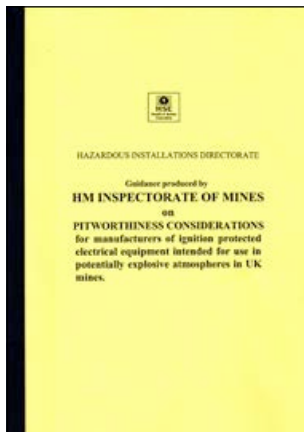


Pitworthiness considerations

For manufacturers of ignition protected electrical equipment intended for use in potentially explosive atmospheres in UK mines



Contents

Introduction 3

General considerations 5

Additional requirements for switchgear 7

Additional requirements for motors 8

Additional requirements for machines (other than locomotives) 9

Additional requirements for cable entries 9

Additional requirements for cells and batteries 10

Additional requirements for flameproof apparatus 11

Provision of isolating Facilities for Flameproof Enclosures 11

Additional requirements for intrinsically safe circuits and apparatus 12

Portable (Handheld) Intrinsically Safe Apparatus 12

Segregation of Intrinsically Safe Circuits from Power Circuits and Non-Intrinsically Safe Auxilliary Control and Monitoring Circuits in Flameproof Enclosures 13

Additional requirements for the prevention of inadvertent starting (POIS) 14

Intrinsically Safe Circuits 14

Circuits Complying Generally with BS 3101 as non incendive, low voltage, control interlock and monitoring circuits 15

Non-intrinsically Safe Circuits 15

Appendix A: List of British Standards relevant to mining 16

Appendix B: Circulating currents in flameproof induction motors 19

This is a web-friendly version of *Pitworthiness considerations*, originally produced by HM Inspectorate of Mines

Appendix C: Motors supplied via electronic convertors 21

**Appendix D: Copy of the General Approval issued under
Regulation 20 of the Electricity at Work Regulations 1989 for
ATEX Categories M1 and M2 Equipment 22**

Further information 23

Introduction

1 The first part of Regulation 19 of the Electricity at Work Regulations 1989 (EAWR) requires UK mine managers to identify zones below ground in a mine where firedamp is likely to occur in a quantity sufficient to indicate danger. Within these zones, precautions are necessary to minimize the risk of ignition of firedamp from electrical causes. The second part of the same regulation, requires all electrical equipment taken into those zones to be of a type that is not capable of causing an ignition. The generic terms applied to such equipment are either 'explosion protected', 'ignition protected', or 'non-incendive'. The two most common types of protection (or concepts of protection) found in UK mining equipment are the flameproof enclosure (type d) and the intrinsically safe circuit (type i).

2 The various concepts of protection are described and specified in certain well established national and international standards, such as UK (BS) Standards, European (EN) Standards and International Electrotechnical Commission (IEC) Standards. The latest harmonised European Standards being recognised in all the countries in the European Union (EU) for the purpose of allowing free trade in compliance with the Directives relating to equipment intended for use in potentially explosive atmospheres in mines. The first of these Directives was introduced in 1982 and is known as the 'Gassy Mines Directive - 82/130/EEC'. This remains in force and runs concurrent with the later 'ATEX Directive - 94/9/EC' until the end of June 2003, at which time it is totally replaced by the ATEX Directive.

3 For electrical equipment to be accepted throughout the EU it should be constructed in conformity with an appropriate European Directive. In the case of equipment certified to the Gassy Mines Directive, the certifying authority's certificate attests conformity with the harmonised EN Standard(s) relevant to its type of explosion protection. In the case of the ATEX Directive the certificate attests conformity with the 'Essential Health and Safety Requirements'. In both cases it is recognised that equipment that is certified as protected against firedamp ignition is also safe against ignition of a coal dust cloud.

4 Certification is performed by certification bodies notified to the European Commission by member state National Governments. In the UK, the appointment of certification bodies under the Gassy Mines Directive 82/130/EC is made in accordance with the "Electrical Equipment for Explosive Atmospheres (Certification) Regulations 1990' Under the ATEX Directive 94/9/EC, bodies are appointed in accordance with the requirements of the 'Equipment and Systems Intended for use in Potentially Explosive Atmospheres Regulations 1996'.

5 Equipment meeting the requirements of these Directives is accepted by UK statutory provisions as meeting the requirements of Regulation 19 of the EAWR 1989* and their accompanying Approved Code of Practice *The Use of Electricity in Mines*. It can therefore be energised in those zones designated by the mine manager as being places where a potentially explosive atmosphere exists.

6 A certificate issued by one of the notified certification bodies does not, however provide any guarantee that the equipment is safe with respect to factors other than firedamp and coal dust ignition risks. For example, it does not guarantee compliance with all of the legal requirements of the member states. Which in the case of UK coal mines include:

* it is likely that Regulation 19 of EAWR will be replaced by a general regulation addressing firedamp coal dust clouds and none electrical equipment to fully implement the ATEX Directive's intentions

- Health & Safety at Work etc. Act 1974 (HSW Act)
- Mines and Quarries Act 1954 (M&Q Act)
- Regulations made under the above-mentioned Acts, such as the EAWR 1989.

Manufacturers are therefore advised to check the legal requirements relating to the use of electrical equipment in the countries in which they intend to market their product

7 In addition to Regulation 19 of EAWR 1989, Regulation 20 requires all electrical equipment to be de-energised or made safe if firedamp is detected, in its vicinity, in a concentration exceeding 1.25% by volume in the general body of mine air. This requirement does not however apply to equipment which is essential for safety and is Approved by HSE to remain energised when the concentration of firedamp exceeds this statutory limit for the purpose of Regulation 20.

8 Certification then, is not always sufficient for some types of electrical equipment, particularly those items or systems intended to continue in operation in an explosive atmosphere and those which have to meet performance criteria. Examples of such equipment comprise, environmental monitoring and data transmission systems, gas detectors, signalling and communication equipment, miners' caplights, equipment necessary for the safety of workers and shot firing circuit testers. HM Inspectors of Mines (HMIM) approve such equipment on behalf of HSE for the purpose of Regulation 20 of the EAWR 1989 and other mining specific legislation, in addition to it being certified. Equipment certified to the Gassy Mines Directive 82/130/EC usually needs each individual item of such equipment to be approved whereas equipment certified as 'Category MI equipment' to ATEX Directive 94/9/EC is automatically approved for the purpose of Regulation 20 of EAWR 1989 by virtue of a general approval issued by the Mines Inspectorate in 1999 (Copy attached at Appendix D).

9. There is also other legislation (eg M&Q Act 1954 s.64, Coal Mines Ventilation Regulations and the various Shot Firing Regulations) requiring certain electrical equipment to be approved for the purpose of this legislation before it can be used underground in mines. Equipment in this category includes miners' caplights, methane detectors and shot firing circuit testers, which are additionally required to meet specified performance and operational requirements as well as being protected against firedamp ignition. This legislation and its need for HSE Approval applies irrespective of whether or not the equipment complies with the ATEX Directive.

10 The legal requirements applicable to the safe use of electrical equipment and the need for certain kinds of electrical equipment to be approved before it can be used, are some of the reasons that HMIM take an active interest in the certification of electrical equipment for use in UK mines. There are others which, although not referred to directly in regulations, fall within the general requirements of the Health & Safety at Work etc. Act and in particular Section 6 of the Act.

11 For example, danger may arise from the non-compatibility of equipment. Since 1947, when the UK coal industry was nationalised, the National Coal Board, and later British Coal Corporation, formulated their own specifications for certain electrical equipment used in their mines. The main reason being, that equipment built to these electrical specifications would be completely interchangeable irrespective of the manufacturer and its place of usage. Some of these NCB Specifications were subsequently adopted as British Standards where none had previously existed. Following privatisation of the coal industry on 1 January 1995, many of these specifications and standards continued to be used so as to maintain compatibility with existing mining equipment and circuits. It is important therefore to

ensure that designers of new equipment are aware of this background and comply with other relevant specifications and standards dealing with safety or compatibility of equipment. Where it is appropriate to do so, equipment should be compatible both electrically and dimensionally with equipment that exists in the mine, especially where it can be interconnected.

12 The foregoing are the main areas of concern overseen by HMIM when applications are made to a notified body in UK for certification of electrical equipment. Together they are known as 'pitworthiness considerations' and this booklet is a collection of this data which has been gathered over a period of many years.

13 The guidance contained in this document should be used by both designers and manufacturers. Especially where the equipment is innovative in design, in which case, it is in the interests of the manufacturer to commence this involvement at an early stage.

14 All UK Notified Bodies have an arrangement with HMIM, whereby they inform HM Inspectors of Electrical Engineering in Mines of

- all applications for new (prime) certificates, and
- those applications for supplementary certificates that contain a major change in the product's pitworthiness

Manufacturers should not therefore be surprised if they are contacted by HMIM for more information about their application to a UK Notified Body for certification. These procedures are usually described in the freely available guidance literature supplied to applicants by the UK Notified Bodies.

15 There will, of course, be some instances when electrical equipment will be manufactured in the UK for sole use overseas. In such cases, the equipment may not comply with the requirements of this document and the manufacturer should not market this equipment in the UK. If the manufacturer subsequently intends to market such equipment in the UK, it should comply with the requirements of this document as should any equipment manufactured overseas for use in the UK.

16 The following is intended as a guide to pitworthiness considerations. Obviously the guidance given is not exhaustive and it should be added to/modified in the light of technological development and to cover equipment posing special problems in which case the manufacturer should discuss the relevant aspects with the Mines Inspectorate. Section 17 applies in general to all applications for certification while the remaining paragraphs cover particular types of equipment/protection.

General considerations

17 Designers and manufacturers of explosion protected electrical equipment should give proper attention to :

- a) the design, construction and proposed method of use of the electrical equipment and -its compliance with the appropriate legal requirements (especially EAWR 1989).
- b) the need for statutory approval where it is necessary to comply with Acts of Parliament and Regulations made under them.

- c) foreseeable hazards arising from innovatory designs or new techniques not previously used in mines.
- d) the design and construction of the equipment and its ability to meet the requirements of relevant user specifications. Especially where these relate to compatibility with existing equipment, or circuits, to which the equipment is to be connected (See Appendix A)
- e) the robustness of the general design and construction which should be suitable for the intended method of use in the harsh environment found in mines.
- f) the provision of suitable and compatible electrical protection. For example, suitable earth fault, short circuit and overcurrent protection are required by UK law on power circuits. The protection may also need to be compatible with existing circuit protection (taking account of any current limitation required by the EAWR ACOP) to prevent unwanted spurious tripping of safety critical circuits and allow grading of trip current settings, etc.
- g) the adequacy of clearances distances between line conductors to prevent flash over. Also, creepage distances between live parts, the comparative tracking index (CTI) of the insulating materials and the likelihood of contamination on them.
- h) the possibility of thermite reaction frictional ignition hazards arising from the use of light alloys in the vicinity of rusty iron or steel
- i) the possibility of dangerous electrostatic discharge sparks arising from plastic materials with a high surface resistivity.
- j) the provision of suitable means of isolation and/or immobilisation of circuits and dangerous moving parts. (See also section 23.4 & 23.5).
- k) the provision of adequate safeguards with circuit designs to prevent unintended energisation, starting or movement of equipment. (See also section 25)
- l) the avoidance, where possible, and the control if not, of any flammable, toxic or radioactive materials used in the construction.
- m) the provision of external and internal warning labels, giving advice to users, such as "Do not open when energised", or "Batteries should not be removed underground".
- n) the suitability of cable entry devices for their intended duty and for the special types of cables used in mines.
- o) the provision of earthing and bonding facilities where it is necessary to prevent earth fault current passing through equipment flanges and joints. This being especially true where the flanges provide flamepaths for flameproof enclosures.
- p) the provision of adequate guarding or other precautions to prevent skin burns where external surface temperatures can exceed 90°C in normal use.
- q) the need for laser devices, either open path types or guided by optical fibre types, to comply with relevant European Standards and any safe viewing classification requirements. The dangers to be considered are accidental viewing of the beam by persons and the ignition of coal dust in the form of dust cloud particles or layers. Similar consideration will need to be given to optical data transmission systems.

- r) the provision of a clear technical description of the equipment, its operation and sufficient information to allow the user to ensure that the equipment can be safely used, tested and maintained.
- s) the use of labels that remain legible and durable in the arduous mining environment. While adhesive plastic labels may be acceptable for components, the externally mounted apparatus labels should be more durable in the mining environment. For example, an engraved brass or stainless steel label welded or riveted in place. However, it is not expected that labels be more durable than the apparatus to which they are attached.
- t) the need to liaise with potential users, to establish any reasonably anticipated misuse that may occur in service and to take account of it in the user instructions (Note - This is a requirement of the ATEX Directive).

Additional requirements for switchgear

18 The types of apparatus referred to in this section are generally automatically or manually operated circuit disconnecting devices, intended for use on three-phase mining power circuits, working at voltages over 250V. Designers and manufacturers of switchgear should give additional attention to:

- a) the provision of an effective means of isolation, earthing and interlocking for the electrical circuit in which it is to be used. Particular regard should be paid to its robustness, reliability, positive operation, padlocking facilities and prevention of incorrect assembly after maintenance. For example, the use of "D" section operating shafts and spindles are better than square shape in preventing incorrect re-assembly after maintenance. (See also section 23.4 & 23.5).
- b) the avoidance of flammable liquids in the design of new switchgear. (See Reg. 27 of EAWR 1989 with regard to the prohibition of flammable insulating oil).
- c) the provision of suitably rated earth fault, overcurrent and short circuit protection for all main and, where appropriate, auxiliary circuits. Further guidance on this can be found in the Electricity at Work Regulations 1989 ACOP.
- d) the provision of means to prevent unauthorised interference and resetting of protection devices, as appropriate. Also the means for electricians to test the correct functioning of circuits and equipment.
- e) the provision of live compartment indicators where there is a risk of either dangerous electric shock or the production of incendive sparking due to error. Such indicators should be designed so that they do not affect insulation readings during testing of the power circuits with which they are associated. For example, capacitive or inductive coupling is better than resistive coupling. Also any voltage reducing component associated with phase voltage indication should be rated for the line voltage to prevent breakdown failure during a phase-earth fault.
- f) the design of circuit breakers, so that contact make and break is substantially independent of the operator's physical strength, skill and speed of operation.
- g) the provision of operational features such as pre-start alarms (with an acoustic monitoring interlock), sequence interlocking (inadvertent starting of machines from adjacent switchgear), opto-isolators (shielding from extraneous light sources) and software (thorough testing and security of programs) where switchgear is to be used to control machines.

- h) the provision of additional warning labels where more than one power supply source is taken into an enclosure, or where identification of outlets is necessary when multiple cable entries are used.
- i) the provision of safeguards if the apparatus is to be used for remote operation. For example, only one start facility should be available at any one time and all stop devices should remain functional at all times irrespective of the mode of start selected.
- j) the positioning of controls such that the operator does not have to assume a position of danger to operate the machinery.
- k) the provision of safe access to all parts needing maintenance.
- l) the provision of dual isolators and interlocking if the switchgear is to be used for parallel feeder or ring main operation.
- m) the arrangement for earthing of both the incoming and outgoing circuits should be by closure of the circuit breaker to cater for human error leading to inadvertent incorrect circuit earthing. Appropriate labelling should also be provided to warn those performing maintenance that this switchgear is different from that normally encountered and needs special precautions when isolating and earthing its main circuits.
- n) the provision of key coding or dowels on either plugs or sockets to prevent incorrect or inappropriate coupling, especially where multiple plugs and sockets are used and danger could arise from cross connections.

Additional requirements for motors

19 Designers and manufacturers of equipment with electric motors should give additional attention to:

- a) the provision of temperature monitoring, arranged to initiate a control circuit trip when predetermined levels are exceeded on motors that are not forced air cooled, or continuously rated without cooling.
- b) not connecting winding, or bearing temperature devices into intrinsically safe circuits where there is possibility of breakthrough of mains voltage between the motor winding and the detector. Such temperature device circuits should always be terminated, at both ends, in a flameproof enclosure. A warning label to this effect should also be fitted adjacent to any auxiliary cable entry for such circuits.
- c) the provision of suitable cable terminations and warning labels if heaters are used to prevent condensation.
- d) the provision of adequate guarding of all dangerous moving parts, for example cooling fans should have an IT rating of at least IP2X.
- e) the provision of sufficiently strong and robust bearings and mounting arrangements (having regard to the possible flexing of the machine, its movement and any vibration) for motors designed for integral fitting to machines.
- f) the provision of insulated bearings if there is a need to prevent currents circulating through the motor/carcass/shaft. (See appendix B)

- g) the assessment of factors such as excessive motor temperature, high transient voltages, circulating currents and harmonics if motors are supplied at variable frequency from electronic converters. (See appendix C).

Additional requirements for machines (other than locomotives)

20 Designers and manufacturers of machines other than locomotives should give additional attention to:

- a) the provision of immobilisation facilities and special interlocking arrangements particularly where multiple motor drives are used, for example to facilitate cutter pick changing on a coal cutter.
- b) the provision of pre-start alarms where necessary to prevent danger.
- c) the design of the machine's control circuit. In particular any sequence control interlocking facilities, which should be arranged such that inadvertent starting is minimised and the machine remains in a safe condition should any part of the control circuit fail.
- d) the provision of a sufficient number of emergency stop switches/buttons, strategically located around the machine and identified to ensure safe operation.
- e) the accessibility to all parts for maintenance purposes and the ability to permit ready operation of all controls.
- f) the arrangement of any remote control circuit, so that it neither gives rise to inadvertent movement of the machine, nor overrides any local stop control device.
- g) the provision of adequate precautions to protect against incorrect or inadvertent movement as a result of electro-magnetic radiation. Particularly in machines that have safety related functions controlled by microprocessors, or by radio control.
- h) restricting the output power from radio transmitters so that it is incapable of initiating mining type electrical detonators. This usually restricts maximum transmitter outputs to less than 500mW. (Guidance on the hazard assessment of intrinsically safe equipment incorporating radio frequency transmitters is contained in an HSE report No IR/L/IC/89/06 entitled "Prevention of inadvertent firing of detonators by radio-frequency transmitters in Group I certified intrinsically safe equipment").
- i) the provision of adequately rated interconnecting cables and cable terminations which are suitable for the intended duty together with the provision of additional mechanical protection, and/or cabling handling arrangements, against crushing or abrasion of all cables associated with the machine.

Additional requirements for cable entries

21 Designers and manufacturers of equipment with cable entries should give additional attention to:

- a) the provision of instructions to the user on the type or range of types of cable entry/entries allowed to be used with the equipment.

- b) the use of cable entries that allow them to be fitted to the equipment whilst attached to the cable. For example, many types of screw compression glands might require the use of a bolt-on adapter.
- c) the inclusion of clear instructions to the user of sizes of cables allowed to be used, with each gland. In particular, for compression type glands, the dimensions of seals and the mating diameters of cable inner and outer sheaths are specified and the seals marked appropriately where more than one type can be fitted in a particular size of cable gland.
- d) the types of plugs and sockets provided and their non interchangeability with those designated for use in other types of circuit, eg in UK mines the use of 50A restrained type plugs and sockets is confined to the supply of 125V equipment such as hand held electric drills.
- e) the design and types of cable entries to prevent the installer and user confusing IS and non IS cable entries.
- f) the arrangement of plugs and sockets on equipment with more than one intrinsically safe circuit, so that they are physically different from one another (eg key coded) or are distinctly marked to avoid the risk of unintended interconnection of unrelated circuits.

Additional requirements for cells and batteries

22 Designers and manufacturers of equipment containing cells and batteries should give - additional attention to:

- a) the fact that the majority of cells and batteries produce hydrogen and possibly oxygen under certain circumstances and including them inside Group I (methane) explosion protected enclosures may render the type of ignition protection ineffective.
- b) the identification of the location of the batteries in the equipment where this is not obvious.
- c) the use of a sealed or encapsulated battery wherever possible.
- d) the provision of instructions and labels attached to the apparatus indicating if its batteries can only be recharged or replaced at the surface/safe zones.
- e) except in the case of small button cells used to retain memory in electronic circuits, the use of a switch connected close to the battery terminals to allow non IS outputs to be switched off,. In cases where the battery is in a separate unit, the inclusion of a switch locking-off feature.
- f) the fact that battery powered miners' caplights and handlamps may only be used in UK mines if they are approved for the purposes of Section 64 of the Mines & Quarries Act 1954 irrespective of any notified body certification. Only caplights complying with EN50033^{2*} and meeting the performance requirements of BS 4945 or IEC 62013-2 will be approved^{3**}.

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^{2*} *The ATEX version of EN50033 might be published with a different number*

^{3**} *The approval of ATEX Category M2 Caplights needs special consideration and manufacturers are advised to discuss this matter with HSE Mines Inspectorate*

Additional requirements for flameproof apparatus

23 Designers and manufacturers of flameproof equipment should give additional attention to :

- a) the need for mining equipment to be more robust than is normally encountered in surface industries. Certain parts of apparatus, for example overhanging or extended cable entries may therefore require additional mechanical support. Manufacturers should be prepared to demonstrate that all parts have adequate strength.
- b) the need for tracking values and other qualities of insulating material to be suitable for the duty and creepage and clearance distances between live conductors and between live conductors and other parts to take account of possible contaminants encountered in the harsh mining conditions. To minimize the possibility of internal insulation failures, tracking, subsequent pyrolysis and explosion of gas, it is preferable to have insulating materials with a CTI of 400 or better and for clearances and creepage distances at least as good as those in EN 50019.
- c) the need for greases and compounds applied to the surfaces of flameproof paths for the purposes of combating corrosion in wet mines, not to be hard-setting under extended service in any reasonably foreseeable conditions. Manufacturers are advised to seek the guidance of a testing authority to determine whether the application of coatings to flameproof flanges can affect flame transmission properties. Usually, greases and compounds used to protect against corrosion are electrical insulators and it has been customary to add a warning in certification acceptance documents that reliance should not be placed on the preservation of electrical continuity through the compounds where, say, an earth path includes the treated flameproof joint. It has been decided that some degree of electrical conductivity in such materials should not preclude their acceptance on the grounds that accidental contamination of insulating parts within enclosures could promote high voltage electrical breakdown. However, a note drawing attention to the point should be included in addition to the usual note concerning the implication of insulating properties.

Provision of Isolating Facilities for Flameproof Enclosures

- d) the need to generally assist persons having to carry out maintenance by producing flameproof enclosures with an integral isolator where;
 - the enclosure contains circuits which produce incendive sparks in normal use, or
 - there is a risk of mistakes being made when carrying out the isolation procedure.
- e) the need for an integral isolator to interrupt not only the incoming main supply, but all incoming non-intrinsically safe circuits and any other circuits where prevention of inadvertent starting relies upon isolation.

In general, a flameproof enclosure without an integral isolator should only be used where;

- the main supply voltage to the flameproof enclosure does not exceed 250V; and
- the number of incoming non-intrinsically safe circuits does not exceed two; or

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- the number of incoming BS 3101 circuits does not exceed four; or
- the combined total of incoming non-intrinsically safe circuits and BS 3101 circuits does not exceed four.

Where an integral isolator is not provided, a label should be fitted to the cover of the enclosure warning of the need to isolate at another place. Where a non-intrinsically safe circuit enters the enclosure, an insulating cover plate should be provided at the place where access is normally gained to any non-intrinsically safe circuits when the cover of the enclosure has been removed. This insulating cover should carry a warning reminding persons of the danger if they have not isolated the incoming circuits.

Additional requirements for intrinsically safe circuits and apparatus

24 Designers and manufacturers of equipment or systems containing intrinsically safe circuits and apparatus should give additional attention to:

- a) the identification and segregation of circuits, especially where more than one intrinsically safe power supply is available in an enclosure.
- b) the need for precautions for the use of testing instruments, particularly those having outputs for insulation testing. To minimize the danger when connecting to unspecified circuits. This will usually give rise to the need for special labelling as such instruments are capable of damaging components there will be a need for labelling and instructions on use.
- c) the need for electrical circuits intended to remain energised in an explosive atmosphere to be approved by HMIM.
- d) the fact that the use of intrinsically safe circuits with a level of protection “ib” results in the apparatus and circuit being categorised as “M2” under the ATEX Directive. As such it has to be de-energised or made safe if firedamp concentrations exceed the statutory limit. The decision to use intrinsically safe “ib” circuits has, therefore, to be given careful consideration and the following rules are generally applied by HMIM;
 - level of protection “ib” should not be used for any apparatus or circuit intended to remain energised in firedamp concentrations exceeding the statutory limit of 1.25%. As a consequence, no “ib” apparatus or circuit will be approved by HSE under Regulation 20 of the Electricity at Work Regulations 1989 by HMIM.
 - level of protection “ib” should be avoided for battery-powered circuits where it is possible to do so.

Portable (Handheld) Intrinsically Safe Apparatus

- e) the need for certain hand held IS apparatus to be safe against ignition of hydrogen. Following an explosion or fire below ground, mines rescue teams may need to use instruments such as methanometers and carbon monoxide detectors in atmospheres containing gases other than methane. Present certification practice is to assess the safety of these instruments in a hydrogen atmosphere i.e. the worst case flammable atmosphere a mines rescue team is likely to encounter. Any handheld equipment submitted for Group I certification that is liable to be used in UK mines by rescue teams should, therefore, be assessed for hydrogen safety as well as for safety in firedamp atmospheres.

An instrument that has been certified for both Groups I and IIC may be acceptable providing it is marked with both Groups I and IIC certificates and coding

Segregation of Intrinsically Safe Circuits from Power Circuits and Non-Intrinsically Safe Auxiliary Control and Monitoring Circuits in Flameproof Enclosures.

- f) the need to adopt extreme care when designing intrinsically safe monitoring circuits that emanate from high voltage equipment enclosures, because of the risk of them being contaminated by the high voltage conductors during faults. This is particularly true of intrinsically safe circuits connected onto pit-wide data transmission highways to deliver information to a remote station (eg the mine surface).
- g) the need to be aware that intrinsically safe circuits, or parts of circuits, with an external power source, entering and/or leaving flameproof enclosures will be regarded as "Associated Apparatus" as defined in EN 50020 and Notified bodies will treat them as such for certification purposes. Details of the segregation between IS circuits and power circuits being recorded on the appropriate certification documents.
- h) the need to provide separation of intrinsically safe circuits from non-intrinsically safe circuits (including power circuits). Where the layout of the circuits can be fully specified and the fault level does not exceed 1 MVA the segregation requirements of EN 50020 are considered adequate. Where the layout of the circuits cannot be fully specified or where the fault level exceeds 1MVA, it is preferable to house the circuits in separate enclosures or chambers. Where this is not practical the separation within the flameproof enclosure may be achieved by an insulated or earthed metal barrier.
- j) the need to take account of the fact that where pressure piling may present a problem, any metal barrier housed within a flameproof enclosure may contain holes or slots provided holes do not exceed 1 cm diameter, slot widths do not exceed 0.5 cm and the area of metal is at least 50% of the total of the barrier.
- j) the need to wire all connections to intrinsically safe circuits with conductors having a grade of insulation capable of withstanding an rms ac test voltage of 500V.
- k) the need to adequately separate the wiring of connections to intrinsically safe circuits from all other wiring in the flameproof enclosure and to make it readily identifiable. Where coloured cables are used for identifying IS circuits the colour should be light blue (or predominantly light blue where tracer stripes are included to identify particular wires).
- l) the need to determine adequate separation distances between intrinsically safe circuits and non incandive, low voltage, control interlock and monitoring circuits generally complying with BS 3101. The latter may be regarded as non-intrinsically safe circuits energised at 250V rms ac, only if the conditions in clause 6.2.2 of BS 7202:1989 are met.
- m) the need to segregate intrinsically safe power supplies if more than one is available in an enclosure. Each should be separately identified and clearly segregated.

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- n) the need to be able to readily distinguish cable entries where intrinsically safe circuits enter or leave a flameproof enclosure. The cable entry should be readily distinguishable and separated from non-intrinsically safe entries including non incensive, low voltage, control interlock and monitoring circuits. It is preferable for intrinsically safe circuits to enter and leave the apparatus via a suitably interfaced non-flameproof section. This permits the use of non-flameproof-type cable entries which can readily be identified.
- o) the need to wire all non incensive, low voltage, control interlock and monitoring circuits with conductors having at least 250 volt grade insulation and adequately separated from power circuits and be readily identified by any means except light blue insulation colouring.
- p) the need to adopt good engineering practice for all non-intrinsically safe control and monitoring circuits in an attempt to ensure that no invasion of the circuit takes place. All wiring should have a grade of insulation appropriate for their duty and be readily identified by any means except light blue insulation colouring.

Additional requirements for the prevention of inadvertent starting (POIS)

25 Designers and manufacturers of machines should give additional attention to:

- a) the need to design control circuits so that the risk of inadvertent starting of machinery whilst maintenance is being carried out is minimised eg by the operation of a switch, contractor or relay, the withdrawal and insertion of components or circuit cards or the use of test instruments.
- b) the need for control/pilot circuits used for mining apparatus and machinery to be one of the following types:
 - intrinsically safe circuits (EN 50020);
 - circuits complying generally with BS 3101 as non incensive, low voltage, control interlock and monitoring circuits (BS 7202);
 - non-intrinsically safe circuits energised at voltages not exceeding 250V.

Intrinsically Safe Circuits

- c) the need for circuits entering an enclosure that are intrinsically safe but not taken through an integral isolator, to comply with the following;
 - relays whose operation might cause equipment to start should be contained within an enclosure having a degree of protection of at least IP 4X and carry a warning label eg 'Operation of this/these relay(s) may cause apparatus to start'.
 - the apparatus should be designed so that the withdrawal or replacement of plug-in cards, components or chassis will not cause equipment to start.
 - where the use of a test instrument is necessary for fault finding, or for normal maintenance, purpose designed test points should be provided to allow the test instruments to be connected without the risk of initiating a start of the machinery.
 - any built-in test facility should be so arranged that when the circuit is energised for testing, any outputs that might cause or allow equipment to start in an unintended manner are automatically disconnected.

Circuits Complying Generally with BS 3101 as non incendive, low voltage, control interlock and monitoring circuits.

- d) the need for any incoming control circuit to be preferably wired through a cover/isolator interlock so that the circuit remains open whilst the isolator is 'OFF' or the cover of the enclosure is removed. If this is not possible then compliance with the requirements listed in paragraph 25.3 may be considered as an alternative. The above requirements do not obviate the necessity for users of the equipment to isolate circuits at the source of supply where it is necessary to do so.

Non-intrinsically Safe Circuits

- e) the need to provide complete isolation of control circuits where an ignition risk is present and protection against inadvertent starting is to be provided. Unless the enclosure has an integral isolator which isolates all accessible circuits, it should also bear a warning of the need to isolate at another place.
- f) the need to provide earth leakage protection on non IS control circuits.

Appendix A

List of British Standards relevant to mining

BS 535	Light sources for miners' portable electric lamps.
BS 542	Cable glands and sealing boxes for association with apparatus for use at mines and quarries. (Obsolete)
BS 1259	Intrinsically safe electrical apparatus and circuits for use in explosive atmospheres. (Obsolete)
BS 3101	Control and interlock circuits primarily associated with flameproof restrained plugs and sockets for use in coal mines.
BS 3454	1.9/3.3kV, 300A Bolted flameproof cable couplers and adapters (including 380/660V and 640/1100V, 300A adapters) for use in coal mines.
BS 3905	3.8/6.6kV, 300A Bolted flameproof cable couplers and adapters, for use in coal mines.
BS 4683	Electrical apparatus for explosive atmospheres. Part 1 Classification of maximum surface temperatures. (Obsolete)
BS 4683	Electrical apparatus for explosive atmospheres Part 2 The construction and testing of flameproof enclosures of electrical apparatus. (Obsolete)
BS 4945	Functional and performance characteristics of miners' cap lamps.
BS 5067	Specification for flameproof transformers for use in mines.
BS 5125	Specification for 50A flameproof restrained and bolted plugs and sockets for voltages not exceeding 650V, primarily for use in mining.
BS 5126	Mining type flameproof supply and control units for use on systems up to 1100V.
BS 5620	Specification for 200A flameproof restrained and bolted plugs and sockets for voltages not exceeding 1100V, primarily for use in mining.
BS 5754	Specification for electrical analogue and state signals for use in coal mines.
BS 6182	Intrinsically safe power supplies for use in coal mines.
BS 6353	Specification for underground loudspeaker communication systems in coal mines.

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BS 6556	Low speed digital signals for use in coal mines.
BS 6704	Selection, installation and maintenance of intrinsically safe electrical equipment in coal mines.
BS 6705	Specification for electrical measuring instruments for use on intrinsically safe circuits in coal mines.
BS 6708	Specification for trailing cables for mining purposes.
BS 7202	Specification for non-incendive low voltage control/interlock and low voltage earth fault monitoring circuits for use in mines.
BS 7383	Specification for cold-pour resin-based compound for use as a filling medium in terminating cables in enclosures for voltages not exceeding 11kV for use in coal mines.
BS 7765	Detonators for civil use (includes mining electrically initiated detonators)
BS7924	Code of Practice for the repair and overhaul of certified electrical apparatus intended for use in mines susceptible to firedamp.
BS EN 50014	Electrical apparatus for potentially explosive atmospheres: General requirements
BS EN 50015	Electrical apparatus for potentially explosive atmospheres: Oil immersion 'o' (Not suitable for mining equipment by virtue of Regulation 23 of EAWR 1989)
BS EN 50016	Electrical apparatus for potentially explosive atmospheres: Pressurised apparatus 'p'
BS EN 50017	Electrical apparatus for potentially explosive atmospheres: Powder filling 'q'
BS EN 50018	Electrical apparatus for potentially explosive atmospheres: Flameproof enclosure 'd'
BS EN 50019	Electrical apparatus for potentially explosive atmospheres: Increased safety 'e'
BS EN 50020	Electrical apparatus for potentially explosive atmospheres: Intrinsic safety 'i'
BS EN 50028	Electrical apparatus for potentially explosive atmospheres: Encapsulation 'm'
BSEN 50033	Specification and testing of miners' caplights in relation to the risk of explosion, for mines susceptible to firedamp.
BS EN 50039	Electrical apparatus for potentially explosive atmospheres: Intrinsically safe electrical systems "i"
BS EN 50054	Electrical apparatus for the detection and measurement of combustible gases. General requirements and test methods.

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- BS EN 50055 Electrical apparatus for the detection and measurement of combustible gases. Performance requirements for Group 1 apparatus indicating up to 5% (V/V) methane in air.
- BS EN 50056 Electrical apparatus for the detection and measurement of combustible gases. Performance requirements for Group 1 apparatus indicating up to 100%(V/V) methane.
- BS EN 50303 Group I, category M1 equipment intended to remain functional in atmospheres endangered by firedamp and/or coal dust.
- BS EN 60529 Specification for degrees of protection provided by enclosures (IP code).
- IEC 62013-2 Caplights for use in mines susceptible to firedamp - Performance and other safety-related matters.

Appendix B

Circulating currents in flameproof induction motors

The circulation of stray currents through the frame/endplates/rotor shaft arrangements of induction motors is a phenomenon which has been known to manufacturers for many years.

There are recognised design solutions to minimise the shaft voltages and these should be adopted.

A particular manifestation of circulating currents is premature bearing failure brought about by the circulating currents eroding the paths on which the bearing elements run. Such failure can be a very costly replacement exercise both in terms of labour costs and in the downtime of plant. There is also the very real danger arising from a fire which can occur as a direct result of a collapsed bearing. The simplest way of preventing such erosion is to use an insulated bearing at one end of the motor, normally and preferably the non-drive end. Such an arrangement will break the circuit and prevent the current flowing but unfortunately it brings another problem in its wake.

The interruption in the path results in the appearance of a potential difference across the insulation which, in a totally enclosed motor, is shunted by the flameproof shaft gland, whose outer edge is the external extremity of the flameproof enclosure. Although the motor will have been designed to ensure that there is always a gap between the flameproof gland and the shaft which is, coincidentally, sufficiently large to prevent a spark occurring, it should be assumed that the gap will, because of bearing wear or contamination by electrically conducting particles, at some time during the life of the motor become small enough for the potential difference to break it down. The result of such a breakdown will be a spark, the energy of which cannot be determined in all circumstances for every motor and so, in the absence of any evidence to the contrary, for safety reasons should be assumed to be incandescence. In the normal scheme of things the outer extremity of the flamepath associated with the shaft gland is outside the flameproof enclosure since the bearing sub-enclosure is not normally designed to be flameproof. An acceptable solution for the immediate problem, therefore, is to make the bearing enclosure flameproof.

If a means of bearing lubrication is present it should, by some means, also be rendered flameproof, a difficult job because it is likely that high-viscosity lubricating materials have to pass along it. There are various ways in which this problem may be overcome, depending on the design of the endplate and the means of lubrication.

One acceptable solution where the greaseway is provided by a radial hole drilled in the endplate is to provide, at the outer end, a flametrap in which the flamepath is sufficiently small to comply with the requirements of the appropriate flameproof Standard but of a sufficiently large cross-sectional area to offer the lubricant an acceptably low resistance to flow.

Motors fitted with an integral cooling fan on an extension of the shaft at the non-drive end also present problems because, even with a flameproof bearing sub-enclosure, sparking can occur at the gap between the shaft and the bearing endcap. The risk of such sparking can be minimised if the endcap incorporates an annular ring of suitable insulating material.

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Solutions for other arrangements have been produced over the years and designers facing problems of this sort should seek the advice of either the certification authority or HMIM.

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Appendix C

Motors supplied via electronic convertors

- 1 Electronic convertors are designed to provide a supply which approximates to a sine wave but has an infinitely variable frequency of (normally) between 0 and 60hz.
- 2 The performance Standards for electric motors give specific limitations of the amount of deviation from a sine wave that a motor is expected to tolerate in its electricity supply. Any deviation beyond these limits can, and usually does, give rise to much higher motor temperatures than would be expected if it were connected to a sinusoidal supply.
- 3 Generally, a frequency converter/motor combination is tested and certified together so that any measurements which are made take into account any deviations from the normal sinusoidal wave form throughout the frequency range. However, flameproof motors for mining use are normally of a sufficiently robust construction that, provided inbuilt thermal protection and the associated circuitry is provided, they can be used on synthetic supplies of any frequency range without significant harm. Non-flameproof motors for example, Increased Safety 'e' will require individual attention.
- 4 Manufacturers are however warned that supplementary certification will be necessary for motors intended for use on variable frequency supplies if they have a fixed frequency quoted in their certification documents.

Appendix D

Copy of the General Approval issued under Regulation 20 of the Electricity at Work Regulations 1989 for ATEX Categories M1 and M2 Equipment :

HSE(M) FILE REF:L4.3/3/96
HSE(M) Approval No EAWR 19 & 20 (ATEX) 1

HEALTH AND SAFETY AT WORK ETC ACT 1974 (a)

ELECTRICITY AT WORK REGULATIONS 1989 (b)

**APPROVAL OF ELECTRICAL EQUIPMENT FOR THE PURPOSES OF
REGULATIONS 19 & 20 OF THE ELECTRICITY AT WORK REGULATIONS 1989**

1 I approve, pursuant to regulation 19(2)(a) of the 1989 Regulations Category M1 and Category M2 equipment, in relation to which the requirements of regulation 6(2) of the 1996 Regulations have been complied with, for the purpose of being energised in certain zones below ground specified in regulation 19(1) of the 1989 Regulations;

2 I approve, pursuant to regulation 20(1) of the 1989 Regulations Category M1 equipment, in relation to which the requirements of regulation 6(2) of the 1996 Regulations have been complied with, for the purposes of remaining energised in the circumstances described in regulation 20(1) aforesaid.

In this certificate—

(i) "The 1989 Regulations" means the Electricity at Work Regulations 1989/635;

(ii) "The 1996 Regulations" means the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996/192;

(iii) "Category M 1 equipment" and "Category M 2 equipment" mean equipment within those descriptions specified in paragraph 1 of Schedule 4 to the 1996 Regulations.

Dated 27 October 1999

D.Mitchell

The holder of a post designated HM Chief Inspector of Mines, a person duly authorised by the Health and Safety Executive to act in that behalf

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Further information

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