the correct selection, installation and maintenance of intrinsically safe electrical equipment for use in potentially explosive atmospheres in coal mines. This standard supersedes BS 6704 : 1987 which is withdrawn.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Attention is drawn to the Health and Safety at Work etc. Act 1974 [1] and the Mines and Quarries Act 1954 [2], the Regulations made under these Acts and also any other appropriate statutory requirements or Bye-laws. These place responsibility for complying with specific safety requirements on the manufacturer and the user. The addresses of the recognized certification test houses appointed by the Secretary of State for Employment under the Electrical Equipment for Explosive Atmospheres (Certification) Regulations 1990 [3] are:

Health and Safety Executive,
Electrical Equipment Certification Service (EECS),
Harpur Hill,
Buxton,
Derbyshire,
SK17 9JN.

SIRA Certification Service, (SCS)
Saighton Lane,
Saighton,
Chester,
CH3 6EG.

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

Section 1. General

1.1 Scope

This British Standard describes the concept of ensuring electrical safety in hazardous atmospheres in coal mines by means of the type of protection 'i' (intrinsic safety), provides background information and gives recommendations on the selection, installation, inspection and testing, and maintenance and repair of intrinsically safe electrical apparatus, systems and networks.

Electrical safety of apparatus installed outside the hazardous atmosphere, or which is safeguarded by a type of protection other than intrinsic safety, is also considered in so far as the selection, installation and maintenance of such apparatus could affect intrinsically safe circuits. Only explosion risks due to the presence of flammable gases and vapours are considered. Combustible dusts are excluded except for coal dust layers which could be ignited by elevated surface temperatures.

Design or performance aspects of intrinsically safe apparatus pertinent to operational safety are not considered.

1.2 References

1.2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 18. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed page 18, but reference should be made to the latest editions.

1.3 Definitions

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

1.3.1 intrinsic safety

A protection technique based upon the restriction of electrical energy within both apparatus and interconnecting wiring, exposed to a potentially explosive atmosphere, to a level below that which can cause ignition by either sparking or heating effects.

NOTE. Because of the method by which intrinsic safety is achieved it is necessary to ensure that not only the electrical apparatus exposed to the potentially explosive atmosphere but also other electrical apparatus with which it is interconnected is suitably constructed.

1.3.2 intrinsically safe circuit

A circuit in which no spark nor any thermal effect produced under prescribed test conditions (which include normal operation and specified fault conditions) is capable of causing ignition of a given explosive atmosphere.

1.3.3 electrical apparatus

An assembly of electrical components and circuits or parts of circuits, usually contained within a single enclosure.

NOTE. An apparatus may occasionally be in more than one enclosure, e.g. a telephone instrument or a portable radio transceiver with a hand microphone.

1.3.4 intrinsically safe electrical apparatus

Electrical apparatus in which all the circuits are intrinsically safe.

1.3.5 associated electrical apparatus

Electrical apparatus in which the circuits are not all intrinsically safe but which contains circuits that can affect the safety of intrinsically safe circuits connected to it.

NOTE. Associated electrical apparatus may be either:

a) electrical apparatus that has an alternative standard type of protection suitable for its use in the appropriate potentially explosive atmosphere, e.g. a flameproof enclosure containing an intrinsically safe power supply; or

b) electrical apparatus not protected for use in a potentially explosive atmosphere, e.g. a recorder that is installed in a safe area on the surface, connected to an intrinsically safe transducer situated within a potentially explosive atmosphere underground and where only the recorder input circuit is intrinsically safe.

1.3.6 intrinsically safe system

Two or more items of electrical apparatus and interconnecting wiring in which any circuits intended for use in a potentially explosive atmosphere are intrinsically safe circuits.

1.3.7 intrinsically safe network

Two or more intrinsically safe systems that are interconnected in a defined manner.

1.3.8 intrinsically safe equipment

A term embracing intrinsically safe apparatus, systems and networks.

1.3.9 normal operation

The operation of intrinsically safe electrical apparatus or associated electrical apparatus when it conforms electrically and mechanically to its design specification and is used within the limits specified by the manufacturer.

1.3.10 fault

A defect of any component, or a defective connection between components, upon which the intrinsic safety of a circuit depends.

NOTE. If a fault can lead to a subsequent fault, or faults, the primary and subsequent failures are considered to be a single fault.

1.3.11 safety coupler

A device that is used to limit the transfer of electrical energy between intrinsically safe circuits.

1.3.12 safety barrier

A device that is used to limit the transfer of electrical energy from a non-intrinsically safe to an intrinsically safe circuit.

1.4 Information on legislation

1.4.1 Legislation affecting the use of electricity in British mines

1.4.1.1 The Electricity at Work Regulations 1989 [4] supported by the Health and Safety Executive (HSE) approved code of practice, *The use of electricity in mines* [5], govern the use of electricity in all mines. Additional requirements for coal mines are also contained in the Coal and Other Mines (Locomotives) Regulations 1956 [6], the Coal and Other Mines (Safety Lamps and Lighting) Regulations 1956 [7], the Coal and Other Safety-Lamp Mines (Explosives) Regulations 1993 [8], the Coal and Other Mines (Ventilation) Regulations 1956 [9], and the Management and Administration of Safety and Health at Mines Regulations 1993 [10].

1.4.1.2 The principal statutory safeguards against the risk of a firedamp ignition by electricity can be summarized as follows.

a) In potentially 'gassy' parts of a mine the use of electrical equipment which is capable of producing incendive sparking in normal working is not permitted. See Regulation 19 of the Electricity at Work Regulations 1989 [4] and **1.4.1.3**.

b) Regular periodic testing of the mine environment using gas detectors and methanometers is required by the Coal and Other Mines (Ventilation) Regulations 1956 [9] and the Management and Administration of Safety and Health at Mines Regulations 1993 [10], and where the amount of flammable gas in the general body of the mine air exceeds 1.25 % by volume the supply of electricity has to be cut off. Signals, telephones, caplamps, gas detectors and other similar essential safety equipment are excluded from the requirement providing they are of a type approved by the Health and Safety Executive (Mines Inspectorate) as being suitable to remain energized when flammable gas concentrations exceed the stipulated limit.

c) Under the Management and Administration of Safety and Health at Mines Regulations 1993 [10], the mine manager is required to ensure that all plant and equipment is safely installed and commissioned and to provide and implement a scheme to ensure the proper inspection, examination, testing and maintenance of all electrical equipment and to appoint a sufficient number of suitably qualified and competent persons to direct and manage, supervise and undertake all the above activities.

1.4.1.3 Regulation 19 of the Electricity at Work Regulations 1989 [4] prohibits the use of certain electrical equipment at safety-lamp mines in zones below ground in which firedamp is likely to occur in a quantity sufficient to indicate danger.

The manager of the mine is responsible for deciding which parts of the mine can be considered free from flammable gas and, using his discretion, he has to identify the zones where Regulation 19 of the Electricity at Work Regulations 1989 [4] applies and show them on a plan of the mine. There are no absolute rules governing the identification of such zones since circumstances and conditions may vary greatly from mine to mine, but guidance is given in the Coal and Other Mines (Ventilation) Regulations 1956 [9] on the method to be used in order to declare a roadway free from flammable gas. However, in general all places within 300 m of a working face and all places ventilated by auxiliary ventilation should, in the absence of evidence to the contrary, be considered hazardous zones.

1.4.1.4 It is generally accepted that electrical equipment certified by a European notified body (see **1.5.1**) as conforming to the appropriate standards for flameproof or intrinsically safe electrical equipment for use in group I atmospheres (class 1 in earlier standards), is acceptable for use in hazardous zones in coal mines.

1.4.1.5 Regulation 20 of the Electricity at Work Regulations 1989 [4] contains the requirement for the supply to all electrical apparatus, with the exception of approved signalling, telephone, gas detection or other equipment required for the safety of persons, to be switched off if the amount of flammable gas in the general body of air at the place in question exceeds 1.25 % by volume. The aim is to ensure that only apparatus essential for safety remains energized in an explosive atmosphere. Such approved apparatus is normally certified as intrinsically safe in accordance with either BS 1259 or category 'ia' of BS 5501 : Part 7 : 1977.

NOTE. The types of electrical equipment approved by the Health and Safety Executive (HSE) for the purpose of Regulation 20 of the Electricity at Work Regulations 1989 [4] are mentioned in **1.4.1.2**b. The HSE also approves other equipment for the purposes of other Regulations. For example shot firing equipment and locomotives should not be confused with the Regulation 20 equipment, as they are neither intrinsically safe equipment, nor allowed to remain energized when flammable gas concentrations exceed 1.25 %.

1.4.2 European legislation

1.4.2.1 ***EU article 100 directives***

Within the European Union under Article 100 of the Treaty of Rome, provision is made for the removal of technical barriers to trade by the issue of Directives. The Council of the European Communities has issued several such Directives and one, Directive 82/130 EEC of 15 February 1982 [11], commonly known as the 'Gassy Mines' Directive, concerns electrical equipment for use in potentially explosive atmospheres in mines susceptible to firedamp. This Directive requires that

member states shall not prohibit the sale, free movement, or use for its proper purpose of such equipment which has been certified as conforming to harmonized standards and which may be marked with the distinctive community mark, as shown in figure 1.

Figure 1. Certification mark

1.4.2.2 *EU article 100A Directives*

A new article 100A Directive was written and published on 23 March 1994 as Directive 9/94/EC [12], commonly known as the 'ATEX' Directive. This applies to all kinds of apparatus, electrical and non-electrical and, as of 1 March 1996, runs concurrently with the old Article 100 Directives until the year 2003, at which time the old Article 100 Directives will be withdrawn.

The ATEX Directive [12] also introduced the concept of aligning apparatus with its usage by describing the requirements for mining apparatus in usage category M1 and usage category M2. These align closely with the existing legal requirements for British mines, with category M2 being the apparatus used in normal circumstances and M1 being that apparatus which can remain energized when firedamp concentrations exceed 1.25 % by volume (normally only that meeting the requirements of intrinsic safety category ia and needing to remain energized for safety reasons).

1.5 Information on certification

1.5.1 British mining certification authorities

Certification of electrical apparatus for mines has been carried out since 1911 in conjunction with HM Mines Inspectorate. The Electrical Equipment Certification Service (EECS) has certified virtually all explosion-protected electrical equipment used in British mines. It has two divisions, MECS (Mining Equipment Certification Service) and for non-mining industries BASEEFA (British Approvals Service for Electrical Equipment in Flammable Atmospheres).

In 1992, by way of an amending Commission Directive, article 8 of Directive 82/130/EEC [11] (the 'Gassy Mines' Directive) harmonized the protection concept standards listed in table 1 and requires certificates to be issued only by an approved body. Article 14 of Directive 82/130/EEC [11] requires each member state to notify the European Commission of its approved bodies.

Certification by a notified body consists of attesting formally that a specified type of apparatus or system conforms to a recognized standard such as BS 1259 or BS 5501 : Part 7.

The certificate issued can be one of the following.

a) *Certificate of conformity*, attesting conformity to standards harmonized under European Union Directives.

b) *Supplementary certificate*, resulting from an application for a variation to a previously certified electrical apparatus or system.

c) *Certificate of assurance*, attesting conformity to non-harmonized standards.

d) *Inspection certificate*, referring to electrical equipment which, although not conforming to European harmonized standards, is of an equivalent degree of safety.

e) *Component certificate*, referring to component parts assessed as suitable for use with appropriately certified electrical apparatus.

1.5.2 Certification to European standards

The harmonized standards referred to in Directives 82/130/EEC [11] and 94/9/EC [12] are European standards (ENs) produced by the European Committee for Electrotechnical Standardization (CENELEC). The European Standards dealing with the design, construction and testing of electrical apparatus for use in hazardous atmospheres and the corresponding British Standards are as shown in table 1.

NOTE. EN 50039 is not yet a harmonized standard for Group I. Until it is harmonized, certificates of conformity may be issued where designs conform to the requirements of appendix 3 to annex B of EEC Directive 82/130/EEC [11].

1.5.3 Certification to British Standards

The construction and test requirements for type 'i' protection (intrinsic safety) are embodied in BS 1259 : 1958, BS 5501 : Part 7 : 1977 and BS 5501 : Part 9 : 1982. To enable interfacing, BS 6709 lays down construction and test requirements for apparatus conforming to these standards. Electrical equipment conforming to any one of these standards is acceptable for installation in accordance with this British Standard. Other British Standards specify electrical input and output characteristics of various types of intrinsically safe equipment necessary to ensure operational compatibility when such equipment is interconnected. These standards, which may also simplify the assessment of intrinsic safety, are BS 5754, BS 6182, BS 6353, BS 6556 and BS 6705.

1.6 Information on certification of electrical apparatus and systems

1.6.1 Intrinsically safe electrical apparatus

Intrinsically safe apparatus which has been certified to BS 1259 or BS 5501 : Part 7 normally falls into one of the following three categories:

a) completely self-contained apparatus which has no electrical connection to other electrical apparatus;

b) apparatus which is self-contained apart from its power supply. Permitted type(s) of power supply are specified in the certification documentation issued for the apparatus;

Table 1. Standards dealing with the design, construction and testing of electrical apparatus for use in hazardous atmospheres

EN	BS EN	Part of BS 5501
EN 50014 : 1992	BS EN 50014 : 1993	Part 1 : 1977[1)]
EN 50015 : 1994	BS EN 50015 : 1994	Part 2 : 1977[2)]
EN 50016 : 1977	—	Part 3 : 1977
EN 50017 : 1994	BS EN 50017 : 1994	Part 4 : 1977[3)]
EN 50018 : 1994	BS EN 50018 : 1995	Part 5 : 1977[4)]
EN 50019 : 1994	BS EN 50019 : 1994	Part 6 : 1977[5)]
EN 50020 : 1994	BS EN 50020 : 1995	Part 7 : 1977[6)]
EN 50028 : 1988	—	Part 8 : 1988
EN 50033 : 1991	BS EN 50033 : 1991	—
EN 50039 : 1980	—	Part 9 : 1982

[1)] Partially replaced by BS EN 50014 : 1993.

[2)] Replaced by BS EN 50015 : 1994, but remains current.

[3)] Replaced by BS EN 50017 : 1994, but remains current.

[4)] Replaced by BS EN 50018 : 1995, but remains current.

[5)] Replaced by BS EN 50019 : 1994, but remains current.

[6)] Replaced by BS EN 50020 : 1995, but remains current.

c) apparatus which is capable of being assessed, tested and certified separately, but which cannot be used except as a component part of a system. Conditions of use are defined in the certification documentation issued for the apparatus.

1.6.2 Intrinsically safe electrical systems

1.6.2.1 *General*

Apart from simple intrinsically safe systems built up from separate items of apparatus as described in **1.6.1**b, intrinsically safe systems have generally been certified to BS 1259 which is now an obsolescent standard and new intrinsically safe systems will be certified to BS 5501 : Part 7 and BS 5501 : Part 9. Where it is necessary to interconnect to existing installations certified to BS 1259, the newly formed system will be certified to BS 1259. (See also the note to **1.5.2**.)

1.6.2.2 *Permitted variations in system layout*

The certification documentation for an intrinsically safe system in accordance with BS 1259 specifies the items of apparatus, either by type or electrical characteristics, that may be connected and the manner by which such connections may be made. In this way a degree of flexibility is provided which permits variations to suit particular site requirements. The standards listed in **1.5.3** provide further flexibility.

NOTE. Notwithstanding these provisions a need may arise to vary the system layout in a manner not covered by the certification documentation, or to include additional items of apparatus. In such cases the certificate holder needs to obtain supplementary certification before the changes are implemented.

1.6.3 Intrinsically safe electrical networks

Intrinsically safe electrical networks can be formed by interconnecting separately certified intrinsically safe systems in a manner permitted by the certification documentation.

Electrical networks so constructed are suitable for use in hazardous areas in coal mines provided all conditions specified in the certification documentation for all the systems involved are met. Such a network may be regarded as an 'uncertified system' in the sense that the specific arrangement and interconnection of all equipment contained therein has not been assessed as a whole nor has a single certificate of intrinsic safety for the enlarged system been issued.

1.6.4 Intrinsically safe categories

1.6.4.1 BS 5501 : Part 7 specifies two categories of intrinsic safety, 'ia' and 'ib'. Category 'ia' apparatus is intended for use in areas of high risk and is incapable of causing ignition in normal operation and with any combination of two faults applied; whereas category 'ib' apparatus takes only one fault into account.

1.6.4.2 Self-contained apparatus or systems certified to BS 5501 : Part 7 or BS 5501 : Part 9 is either category 'ia' or 'ib' and this is specified in the certification documentation and also marked on the apparatus.

1.6.4.3 Apparatus which is approved under mining legislation (see **1.4**) and which can be left energized when the content of firedamp in the general body of air exceeds 1.25 % by volume has to satisfy the requirements for category 'ia'.

1.6.4.4 Batteries have to be category 'ia' since they cannot be completely de-energized. In addition, apparatus permanently connected to batteries has to be category 'ia' because of the difficulty of ensuring that all apparatus is disconnected from the battery in emergency situations.

1.6.4.5 Apparatus and systems certified to BS 1259 are, in general, considered equivalent to those certified as category 'ia' in accordance with BS 5501 : Part 7.

1.6.5 Conditions

1.6.5.1 *General conditions of use*

Certificates of intrinsic safety for both electrical apparatus and systems may specify those conditions of use necessary to ensure that intrinsic safety is maintained. Such conditions are included in the certificate and may be defined on the certification drawings.

1.6.5.2 *Special conditions of use*

For apparatus certified to BS 5501 : Part 7, the letter 'X' after the certificate reference number indicates that special conditions are necessary for its safe use. Where legislation requires that apparatus be approved, additional conditions of use may also be included in the approval documentation.

Suppliers have an obligation to inform the user of any conditions of certification. This may be identified in the maintenance manual or, in the case of a system, on the installation drawing.

1.6.5.3 *Special requirements*

Some types of intrinsically safe apparatus may have to meet special requirements. For example, apparatus used by rescue personnel may have to be tested for intrinsic safety in the presence of hydrogen, and apparatus for detecting or measuring the quantity of firedamp in the general body of air has to meet statutory performance requirements (see **2.1.6**). Another example is that of the intrinsically safe radio transmitter, which has its power output restricted to 500 mW because of the risk of initiating electric detonators.

1.6.6 Multicore cables

In general, different intrinsically safe circuits are not carried in the same multicore cable. However, a particular certification document may permit an intrinsically safe circuit to be carried in a multicore cable containing other intrinsically safe circuits.

Where a multicore cable contains more than one intrinsically safe circuit and all are part of the same certified intrinsically safe circuit, the certification documentation defines fully the permitted arrangement, including any requirements for the multicore cable.

1.6.7 Surface temperature

Where an apparatus has been certified to BS 5501 : Part 7, the maximum surface temperature that any internal circuit component can attain under fault conditions will have been assessed. Where coal dust can form a layer the maximum allowed surface temperature is 150 °C. Where internal parts are so protected that coal dust is unlikely to form a layer, the maximum allowed surface temperature is 450 °C. This latter value is based on the igniting temperature of methane by a hot surface.

NOTE. In accordance with British mining practice, to reduce the risk of skin burns the maximum permissible exterior surface temperature of apparatus when used underground is 90 °C unless appropriate safeguards are taken to minimize the risk of accidental bodily contact. BS 5501 : Part 7 provides no rules for marking apparatus to indicate whether the internal parts have been assessed at 150 °C or 450 °C.

1.6.8 Cells and batteries

1.6.8.1 A special feature of cells and batteries is that they cannot be de-energized in the same manner as an electrical circuit can be isolated. The requirements for cells and batteries for use in intrinsically safe apparatus are given in BS 5501 : Part 7 but requirements affecting use may appear on certificate documents or in the HSE *Electrical equipment certification guide* [13].

NOTE. The Mines Inspectorate as part of their Pitworthiness Assessment under the Electrical Equipment for Explosive Atmospheres (Certification) Regulations 1990 [3] normally permit only sealed batteries of the primary or secondary type having a capacity not exceeding 10 Ah to be used in intrinsically safe circuits. Batteries exceeding this capacity are examined on merit after consideration of the specific design and the balance of risk.

1.6.8.2 Any cell or battery used in intrinsically safe apparatus and which requires a current limiting device for safety purposes is normally encapsulated or enclosed with its current limiting device in such a way that only the intrinsically safe terminals of the assembly or any terminal intended for recharging are accessible. Rechargeable types are provided with some form of protection against the withdrawal of current from the charging terminals, e.g. by including series blocking diodes. A cell or battery intended to be charged underground (or in a hazardous area on the surface) is constructed so that it forms a complete replaceable unit with its current limiting device. A battery power pack is marked with a type designation and with information relating to the apparatus with which it is associated. To prevent inadvertent withdrawal of power from a battery power pack, any output socket or terminal exposed when not in use may be provided with a blanking cover or cap. Similarly a portable battery power supply unit may incorporate a switch in its output circuit which can be locked off during transportation of the power supply unit.

1.6.8.3 When a cell or battery is not intended to be changed underground it may be housed with its current limiting device in a compartment having covers secured by fasteners designed to prevent unauthorized entry. The compartment carries a label giving a warning that it should not be opened underground.

NOTE. Certification documentation for apparatus incorporating primary batteries often identifies the particular battery to be used by the type designation allocated by the battery manufacturer and the apparatus carries a label giving the permissible battery replacement type; for example, the particular brand and designation to be used. This method of control can lead to difficulties in continuing usage if the battery manufacturer introduces new batteries as replacements for existing types. To overcome this problem, it is proposed that wherever possible use should be made of the standard internationally agreed battery type designations specified in BS EN 60086-1.

1.6.9 Earthing

In British mines, metallic enclosures of mains powered electrical apparatus and the wire armouring and/or screens of their associated cables are all effectively bonded to form a single earthing system which is connected to the general body of the earth at one point by earth plates at the surface of the mine. Intrinsically safe systems often employ wire armoured cables where the armouring may be connected to the earth system at more than one point and thus form part of the mine earthing system. For example, a wire armoured data transmission cable interconnecting the outer metallic enclosure of a data transmission out-station with an earthed surface control desk is effectively connected to the earthing system at both ends.

1.6.10 Remote control circuits and earth fault monitoring circuits

Underground electrical machines, such as power loaders, are connected by flexible cables to motor starters which can be controlled from a remote point by means of a low voltage control/interlock circuit (pilot circuit) carried in the flexible cable. Motor starters incorporate low voltage earth fault monitoring circuits to prevent the application of power to faulty equipment. Since low voltage control/interlock circuits and low voltage earth fault monitoring circuits can be exposed while energized on removal of a restrained plug, it is essential that these circuits are incapable of incendive sparking. Such circuits which conform to BS 7202 : 1989 meet those requirements of intrinsic safety necessary to ensure that in normal operation incendive sparking cannot occur.

Non-incendive low voltage control/interlock and low voltage earth fault monitoring circuits, with the exception of external cabling, are contained within explosion protected enclosures.

Low voltage control/interlock and low voltage earth fault monitoring circuits conforming to BS 7202 : 1989 do not exceed 25 V in normal operation. The maximum voltage which could occur on such circuits under fault conditions is declared by the manufacturer and used in determining the distance of separation from intrinsically safe circuits.

1.7 Marking of apparatus certified to BS 5501 : Part 7

The requirements for marking apparatus certified to BS 5501 : Part 7 are closely specified in that standard. For example an item of apparatus designed for connection to other apparatus and which does not incorporate a power source may be marked as shown in figure 2a; however, the marking on older equipment may differ in detail as shown in figure 2b.

U_i (or U_{max}) is the highest voltage and I_i (or I_{max}) the highest current for which the apparatus is designed without adversely affecting its intrinsic safety. These values do not imply any required relationship with the lesser operating values.

L_i (or L_{eq}) and C_i (or C_{eq}) are the maximum values of inductance and capacitance respectively of the apparatus measured at its input terminals.

Similarly, a mains driven power supply unit contained within a flameproof enclosure may be marked as shown in figure 3a; however, the marking on older equipment may differ in detail as shown in figure 3b.

U_o (or U_{max}) and I_o (or I_{max}) are the maximum values of voltage and current for which the apparatus is designed, and that can appear at the output terminals under fault conditions. These should be used to determine whether apparatus and cables can be safely connected. These values do not imply any required relationship with the lesser rated output values which, for the example quoted, may be 18 V and 140 mA.

L_o (or L_{ext}) and C_o (or C_{ext}) are the maximum values of inductance and capacitance which can be safely connected at the output terminals of the power supply unit.

L/R is the maximum value of the inductance to resistance ratio of interconnecting cables.

Manufacturer's name	
Apparatus type	
EEx ia I	
MECS No:	HSE(M) No: .....
U_i = 16 V I_i = 0.8 A	U_{max}: 16 V I_{max}: 0.8 A
L_i = 50 μH C_i = 0.2 μF	L_{eq} = 50 μH C_{eq} = 0.2 μF
a) Current marking	b) Older marking

Figure 2. Example of marking of apparatus for connection to other apparatus and which does not incorporate a power source

Manufacturer's name	
Apparatus type	
EEx d (ia) I	
MECS No:	HSE(M) No: .....
U_o = 22.4 V I_o = 610 mA	U_{max} = 22.4 V I_{max} = 610 mA
C_o = 5.3 μF L_o = 1 mH	C_{ext} = < 5.3 μF L_{ext} = < 1 mH
L/R = 109 μH/Ω	L/R = < 109 μH/Ω
a) Current marking	b) Older marking

Figure 3. Example of marking of a mains driven power supply unit contained within a flameproof enclosure

Section 2. Selection and installation of electrical apparatus and systems

2.1 Selection

2.1.1 Competence of personnel

Personnel engaged in selection and installation of electrical apparatus and systems should be of a competence level as described in annex A.

2.1.2 Intrinsically safe electrical apparatus

Only intrinsically safe electrical apparatus certified to either Class 1 of BS 1259 or Group I of BS 5501 : Part 7 should be used in potentially explosive atmospheres (hazardous areas) of coal mines. Apparatus to be used in systems certified to BS 1259 should be certified to both BS 1259 and BS 5501 : Part 7.

NOTE. For a system certified to BS 1259 it is permissible for the certification documents to call up apparatus certified to BS 5501 : Part 7 but the reverse is not the case.

2.1.3 Intrinsically safe electrical systems

2.1.3.1 Only intrinsically safe systems certified to either Class 1 of BS 1259 or Group I of BS 5501 : Part 9 should be used in potentially explosive atmospheres (hazardous areas) in coal mines. The types of apparatus that can be used in the system and the manner of interconnection are specified in the certification documentation for the system.

NOTE. Intrinsically safe systems can also be formed by interconnecting two or more items of separately certified electrical apparatus which do not have a system certificate confirming that the complete system conforms to BS 1259 or BS 5501 : Part 9. Such systems are suitable for use in hazardous areas in coal mines provided that it can be unambiguously deduced from the certification documentation for each item of apparatus involved that intrinsic safety is preserved. With complex systems such a deduction may prove difficult in practice and it is advisable that systems not covered by a systems certificate should be confined to simple arrangements, for example the interconnection of apparatus with its power supply.

2.1.3.2 Apparatus certified to BS 1259 should not be interconnected with apparatus certified to BS 5501 : Part 7 unless the intended interconnection is specifically allowed by the certification documents.

2.1.4 Surface temperature

Where reliance is placed upon the sealing of an enclosure, the seals should be maintained in good condition and the enclosures should have a label stating 'Maintain dust seals'. It should be ascertained whether the internal parts have been assessed at 150 °C or 450 °C.

NOTE. Intrinsically safe apparatus assessed at 450 °C and constructed to prevent the ingress of coal dust can be used anywhere underground as can intrinsically safe circuits assessed at 150 °C. (See also **1.6.7**.)

2.1.5 Special conditions of use

Reference should be made to the certification documentation to ascertain whether any special conditions affect the selection of apparatus, e.g. some associated apparatus may be certified for use only in a safe environment (i.e. at the surface or in a flameproof enclosure). Separately certified safety couplers and safety barriers can have many special conditions of use which need to be checked. (See also **1.6.5.2**.)

2.1.6 Special requirements

Special requirements may influence the choice of apparatus for a particular purpose. The relevant certification documentation and the marking on the apparatus should be examined to ascertain suitability. For example, gas detection instruments to be used by rescue personnel are certified for use in hydrogen and air mixtures. Such apparatus certified to BS 1259 is marked: 'HSE(M) Cert. No. IS BS 1259 : 1958 Class 1 (H_2)' and similar apparatus certified to BS 5501 : Part 7 is marked: 'EEx ia I (H_2)'. (See also **1.6.5.3**.)

2.1.7 Voltage limitations

2.1.7.1 Care should be taken in the selection of associated electrical apparatus, the input supply to which is derived from the mains, to ensure that a suitable mains supply can be provided. In this respect the nominal voltage of the mains supply should not exceed the value specified in the certification documentation.

2.1.7.2 Where intrinsically safe apparatus is provided with circuits for connection to other electrical apparatus, it is essential that any voltage applied to these circuits does not exceed the value specified in the certification documentation so as to ensure that the intrinsic safety is not impaired. It is essential that this factor also is taken into account when selecting and installing associated electrical apparatus.

2.1.8 Apparatus incorporating cells or batteries

2.1.8.1 When selecting apparatus incorporating cells or batteries, it should be checked to ascertain that it has the correct design features for the application (see **2.1.8.2** and **2.1.8.3**). (See also **1.6.8**.)

2.1.8.2 Portable intrinsically safe apparatus with self-contained batteries is of two types:

a) apparatus where the battery should only be changed at the surface or in a safe area;

b) apparatus where the battery is designed to be changed in the hazardous area.

2.1.8.3 Batteries used with fixed intrinsically safe apparatus may be one of the following:

a) primary batteries which have to be periodically replaced. In this case the battery needs to be of a type which is inherently safe or needs to be housed in an enclosure, to meet the intrinsic safety requirements when the enclosure is removed from the apparatus;

b) rechargeable batteries for periodic replacement and recharge at the surface;

c) rechargeable batteries for trickle charging in-situ.

2.2 Installation

2.2.1 General

The factors which need to be taken into account when installing electrical apparatus and systems with type of protection 'i' are described in **2.2.2** to **2.2.9**. These factors also need to be taken into account when rearranging or extending existing systems.

2.2.2 Documentation

2.2.2.1 It should be ensured that any installation conforms to the requirements of the appropriate certification documentation

NOTE. Attention is drawn to statutory legislation covering such installations (see **1.4**).

Sufficient information to enable the user to ensure that an installation conforms to the certification requirements is normally contained in the following:

a) a block diagram which is included in the certification documentation; and/or

b) the manufacturer's installation drawing which includes all the relevant requirements of certification and which may indicate how the apparatus/system should be installed at particular sites; and/or

c) the manufacturer's installation manual supplied with the apparatus. The manual also gives details of any special conditions for safe use if the letter X is included after the certificate reference.

2.2.2.2 When a network is formed by interconnecting separately certified systems as permitted by the certification documentation, the user should prepare a drawing showing the network configuration. It may also be necessary for the user to prepare a similar drawing when installing a single complex system the layout of which can vary according to the site conditions, e.g. a 'leaky feeder radio communication highway'.

2.2.3 Interconnecting cables

2.2.3.1 *Minimum conductor sizes*

When selecting conductor sizes it is necessary to ensure that the maximum surface temperature of cable conductors does not exceed 150 °C when carrying the maximum current that could flow in the circuit under fault conditions.

In interconnecting cables having stranded copper conductors, the individual strand diameter should be 0.2 mm or greater.

2.2.3.2 *Parameters of cables and connected apparatus*

Where appropriate, certification documents specify the limiting parameters for interconnecting cables and connected apparatus in terms of maximum inductance (L), ratio of maximum inductance to resistance (L/R) and maximum capacitance (C).

Characteristics of mining type cables are given in annex B, where tables B.1, B.2, B.3 and B.4 give the L/R ratios for the types of cable commonly used in mines. Reference should be made to manufacturers' data to determine the values for other types of cable. In situations where the certification allows particular multicore cables to contain more than one intrinsically safe circuit the additional cable construction requirements are those specified in **5.2** of BS 5501 : Part 9 : 1982. The mining type cables listed in tables B.1, B.2, B.3 and B.4 meet these requirements.

NOTE. It is sufficient for a cable to conform to either the maximum L value or the maximum L/R ratio in addition to the maximum C value.

2.2.3.3 *Multicore cables carrying more than one intrinsically safe circuit*

Where two or more independent intrinsically safe circuits (i.e. each circuit is covered by a separate certificate of intrinsic safety) are to be carried in a multicore cable one of the following conditions should apply.

a) The complete arrangement meets all requirements specified in the certification documentation for each circuit in the cable, and each circuit in the cable is permitted by its certification documentation to be carried in a multicore cable.

b) Each circuit in the cable is permitted by its certification documentation to be carried in a multicore cable and the only condition stated is that the connection to the cable has to be made through a safety coupler.

c) Each circuit in the cable is enclosed in an earthed metallic conducting screen which provides at least 60 % coverage as specified in BS 5501 : Part 9.

d) Each circuit contained in the cable has a factor of safety of at least four times that required by BS 1259, whether or not the circuits are identical. A recognized certification authority should assess such circuits and establish the enhanced safety factor. An enhanced safety factor may be achieved by the use of a safety coupler of a type mentioned in item b). Reference should be made to the certification documents for the coupler concerned to determine whether this is permissible.

2.2.4 Cable installation

2.2.4.1 Intrinsically safe circuits and non-intrinsically safe circuits should not be run in the same cable. (See also **2.2.9** which gives recommendations for remote control circuits.)

2.2.4.2 Cables carrying intrinsically safe circuits may be run in the same ducting or tray as other cables but high voltage contamination of the intrinsically safe circuits should be avoided and therefore either the cable carrying the intrinsically safe circuits, or the other cables, should be armoured and the armouring connected to earth.

2.2.4.3 Where practicable, multicore cables containing more than one intrinsically safe circuit should be firmly fixed throughout their length and run where the risk of mechanical damage is low; otherwise additional protection should be considered.

2.2.4.4 To avoid electromagnetic induction effects, cables containing intrinsically safe circuits should not be sited close to heavy current carrying single core cables or conductors, nor should they be sited close to high voltage uninsulated conductors.

2.2.4.5 The method of cable entry to the apparatus should be appropriate to the type of cable used. The cable should always be fixed firmly at or near to the point of entry by a cable gland or other suitable means to prevent undue stress on conductors or their terminations. Also the degree of environmental protection provided by the apparatus enclosure should be maintained.

2.2.4.6 The method of conductor termination should be such as to avoid reduction of the electrical clearance provided at the terminal blocks or connectors of the apparatus. To achieve this the insulation of conductors should be continued as close to the point of connection as possible. Care should be taken to ensure that all strands of stranded conductors are properly terminated and the length of core tails should be kept to a minimum.

2.2.5 Junction boxes

2.2.5.1 *General*

In general, intrinsically safe and non-intrinsically safe circuits should not be wired through the same junction box.

NOTE. Junction boxes used in intrinsically safe systems are defined as accessories in clause **6** of BS 5501 : Part 9 : 1982.

2.2.5.2 *Construction*

To reduce the risk of interconnection between separate intrinsically safe circuits, or an intrinsically safe circuit and earth, in general junction boxes used should have a minimum electrical clearance of 6 mm in air between terminals and 3 mm between any terminal and earth. Enclosures of junction boxes should provide a degree of protection appropriate to the conditions at the site of installation with a minimum of IP 20 as defined in BS EN 60529.

2.2.6 Terminal boxes

Where terminals of intrinsically safe and non-intrinsically safe circuits in associated apparatus are adjacent, their points of connection should be separated by at least 50 mm, or by an insulating barrier or earthed metal barrier which extends to at least the height of the terminals being protected and to within 1.5 mm of the inside surface of the enclosure.

All other metal parts of terminals should conform to the creepage and clearance requirements specified in BS 5501 : Part 7. When field connections are made this segregation should not be reduced.

2.2.7 Safety couplers and safety barriers

Where a certified system includes separate safety couplers or safety barriers it is essential that only permitted devices are used, that they are indeed present and are properly installed.

NOTE. This is essential for safety and for conformity to certification documents, as the presence or otherwise of safety couplers and barriers may have no affect on the basic functioning of the system.

Where asymmetrical safety couplers or safety barriers are used it is recommended that the incoming and outgoing cables should be identified so as to avoid wrong connection.

2.2.8 Earthing

2.2.8.1 Where wire armoured cables are used it is important that the wire armouring is properly connected to the metallic enclosure and to any junction box in the line to provide a low resistance path for any system earth fault currents that might flow. If such effective connections cannot be achieved (owing, for example, to the use of non-metallic enclosures) additional bonding conductors may be necessary.

2.2.8.2 With the exception of cases where there is no doubt, it is essential that the apparatus and/or system certification documentation be consulted to determine whether the particular intrinsically safe circuit should be connected to, or isolated from, earth.

2.2.8.3 Special attention should be given to those systems incorporating separately certified power supply units which have provision for optional earthing, since this earth connection may be either required or prohibited in the system certification documentation.

2.2.8.4 Where earth connections are necessary to preserve the integrity of an intrinsically safe circuit, the impedance of the connection of the apparatus to the earthing system of the mine should be as low as possible but in any event should not exceed 1 Ω. The conductor used for the connection should be equivalent to a copper conductor of 4 mm^2 minimum cross-sectional area.

2.2.8.5 Any earth conductor used for an earth connection as described in **2.2.8.4** should be insulated to prevent it forming a path for earth fault currents which might flow in metallic parts of power apparatus with which the conductor could otherwise come into contact. It should also be given mechanical protection where there is any risk of damage.

2.2.8.6 The earth connections described in **2.2.8.4** should not be made by plugs and sockets unless such an arrangement is specifically detailed in the certification documentation.

2.2.8.7 Where the conductors of an interconnecting cable are protected by a surrounding metal screen for intrinsic safety segregation purposes, the screen should be connected to earth at one point only, unless the certification documentation states otherwise.

2.2.9 Remote control circuits and earth fault monitoring circuits

2.2.9.1 Where there is inadequate separation from power conductors, low voltage control/interlock circuits and low voltage earth fault monitoring circuits are regarded as non-intrinsically safe circuits and should not be run in the same cable as any intrinsically safe circuits.

2.2.9.2 The maximum voltage on low voltage control/interlock and low voltage earth fault monitoring circuits conforming to BS 7202 : 1989 does not exceed 25 V in normal operation.

The maximum voltage which could occur under fault conditions should be considered to be 250 V provided that all the following conditions are met.

a) The prospective earth fault current of the associated power systems is restricted to not more than 15 A for 550 V systems and 2 A for systems of higher voltage.

b) The switchgear with which the low voltage control/interlock circuit is associated is fitted with sensitive earth leakage protection capable of operating at 0.2 times the prospective earth fault current.

c) The low voltage control/interlock circuit is capable of carrying the prospective earth fault current without developing a voltage to earth greater than 100 V during a period of 5 s.

d) The low voltage control/interlock circuit conductor in the flexible cable is separated from all power conductors by an earthed metal screen capable of carrying earth fault currents until the power circuit protection operates.

Where all the conditions listed in items a) to d) cannot be met, the maximum voltage which could occur under fault conditions should be considered to be that of the incoming supply.

2.2.9.3 Where pilot circuits and intrinsically safe circuits are contained within the same enclosure, as for example when a pilot circuit is connected to the contacts of a relay the coil of which is energized from an intrinsically safe source, adequate segregation should be maintained between them. Adequate segregation is provided at the design and certification stage, and installation users should ensure that this segregation is not reduced.

Section 3. Inspection and testing

3.1 General

This section gives recommendations for the inspection and testing of intrinsically safe systems, intrinsically safe apparatus, or associated electrical apparatus, in so far as they can influence intrinsic safety. Personnel engaged in inspection and testing should be of a competence level as described in annex A.

3.2 Inspection

3.2.1 General

Inspection should be carried out in accordance with **3.2.2** to **3.2.11** before, during and after installation, before any intrinsically safe equipment is energized.

3.2.2 Inspection for damage

Equipment should be inspected to determine that no obvious damage or deterioration has been caused during transport by careless packing, vibration, or other environmental factors.

3.2.3 Conformity to documentation

Equipment should be inspected to ensure that it conforms to the appropriate documentation referred to in **2.2.2**.

3.2.4 Labelling

Labels should be inspected to determine that certificate numbers and apparatus system types correspond to those specified in the certification documentation. All other label data, such as supply voltage and limiting parameters of connected circuits, should be noted and checked against the conditions under which the equipment is to be used.

3.2.5 Enclosures

Equipment should be inspected to determine that covers are correctly secured with any dust seal properly in place, and that unused cable entries, including plugs and sockets, are properly blanked off.

3.2.6 Fuses

Fuses which it is possible to replace on site should be inspected to determine that they are of the type and rating specified in the certification documentation.

NOTE.This information is normally shown on the apparatus adjacent to the fuse.

Inspection should include those fuses protecting the mains transformer primary windings of any mains fed associated apparatus and fuses protecting non-intrinsically safe control circuits connected to the contacts of any intrinsically safe relays.

3.2.7 Lamps

Filament lamps intended to be replaced on site should be inspected to determine that they are of the type and rating specified in the certification documentation and that any additional protective housing is in order.

3.2.8 Earthing

Installations should be inspected to determine that the only connections to the earth system are those specified in the certification documentation and that the earth connections have been made in accordance with **2.2.8**.

NOTE. In some systems it may not be permissible to earth individual items of apparatus, even though those items of apparatus may have facilities for earth connections.

3.2.9 Cables

Installations should be inspected to determine that the cables used conform to the certification documentation, paying particular attention to multicore cables (see **1.6.6** and **2.2.3.3**). Any cable screens provided should be inspected to ensure that they are earthed in accordance with the certification documentation.

3.2.10 Safety couplers and safety barriers

3.2.10.1 When an intrinsically safe system employs safety couplers or safety barriers, the installation should be inspected to determine that the permitted type has been installed at the locations specified in the certification documentation and that the safety couplers or barriers are connected into the circuit the right way round.

NOTE. Most safety couplers and barriers are certified subject to special conditions of use.

3.2.10.2 Particular attention should be paid to inspection of earthing, where required, of safety couplers and safety barriers since safety may depend on an effective earth connection.

3.2.10.3 All installations should be inspected to determine that any relay or similar device which may be serving as a safety barrier between circuits has not deteriorated or been damaged in such a way that the intended segregation has been reduced.

3.2.11 Junction boxes and enclosures containing safety couplers or safety barriers

Junction boxes and enclosures containing safety couplers or safety barriers should be inspected to determine that connected wiring conforms to the certification documentation.

3.3 Routine inspection

After installation, all intrinsically safe equipment should be periodically inspected by competent personnel (see annex A) at intervals determined by them having regard to its usage and environmental conditions. This is to ensure that there has been no damage, deterioration or unauthorized interference which can impair intrinsic safety. In general, internal examinations of equipment should only be carried out if specified in either the manufacturer's or the user's instructions.

3.4 Insulation and earth continuity testing

3.4.1 Insulation testing

Insulation testing of equipment should be carried out using a low voltage intrinsically safe test instrument after the equipment has been isolated from its source of supply.

Test instruments having an open circuit voltage exceeding 24 V, even if they are certified intrinsically safe, should not be used for testing intrinsically safe equipment. However, such instruments may be used for testing cables, including any junction boxes, provided the cables are completely disconnected and at the time of testing they do not extend into a part of the mine where concentrations of methane of 1.25 % by volume or greater may be present.

NOTE. Some equipment may be designed to operate at a relatively low value of insulation resistance. In cases of doubt reference should be made to manufacturer's data to determine acceptable values.

3.4.2 Earth continuity testing

Earth continuity testing should only be carried out after the equipment has been isolated from its source of supply.

For testing carried out in hazardous areas a certified intrinsically safe test instrument should be used; but in non-hazardous areas either underground or on the surface, use of non-intrinsically safe continuity testers is permissible provided that all circuits to hazardous areas have been disconnected.

3.5 Records

The results of inspections and tests, and of any action taken to correct defects, should be recorded.

Section 4. Maintenance and repair

4.1 General

This section gives recommendations for maintenance and repair work. Any maintenance or repair work not carried out in-situ should be carried out in a properly established workshop.

It is essential that maintenance of intrinsically safe equipment is properly planned and only carried out by competent personnel (see annex A) trained for the work and in accordance with manufacturers' recommendations.

Where the work extends from one working shift into the next, the oncoming shift should be adequately briefed. On completion of maintenance, equipment should be checked to ensure that intrinsic safety has not been impaired.

Wherever possible, intrinsically safe equipment should be made electrically dead before any maintenance work is carried out. However, live maintenance may be carried out provided that it is done in a safe manner according to accepted electrical practice and is restricted to the work detailed in **4.2**.

It should be recognized that certification generally requires apparatus to be within an enclosure and while the safety of apparatus may not be impaired by the removal of covers and exposure of live conductors, the apparatus may not be strictly in its certified state. Care should therefore be taken while working on live equipment that inadvertent bridging of components or connections by careless use of tools or other devices does not occur.

Enclosures containing only electronic assemblies are generally best left undisturbed and internal examinations should only be made if malfunction or damage is evident.

Any dust cover opened or removed should be replaced correctly since it may have been provided to prevent coal dust forming a layer on electrical components.

4.2 Maintenance work in a hazardous area

Maintenance work in a hazardous area should be restricted to the following:

a) disconnection of, and removal or replacement of, items of electrical apparatus and cabling;

b) adjustment of any control necessary for calibration;

c) changing of user-selectable links (where practicable);

d) removal and replacement of any plug-in components, printed circuit boards, batteries or other assemblies as specifically recommended by the manufacturer;

e) use of any test device permitted by the certification documentation;

f) use of any test instrument in accordance with **4.6**;

g) any other maintenance activity specifically permitted by the certification documentation.

4.3 Maintenance work in a non-hazardous area

Maintenance of associated electrical apparatus and parts of intrinsically safe circuits located in a non-hazardous area, while such equipment remains connected to an intrinsically safe circuit in a hazardous area should be restricted to that listed in **4.2**.

4.4 Cable disconnection

Cables should be disconnected from intrinsically safe equipment in such a way that live terminals or conductors are not left exposed. Where disconnection is carried out at a junction box the terminations of the cable to be made electrically dead should be disconnected rather than those of the cable remaining in use.

Special care should be taken with multicore cables containing more than one intrinsically safe circuit. If possible equipment should be isolated from its source of supply before such cables are disconnected. Where this is not possible, each conductor should be disconnected and then insulated before the next disconnection is made.

4.5 Batteries

When rechargeable batteries associated with intrinsically safe apparatus are charged on the surface, care should be taken to ensure that neither the type of charging equipment employed nor the method of charging adversely affects the protective features of the battery.

Where the manufacturer of the intrinsically safe apparatus has specified a particular type of charger and the charging procedures it is essential that these should be used.

Where the manufacturer does not recommend a particular type of charger the certification documents may state charging parameters, and the charging arrangements should be such as to allow these instructions to be followed.

Loose primary cells and batteries should not normally be taken underground since they can give rise to danger with respect to the hot-wire risk and the inadvertent ignition of detonators.

4.6 Electrical measuring instruments

A general purpose electrical measuring instrument which has been certified intrinsically safe and conforms to BS 6705 may be used to test any intrinsically safe circuit provided it is used in accordance with its certification conditions and with **3.4**. Before any such instrument is taken into a hazardous area it should be checked to ensure that it is not physically damaged and is in proper working order.

Provided that the instrument is not connected simultaneously to separate live intrinsically safe circuits it may be used for:

a) testing between the conductors of external cables;

b) testing between the pins of an external plug or socket;

c) testing between the terminals of a connector block;

d) testing between any specially provided test points;

e) any other testing specifically permitted by the certification documentation.

4.7 Repair and overhaul

Factors taken into account in the design of intrinsically safe equipment and associated electrical apparatus to ensure intrinsic safety include the choice of components of specific types and ratings and the physical separation and electrical insulation of both components and wiring. As it is essential for safety that all of these factors remain unaltered, repair and maintenance of intrinsically safe and associated apparatus should be carried out with a full knowledge of the design features upon which safety depends. Certification drawings may not always be adequate for this purpose since, while safety requirements may be unambiguously stated, their full implications may only be apparent to those experienced in the design and certification of intrinsically safe apparatus and systems. For example, if a drawing contains a statement to the effect that a certain proprietary loudspeaker type XYZ has a coil resistance of 3 Ω and a maximum inductance of 2 mH, this does not necessarily mean that every loudspeaker type XYZ has a maximum inductance of 2 mH, but requires that every loudspeaker has to be checked to ensure that this value is not exceeded.

It follows therefore that repair of intrinsically safe equipment or associated apparatus should not be undertaken lightly. Where such repairs are carried out the operation should be properly planned and the support of the original manufacturer or certificate holder should be enlisted as necessary since they may have to supply additional information on design or testing features so that repairs can be carried out without infringing the intrinsic safety of the design.

Annexes

Annex A (normative)
Competence of personnel

A.1 General

The depth of knowledge of intrinsic safety required for a given task depends very much on the size and complexity of the installation and on the level of work to be undertaken. For every activity there should be a person in charge who has adequate knowledge of the protection technique and knows when, and where, to seek further information. At a colliery this person should be the senior electrical engineer or a person delegated by that engineer. Similarly, where work is undertaken at a workshop not under the control of a colliery engineer, a person should be formally appointed by the manager of the workshop to assume responsibility for the work undertaken.

A.2 Education and training of electrical personnel

The Management and Administration of Safety and Health at Mines Regulations 1993 [10] require that all members of electrical engineering staff at collieries receive instruction on intrinsic safety and its application in mines as part of their education and training. Such staff should have sufficient knowledge to plan, install and maintain apparatus, systems and networks in a safe manner. Advances in technology and improvements in safety standards require that all concerned receive further training as necessary and have access to up-to-date information on the subject.

Craftsmen in workshops may have had no special training or instruction in intrinsic safety techniques and it is therefore necessary to define precisely the work they may carry out under supervision.

NOTE. Information on general principles is contained in the British Coal Corporation publication *Intrinsic safety in coal mines*, 1982 [14]. Additional information is available in the standards listed in this publication and from the organizations mentioned in **1.5**. Information on specific equipment should be obtained from the manufacturer.

Annex B (informative)
Characteristics of mining type cables

B.1 General

The information given in this annex has been supplied by the British Cable Makers Confederation and relates to a range of cables which are widely used in British mines. The values of inductance have been obtained by measurement on sample cables, and the values of inductance to resistance ratios have been calculated from the values of loop resistance.

These inductance to resistance ratios therefore relate to the typical values to be expected for cables having certain forms of construction, and should not be regarded as accurate for individual lengths of cable due to the spread of manufacturing tolerances.

The information can be used to establish, for a particular cable, that the cable inductance, or inductance to resistance ratio, is well below the relevant values permitted in the certification documents. Where the values for the cable are near to the limits permitted by the certification documents, further investigation is advisable.

B.2 Multicore cables incorporating twisted pairs of conductors laid up into a compact and symmetrical cable

The inductance to resistance ratio of diametrically opposite cores in the outer layer of telephone cable is given in table B.1 together with physical attributes.

The values in table B.1 are nominal values and apply to the widest spaced conductors in the cable. For all practical purposes the inductance of a loop formed by adjacent conductors is of the order of that for a twin cable of the same conductor and core diameter.

Table B.1 Telephone cable inductance and resistance ratios (nominal values)

Number of pairs of insulated conductors laid up	Loop inductance μH/km	*L/R* ratio μH/Ω
1	670	28
quad[1)]	850	36
4	1100	45
7	1280	53
10	1470	61
12	1500	62
19	1620	67
27	1740	72
30	1770	73
37	1820	75
48	1900	79
61	1960	81
91	2070	86

Conductor: plain annealed copper wires in accordance with BS 6360

Area: 1.5 mm^2

Number and nominal diameter of wires: 7/0.5 mm

Nominal diameter of cable: 1.59 mm

Radial thickness of insulation:
nominal 0.5 mm
minimum 0.38 mm

Diameter over insulation:
maximum 2.64 mm
minimum 2.36 mm

[1)] Four individual cores for optimum dielectric properties.

B.3 Multicore cables incorporating separate conductors laid up into a compact and symmetrical cable

The inductance to resistance ratio of diametrically opposite cores in the outer layer of signalling cable is given in table B.2 together with physical attributes. Tables B.3 and B.4 give similar information for cables conforming to BS 6708 and generally in accordance with BS 6346, respectively.

The values in tables B.2, B.3 and B.4 apply to the widest spaced conductors in the cable. For all practical purposes the inductance of a loop formed by adjacent conductors is of the order of that for a twin cable of the same conductor and core diameter.

Table B.2 Signalling cable inductance and resistance ratios (nominal values)

Number of cores	Loop inductance μH/km	*L/R* ratio μH/Ω
2	670	28
4	850	36
7	1030	43
10	1240	52
12	1270	54
14	1310	55
19	1390	59
37	1600	68
61	1750	74
91	1860	78

Conductor: plain annealed copper wires conforming to BS 6360

Area: 1.5 mm^2

Number and nominal diameter of wires: 7/0.5 mm

Nominal diameter of cable: 1.59 mm

Radial thickness of insulation:
nominal 0.5 mm
minimum 0.38 mm

Diameter over insulation:
maximum 2.64 mm
minimum 2.36 mm

Table B.3 Electrical characteristics of pliable wire armoured cables conforming to BS 6708 : 1991

Cable type	Loop inductance μH/km			*L/R* ratio μH/Ω		
	Core/core adjacent	Core/core adjacent	Core/screen	Core/core opposite	Core/core opposite	Core/screen
62 (2-core)	800	—	360	83	—	51
63 (3-core)	810	—	380	84	—	60
64 (4-core)	820	980	430	85	101	72

Table B.4 Electrical characteristics of two-core steel wire armoured cable generally in accordance with BS 6346 (nominal values)

Conductors		Loop inductance	*L/R* ratio
Nominal cross-sectional area mm^2	Number and nominal diameter of wires	μH/km	μH/Ω
1.5	7/0.53 mm	690	33
2.5	7/0.67 mm	700	54
4.0	7/085 mm	700	87
6.0	7/1.04 mm	670	125

List of references (see 1.2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1259 : 1958	*Intrinsically safe electrical apparatus and circuits for use in explosive atmospheres*
BS 5501 :	*Electrical apparatus for potentially explosive atmospheres*
BS 5501 : Part 7 : 1977	*Intrinsic safety 'i'*
BS 5501 : Part 9 : 1982	*Specification for intrinsically safe electrical systems 'i'*
BS 6705 : 1987	*Specification for electrical measuring instruments for use on intrinsically safe circuits in coal mines*
BS EN 60086 :	*Primary batteries*
BS EN 60086-1 : 1996	*General*
BS EN 60529 : 1992	*Specification for degrees of protection provided by enclosures (IP code)*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 5501 :	*Electrical apparatus for potentially explosive atmospheres*
BS 5501 : Part 1 : 1977	*General requirements*
BS 5501 : Part 2 : 1977	*Oil immersion 'o'*
BS 5501 : Part 3 : 1977	*Pressurized apparatus 'p'*
BS 5501 : Part 4 : 1977	*Powder filling 'q'*
BS 5501 : Part 5 : 1977	*Flameproof enclosure 'd'*
BS 5501 : Part 6 : 1977	*Increased safety 'e'*
BS 5501 : Part 8 : 1988	*Encapsulation 'm'*
BS 5754 : 1987	*Specification for electrical analogue and state signals for use in coal mines*
BS 6182 :	*Intrinsically safe power supplies for use in coal mines*
BS 6182 : Part 1 : 1994	*Specification for d.c. power supplies*
BS 6182 : Part 2 : 1982	*Specification for a.c. power supplies*
BS 6182 : Part 3 : 1982	*Specification for rechargeable battery units*
BS 6346 : 1989	*Specification for PVC-insulated cables for electricity supply*
BS 6353 : 1983	*Specification for underground loudspeaker communication systems in coal mines*
BS 6360 : 1991	*Specification for conductors in insulated cables and cords*
BS 6556 :	*Low speed digital signals for use in coal mines*
BS 6556 : Part 1 : 1985	*Specification for optical coupling*
BS 6556 : Part 2 : 1985	*Specification for transformer coupling*
BS 6556 : Part 3 : 1985	*Specification for message protocols*
BS 6708 : 1991	*Specification for flexible cables for use at mines and quarries*
BS 6709 : 1986	*Specification for interconnection of electrical apparatus, constructed to two or more British Standards, for use in mines susceptible to firedamp*
BS 7202 : 1989	*Specification for non-incendive low voltage control/interlock and low voltage earth fault monitoring circuits for use in mines*

BS EN 50014 : 1993	*Electrical apparatus for potentially explosive atmospheres — General requirements*
BS EN 50015 : 1994	*Electrical apparatus for potentially explosive atmospheres — Oil immersion 'o'*
BS EN 50017 : 1994	*Electrical apparatus for potentially explosive atmospheres — Powder filling 'q'*
BS EN 50018 : 1992	*Electrical apparatus for potentially explosive atmospheres — flameproof enclosures 'd'*
BS EN 50020 : 1995	*Electrical apparatus for potentially explosive atmospheres — Intrinsic safety 'i'*
BS EN 50033 : 1991	*Specification for construction and testing of miners' caplamps in relation to the risk of explosion, for mines susceptible to firedamp*

Other references

[1] GREAT BRITAIN. Health and Safety at Work etc. Act 1974. London: HMSO[1)]
[2] GREAT BRITAIN. Mines and Quarries Act 1954. London: HMSO[1)]
[3] GREAT BRITAIN. Electrical Equipment for Explosive Atmospheres (Certification) Regulations 1990. London: HMSO
[4] GREAT BRITAIN. Electricity at Work Regulations 1989. London: HMSO
[5] HEALTH AND SAFETY EXECUTIVE. Code of approved practice No. 34. *The use of electricity in mines*. 1989. London: HMSO
[6] GREAT BRITAIN. Coal and Other Mines (Locomotives) Regulations 1956. London: HMSO
[7] GREAT BRITAIN. Coal and Other Mines (Safety Lamps and Lighting) Regulations 1956. (SI 1956 No. 1765 amended) London: HMSO
[8] GREAT BRITAIN. Coal and Other Safety-Lamp Mines (Explosives) Regulations 1993. (SI 208) London: HMSO
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[1)] Referred to in the foreword only.
[2)] Available (gratis) from HSE Certification Unit, Harpur Hill, Buxton, Derbyshire, SK17 9JN.
[3)] Apply to HSE (Mines Inspectorate) St Anne's House, Stanley Precinct, Bootle, Merseyside, L20 3RA.

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