Deep Mined Coal Industry Advisory Committee

The Mining Association of the United Kingdom

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# The prevention and control of fire and explosion in mines

## INTRODUCTION

This information and guidance was prepared, in consultation with the Health and Safety Executive (HSE), by a working group representative of all sides of the mining industry. It represents what members of the working group consider to be good practice.

*Members of the working group on the prevention and control of fire and explosion in mines*

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| | |
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| **Mr S Denton** | HM Inspector of Mines, HSE, Chairman |
| **Mr A Allsop** | Union of Democratic Mineworkers |
| **Mr M Davies** | Tower Colliery Limited |
| **Mr P Fenner** | UK Coal Mining Limited |
| **Mr D Flack** | Federation of Independent Mines |
| **Dr P Holmes** | British Gypsum Limited |
| **Mr S Hunneyball** | TES Bretby Limited |
| **Dr B Jones** | Mines Rescue Service Limited |
| **Mr S Mills** | British Gypsum Limited |
| **Mr G Robinson** | Cleveland Potash Limited |
| **Mr N Rowley** | Cleveland Potash Limited |
| **Mr E Ruck** | UK Coal Mining Limited |
| **Mr R Young** | British Association of Colliery Management |
| **Mr G Goodlad** | HM Principal Inspector of Engineering in Mines, HSE |
| **Mr R Leeming** | HM Inspector of Mines, HSE |
| **Mr M Williams** | HM Inspector of Mechanical Engineering in Mines, HSE |
| **Mr R Gates** | HSE, Working Group Secretary |

*Papers only*

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| **Mr R Fenton** | The Mining Association of the United Kingdom |
| **Mr I Lavery** | National Union of Mineworkers |

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## WHO SHOULD READ THIS BOOKLET?

1. This guidance is for all mines except storage mines. It should be read by:

- Mine owners
- Mine managers;
- Other mine staff who have a role in ensuring explosion and/or fire safety through supervision, inspection and maintenance etc;

and may be useful to:

- Safety representatives;
- Employee representatives;
- Employees.

It can be used as a tool for training and refresher training.

2. HSE has prepared separate guidance for mines or parts of mines used to store documents or items below ground.

## WHAT THIS GUIDE IS ABOUT

3. Fires and explosions have the potential to kill many people. This guidance tells you how to comply with the law; how to carry out fire and explosion risk assessments; and how to identify the measures necessary to avoid, control and mitigate those risks. It will help mine owners and managers to prepare their fire and explosion protection plans.

4. These risk assessments will also help mine managers to prepare their emergency plans setting out the action to be taken to effect the evacuation and rescue of people from below ground in the event of a fire or explosion.

5. While fire and explosion risk assessments have to be carried out both below ground and on the surface, this guidance relates primarily to fire and explosion risks below ground. However, the general principles should be applied to those buildings and equipment on the surface of a mine where a fire or explosion could prejudice safety below ground. For example, heapsteads, winding engine houses, firedamp drainage houses, fan houses and main ventilating fans.

6. The Fire Precautions (Workplaces) Regulations 1999 and the Fire Precautions (Special Premises) Regulations 1971 apply above ground at mines. For general guidance on these and other fire safety legislation, and on fire and explosion precautions above ground, refer to the HSE/Home Office guidance ‘Fire Safety, An Employer’s Guide’, ISBN 0-11-341229-0.

## LEGAL FRAMEWORK

### Primary legislation

7. The two main pieces of primary health and safety legislation (Acts of Parliament) relevant to fire and explosion in mines are:

- **The Mines and Quarries Act 1954**, which includes provisions that have a bearing on fire and explosion.
- **The Health and Safety at Work etc Act 1974**, which contains duties relating to safe systems of work and ensuring the health and safety of employees and others who may be affected by a work activity.

### Provisions relating to worker protection

8. There are a number of legal requirements that collectively require employers/mine owners, and in some cases mine managers, to assess the likelihood of a fire or explosion, its nature and extent, and the numbers of people who would be put at risk.

- Regulation 3 of **The Management of Health and Safety at Work Regulations 1999** requires all employers and self-employed people to assess the risks to workers and any others who may be affected by their work or business. That assessment must include the risks from fire and explosion hazards where they exist.
- Regulation 4 of **The Mines Miscellaneous Health and Safety Provisions Regulations 1995** requires mine owners to produce a health and safety document that demonstrates that the risks to which people at work at the mine are exposed have been assessed in accordance with regulation 3 of **The Management of Health and Safety at Work Regulations 1999**. In particular, regulation 4(2)(a) and 4(5)(a) of the 1995 Regulations require respectively an explosion and a fire protection plan to be included in the health and safety document.
- Regulation 4(1) of **The Mines Miscellaneous Health and Safety Provisions Regulations 1995** requires that these plans must be based on a risk assessment, the outcome of which demonstrates that adequate measures concerning the design, use and maintenance of the mine and its equipment have, and will continue to be taken. The health and safety document must also set out how the measures will be co-ordinated, taking account of both normal and emergency situations.
- Regulations 3 and 4 of **The Coal Mines (Owner's Operating Rules) Regulations 1993** require mine owners to set down in writing operating rules on a number of issues, including both mine fires and frictional ignitions of flammable gas and to notify the HSE of them.
- Regulation 19 of **The Electricity at Work Regulations 1989** requires the identification of zones below ground in safety-lamp mines in which firedamp, whether or not normally present, is likely to occur in a quantity sufficient to indicate danger, and the preparation of a suitable plan identifying such zones. It also defines the types of equipment that can be used in those zones.
- Regulation 20 of **The Electricity at Work Regulations 1989** relates to cutting off the supply of electricity when any person detects firedamp in a concentration exceeding 1.25% by volume in the general body of air either below ground or at any place on the surface where any exhauster in a firedamp drainage system is installed, firedamp is monitored, or its heat content is measured.
- Regulation 16 of **The Coal and Other Mines (Locomotives) Regulations 1956** requires district officials (persons in charge of parts of the mine) to discontinue the running of any

locomotive in a length of road where the firedamp content in the general body of mine air exceeds 1.25% by volume.

- Regulation 4 of **The Escape and Rescue from Mines Regulations 1995** requires managers to prepare and maintain a written plan (emergency plan) setting out the action to be taken to effect safely and promptly the evacuation and rescue of people from the mine should an emergency situation occur. In preparing this plan, managers will need to take account of any relevant risk assessment made in accordance with regulation 3 of the Management of Health and Safety at Work Regulations 1999.
- Regulation 9 of **The Mines (Safety of Exit) Regulations 1988** requires that where there are more than 50 people employed in any place below ground where there is only one intake airway, it is constructed of fire resistant materials and is kept free, so far as is reasonably practicable, from the risk of fire. There must also be suitable and sufficient means of extinguishing any fire and provision of automatic means of detecting the outbreak of fire.
- **The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956** set out requirements for the maintenance of incombustible matter in mine roadway dust including sampling, sample analysis, type of analysis and keeping records of analyses. The regulations also contain requirements relating to 'barriers to the extension of flame' such as stone dust barriers and water trough barriers;
- **The Provision and Use of Work Equipment Regulations 1998** impose requirements upon employers in respect of work equipment provided for or used by their employees at work. The requirements also apply to the self-employed and people in control of premises.
- **The Dangerous Substances and Explosive Atmospheres Regulations 2002** apply to mines apart from the provisions of regulations 5(4)(c), 7 and 11. They impose requirements for the purpose of eliminating or reducing risks to safety from fire, explosion or other events arising from the hazardous properties of a 'dangerous substance'. The duties fall on employers, and include requirements for them to:
    - Carry out assessments of risk from dangerous substances (which, where they are present, will include flammable gases and flammable dust);
    - Eliminate or reduce risk so far as is reasonably practicable;
    - Make arrangements for dealing with accidents, incidents and emergencies;
    - Provide employees with information, instruction and training in relation to dangerous substances;
    - Ensure that containers and pipes clearly identify their contents.

9. The requirements to classify places into zones do not apply at mines. This document contains guidance on zoning in mines in the section dealing with the explosion plan. The co-ordination duties also do not apply because similar provisions are already contained within **The Management and Administration of Safety and Health at Mines Regulations 1993**.

**Provisions relating to the supply of products**

10. Relevant product directives (otherwise known as Free Market Directives) usually apply to manufacturers and suppliers and set standards for them to achieve in order to be able to 'CE' mark their machinery and equipment. The main ones relevant to fire and explosion in mines are:

- The **Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996** ('the EPS Regulations') require people placing equipment on the market and putting into use to ensure that it meets relevant safety standards in relation to explosion protection.

- **The Supply of Machinery (Safety) Regulations 1992** apply to all machinery and the essential health and safety requirements cover all hazards including fire and explosion hazards caused by machines.

**List of legislative provisions**

11. A full list of legislative provisions relevant to fire and explosion in mines can be found in the Annex 4 at the end of this document.

## FIRE AND EXPLOSION RISK ASSESSMENT

### Introduction

12. Under the Management of Health and Safety at Work Regulations 1999 mine owners, as employers, must have in place procedures to ensure that fire and explosion risks are assessed at each of their mines.

13. The Management and Administration of Safety and Health at Mines Regulations 1993 provide for mine owners to appoint others to discharge legal duties on their behalf. Mine managers, assisted by members of staff with competence in the relevant areas, will often be better placed than owners to undertake these assessments. This does not relieve owners of their duty to ensure that suitable and sufficient risk assessments are done at each of their mines.

14. Where there is any lack of knowledge, expertise or competence that might prejudice the assessments, those carrying out the assessments should seek the advice of specialists.

### Risk Assessment

15. Regulation 3(1) of The Management of Health and Safety at Work Regulations 1999 requires every employer to undertake risk assessments for the purpose of identifying the measures he needs to take to comply with the requirements and prohibitions imposed on him by or under the relevant statutory provision.

16. Assessing risks is important in order to identify their relative importance and to obtain information on their nature and extent. This will help both to prioritise risks and determine where to place the most effort in prevention and control, and to make decisions on the adequacy of existing control measures.

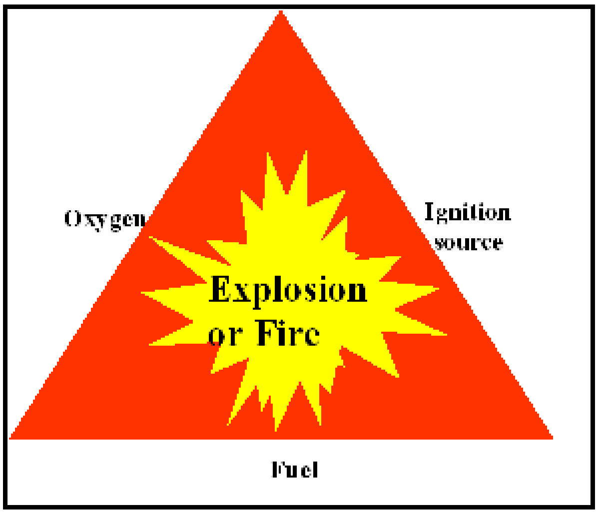
#### *Main stages*

17. The main stages of the fire and explosion assessment process are to:

- Identify the hazards - the potential sources of ignition and materials that would cause a fire or explosion to spread;
- Consider the precautions already in place for the prevention and mitigation of each fire and explosion hazard;
- Evaluate the likelihood of a fire or explosion occurring due to a particular hazard;
- Consider the consequences of a fire or explosion, and decide who might be harmed and how;
- Determine what further measures are necessary to prevent, control or mitigate a fire or explosion;
- Record significant findings; these should be included within the fire protection plan and the explosion protection plan required by regulation 4(2) of The Mines Miscellaneous Health and Safety Provisions Regulations 1995;
- Review the risk assessment periodically, or when you think that a change in circumstances will significantly affect the risks to which people are exposed (e.g. moving from a non-gassy to a gassy seam).

### Identifying the hazards

18. While fire hazards are likely to be present at nearly all mines, if there are no explosion hazards present then there will be no risk to people from an explosion and therefore no need to introduce any explosion prevention and control measures. In this case there is no need to read the parts of this guidance that relate solely to explosion risks.




***Sources of fuel***

19. Anything that can burn is potential fuel for a fire or, in some cases, an explosion. Some of the most common fuels found in mines are:

- Firedamp (a naturally occurring mixture of hydrocarbon gases);
- Coal/coal dust;
- Wood;
- Diesel;
- Tyres and plastic materials;
- Mineral oils and grease;
- Rubbish and other waste material;
- Paper and plastics;
- Bottled gases e.g. acetylene, propane;
- Some explosives.

***Sources of ignition***

20. Owners and managers will need to consider what can cause an explosion or start a fire. A source of ignition is anything that has the potential to get hot enough to ignite a material, substance or atmosphere in the workplace. These sources of heat might include:

- Friction from:
  - Defective bearings – conveyor idlers, drums, wheels/axles;
  - Conveyor belts rubbing against some fixed object, such as a roadway support or a tail end structure, or running in spillage;
  - Seized brakes on vehicles;
- Internal combustion engines – exhaust systems, air inlets, hot surfaces;
- Spontaneous heating of coal in the waste or of broken coal in the road side in high risk seams;
- Incendive sparks from cutting machinery picks;
- Electrical and mechanical machinery and equipment;
- Electrical sparking and hot surfaces from electrical equipment and distribution systems;
- Short circuits and earth faults on electrical equipment and distribution systems;

- Natural sources, for example electrostatic discharges and lightning;
- Explosives and detonators;
- Compression of air or gases;
- The thermite reaction between light alloys and iron/steel. Light alloys are those containing such metals as aluminium, magnesium or titanium. Specifically, alloys containing more than 15% of one or more of these, or, in the case of magnesium/titanium alloys, containing more than 6% of magnesium and titanium together;
- Hot work – burning, welding, and grinding;
- Smokers' materials, e.g. cigarettes, lighters and matches.

***Sources of oxygen***

21. The main source of oxygen for a fire or explosion is in the general body of air. Unless a fire or explosion occurs in an enclosed space, such as a sealed storeroom or within pipe work, it is safe to assume that it will always have a ready supply of oxygen as the mine's ventilation system will continue to draw air around the mine workings.

22. There are also other sources of oxygen that you may need to take into account when making your risk assessment, such as:

- Chemicals that release oxygen when heated (oxidising agents) such as hydrogen peroxide. Manufacturers' labels should identify which chemicals are, or contain, oxidising agents. The most common oxidising agents found below ground are degreasing compounds. Oxidising agents or substances containing an oxidising agent should be labelled with the international standard symbol;


- ANFO (or its constituent ammonium nitrate, another oxidising agent);
- Bottled oxygen;
- Compressed air in ranges (but this may only contribute to the risk if the range is likely to fracture in the event of a fire).

**Evaluating the likelihood of a fire or explosion**

23. The next stage is to evaluate the likelihood of a fire or explosion occurring and to decide whether there are sufficient measures in place to avoid, control or reduce them, or whether more needs to be done.

24. The risk assessments will need to take account of the control measures that are in place. For example, the risk of an explosive atmosphere occurring will normally be controlled by the ability of the ventilation system, including local ventilation arrangements, to dilute any flammable gas, and by any firedamp drainage system.

25. The risk assessments will also need to consider:

- Whether there are any areas of the mine where additional control measures may be necessary (e.g. in single-entries);
- Any abnormal circumstances which might arise, in particular the malfunctioning of ventilation equipment or the firedamp drainage system;
- Special situations, e.g. when maintenance work is being carried out.

**Deciding who might be harmed and how**

26. When assessing risks that might arise from fire and explosion hazards owners and managers will need to consider the effects on those in the immediate area and to others. The outcomes of this process will help determine the necessary preventative and protective measures for inclusion in the fire and explosion protection plans.

27. The assessment will have to consider the potential risks arising from:

- The nature and extent of any flame, heat or blast wave;
- The possible disruption of the ventilation system; for example, due to ventilation doors being blown open or left open, or due to the buoyancy effects of hot gases affecting the airflow;
- The potential for oxygen depletion;
- The reduction in visibility due to smoke;
- The spread and possible concentrations of toxic and noxious gases and other products of combustion;
- The distance to a place of safety.

**Recording significant findings**

28. Regulation 3(6) of the Management of Health and Safety at Work Regulations 1999 requires employers of five or more employees to record:

- The significant findings of assessments;
- Any group of employees identified by the assessment as being specifically at risk.

29. Regulation 5(4) of the Dangerous Substances and Explosive Atmospheres Regulations 2002 requires employers of five or more people to include within the record of significant findings particulars of the avoidance and control measures taken, or proposed, to comply with the requirements of these regulations along with other information relating to the workplace and work processes.

30. Regulation 4(1) of the Mines Miscellaneous Health and Safety Provisions Regulations 1995 requires all mine owners to prepare a health and safety document which:

- Demonstrates that risks have been assessed;
- Demonstrates that adequate risk avoidance and control measures have and will continue to be taken;
- Includes a statement of how these measures will be coordinated.

31. Regulation 4(2) of the Mines Miscellaneous Health and Safety Provisions Regulations 1995 requires that, where appropriate, the health and safety document should include a fire protection plan and an explosion protection plan.

32. The net effect of these requirements is that where the assessments indicate there are fire risks the health and safety document will need to include a fire protection plan, and where there are explosion risks it will need to include an explosion protection plan.

33. Further guidance on fire protection and explosion protection plans can be found later in this document.

**Reviewing the assessments**

34. Mine owners should review the fire and explosion risk assessments at set intervals, and when there has been a significant change in either the layout of the mine (when activity moves from one area to another etc.), or the ventilation or firedamp drainage systems, or when there has been

a significant change to working methods, as any of these may change the nature of the hazards and different risks may develop. Examples include:

- Moving a conveyor may also require the movement of fire fighting equipment so that it remains on the intake air side and is available for fighting fire at the delivery, drive and loop take up;
- Reversing the airflow in a district, area of a mine, or the whole mine will need a complete reassessment of fire (and where necessary, explosion) risks.

35. Owners and managers will need to review the assessments at least annually, and more frequently at mines where there is a high level of activity and circumstances change more quickly.

**Risk assessment and the emergency plan**

36. The assessment of the residual risks that remain after all reasonably practicable measures have been taken will form a basis for the emergency plan for safe evacuation and rescue required by regulation 4 of The Escape and Rescue from Mines Regulations 1995.

37. Those making the assessments will need to consider the direct effects to those in the immediate area of a fire or explosion. Because mine ventilation systems provide air to all places in the mine where people work or pass all people below ground are likely to be at some level of risk should a fire break out or an explosion occur. The level of risk to which each person is exposed will vary depending on a number of factors including:

- How close they are to the fire or explosion;
- Whether they are on the intake side or downstream;
- How far they are from the nearest unaffected place or safe haven;
- How long it would take them to reach a place of safety, bearing in mind such factors as the loss of visibility in smoke-affected roadways;
- The type and duration of their self-rescuers.

38. The assessments will identify the need to ensure that means of egress from the mine, and routes to any safe havens, are well maintained and signposted. The emergency plan should also set out:

- Organisational arrangements, including the roles and responsibilities of those who will have to implement fire-fighting;
- Emergency arrangements, including where appropriate the procedures for contacting the mines rescue service and, in the event of a fire on the surface, other emergency services;
- Arrangements to contact HM Inspectorate of Mines.

39. It is important that the deployment and safety checking systems at the mine are effective in keeping track of both who is below ground and where they are working. This is particularly important in the case of mobile workers such as transport operators, maintenance staff, officials and management staff, all of who may travel several miles to a number of different locations during their shift.

## FIRE AND EXPLOSION PREVENTION AND CONTROL

40. The objective of fire and explosion control measures is to avoid any of the fire or explosion risks by eliminating either the potential ignition sources or potential fuel sources, or both. However, it is likely that some potential fuels and some ignition sources will remain, so these need to be reduced by:

- Minimising the inventory of potential fuels (also known as minimising the fire load);

- Minimising the number of potential ignition sources;
- Keeping potential ignition sources apart from potential fuel.

41. Mines can minimise the amount of fuel by:

- Limiting the amount of flammable materials taken below ground (see paragraph 6, Part II, Schedule 1 to regulation 6 of The Mines Miscellaneous Health and Safety Provisions Regulations 1995);
- Where reasonably practicable, using fire resistant fluids instead of mineral oils (see regulation 8 of The Mines Miscellaneous Health and Safety Provisions Regulations 1995);
- Using only fire resistant conveyor belting;
- Using firedamp drainage systems to prevent flammable gas entering the general body of mine air;
- Ensuring that rubbish and other flammable waste material is removed promptly; for example paper, wood, plastic and old vehicle tyres;
- Removing potentially flammable dust and spillage from the mine;
- Progressively replacing oil-filled electrical equipment and bitumen-filled electrical cable couplers and joints with safer alternatives;
- Keeping to a practical minimum flammable material in structures below ground.

42. Mines can minimise sources of ignition by:

- Avoiding hot surfaces and frictional sparking through good design, installation, commissioning and by regular inspection, testing and maintenance, including the periodic and effective monitoring of bearings, brake units etc;
- Checking that moving parts are not unintentionally rubbing against fixed objects;
- Ensuring proper lubrication;
- Removing ignition sources from equipment that is out of use; for example, vehicle batteries;
- Reducing the number of plug and socket electrical connections; for example, cable couplers;
- Closely monitoring remaining oil-filled electrical equipment and bitumen-filled couplers;
- Prohibiting the use of flame cutting unless safety precautions are in place;

and at safety lamp mines or in safety lamp parts of mines:

- Taking effective steps to prevent smoking materials being taken below ground. Section 66 of The Mines and Quarries Act 1954 relates to the prohibition of possession of smoking materials in safety lamp mines and safety lamp parts of mines;
- Maintaining spark-arrestors and flame traps on internal combustion engines;
- Using only those explosives, detonators, exploders, exploder test apparatus and circuit testers that are approved by the Health and Safety Executive, to comply with regulation 5 of The Coal and Other Safety Lamp Mines (Explosives) Regulations 1993, and using them only for their intended purpose(s);
- Using only permitted lights as required by section 62 of The Mines and Quarries Act 1954;
- Controlling the use of light alloys in potentially flammable atmospheres;

and at non-safety lamp mines:

- Encouraging people not to smoke below ground, or to do so only in designated places or other places where there is no potential fuel source.

43. Fuel and potential ignition sources can be kept apart by:

- Shrouding or enclosing hot components;
- Separating electric cables, fuel and hydraulic pipes from hot components by routing and the provision of physical barriers;
- Storing flammable materials away from electrical sub-stations and other potential ignition sources;
- Preventing the build up of flammable material around equipment;
- Enclosing in flameproof enclosures electrical arcs and sparks generated in normal operation;
- Using water to cool, quench, lubricate and/or induce airflow around potential ignition sources, such as cutter picks and drill bits.

44. The fire and, where appropriate, explosion risk assessments will have identified the residual risks, taking account of the control measures already in place, and determined whether or not they are adequate to avoid or control those risks. The next step is to identify what additional fire and explosion control measures are needed, for example:

- **Equipment monitoring** (see Annex 1 – conveyors and other equipment);
- **Detection and warning**; for example by increasing the number of flammable gas, products of combustion or smoke detectors in vulnerable places.
- **Minimising or mitigating the effects**; for example by installing automatic fire fighting equipment, barriers to the extension of flame, or additional explosion-suppression barriers.

45. The control measures adopted should be proportionate to the amount of harm that could be caused. Later sections of this guide give further information on specific control measures.

46. Mine owners need not take further avoidance and control measures where the risk assessment indicates that existing measures are adequate and that risk has reduced to as low as reasonably practicable.

## FIRE PROTECTION PLAN

47. Where there are fire hazards at any mine the owner of that mine must ensure that the health and safety document prepared in accordance with regulation 4 of the Mines Miscellaneous Health and Safety Provisions Regulations 1995 includes a fire protection plan. The plan must take into account:

- Likely sources of fire, taking into account the presence of fuel, ignition sources and oxygen;
- Precautions to be taken to protect against, to detect and combat the outbreak and spread of fire.

48. The plan will need to set out the measures to:

- Avoid or control sources of ignition;
- Minimise the amount of flammable materials below ground;
- Detect fires and give warning in the event of fire;

- Fight fire.

## FIRE AVOIDANCE AND CONTROL MEASURES

### Avoidance and control of sources of ignition

49. This section covers the following:

- Selection, provision and use of suitable work equipment;
- Inspection and maintenance of work equipment;
- Control of naked flames and 'hot work';
- At safety lamp mines, arrangements to prevent smoking materials, and matches from being taken below ground.

### Selection, and use of equipment

***General***

50. There are a number of legal provisions that relate to the safe use of equipment. In particular regulation 4 of The Provision and Use of Work Equipment Regulations 1998 requires employers to ensure that such equipment is suitable for its intended use. Regulation 12 of those Regulations requires protection against specific hazards, which includes protection against work equipment catching fire or overheating.

51. In selecting equipment for use below ground mine owners and managers will need to make manufacturers or suppliers aware of the environment in which the equipment is to operate so that they can reduce fire hazards to a minimum.

52. The use of flammable, materials in equipment designed specifically for use below ground in mines should already have been minimised by the equipment manufacturers. Where equipment designed for surface use is adapted for use below ground, or where equipment is assembled by the user for their own use, then the requirements of regulation 10 of The Provision and Use of Work Equipment Regulations 1998 are relevant. This will require the application to that equipment of the essential health and safety requirements contained within The Supply of Machinery (Safety) Regulations 1992.

53. Two examples of relevant manufacturing European standards to support The Supply of Machinery (Safety) Regulations 1992 are:

- BS EN 1889-1- Machines for underground mines - Mobile machines working underground - Safety - Part 1: Rubber tyred vehicles;
- BS EN 1889-2 - Machines for underground mines - Mobile machines working underground - Safety - Part 2: Rail locomotives.

Both apply to machinery used below ground at any mine and contain relevant clauses on fire resistant materials, fluids, monitoring and extinguishing systems.

**Locomotive designed specifically for use below ground in potentially flammable atmospheres**

54. Friction, often associated with defective bearings, particularly on conveyor systems, is the cause of many fires in mines. When bearings fail or start to fail temperatures can rapidly increase to the ignition point of lubricants and the melting point of plastic and rubber seals, hastening bearing failure, and causing the temperature to rise rapidly. In some circumstances it can rise above the ignition temperature of firedamp.

55. In coal mines the maximum surface temperature of equipment should be kept below $150^{o}C$, as above this it will be hot enough to ignite coal dust layers that may have accumulated on it. This temperature is below the ignition point of hydraulic oils, lubricating oils and greases.

56. Owners and managers of non-coal mines will need to ensure that they have in place measures to ensure that mineral oils do not come into contact with surfaces hot enough to ignite them, for example, turbo chargers and exhaust systems on internal combustion engines.

57. The fluid used in any hydraulic system should comply with regulation 8 of the Mines Miscellaneous Health and Safety Provisions Regulations 1995. This means that where reasonably practicable the hydraulic fluid should be both difficult to ignite and satisfy the specification approved by the Health and Safety Executive in relation to fire resistance and hygiene.

58. Coal mines should continue to use fire resistant fluids because it has proved reasonably practical to use fire resistant fluids in purpose-designed equipment that has been available for many years.

59. At non-coal mines, where equipment used below ground is not purpose-designed, fire resistant fluids should still be used unless it is not reasonably practicable to do so.

60. Where it is not reasonably practicable to use fire-resistant hydraulic fluids suitable and sufficient fire protection measures should be taken including:

- Separating hydraulic lines and cables etc from hot surfaces such as exhaust systems and turbochargers by routing and the provision of physical barriers;
- The provision of temperature monitoring on hydraulic systems to warn of excessive fluid temperature;
- The provision of fire suppression systems.

61. Mines can reduce the likelihood of equipment failure by ensuring that operators use it only within its rated duty.

### *Electrical equipment*

62. In addition to the requirements relating to all work equipment, regulation 4 of The Electricity at Work Regulations 1989 requires mine owners and managers to ensure that electrical systems are constructed and maintained to prevent danger.

63. To prevent electrical equipment becoming an ignition source, it should be:

- Rated for normal operation and for foreseeable faults;
- Sufficiently robust for the harsh operating conditions found below ground in many mines;
- Protected against mechanical damage – this is particularly important in relation to cables;
- Protected electrically against dangers arising from overloading, leakage current and short circuits;
- Maintained and operated in accordance with the manufacturer or supplier's instructions.

64. Because of the fire risk, regulation 23 of The Electricity at Work Regulations 1989 prohibits the introduction below ground of electrical equipment using oil as a means of cooling, insulation or arc-suppression. Whilst it does not prohibit the continued use of existing oil-filled electrical equipment below ground, such equipment should be replaced progressively with safer alternatives.

65. Other measures that will reduce the likelihood of a fire occurring include:

- Using resin instead of bitumen in cable couplers/connectors/joints, and progressively replacing existing bitumen filled couplers;
- Not allowing dust to accumulate on electrical equipment to the extent that it might overheat;
- Not allowing ventilation openings to become blocked;
- Operating short time rated equipment only within its time rating;
- Providing vehicles designed for use below ground with isolators or circuit breakers to the battery circuits, to enable the battery circuit to be isolated when the vehicle is not in use. Vehicles designed for surface use will require such devices fitting before they are taken below ground.

**The aftermath of a fire following a short-circuit in a large lead-acid battery on a mine vehicle**

### Machinery and equipment monitoring

66. The effective monitoring and protection of machinery and equipment, particularly where it is unattended, is an essential control measure for both asset protection and health and safety purposes. The continuous monitoring and protection of machinery and equipment can significantly reduce the likelihood of a fire occurring by detecting abnormal operating conditions and generating a warning and/or stopping the machinery or equipment before it becomes a hazard.

67. The amount and type of monitoring that it is reasonably practicable to install will depend on the potential fire hazards and risks identified during assessment. Where there is no fire risk, or the fire risks are very low, monitoring may not be a reasonably practicable control measure. However, as the fire risks increase so should the level of monitoring.

68. There are a number of different types of monitoring devices, some of which can be used on all machinery and equipment and some that are appropriate only to specific types. The main types of monitors are:

- Temperature measuring devices (e.g. probes, stick-on sensors);
- Thermal protective devices (e.g. thermostats, fusible plugs);
- Position or limit switches (e.g. high/low water level, brake on/off limit switches);
- Wear measuring devices (e.g. brake pad wear);
- Abnormal operating condition devices (e.g. belt alignment, belt slip and blocked chute probes);
- Infrared devices.

69. The monitoring system should give an indication locally and to a suitable control point, either above ground or in some secure place below ground, where someone can hear or see it and react if necessary.

70. Temperature monitors and thermal protective devices should stop equipment automatically before its temperature exceeds a level that might give rise to a fire. In coal mines the surface temperature at which equipment is automatically tripped should not exceed 150$^{o}$C.

71. Temperature devices that generate a continuous signal are more flexible than ones that only produce a signal in an alarm condition. They allow mines to configure the monitoring system software to both generate alarms if certain temperatures are exceeded and initiate a stop sequence if a monitor indicates a hazardous situation.

72. A senior member of the mine management structure should be responsible for setting warning, alarm and trip levels. The setting levels for individual monitors should be recorded as part of the planned preventative maintenance scheme and should not be changed without permission from the responsible person.

73. Mines should set their monitoring systems to generate an alarm if the temperature measured by any probe reaches a predetermined level above the normal maximum operating temperature. This level should be high enough not to generate false alarms but not so high that the monitored equipment could cause a fire before generating the alarm. When monitoring systems generate frequent false alarms, because the alarm level is not set high enough above the normal maximum running temperature, operators soon become used to cancelling alarms because they know that, in most circumstances, there is no real risk. However, this makes them far less likely to respond quickly or appropriately to a real emergency. The senior management member responsible for the monitoring system should therefore ensure as far as possible that alarms operate only when there is a genuine reason for them to do so.

**A modern conveyor drive unit with provision for monitoring key components whose failure could lead to a fire**

74. Excess temperature **alarm** levels should be no more than 10$^{o}$C above the maximum running temperature under normal conditions. The monitoring system should **automatically stop** the equipment if a temperature of 20$^{o}$C above the normal maximum running temperature is detected, or an alarm at a lower temperature persists in excess of 30 minutes.

75. Monitors should stop equipment or machinery through local circuitry rather than through data transmission systems.

76. Any machinery or equipment that has been stopped by the monitoring system either due to overheating, or other alarm condition indicating a potentially hazardous state, should not be restarted unless a competent person has thoroughly examined it and found it to be safe.

77. Monitoring systems should be designed to detect the failure of any monitor and, in the event of a malfunction any safety-critical monitor, stop the equipment prevent it from re-starting.

78. Further guidance on machinery and equipment monitoring is contained in Annex 1.

**Inspection, testing and maintenance**

79. Regulation 11 of The Management and Administration of Safety and Health at Mines Regulations 1993 and regulations 5 and 6 of The Provision and Use of Work Equipment Regulations 1998 impose similar requirements in relation to the installation and maintenance of equipment. The regular testing, inspection and maintenance of equipment can also reduce the risks. There is further information on the manager's scheme of maintenance in the Approved Code of Practice to The Management and Administration of Safety and Health at Mines Regulations 1993, and on equipment installation and maintenance in the guidance to The Provision and Use of Work Equipment Regulations 1998.

80. As part of their inspection, testing and maintenance regimes, mines should use routine condition monitoring techniques where the failure of a component might lead to a fire. Many of these techniques, such as wear debris analysis, shock-pulse monitoring, vibration monitoring, can be carried out on site without the need to remove equipment or components. Where the mine does not have the knowledge or experience to carry out such procedures, managers should consider using specialist contractors.

81. The installation, testing and maintenance scheme should include all equipment monitors and protective devices, and should include procedures to ensure that these are regularly checked to ensure that the devices are properly calibrated, their trigger levels are appropriate, and that they operate as intended.

## Belt Conveyor Installations

82. In the last 20 years belt conveyors have been responsible for the largest proportion of fires in mines. Bearing failure, commonly from conveyor idler rollers and drums, causes many fires. In most cases, where idler roller bearings fail it is because they have been subjected to continual loads far in excess of their specified safe working load. This is often as a result of the conveyor belt bearing heavily on them at changes of gradient along the belt line, particularly at the entry and exit points of drives, loop take ups, discharge and return end units.

83. Part 2 of the Model Rules on Mine Fires, which forms guidance to the Coal Mines (Owner's Operating Rules) Regulations 1993, contains detailed recommendations on fire precautions associated with underground belt conveyors in coal mines. The principles that are also applicable to non-coal mines are set out below.

### *Designing conveyors to minimize the risk of fire*

84. Mines can minimise the likelihood of conveyor fires by:

- Using fire resistant conveyor belting;
- Ensuring that the conveyor is of sufficient capacity to carry the maximum expected load;
- Maintaining conveyor systems to ensure maximum specified loads on rollers and idlers are not exceeded;
- Using only drums, rollers and idlers manufactured to appropriate standards with suitable engineering tolerances;
- Using fire resistant fluids in hydraulic systems, traction couplings etc;
- Specifying fire-resistant grease in idler bearings;
- Using brake designs that are less vulnerable to sticking in the 'on' position and which are less prone to dust and other contaminants building up in the brake path;
- Installing monitors on vulnerable components to detect deterioration or abnormal operation and providing appropriate protective devices. Annex 1 contains further guidance;
- Designing and constructing transfer and loading points so as to minimise spillage and dust, They should be shrouded but have facilities for safe inspection and cleaning;
- Providing cleaning conveyors where necessary to remove spillage, particularly from beneath belt scrapers;
- Ensuring that all parts of the conveying system are accessible for inspection and can be safely cleaned;
- Using fire resistant materials in roadways at transfer and loading points.

### *Fire-resistant conveyor belting for use below ground*

85. Mines should use fire-resistant conveyor belting below ground, as this will not ignite by frictional heat when a rotating drum rubs against a stalled conveyor, and flame will not propagate along the belt if part of it is exposed to flame. This is because a burning conveyor belt releases high volumes of smoke, carbon monoxide and other toxic fumes that can quickly pollute the general body of mine air. As belt fires propagate along a belt in the direction of the airflow they are difficult to extinguish because the smoke and toxic fumes prevent persons fighting the advancing front of the fire along the belt.

86. Although there is currently no European standard, there are several standards in other countries covering fire-resistant conveyor belts. These vary in the degree of fire resistance required, both in terms of the ease of ignition and the propensity of burning. Mines should

therefore use below ground only conveyor belts that as a minimum comply with BS3289, which has been used reliably for many years in UK mines.

**Test apparatus used to determine if conveyor belting meets the fire-resistance standards of BS3289**

### *Clearances around conveyors*

87. Section 36(1)(b) of The Mines and Quarries Act 1954 requires mine managers to prohibit the use of a conveyor if it or its load rubs against the roof or sides of the road or anything in it. Mines should therefore ensure that conveyors are correctly positioned and aligned within roadways, and that there is sufficient clearance around rollers and idlers, so that they are not in contact with anything flammable.

### *Conveyor housekeeping*

88. Conveyor drives, loops, return ends and belt lines should be examined regularly to ensure that:

- Flammable materials, including coal dust and coal spillage, have not accumulated within or beneath them;
- Pieces of mineral are not wedged between moving parts and the conveyor structure;
- There is no leakage of lubricant from any drum or idler;
- There are no drums or idlers rotating with collapsed or seized bearings - any faulty roller should be replaced or removed until a replacement is available and can be fitted;
- That the belt is properly aligned and graded and is not rubbing against the roadside, fixtures and fittings, or any static element of the conveying system;
- All necessary safety devices are fitted and working.
- Belts are properly tensioned to avoid slipping.

### **Naked lights/flame/hot work**

89. Mines should not use open flame apparatus, such as burning and welding equipment, where there is a risk of fire unless control measures are first put in place to prevent the accidental ignition of materials or substances and the spread of fire. See Schedule 1, Part II, paragraph 3 of The Mines Miscellaneous Health and Safety Provisions Regulations 1995, relevant to all mines.

90. At safety lamp mines, section 67(1) of The Mines and Quarries Act 1954 prohibits the taking below ground of any article capable of producing unprotected sparks or flame other than with the authorisation of the Health and Safety Executive. This includes burning, welding and grinding work. Coal mine owners should refer also to paragraph 40 of the Model Rules on mine fires that form guidance on The Coal Mines (Owner's Operating Rules) Regulations 1993. These measures may include:

- Removing flammable materials and substances from the immediate vicinity;

- Using tools with non-flammable components; for examples, hoses or cables;
- Using a spark-igniter rather than an open flame;
- Using flashback arrestors and non-return valves at the cutting or welding torch;
- Wetting down the immediate area where coal or other flammable materials are present;
- Partitioning off the area to prevent the spread of sparks, flames and hot metal;
- Spreading non-flammable dust beneath the work area to catch sparks and hot metal;
- Ensuring that only competent persons undertake and supervise such work;
- Frequent inspections by a competent person before, during and after the work. Inspections should continue until it is certain that there is no smouldering material;

and additionally at safety lamp mines:

- Monitoring the general body of mine air for the presence of flammable gas.

91. The measures taken to protect against the spread of fire may include fire extinguishers, automatic fire suppression systems, and at coal mines should also include an adequate water supply for fire fighting. See also guidance on The Coal Mines (Owner's Operating Rules) Regulations 1993 contained in section 2 of The Model Rules on mine fires.

92. Other published guidance on burning and welding includes:

- HSE Information Sheet on the Use of Acetylene;
- HSE guidance sheet HSE 8 ‘Oxygen: Fire and explosion hazards in the use and misuse of oxygen’;
- British Standards BS 5741 and BS 5120;
- Codes of Practice CP4, CP5, CP6 and CP7 issued by the British Compressed Gases Association and approved by HSE.

**Smoking and smoking materials**

93. Section 66 of The Mines and Quarries Act 1954 makes it an offence for any person to possess smoking materials below ground at safety lamp mines.

94. Section 66(1) requires mine managers to put in place arrangements to prevent smoking, and the possession of smoking materials below ground at all such mines. The measures will need to include suitable arrangements for carrying out searches for such materials at the surface, and below ground. The Mines (Manner of Search for Smoking Materials) Order 1956 sets out who should be searched and how.

**Spontaneous combustion**

95. Some materials and substances, including most types of coal, will start to oxidise when exposed to air. When there is sufficient oxygen to cause the substance to oxidise and give out heat, but insufficient flow to carry away the heat quickly enough, the temperature will start to rise leading to further increases in the rate of oxidation, rate of heat output, and the rate of temperature rise. This can lead to the spontaneous burning (or combustion).

96. Spontaneous combustion is different from most other fire hazards in that the substance is both the fuel and the ignition source. Where spontaneous combustion could occur mine owners and managers should still apply the same risk avoidance and control principles that they apply to the risks arising from other fire hazards to determine the measures they need to take to reduce those risks to as low as reasonably practicable.

97. While coal mines with spontaneous combustion prone seams have by far the highest hazards, spontaneous heating can occur at other mines in sawdust, solvent soaked rags and in

piles of other organic substances. Apart from coal, mines can generally avoid other potential sources of spontaneous heating and combustion through good housekeeping.

98. Some coals are more liable than others to spontaneous combustion. The 'crossover temperature method' is perhaps the simplest method of estimating how prone to spontaneous combustion a particular coal seam in a particular locality might be. In the UK coal seams have been worked for so long that their properties are well known and well understood and may not need further investigation.

99. Further investigation may be necessary if circumstances suggest the mine may be moving into an area of the seam with different spontaneous combustion characteristics; for example, if there is an increase in the frequency or seriousness of spontaneous heating. Where a mine owner does not have the in-house expertise to investigate properly whether a seam's characteristics have changed, they should engage a competent third party.

100. Coal mine owners should have in place an adequate policy and procedures for the prevention and control of spontaneous combustion. For each of their mines they should:

- Designate the seams that are liable to spontaneous combustion;
- Ensure that the manager has in place an appropriate plan to prevent and control spontaneous combustion, bearing in mind the circumstances at that mine;
- Ensure that there are procedures in place to implement the suitable and sufficient measures identified in the plan to prevent and control spontaneous combustion;
- With the manager, ensure that there is a person appointed to the mine management structure responsible for overseeing the operation of the plan;
- Ensure that mines include these measures in their fire protection plans;
- Ensure that both the owner and manager's plans are regularly reviewed and, if necessary, amended.

101. Further guidance on spontaneous combustion and control measures can be found in Annex 2, which also contains references to other useful guidance.

**Control of flammable materials below ground**

102. The requirement to limit to the amount strictly necessary the quantity of flammable materials taken below ground in mines is contained in Schedule 1 of the Mines Miscellaneous Health and Safety Provisions Regulations 1995. For diesel fuel, regulation 27 of the Coal and Other Mines (Locomotives) Regulations 1956 provides for further controls on the amount of fuel oil that may be kept below ground at some mines. Regulation 32(2) of the Miscellaneous Mines (General) Regulations 1959 prohibits the storage of oil and other flammable materials at any place below ground containing electrical apparatus.

103. In addition to controlling the amount and types of flammable materials that are taken below ground, owners and managers will also need to ensure that there is a system in place to remove waste promptly from any areas of risk to reduce the fire load present. This will include for example, wood off-cuts, rags, packaging materials, tyres and other flammable parts of equipment etc.

104. The fire protection plan will need to set out measures to control the amount and location of flammable materials below ground. This includes limiting the amount of:

- Non-metallic materials used; e.g. plastics/fibreglass, rubber, wood;
- Flammable liquids stored and used below ground;
- Flammable waste.

105. Owners and managers of all mines, particularly coal and other safety lamp mines, should avoid taking highly flammable materials below ground. For coal mines, regulation 2(1) of The Coal

and Other Mines (Fire and Rescue) Regulations 1956 requires any highly flammable material that is stored below ground to be kept in a fireproof room, compartment or box.

**Fire resistant materials in structures above and below ground**

106. Fires can also be spread by materials used in the construction of buildings and structures above and below ground. This threat can be mitigated by ensuring that only fire resistant materials are used to construct:

- Electrical sub-stations;
- Transformer houses;
- Engine rooms or motor rooms;
- Battery charging and battery transfer stations;
- Booster fan sites and roadways for 25m on the return side(s) of the booster fan(s);
- Fuel stores and refuelling points;
- Places used for the storage of explosives (other than compartment linings);
- Other buildings or structures housing materials or equipment that could give rise to a significant fire.

107. Firedamp drainage ranges passing through any of these places should use highly fire resistant pipes, such as those made from steel or phenolic GRP, to minimise the likelihood of a flammable gas release into a fire.

108. There are some relevant legal requirements. For coal mines, regulation 2(2) of The Coal and Other Mines (Fire and Rescue) Regulations 1956 has the effect of requiring buildings or structures at the top of shafts or outlets should be made of fire resistant material, because in the event of fire, the smoke and toxic gases could be drawn down into the shaft or outlet and subsequently into the mine itself.

109. Regulation 2(3) of those Regulations introduces the same requirement to use only fire resistant materials in engine-rooms or motor rooms below ground at coal mines. These will include any places where fixed equipment is driven by either diesel engines or electric motors, such as pump lodges and booster fan sites.

110. Also for coal mines Part 3 of the Model Rules on Mine Fires, which form guidance on The Coal Mines (Owner's Operating Rules) Regulations 1993, contains further recommendations in relation to fire precautions in winding engine houses; the principles in these are also relevant to owners and managers of non-coal mines.

111. While regulations 31 and 32 of the Miscellaneous Mines (General) Regulations 1959 do not prohibit the use of flammable materials in structures above and below ground at such mines, they place additional requirements in relation to fire fighting and control of the fire risk respectively. However, such mines should use fire resistant materials in structures wherever practicable.

112. Fires in cable ducts on the surface have also led to smoke being drawn down shafts, so these should also be constructed of fire resistant materials and be sealed at the shaft side.

113. Where equipment contains flammable materials, for example, winding engine transformers that contain large volumes of mineral insulating oil, it should be sited well away from the shafts.

**Toxic fumes from non-metallic materials**

114. Certain types of non-metallic materials produce high levels of toxic fumes when burnt, e.g. polyurethane foams and urea-formaldehyde foams, therefore these materials should not normally be used below ground at a mine. This does not apply to some personal protective equipment containing small amounts of polyurethane. Neither should they be used at the surface of a mine in such a place that the products of their combustion would be likely to enter the mine.

## Detecting fires and raising the alarm

115. Fires and spontaneous heatings affect their surrounding environment, and these changes can be detected and monitored using fixed-point environmental monitors, hand-held monitors and the analysis of air samples. The primary purpose of a fire detection system is to give an early warning to those who may be affected by fire, so that they can either commence fighting the fire if it is safe to do so, or to evacuate to a place of safety.

**Modern vortex flow sensor for measuring the general body air velocity**

116. Fire detection and warning systems are not a substitute for effective fire prevention measures. The principal means of detecting fire are patrolling and inspection, the use of fixed and portable environmental monitors and, in some cases, laboratory analyses of air samples.

117. The fire risk assessment should identify fire hazards and those areas where people are potentially at risk; this will help to determine what fire detection measures are needed.

118. The measures that it is reasonably practicable for a mine to take will vary according to the level of risk within the mine.

119. At some mines fire risks will be high and it will be reasonably practicable for owners to install a comprehensive environmental monitoring system as well as providing hand-held monitors and taking and analysing air samples at places at particular risk.

**An exploded view of a modern, hand-held, multigas sensor that will simultaneously monitor the concentration of up to five different gases together with temperature, atmospheric pressure and air velocity.**

**(**The black object in front of the instrument is an interchangeable sensor head, allowing customisation of the instrument to meet user needs.)

120. Any properly sited and maintained environmental monitor will increase safety, even at low risk mines, particularly where they monitor areas of the mine where people do not regularly pass.

### *Patrolling and inspection*

121. Patrolling and inspection play an important part in both fire prevention and fire detection. People carrying out this work properly can identify where standards are deteriorating and instigate remedial action before the situation becomes hazardous. Such inspections may also identify abnormally hot surfaces or other hotspots, e.g. bearings overheating or smouldering materials that may lead to a fire.

122. In the majority of cases when fires have occurred people have discovered them before environmental monitoring systems have generated a warning or alarm. Therefore, even where mines use fire-detection and equipment monitoring systems managers will still need to make arrangements for regular inspections and checks.

123. Managers will need to determine the level of patrolling necessary to address the fire risks present; the higher the residual fire risk after all reasonably practicable fire prevention measures have been taken, the shorter the interval should be.

124. Those appointed to inspect districts where significant fire risks exist should carry a suitable hand-held fire detector; for example, a carbon monoxide detector or detector tubes and pump.

125. At mines where the residual fire risk is low managers may decide that the regular inspections carried out by supervisors and maintenance personnel in accordance with the provisions of regulations 12 and 11 respectively of The Management and Administration of Safety and Health at Mines Regulations 1993 are sufficient to secure safety. At mines where the residual fire risks are higher, for example because of the presence of flammable dust, then additional patrolling will probably be required.

126. Portable infrared detectors, known as thermal imagers, are very sensitive devices that can detect elevated temperatures due to, for example, failing mechanical or electrical components or spontaneous combustion. They present the information as a visual image and are easy to use and will help those making inspections to determine potential ignition sources.

127. For coal mine owners and managers further information on the patrolling and examination of belt conveyors is contained in Part 2 of the Model Rules on Mine Fires.

### *Fixed environmental monitoring*

128. Examples of areas where the use of fire detectors should be considered include:

- At intervals along main intake and return roadways;
- On the intake and return sides of main working areas;
- On the return side of any conveyor drive, conveyor tension unit (loop take-up), delivery head roller or return end roller;
- Within sub-stations or any other place containing significant amounts of equipment that could cause fire;
- Areas where flammable materials are kept;

and on mine surfaces in:

- Unattended winding engine houses;
- Firedamp drainage houses and places where the heat content of drained gas is measured;
- Rooms containing gas-fired plant;
- Main ventilating fan houses.

129. There are various types of monitors which detect:

- Carbon monoxide levels:

- Products of combustion;
- Volatile organic compounds;
- Smoke.

130. Not all types of fire detectors are suitable for all circumstances. For example:

- Products of combustion detectors will not work reliably in return airways as they are sensitive to small concentrations of fumes and naturally occurring hydrocarbon gases in the general body of mine air. Neither will they work reliably in areas subject to large fluctuations in temperature and pressure;
- Some smoke detectors are unsuitable for use in high velocity airstreams.

131. Where there is any doubt about the suitability of a particular type of fire detector in a particular location, or where a mine has insufficient expertise to properly manage the monitoring system, the owner or manager should seek the advice of a competent person.

132. Mines should have in place procedures to ensure that they site monitors to give the best chance of detecting a fire, or impending fire, at a very early stage. Managers therefore need to ensure that they have effective arrangements for positioning, installing, and commissioning them.

133. Those responsible for positioning the detectors will need to consider the presence or otherwise in the general body of mine air of:

- Diesel exhaust fumes;
- Shotfiring fumes;
- Solvent vapours;
- Oils;

and, the effect on airflow of the passage of men, materials and vehicles.

134. Detectors should be sited in the best possible place for detection whilst ensuring facilities are provided to allow easy testing and maintenance.

135. Prior to installation those installing fire detectors should use artificial smoke, released near each potential fire source, to determine the best position for each detector.

136. For smoke detectors an aerosol spray should be used to check that a detector is functioning correctly after installation. Do not use artificial smoke for the post-installation check as its particles may coat the sensor and reduce its sensitivity.

137. Mines will need to check that fire detector positions are still appropriate following any change to the ventilation system changes (velocity, direction of the airflow etc) that might affect the ability of a detector to detect a fire. Similar checks should be made if the installation of plant or equipment close to a detector is likely to affect the airflow past it.

138. Products of combustion, volatile organic compound and carbon monoxide detectors should be sited far enough downwind from the fire hazard they are monitoring to ensure adequate air mixing.

139. Tube bundle type detectors, which take a sample from the mine air through narrow bore tubes to the surface for analysis, are more accurate but there is a time delay between the sample being drawn into the tube and it being analysed on the surface. The delay corresponds to the time taken for the air to travel from the sampling point along the tube to the surface and will therefore vary according to location.

140. The delay between sample acquisition and analysis means that tube bundle systems are of limited help to decision making in circumstances where gas concentrations fluctuate rapidly. They are good for establishing trends over longer periods. They will also remain operational where real-

time signals from instantaneous detectors have been lost due to an incident, and for this reason they can prove extremely useful to mines rescue personnel.

141. Electrical CO transducers can give instantaneous readings both at or close to the detector and remotely at the surface.

142. There should be a sufficient number of detectors and/or sampling points throughout the mine to enable trends to be established at particular locations.

143. Another means of detecting potential fires on fixed plant is by the use of infrared heat sensors. This method does not rely on measurement of any resultant fire products in the environment but detects the rise in infrared radiation as a result of increasing temperature of the faulty machinery component. Fixed point, non-contact infrared detectors are available which can be sited to protect high-risk components.

### *Air samples*

144. Where mines take samples for laboratory analysis, for example where coal mines take such samples as a way of complying with Part II of The Coal and Other Mines (Ventilation) Regulations 1956, those taken at places in districts liable to spontaneous combustion should be analysed for carbon monoxide.

145. Air samplers should use only stainless steel sampling tubes where the analysis is to include a determination of the hydrogen concentration.

146. The records of these analyses should be kept in such a way as to make obvious any departure from the normal or expected trend.

147. The results of analysis for carbon monoxide of air samples taken from firedamp drainage systems or pack pipes can also give useful information on the early onset of spontaneous heating.

### *The Graham ($CO/O_2$ deficiency) ratio*

148. The Graham ratio is a derived parameter with carbon monoxide produced by the heating as the numerator and oxygen absorbed by the oxidation process as the denominator. Both values are obtained from the same sample and so both are equally affected by any fluctuation in ventilation. The ratio is a very sensitive indicator of the onset of spontaneous combustion and its rise proof increasing severity of the heating. It is the most important single parameter for a mine to monitor in order to keep a regular check on its trend. It should be used with other gas analyses to assess more precisely the progress of spontaneous heating.

149. The trend of the Graham ratio during a heating shows a gradual rise followed by an eventual sharp increase in value as the heating develops. Mines can quickly establish a normal value for the Graham ratio for each part of the mine where spontaneous combustion may occur and can therefore readily determine small deviations that might indicate a heating. When the oxygen deficiency is less than 0.1% or the carbon monoxide concentration is less than 10ppm mines will need to take account of the fact that a small change in either quantity may cause a large change in the ratio.

150. The Graham ratio cannot be applied when the oxygen concentration is modified by the use of nitrogen injection'.

151. Annex 2 contains further information, including references to other useful guidance.

## Particular situations

### *Conveyor transport systems*

152. While this section relates principally to coal mines, non-coal mine owners and managers may wish to follow these recommendations to further reduce risks and to minimise the chance of operational disruption. Further guidance is given in Part 2 of The Model Rules on mine fires, which accompany The Coal Mines (Owner’s Operating Rules) Regulations 1993.

153. A conveyor belt fire at a coal mine can be particularly serious as it can spread to the product on the belt and, in the most serious cases, to the coal in the roadsides.

154. In the early stages of conveyor belt fires the products of combustion are likely to include gases other than CO given off by the heating of the belt material. In intake airways POC monitors offer the best option because they can detect a range of gases, including hydrogen, alcohols and phenols.

155. On intake roadways, levels of contaminants that may affect POC monitors are normally low and there is little change in the background level. This allows the POC sensor to be set at its optimum sensitivity.

156. As the conveyor drive, loop take up and return end roller have the highest likelihood of causing a significant fire mines should install suitable fire detectors downstream of the units that they are designed to protect.

157. One monitoring point downstream of an in-line transfer point could detect a fire on any of the three units. In the case of conveyors where the transfer point is several hundred metres from the drive and loop, the transfer point and the drive and loop should be separately monitored.

***Single entry working places***

158. Mines should use either CO or POC detectors to monitor the air going into single entries. Where the air is not greatly affected by diesel exhaust or shotfiring fumes, or other contaminants POC monitors should be used. Otherwise CO monitors would be more suitable.

159. Where the manager has decided that more than 9 but not more than 18 people will work in a single entry regulation 7(5)(c) of the Mines (Safety of Exit) Regulations 1988 requires the manager to make suitable rules for the safe working in and exit from that place. Paragraph 32(a)(vii) of the Approved Code of Practice indicates that the rules should specify precautions including a fire detection system with automatic alarm.

160. For force-ventilated single entries the monitor(s) should be sited on the intake side of the auxiliary fan but close enough to give a reading representative of the air that it draws in.

161. Return air from force-ventilated single entries should be monitored using a carbon monoxide detector with the detector head sited in the general body of mine air within the single entry close to the outbye end. However, the local display unit should be sited in the main ventilation circuit on the intake side of the entrance so that people can still read it if a fire occurs.

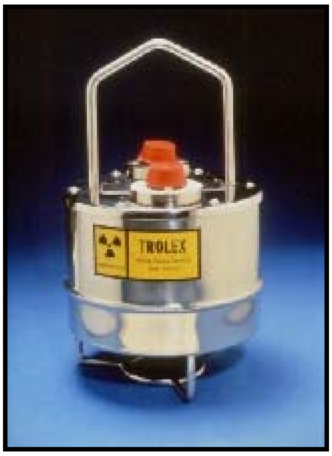
162. For exhaust-ventilated single entries the monitor(s) should be sited on the intake side of the entrance to the single entry and arranged to give a reading representative of the air being drawn into the single entry.

163. In both cases mines should arrange the monitoring system to alert people in the single entry to the presence of abnormal levels of products of combustion or carbon monoxide, so that they can start to evacuate, as well as generating an alarm at a manned point.

164. For single-entries over 1,000m long, mines should consider installing intermediate detectors to give an earlier warning of any fire or heating part way along the single entry.

***Battery charging stations***

165. Smoke detectors are suitable for use in battery charging stations. Carbon monoxide monitors should only be used as fire detectors in battery charging stations in conjunction with a hydrogen detector, as hydrogen from the charging process can affect the CO sensor. If the CO sensor and hydrogen sensors both show increased readings then hydrogen pollution may be the cause of the apparent rise in CO, although a visual inspection will be necessary to confirm this. If only the CO reading increases it may indicate that a fire has broken out.




**Intrinsically safe (IS) smoke detector. No longer manufactured but likely to remain in service with current users for many years.**

**Alarm systems**

166. The location of audible or visible fire alarms will depend on the layout of the mine and the likely rate that smoke and fumes from a fire would spread. Mines need to design alarm systems to provide immediate warning to anyone who may be at risk either in the vicinity or on the return side of a fire.

167. Where underground fixed environmental monitoring equipment is connected to a data acquisition and alarm system there should also be provision for a local indication below ground.

168. There also needs to be a system for people to raise an alarm. This can be via the telephone, intercom or radio system, which usually include audible alarms that people can activate.

169. At larger mines surface control room operators will supervise the alarm system, and pass on information and warning messages to other persons in the mine, including those managing any emergency situation. They will need instruction and training to do this.

170. Smaller mines with simple monitoring and alarm systems but no control room should arrange for a repeater alarm at an appropriate point on the mine surface where it can be heard by someone who can react and, where necessary, initiate the mine emergency plan. Surface personnel will need appropriate training or instruction in these procedures.

**Alarm levels**

171. Setting appropriate alarm levels is key to an effective monitoring and warning system. Trigger levels should not be set so high that they do not generate an alarm until a fire is well established, neither should they be set so low that they repeatedly generate false alarms; for instance when a diesel-powered vehicle passes a detector.

172. As with equipment monitors a senior member of the management structure should be responsible for:

- Setting warning and alarm levels;
- Ensuring that these are reassessed periodically or following any significant change in circumstances;
- Prioritising them.

173. The setting levels for individual monitors should be recorded as part of the planned preventative maintenance scheme and should not be changed without permission from the responsible person.

***The multi-discriminatory alarm system (MDA)***

174. The successful management of a spontaneous heating relies on the early detection of carbon monoxide, which means that an alarm is required at low concentrations of the gas. This

can often be just a few parts per million and well below peak concentrations associated with diesel exhausts and shotfiring fumes.

175. MDA is a computer program that is applied to the detection of spontaneous heating and fires. It is designed to trigger an alarm on detection of low probability events, such as spontaneous heating, and to ignore high probability events, such as increases in carbon monoxide from diesel exhausts or shotfiring. Because MDA alarms will ignore transient peaks they can be set to be more sensitive to a gradual increase in carbon monoxide and will therefore generate an alarm at an earlier stage in the development of a heating. They also reduce the number of false alarms.

### Testing and inspection

176. The manager's scheme of maintenance required by regulation 11 of The Management and Administration of Safety and Health at Mines Regulations 1993 should set out the arrangements for testing and inspection of individual detectors and of the alarm systems at regular intervals. This should include sending them away periodically for recalibration.

## FIRE FIGHTING

### Fire-fighting measures

177. The fire risk assessment will help managers determine what type of fire-fighting equipment is appropriate and where to site it.

### Selection and siting

#### *Selection*

178. In selecting fire-fighting equipment, managers will need to take account of the nature of the fire hazard. This is particularly important if the fire might involve electrical equipment and/or flammable liquids.

#### *Siting*

179. For coal mines, Part II of The Coal and Other Mines (Fire & Rescue) Regulations 1956 contain provisions relating to fire precautions and equipment, and the Model Rules on Mine Fires, guidance on the Coal Mines (Owner's Operating Rules) Regulations 1995 gives guidance on the provision of fire-fighting equipment both above and below ground.

180. For other mines, regulations 31 and 33 of the Miscellaneous Mines (General) Regulations 1959 require the provision of suitable and sufficient means of extinguishing fire at certain places both above and below ground. For further guidance, owners and managers of such mines can refer to the Model Rules on Mine Fires and select the systems and equipment appropriate to their circumstances.

181. Where groups of people work immediately on the return side of areas or equipment giving rise to a higher likelihood of fire, fire-fighting equipment should be grouped to form fire points on the intake air side of the vulnerable areas or equipment. Paragraphs 29-31 of the Model Rules give further guidance on fire points.

182. In areas of the mine where a fire would have particularly high consequence; in particular where more than 50 people work in an area with only one intake, or where there are long single entries, mines should consider as part of their control measures installing automatic fire suppression systems to cover machinery and equipment that might cause a significant fire.

183. In return airways to longwall faces fire-fighting equipment should be kept as close to the face end as is practically possible.

184. In auxiliary ventilated single entries, the fire-fighting equipment within the single entry should be on the intake side of vulnerable equipment within the single entry. Fire-fighting equipment should also be located within the main ventilation circuit, close to the single-entry entrance on the intake side.

185. Fire-fighting equipment should be clearly visible and its location conspicuously indicated with a reflective sign. The Health and Safety (Safety Signs and Signals) Regulations 1996 are relevant and describe suitable signs. It is important that users are able to gain access to the equipment without exposing themselves to risk. Such equipment should not be sited beneath or on the tight side of conveyors or other equipment.

**Fire extinguishers**

186. Mines should site fire extinguishers:

- In conspicuous positions close to any machinery or equipment that gives rise to the fire risks. Below ground it should be sited on the intake side of the fire risk and in buildings it should be sited close to fresh air;
- On diesel-powered or electrically powered mobile plant and equipment;
- At places where flammable materials are stored;
- In other locations indicated by the outcome of the fire risk assessment.

187. Managers should ensure that fire extinguishers are suitable for the type of fire that may occur and that they have adequate capacity to either extinguish the fire or to contain it sufficiently long enough to allow people to escape. In deciding what is appropriate, managers will need to consider:

- What type of fire might occur;
- What other fire fighting measures are available; for example, mains water, dust or sand;
- What backup provision needs to be made against the possibility that an extinguisher could fail to operate, particularly in safety-critical locations such as winding houses, intake airways or locations where a fire could threaten an escape route.

188. Fire extinguishers should be provided near electric motors (other than those that are part of portable apparatus), transformers or switchgear (including electrical sub-stations, transformer houses, motor rooms and panel trains), workshops below ground (especially those where burning and welding take place), and battery charging and transfer stations.

189. Regulation 5(1)(b) of the Coal and Other Mines (Fire and Rescue) Regulations 1956 specifically requires managers of coal mines employing more than 30 people below ground to provide sufficient portable fire extinguishers and a sufficient supply of dust and sand.

190. Regulation 7(b) of those Regulations requires at least one fire extinguisher, or a sufficient supply of dust or sand, to be carried on mineral cutting equipment where there has been, or is likely to be, and ignition of gas.

**On-board fire fighting systems**

191. Where diesel-powered machines are used underground, they should carry both portable fire extinguishers and should be fitted with a fixed fire-quenching system containing sufficient outlets to cover the main potential fire sources.

192. Automatic fire-quenching systems should be capable of manual operation from the operator position and, on large machines, from at least one other suitable position on the outside structure of the machine.

**Automatic fire extinguishing system fitted to a rubber-tyred, diesel vehicle for use below ground**

193. Where vehicles or other equipment are fitted with a fire-quenching system that relies on the melting of a pressurised plastic tube to release the quenching agent, there is no need to provide for manual operation. The pressurised plastic tube should be carefully routed as close as practicable to the potential fire sources to ensure prompt discharge of the extinguishant. However, the use of such systems should be confined to smaller vehicles and equipment.

194. Battery-powered machines should be fitted with suitable means of extinguishing both battery fires and other types of fire.

**Other fire suppression systems**

195. Managers should consider installing water barriers, water curtains or other automatic fire suppression systems where the risk assessment identifies places where the response to a fire alarm may be delayed; for example, unattended equipment such as pumps and booster fans that operates in remote locations. While such barriers generally operate automatically by means of a fusible link, manual initiation from a remote point may be desirable where this provides the most effective system to suit the local conditions.

196. When barriers protecting electrical equipment operate automatically, mines should provide a circuit breaker to de-energise the equipment immediately the automatic system operates. This should be arranged to provide an indication to a manned control point that the barrier has operated.

197. Where tensioned wires with fusible links are used in automatic water barriers, a weight or spring applied tensioning system should be provided to ensure that the correct tension is maintained. The automatic valves should be sited out of the anticipated fire-zone and supply lines in the vicinity of the fire-zone should be of steel pipes with fire-resistant couplings. Hoses should not be used.

198. Facilities should be provided to enable routine testing of the automatic fire suppression system.

**Mains water fire-fighting systems**

199. At places where there are unavoidably large amounts of fuel giving rise to the possibility of a significant fire, it is unlikely that portable fire extinguishers will have sufficient capacity to extinguish such a fire. Where water is suitable as a fire-fighting medium, managers will need to consider providing a fire-fighting water distribution system, with sufficient hydrants, hoses and other fire-fighting equipment.

200. Managers and mechanical engineering staff should ensure that the pressure in water ranges is limited to a safe value, so that it neither exceeds the pressure rating of the pipe work or gives rise to undue risks to workers opening valves. It may be necessary to install pressure-limiting devices to achieve this.

201. At coal mines employing 100 people or more, regulation 6 of The Coal and Other Mines (Fire and Rescue) Regulations 1956 requires the provision of adequate supplies of water and the

means of delivering it at adequate pressure and volume to places in the mine where people work or pass where a fire is liable to occur.

202. Managers of coal mines will need to ensure that the fire fighting system has sufficient capacity to meet a major fire in the coal seam itself.

203. Where water is unsuitable for fighting potentially large fires, mines should provide high capacity fixed or mobile fire fighting equipment.

**Fire hoses**

204. Paragraphs 29 and 30 of Section 2 of The Model Rules on Mine Fires give guidance on the requirements for fire hoses at coal mines, but its principles apply to other mines where mains water is provided for the purpose of fire fighting.

205. There should be sufficient hoses close to each hydrant on the intake side to reach from the hydrant to the potential fire sources it protects, or to the next hydrant. In long conveyor roadways there should be sufficient fire hoses to enable fire fighting to take place at any point in the roadway.


**A well laid out and maintained fire point below ground in a coal mine**

206. At least one suitable nozzle should be provided with each set of fire hoses.

207. Fire hoses are vulnerable to damage and therefore need storing carefully. They should be placed in racks suspended above floor level, or in suitable containers, and positioned to reduce the likelihood of them being struck or run over by passing vehicles or their loads.

208. Hoses should be coiled ‘male-end-out’ so that they can be connected to the hydrant or the previous hose and run out downstream under tension to avoid kinking.

209. Hoses should not be tied in a reel but should be free to be run out.

210. Fire hoses should not be used for purposes other than fire fighting.

**Inspection, testing and maintenance of equipment**

211. The inspection, testing and maintenance of fire-fighting equipment (including fire-fighting systems on board vehicles) will fall within the requirements of both regulation 11 of The Management and Administration of Safety and Health at Mines Regulations 1993 and regulations 5 and 6 of The Provision and Use of Work Equipment Regulations 1998.

212. Fire-fighting equipment should be included within the manager’s scheme for planned preventative maintenance.

213. Regulation 9 of the Coal and Other Mines (Fire and Rescue) Regulations 1956 requires managers of coal mines to put in place arrangements to ensure that:

- All fire fighting equipment is inspected by a competent person at intervals not exceeding 30 days;
- Each fire extinguisher is discharged and refilled by a competent person, at intervals not exceeding those specified by the manufacturer or supplier.

214. Paragraphs 32 and 33 of the Model Rules on Mine Fires, in The Coal Mines (Owner's Operating Rules) Regulations 1993, give guidance to coal mine owners on the testing of fire fighting equipment. Further relevant guidance on the testing and maintenance of fire extinguishers can be found in the HSE/Home Departments' publication 'Fire Safety, an employer's guide'.

215. Those carrying out periodic tests should complete reports of their findings as required by The Management and Administration of Safety and Health at Mines Regulations 1993, regulation 11(4), and at coal mines by Coal and Other Mines (Fire and Rescue) Regulations 1956, regulation 9(2).

216. Inspectors appointed under regulation 12 of The Management and Administration of Safety and Health at Mines Regulations 1993 and assigned to a zone should ensure that fire-fighting equipment in that zone is kept clean and free from damage, and is adequately identified by signs.

217. Where water ranges and hydrants are installed, mines should put in place arrangements to ensure that hydrants are opened periodically to check that they remain in working order. They should also examine the physical condition of the hydrant outlet to ensure that hose connections can be freely made. Similarly they should check the connectors at each end of the fire hoses for any sign of damage that might prevent them coupling and, where possible, check the operation of the snap-locks on the female ends (in the middle of each coil) by pulling the snap-locks out and checking that they return freely.

218. They should note any defects on the report they are required to complete at the end of each shift by regulation 12(8) of The Management and Administration of Safety and Health at Mines Regulations 1993. Wherever possible, they should try to either remedy the defective equipment within their shift or ensure that it is dealt with on the next working shift.

**Training**

219. The Fire Protection Plan will identify the need to train or instruct mineworkers in fire fighting techniques, and managers should include the arrangements for such training within the training scheme required by regulation 25 of The Management and Administration of Safety and Health at Mines Regulations 1993. The training should be appropriate to the fire hazards identified by the Fire Risk Assessment and the fire fighting measures provided.

220. The scheme should specify who has responsibilities for fire fighting training, both on the surface and below ground. It will also include details of:

- The type of training and refresher training;
- The frequency at which to carry out particular types of training and refresher training;
- Who should receive training (see paragraphs 3 and 4 of the Model Rules on Mine Fires, which form guidance to The Coal Mines (Owner's Operating Rules) Regulations 1993);
- Who should deliver the training;

221. The training scheme should also set out arrangements for on-site instruction and practice in fire fighting.

222. Every person at a mine who may need to use fire-fighting equipment should receive refresher training annually. In addition, they should receive instruction at intervals not exceeding six months; for example, by on-site briefing (toolbox talks) given by a command supervisor who has received suitable training. Paragraphs 5-7 of the Model Rules on Mine Fires give further guidance useful to all mines.

223. The content of the training sessions should include:

- Raising the alarm;
- When to attempt to fight a fire and when not to;
- Types of fire extinguishers and their use;
- Fire prevention measures;
- Means of egress in an emergency situation.

***Surface personnel***

224. At mines where there are office and canteen personnel, instruction on the action to be taken in the event of fire needs to be given at least every twelve months. This should include as appropriate:

- Practice in the evacuation of the premises;
- How to deal with fires;
- Use of fire hoses and attachments;
- Practice in the operation of fire extinguishers; and
- Such other provisions that are required by any fire certificate.

**ARRANGEMENTS FOR EVACUATION**

225. Guidance on safe evacuation and rescue in an emergency situation is contained in the Approved Code of Practice to the Escape and Rescue from Mines Regulations 1995.

226. Further information on the use of self-rescuers is given in the HSE guide 'Guidance and information on escape and rescue from mines' (HSE Guide L71, ISBN 0-7176-0939-1) available from HSE Books.

## EXPLOSION RISK ASSESSMENT

227. This section contains information on matters solely related to explosion hazards. It relates mostly to gas explosion hazards in coal mines and in other safety lamp mines where flammable gas may be present. However, there are parts that deal with hazards that arise from substances taken into mines, such as paints, fuels and explosives, which will be applicable to all mines using those substances.

### The risk of explosion

228. Where a dangerous substance is, or is liable to be, present at the workplace regulation 5 of The Dangerous Substances and Explosive Atmospheres Regulations 2002 requires, the employer to make a suitable and sufficient assessment of risks that arise from the use of that substance.

229. Mine owners should assess the potential for explosive atmospheres to occur in their mines arising from the presence in the general body of mine air of flammable gas, dust, mist or vapour. They will also need to assess the risks to workers arising from explosions associated with substances taken into the mine.

230. Mine owners should consider this as part of the overall risk assessment required by regulation 3 of The Management of Health and Safety at Work Regulations 1999.

231. Regulation 4(1) of The Mines Miscellaneous Health and Safety Provisions Regulations 1995 requires mine owners to prepare a health and safety document that demonstrates that risks have been assessed in accordance with regulation 3 of The Management of Health and Safety at Work Regulations 1999. The significant findings relating to explosive atmospheres must be taken into account when determining the protective measures in the Explosion Protection Plan required by regulation 4(2)(a) of The Mines Miscellaneous Health and Safety Provisions Regulations 1995.

232. The risk of an explosive atmosphere occurring and its consequences will vary from mine to mine, depending on the type of mine, its layout, the mineral being extracted and the likelihood of flammable gases, flammable dust, or mist or vapours occurring in potentially explosive concentrations. In some mines there may be places where gas explosive atmospheres are very unlikely to occur, but where there might still be an explosion hazard due to the presence of potentially explosive concentrations of flammable dust in air (e.g. within a bunker), or of a mist or vapour.

233. Explosive atmospheres may not only cause a hazard at the place where they occur, but also along the mine’s return airways and any other interconnected roadways in the mine workings, even if it is only for a short duration and/or at a particular location. This has the potential to expose large numbers of people to significant risk, so the risk assessment will need to consider how the explosion might spread through the mine.

234. Gas explosions have been responsible for the vast majority of dust explosions in mines, where the turbulence from the explosion has raised clouds of dust into the air in sufficient concentrations to form an explosive dust atmosphere. This is then ignited by the burning firedamp to cause a much more violent explosion. However, there have been a few flammable dust explosions in mines that have occurred in the absence of an initiating firedamp explosion. These have resulted from catastrophic failures of mineral transport systems, or from the use of inappropriate explosives, or from the use of explosives for other than their intended purposes.

235. The risk assessment will therefore need to consider whether there are circumstances and/or areas of the mine where flammable gas (usually firedamp) is not normally likely to be present in quantities sufficient to form an explosive atmosphere but where there is a potential for a flammable dust explosive atmosphere due to:

- For example, the breakage of a mineral-carrying conveyor on a steep gradient;
- Shotfiring operations.

236. A Health and Safety Laboratory research report **HSL/2002/24** ‘**Development of a Fire and Explosion Risk Assessment Methodology for Underground Mines** is posted on HSE’s website and contains a structured fire and explosion risk assessment model.

### Explosion hazards

#### *Mists and vapours*

237. Some substances give off mists or vapours at ambient temperature and pressure and can form explosive atmospheres. These will include:

- Petrol;
- Cellulose-based paints;
- Aerosols commonly used as an aid to starting diesel engines above ground.

238. Diesel fuels, most mineral oil lubricants and resins used for strata control purposes can also give off vapours although these are not normally explosive at ambient temperature and pressure, but may become so in a fire.

#### *Flammable gases*

239. The potential for an explosive atmosphere is present at all coal mines and may be present at other mines; for example, those working in, or close to, coal measures or other hydrocarbon-bearing strata.

240. At other mines where there is little or no likelihood of an explosive atmosphere caused by gas from the strata, owners and managers will still need to consider circumstances in which a flammable gas explosive atmosphere may occur due to work activity, such as:

- A hydrogen flammable atmosphere due to lead-acid battery charging;
- A flammable atmosphere resulting from some mishap with flame welding or cutting equipment.

241. Where flammable gases are present in mines, ventilation systems and, where necessary, firedamp drainage systems should be of sufficient capacity to keep concentrations in the general body of mine air well below the lower explosive limit. However, the explosion risk assessment will need to take account of changing conditions that may result in flammable gas concentrations in the general body of mine air, or layering in the roof, above the lower explosive limit, such as:

- The stoppage of a ventilating fan – main, booster, auxiliary;
- Major changes to the ventilation system – for example, when forming a new air circuit;
- The concentration of gases in the mine atmosphere when sealing off part of a mine or a district. For further information, see the Institution of Mining Engineers’ publication ‘Sealing Off Fires Underground’;
- The settlement of coal mine wastes;
- An outburst or sudden emission of firedamp from the strata, including loss of gas containment during drainage hole drilling;
- The breakdown of a firedamp drainage system;
- Periods of rapidly falling atmospheric air pressure.

242. At coal and other safety lamp mines, the explosion risk assessment will also need to take account of increased flammable gas concentrations that can occur locally due to cutting and shotfiring because this will affect the type of equipment used.

### *Coal dust*

243. Sudden violent turbulence or catastrophic failure of coal transport equipment may give rise to a potentially explosive flammable dust atmosphere. The only potentially explosive dust encountered in British mines is coal dust. Depending on the type of coal, the lower explosive limit of dust in air lies between 40-60g/$m^3$.

244. The explosion risk assessment will need to consider the circumstances where an such concentrations of dust in air might occur:

- In normal operation, possibly inside bunkers;
- As a result of some unplanned event, such as following:
  - o The breakage of a coal carrying belt conveyor, particularly on a steeply inclined roadway;
  - o The inappropriate use of explosives;
  - o A high-speed crash involving coal-carrying vehicles;
- Following a firedamp explosion.

### Assessing explosion risks

245. The assessment of risks arising from explosion hazards will need to take account of the control measures that are in place. For example, in the case of potentially explosive flammable gas, mist and vapour atmospheres effective ventilation will reduce the likelihood of an explosive atmosphere occurring and will therefore mitigate the risks. In coal mines, firedamp drainage systems will remove flammable gas at source and prevent it from entering the mine air.

246. Firedamp is a mixture of naturally occurring flammable gases that forms the most common potentially explosive gas in mines. It is commonly predominantly methane and burns or explodes at concentrations between 5% and 15% in air. However, other flammable gases that can occur and may need taking into account include:

- Mixtures of higher hydrocarbon gases in the vicinity of oil bearing strata;
- Hydrogen released during battery charging and by spontaneous combustion (water gas) – explosive limits are between 4% and 74% by volume in air;
- Carbon Monoxide – explosive limits between 12.5% and 74% by volume in air.

247. In mines where flammable gas is present the assessment will need to consider what measures are necessary:

- To avoid the gas entering the general body of mine air, or where this is impracticable;
- To minimise the amount of gas entering the general body of mine air;
- To dilute that which enters the general body of mine air so that it does not form an explosive atmosphere.

248. The assessment will also need to consider:

- Whether there are any areas of the mine where additional control measures may be necessary (e.g. in single-entries);
- Any abnormal circumstances which might arise, in particular the malfunctioning of ventilation equipment or the firedamp drainage system;
- Special situations, e.g. when maintenance work is being carried out.

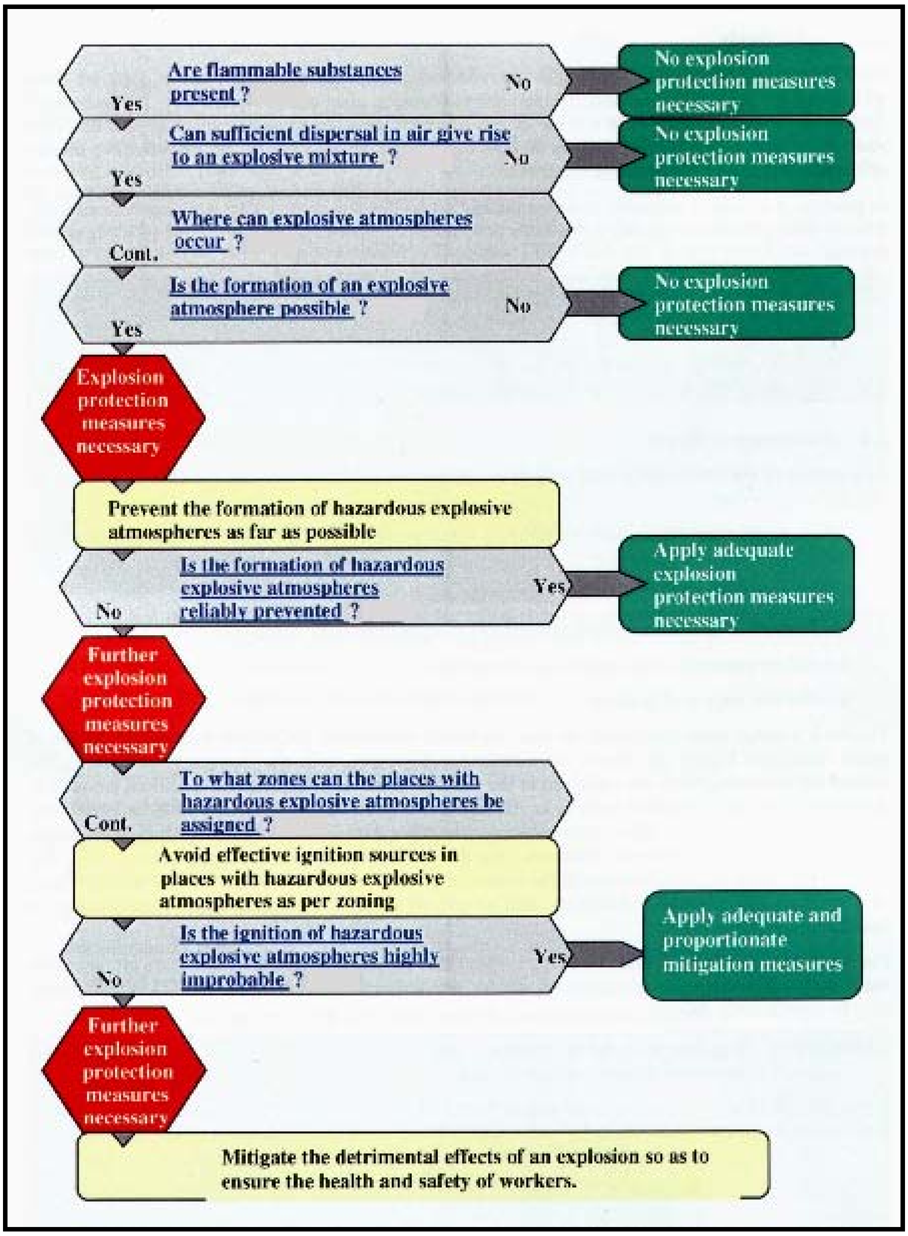
249. Comparing the measures necessary with those that are already in place will enable owners and managers to identify what, if any, further reasonably practicable measures they need to introduce to effectively control the explosion risks present.

250. Having established that all reasonable measures have been taken to **reduce** the chance of an explosion occurring, mines should identify what precautions are in place to mitigate an explosion should one occur, including:

- Stone dust or water barriers;
- The consolidation of roadway dust and spreading of non-flammable dust;
- Fire extinguishing systems etc;

and assess whether they are sufficient to properly address the remaining risks.

251. The flow chart below summarises this process:




## EXPLOSION PROTECTION PLAN

252. The fire and explosion risk assessment process will have identified the potential fire and explosion hazards present, the risks they give rise to, and the measures necessary to avoid and control those risks. The explosion protection plan required by regulation 4 of The Mines Miscellaneous Health and Safety Provisions Regulations 1995 will need to set out those measures to be taken:

- To prevent an explosive atmosphere occurring;

- To exclude, or control, potential sources of ignition;
- In the event of an explosive atmosphere of any type occurring or where the concentrations of flammable gas in the mine air exceed legal limits; and
- To mitigate the consequences if an explosion occurs.

253. The measures which will need to be set out in the plan may include:

- Firedamp drainage arrangements to control emissions of firedamp from the strata and waste areas;
- The provision of suitable work equipment; including appropriately certified electrical and mechanical equipment and, where the risk assessment has shown that there is an increased risk of frictional ignition, cutting equipment designed to minimise the risk of ignition occurring;
- Ventilation arrangements (both main and auxiliary) to control the level of firedamp in the atmosphere and prevent explosive atmospheres occurring; including the measures to provide effective ventilation to pick points and around cutting drums (rotary air curtains etc), heads and mats (venturi sprays etc);
- Procedures for monitoring, testing and preventative maintenance of safety-critical equipment;
- Arrangements for monitoring and detection of dangerous levels of firedamp by the use of portable automatic firedamp detectors at suitable places;
- Arrangements for stopping machinery, and the isolation of electrical equipment if dangerous levels of firedamp are detected; including the use, where practicable, of continuous firedamp monitoring systems that automatically de-energise equipment in the affected area;
- Arrangements for automatically cutting off power supplies to equipment in single-entries should the auxiliary ventilation system fail;
- Arrangements for safely degassing working places where flammable gas concentrations have exceeded statutorily permitted thresholds;
- The use of protective systems to mitigate the effects of any explosion; including stone dust barriers, water barriers, or flame extinguishing systems;
- Preventative and protective systems on the mine surface, such as those designed to prevent flash backs in the firedamp drainage plant;
- Any other relevant explosion control measures below and above ground.

254. The emergency arrangements identified as a consequence of the explosion risk assessment should be included within the Emergency Plan required by regulation 4 of The Escape and Rescue from Mines Regulations 1995. These will include arrangements for:

- Withdrawing workers from the affected area;
- De-energising equipment;
- Degassing affected areas.

255. Mine owners and managers should review the explosion protection plan and the emergency plan periodically or after any significant change in circumstances.

## EXPLOSION CONTROL MEASURES

256. These fall into six broad categories:

- Zoning of the workplace;

- Selection of suitable equipment;
- The prevention of explosive atmospheres;
- De-energising equipment in explosive or potentially explosive atmospheres;
- The control of other ignition sources;
- Degassing operations.

**Zoning**

257. The zoning requirements in the Dangerous Substances and Explosive Atmospheres Regulations 2002, which apply to all types of potentially flammable atmospheres, do not apply to mines either above or below ground. However, the Electricity at Work Regulations 1989, require managers of safety-lamp mines containing any zones below ground in which firedamp, whether or not normally present, is likely to occur in a quantity sufficient to indicate danger, to prepare a suitable plan identifying such zones.

258. In relation to non-electrical equipment, although the Dangerous Substances and Explosive Atmospheres Regulations 2000 zoning provisions do not apply to mines, mine owners and manager will still need to identify zones where there is an explosive atmosphere or the potential for one to occur. This is because zoning is the only basis from which they can identify equipment appropriate for use in particular circumstances.

259. The zones where different types of explosive atmospheres (gas, dust, vapour or mist) could occur may not be the same and may not even overlap, so it will be necessary to zone for each type of potential explosive atmosphere.

**The selection of suitable equipment**

260. The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 require manufacturers who supply Group I equipment (defined as equipment for use in explosive or potentially explosive atmospheres in mines) to categorise it as either M1, if it suitable for use in explosive atmospheres below ground in mines, or M2, if it is only suitable for use in potentially explosive atmospheres in mines.

261. The Regulations introduce concepts and definitions including:

- The type of explosion protected equipment;
- The categories of the explosion protected equipment;
- The way these categories are to be used in ‘explosive’ and ‘potentially explosive’ atmospheres;
- The explosive atmosphere being formed by either gas, mist, vapour and/or flammable dust under normal atmospheric conditions;
- The methods to be used for verifying that the M1 and M2 equipment conforms to the essential requirements listed in the Annexes to the Regulations.

262. These Regulations require all electrical equipment and internal combustion engines for use in explosive or potentially explosive atmospheres to be certified by a third party Notified Body. For other non-electrical equipment intended for use in explosive or potentially explosive atmospheres a risk assessment and a technical file have to be lodged with a Notified Body by a responsible person (usually the manufacturer or supplier).

263. In order to meet the essential health and safety provisions required by these regulations, the manufacturer has to undertake an ignition hazard assessment for each type or item of equipment. So where the equipment is purchased from a manufacturer or supplier they will already have undertaken this assessment and lodged a technical file with a Notified Body. However, where equipment or components are manufactured, assembled or installed by the user some of the duties

under these Regulations will fall on the user. In this case the technical file should be incorporated as part of the commissioning documents for the equipment. An example of an ignition hazard assessment for a belt conveyor is included at Annex 3.

264. In deciding whether or not equipment is suitable owners and managers need to take account of:

- Existing equipment supplied and installed before 30 June 2003 (the date that The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 came fully into force);
- Equipment placed on the market since 30 June 2003;
- Connecting together existing and new equipment.

265. Equipment put into service prior to 30 June 2003 that is not categorised as either M1 or M2 but permitted under previous legislation can remain in service, be repaired and re-used providing that it is not modified as part of the repair process and remains within the terms of its original specification.

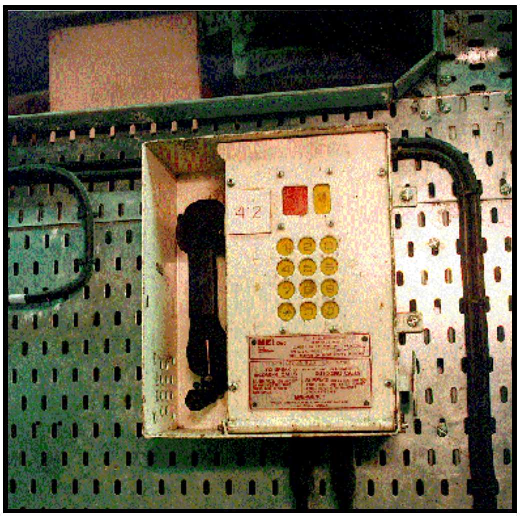
***Equipment for use in explosive atmospheres below ground***

266. When an explosive atmosphere of any kind exists, only Category M1 equipment, or equipment previously approved to remain energised, is permitted because of its very high level of protection. Such equipment is characterised by having either independent double ignition protection, or by being safe with two faults occurring independently of each other. It includes telephones, signalling equipment and gas detectors that need to continue in operation if an explosive atmosphere occurs, as well as monitors in pipe work, such as firedamp drainage ranges, which might carry explosive gas/air mixtures.

267. While cap lamps are categorised as category M2, a mines rescue team could be allowed to wear them in an explosive atmosphere for a short period of time to save life, and if an assessment of the risks involved shows that, given the circumstances the need to enter an explosive atmosphere is fully justified, and the risk of admission is within tolerable limits.

***Equipment for use in potentially explosive atmospheres below ground***

268. Where a potentially explosive atmosphere exists, both M1 and M2 equipment and their equivalents may be used. M2 equipment is suitable for use in potentially explosive atmospheres because it has a high level of ignition protection and is designed for the arduous conditions found in mines. It should be de-energised, or made safe, in the event of an explosive atmosphere occurring.



**An intrinsically safe (IS, ignition-protected) telephone for use in potentially flammable atmosphere**

### *Equipment for use in explosive or potentially explosive atmospheres on mine surfaces*

269. While the zoning requirements in the Dangerous Substances and Explosive Atmospheres Regulations 2002 also do not apply on mine surfaces mine owners and managers should consider adopting them as a means of selecting suitable equipment for surface use. Such an approach will allow mine owners access to a greater range of suitable equipment categorised by The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 as Group II – ignition protected industrial (non-mining) equipment.

### *Suitability of equipment in different explosive atmospheres*

270. The energy required to ignite a coal dust explosive atmosphere (the minimum ignition energy) is over 600 times greater than the energy needed to ignite a firedamp explosive atmosphere, and the maximum experimental safe gap (to contain a spark or flame) for coal dust particles is more than double that for firedamp. Therefore, equipment and protective systems and components that are designed and constructed for use in gas explosive atmospheres are also suitable for use in coal dust explosive atmospheres, because of their higher level of protection.

271. Where the risk assessment identifies areas of the mine where there is a risk of dangerous concentrations of coal dust, but there is little or no likelihood of a gas explosive atmosphere, then the equipment installed in these areas need only be suitably protected such that it cannot ignite an explosive dust atmosphere. However, dust protected equipment will not prevent the ignition of a gas explosive atmosphere and such equipment should be conspicuously marked that it is ‘dust protected’ only, and control measures put in place to ensure that it is not used in a part of the mine where a gas explosive atmosphere could occur.

## Preventing an explosive atmosphere occurring

272. The principal measures to prevent the build-up of an explosive atmosphere are:

- Ventilation systems (including local exhaust ventilation systems) for explosive gas, mist and vapour atmospheres;
- Firedamp drainage for explosive gas atmospheres;
- Removing flammable dust from the mine, or consolidating it so that it cannot be raised into the air;
- Where flammable dust is likely to settle, maintaining a sufficient proportion of incombustible dust in mine roadways such that an explosive dust atmosphere will not occur if it is raised into the air.

### *Ventilation*

273. Sections 55, 56, 58 and 59 of The Mines and Quarries Act 1954 set out the general duties in relation to mine ventilation.

274. Section 55(1) requires mine managers to provide and maintain adequate ventilation to all working places. Providing sufficient ventilation to dilute flammable gases to safe levels and remove them from the mine is fundamental to preventing the occurrence of explosive atmospheres.

275. The Coal and Other Mines (Ventilation) Regulations 1956 include specific provisions relating to:

- Firedamp content;
- Firedamp detectors;
- Ventilating machinery;
- Minimum ventilation quantities;
- The measurement of air quantities;
- Prevention of air leakage;

- Ventilating fans below ground.

276. The explosion protection plan should include:

- The minimum quantity and velocity of air to be delivered when working normally;
- Monitoring arrangements to check that the ventilation system is working as intended;
- Steps to be taken in the event of breakdown or maintenance etc;
- Procedures for the supervision and control of degassing operations and details of any necessary degassing equipment.

277. Where auxiliary fans are used to ventilate single-entries and where an explosive atmosphere could occur in the event of a fan stoppage, the fans should be electrically interlocked to the equipment within the blind end such that power to the equipment will be cut off automatically in the event of the fan stopping. Owners and managers of coal mines can find further guidance in the Model Rules on The Ventilation of Blind Ends (single-entries), guidance on the Coal Mines (Owner's Operating Rules) Regulations 1993. The guidance is also relevant to owners and managers of other mines where explosive atmospheres may occur.

***Measuring flammable gas concentration***

278. Regulations 3 – 8 of the Coal and Other Mines (Ventilation) Regulations 1956 require the determination at certain intervals and locations of the percentage of flammable gas in the general body of mine air (defined as 'the firedamp content').

**The miners' flame safety lamp (oil-lamp) still in use today for detecting potentially explosive concentrations of firedamp in mines. A skilled user can detect concentrations almost down to 1%**

***Firedamp drainage***

279. The majority of the requirements relating to firedamp drainage at coal mines can be found in the Coal Mines (Firedamp Drainage) Regulations 1960. These include requirements relating to boreholes, stand pipes, pipes ranges, valves, exhausters, exhauster houses and calorimeter rooms, the discharge of firedamp, and the supervision of exhausters and pressure control chambers.

280. Other relevant statutory provisions and guidance are contained in The Mines and Quarries Act 1954 and The Electricity at Work Regulations 1989.

281. A firedamp drainage system will incorporate electrical equipment, mechanical equipment and associated interconnected pipe work, and it is important that the drainage system itself does not pose an explosion risk. For this reason:

- The equipment used below ground in the firedamp drainage system must be category M1 where it is likely to be in contact with explosive atmospheres (for example, detectors in the drainage range) or M2 where the atmosphere is potentially explosive;
- Equipment or systems installed and put into use before 30 June 2003 must comply with the requirements applicable at the time it was first put into use;
- Where measuring equipment on the surface is in direct contact with firedamp/air concentrations within the explosive range (e.g. equipment used to measure the heat content or the flammable gas or oxygen content) must be either category M1 ignition protected, or, where Group II (non-mining) equipment is used, category 1;
- To comply with regulation 20 of The Electricity at Work Regulations 1989, all category M2 (or where used on the surface at mines, category 2) equipment needs to be de-energised if the firedamp concentration in the air exceeds 1.25% at any place where firedamp is extracted or its heat content/purity is measured; for example, because of a leaking pipe in the extractor house, or sampling instrument room;

282. Firedamp drainage plants that are not continually supervised should shut down automatically if the concentration of the extracted firedamp inside the extraction system pipe work becomes explosive, or approaches a prescribed limit where it will become explosive. The automatic shut-down should operate when the firedamp purity in the pipe work and extractor pumps falls below 25% by volume;

283. A firedamp drainage system should only be started or restarted in accordance with a defined procedure, as there could be a period when there is an explosive mixture passing through the pipes and extractors;

284. Suitable flame arresters (deflagration or detonation type) or flame suppression devices should be fitted at the base of the surface discharge stack to prevent flame transmission back into the mine pipe work if, for example, lightning strikes the discharge stack;

285. Where the firedamp is delivered to a utilisation plant, regulation 13 of The Coal Mines (Firedamp Drainage) Regulations 1960 requires the delivery to cease if the concentration of firedamp inside the pipes serving the utilisation plant is less than 40% by volume. However, the HSE has granted a number of exemptions from this requirement permitting the utilisation of firedamp at lower concentrations subject to conditions that ensure they pose no greater risk;

286. These Regulations require that firedamp discharge points are kept clear of ignition sources but HSE may consider permitting the flaring of firedamp, again subject to exemption conditions.

287. Mines can find more information within the HSE Contract Research Report No.326-2001, 'The effective design and management of firedamp drainage systems', which is published on HSE's website. The NCB Booklet 'The Ventilation Engineer's Handbook', still widely available at mines, also contains a lot of useful information.

***Preventing explosive dust atmospheres***

288. There are few circumstances in mines that could give rise to the 40-60g/m$^3$ of coal dust in air required to create an explosive atmosphere. However, coal dust explosions are extremely violent and mines should take steps to minimise the opportunity for coal dust explosive atmospheres to occur.

289. Coal dust is most likely to form in layers in conveyor roadways, particularly in areas:

- Where there is a high relative velocity between the mine air and mineral on the conveyor system;
- On the return side of loading, transfer or discharge points;
- In coalface return roadways.

290. Section 74 of The Mines and Quarries Act 1954 requires that mine managers take steps to minimise the amount of coal dust entering the general body of mine air. Coal mines will also need to comply with the relevant statutory provisions relating to the control of inhalable and respirable dust.

291. Mines should provide and maintain dust suppression systems appropriate to their needs, both at the point of cutting or filling out and at dust producing places in the transport system. These will include:

- Sprays at:
  - Picks and other places on or around cutting heads and drums;
  - Transfer points and other dust producing places on the mineral transport system, including downstream of dints and other dust producing repair work;
  - Intervals along conveyor systems operating in roadways where there are high relative air velocities drying the surface of the mineral;
- Local exhaust ventilation, such as exhaust overlap systems with wet or dry filtration and rotary air curtain shearer drums;
- Free standing scrubbers;
- Shrouding of mineral transfer points, particularly those located in high velocity airstreams;
- Dust curtains or barriers, such as 'bondina' curtains at face return ends or downstream of transfer points;
- Arrangements for wetting down shotpiles and dints etc. before filling out.

292. Mine managers will need to balance the requirements for dust suppression against the need to provide effective ventilation around the cutting elements to minimise the likelihood of an ignition of flammable gas. This has a particular bearing on the number, type and location of sprays fitted to cutting heads and shearer drums. Where people at a mine do not have the necessary competencies or expertise to determine appropriate dust and ignition suppression systems on and around cutting heads and drums, managers should seek the advice of a competent third party.

293. Managers should establish minimum water pressure and flow rates for mineral cutting machines.

294. Suppression equipment should be individually represented in the mine's planned preventative maintenance scheme and be subjected to regular testing and maintenance. The tests should include measurements of water pressure and flow rates specified in the manager's scheme. Airflows will be measured as part of ventilation arrangements.

295. Sprays on conveyors should be linked to a load-sensing device so that they operate only when the belts are conveying mineral. This will reduce the likelihood of belt slippage and avoid the build up of water in the roadway in the vicinity of the spray.

296. Free standing scrubbers or wet filters in exhaust overlap auxiliary ventilation systems should be regularly maintained to ensure that sludge does not build up in the system and impede air flow. Where a closed water circuit is used, managers should seek advice on water treatments to prevent bacterial proliferation.

297. Dry filters and curtains will need rinsing, changing or otherwise servicing regularly to maintain efficiency and not impede airflow.

298. As the resistance to flow increases as a filter becomes clogged with dust, and the pressure drop across the filter increases, the periodic use of a pressure gauge across a filter will indicate when its efficiency is falling.

299. Improving the dust suppression system will decrease the rate at which dust, including flammable dust, will accumulate within the mine. The explosion protection measures at coal mines must also include the maintenance of non-flammable matter in dust in underground roads as required by Part II of The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956.

300. These Regulations refer to non-flammable matter as 'incombustible matter'. The maintenance of incombustible matter in roadway dust will both prevent or reduce the likelihood of a dust explosive atmosphere occurring and mitigate the effects of any explosion, limiting both its energy and spread.

301. Regulation 1 disapplies the whole of the Regulations in relation to a mine where the floor, roof and sides of the roads are naturally wet throughout. This means that the Regulations do not apply only at those mines where the wetness of every roadway in the mine is such that there is no dust that can be raised into the air. The remainder of Part I applies to screens on mine surfaces.

302. Part II of these Regulations is disapplied in relation to anthracite workings. For other coal mines it sets out requirements for:

- Maintenance of a minimum percentage of incombustible matter in the dust that accumulates on the roof, floor and sides of ventilated roadways (regulation 5);
- The testing for fineness and characteristics of incombustible dust (regulation 6);
- Sampling, sample analysis, records of analysis and the posting of results in the covered accommodation (regulations 7, 8 and 9).

303. The percentage of incombustible matter required varies in relation to the volatile matter content of the coal. These percentages are set out in a table contained in a schedule to the Regulations.

304. Regulation 8(4) refers to roadways where the dust on the floor has been systematically treated in a manner approved by the Health and Safety Executive to make it indispersable. The approved manner of treating the roadway with flaked calcium chloride crystals is set out in an annex to the Regulations. However, consolidation of the roadway floor may also be carried out with solutions of consolidating agent applied by spraying, provided the same end result is achieved.

305. The methods of analysis of roadway dust approved for the purposes of regulation 9 are set out in a further annex at the end of the Regulations.

### De-energising equipment used in potentially explosive atmospheres in mines

#### *Potentially explosive gas atmospheres*

306. In mines there are legal requirements to switch off or make safe electrical equipment before the mine atmosphere becomes explosive, other than that which is specifically designed and constructed to be safe for continued use in an explosive atmosphere. Regulation 20 of The Electricity at Work Regulations 1989 requires the de-energising of certain types of electrical equipment where the firedamp concentration in the general body of mine air exceeds 1.25% by volume. The Approved Code of Practice to this regulation gives practical guidance on how to comply with its provisions.


**Electrical equipment in the aftermath of the explosion at Golborne Colliery, Greater Manchester, in 1979**

307. If the concentration of firedamp in the general body of mine air exceeds 1.25% the only electrical equipment that should remain energised is that which is both safe for use in an explosive atmosphere and is necessary to secure the safety of people in the mine, including their escape and rescue. The Approved Code of Practice to regulation 21 of The Electricity at Work Regulations 1989 contains a list of examples that includes:

- Telephones, communications and signalling equipment;
- Monitoring instruments and associated equipment;
- Electric safety lamps (miners' cap lamps etc.);
- Rescue equipment.

308. There are no similar regulatory requirements for non-electrical, mechanical equipment, other than regulation 16 of The Coal and Other Mines (Locomotives) Regulations 1956 and some in consents issued by The Health and Safety Executive under section 83 of The Mines and Quarries Act 1954. These require the running of locomotives and other vehicles and equipment powered by internal combustion engines to be discontinued in any length of road where a firedamp level exceeds 1.25% by volume.

309. Where other non-electrical equipment is likely to cause sparks or high temperatures in normal use, and is therefore likely to be an ignition source, it should be isolated when the concentration of firedamp in the general body of mine air exceeds 1.25%.

310. Where such equipment is unlikely to be an ignition source in normal operation, e.g. compressed air driven motors, return sheaves of rope haulage systems, or methane drilling equipment that is appropriately protected against ignition, it should be de-energised at 2% firedamp. This coincides with the requirement in section 79(1) of The Mines and Quarries Act 1954 to withdraw people from places in safety lamp mines affected by the presence of excessive flammable gas (see also section 79(5)(a)). In non-safety-lamp mines people have to be withdrawn when the concentration of flammable gas exceeds 1.25% (see section 79(5)(b) of The Mines and Quarries Act 1954).

311. Compressed air driven or hydraulically powered methane boring equipment may continue to operate in up to 2% concentration of flammable gas in the general body of mine air (beyond which the operators must be withdrawn), provided that it is suitably protected against ignition. This protection will include:

- Water flushing of the drill bit;
- The provision of antistatic hoses;
- Proper earthing.

*Potentially explosive dust atmospheres*

312. The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 require all category M2 equipment, both electrical and non-electrical, to be de-energised when the atmosphere changes from being potentially explosive to explosive. While detectors are readily available to determine when a flammable gas explosive atmosphere occurs there are currently no instruments in use for measuring instantaneous flammable dust concentrations in this range in air below ground in mines.

313. One way of determining a concentration of total (both flammable and inert) dust in air of 15g/m$^3$ is when the visibility using a miner's cap lamp is limited to approximately one metre. If this is taken as the point at which to de-energise equipment, in the worst case, where all the dust in the atmosphere is flammable, it gives a factor of safety of approximately 4:1 to the lower explosive limit of coal dust in air.

**Control of other ignition sources**

314. The main sources of ignition include:

- Naked lights;
- Electrical equipment sparks;
- Frictional heat and sparks from mechanical equipment;
- Spontaneous combustion and other fires.

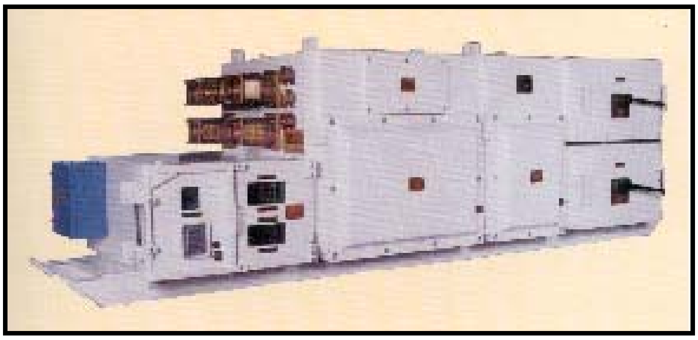
***Naked lights***

315. Section 62 of The Mines and Quarries Act 1954 prohibits the use of lights other than permitted lights in all mines where there is a risk of an explosive atmosphere occurring, and section 67 prohibits the use in such mines of equipment designed or adapted to produce an unprotected flame or spark.

***Electrical equipment sparks***

316. Equipment purchased after 30 June 2003 for installation in areas of the mine having the potential for an explosive atmosphere, must fall into one of two categories:

- Mining explosion protected equipment intended to be used in a potentially explosive atmosphere, but de-energised should the concentration of firedamp exceed 1.25% ('M2');
- High integrity mining explosion protected equipment intended to remain energised in an explosive atmosphere (M1).



**An M2 flameproof multi-contactor motor controller for use in potentially explosive atmospheres**

317. Other requirements relating to the provision and installation of electrical equipment is given in the Approved Code of Practice to The Electricity at Work Regulations 1989.

***Frictional heat and sparks from mechanical equipment***

318. Owners and managers of coal mines should refer to the Model Rules on Frictional Ignition, part of the guidance to the Coal Mines (Owner's Operating Rules) Regulations 1993.

319. Where there are frictional ignition risks owners and managers will need to take appropriate preventative and protective measures including:

- Adequate ventilation;
- Devices or equipment on board mineral-cutting machines to provide ventilation in the cutting zone. Rotary air curtain shearer drums (which use water venturi to induce the airflow) are particularly good for both ventilating the cutting zone and suppressing dust. Venturi sprays on tunnelling machines also serve to provide a turbulent airflow to ventilate the cutting head;
- Water ignition suppression systems, such as pick-back-flushing;
- Equipment design - certain types of picks and pick configurations are less likely to produce incendive sparks than others.

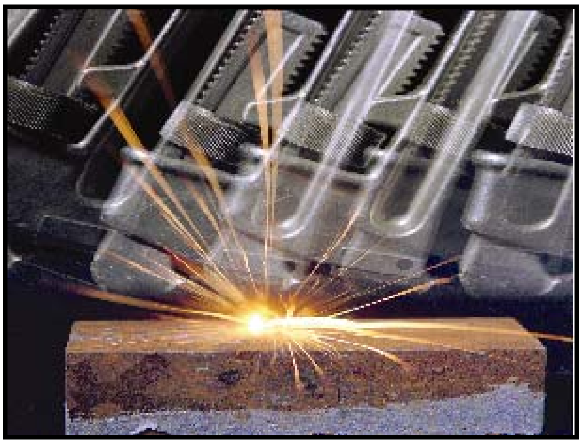
**Coal face shearer with pick back sprays to quell any incendive sparks and a rotary air curtain drum to ensure ventilation of the face side to dilute flammable gas given off during cutting**

320. Where local ventilating and ignition suppression systems are used, the manager's rules contained within the explosion protection plan should specify the minimum permitted airflow, or where these devices are water-powered, the minimum water pressure and flow necessary to achieve the required minimum airflow.

321. The equipment should be fitted with appropriate gauges to indicate to the operator if the pressures and flows fall below those specified. Machines should be fitted with interlock devices to prevent operation of the cutting element when the airflow produced by the local ventilation device, or water pressures and flows, are outside the specified operating criteria.

***Thermite reactions between light alloys and metal/steel***

322. Where light alloys come into close contact with iron or steel and are subjected to an impact, for example from a hammer or a train wheel, it is possible to generate large, very hot incendive sparks due to the thermite reaction between the two different metals.



**Thermite reaction**

**Incendive sparking caused by a light alloy wrench striking a rusty steel surface**

323. For further guidance owners and managers of mines where there is the potential for an explosive atmosphere, coal mines and other safety lamp mines, should refer to paragraphs 24-28 of the Model Rules on Frictional Ignitions.

324. As far as possible mines should avoid using below ground equipment, plant, components, materials or any other item made of light metal (including packaging), or coated with paint containing light metal. This applies in particular to auxiliary and booster fans and fluid couplings with casings made of light metal.

325. Items of equipment made of light metal or with components or materials made of light metal should not be used, transported, stored or discarded in any place where an explosive atmosphere could occur unless they are so protected that there is no possibility of friction or impact generating an incendive spark. In particular, they should not be taken within 300 metres of a coal face or the face of a tunnel in a coal mine.

**Degassing operations**

326. Mine owners and managers should design the mine layout, drivage sequence and mining systems to minimise the opportunity for dangerous concentrations of flammable gas to accumulate and avoid the need to degas. Managers should in particular avoid unventilated single entries and, in seams where an explosive atmosphere will form quickly, to have standby systems, such as venturi, that operate if the auxiliary fan(s) stop.

327. Where, despite the preventative measures, there is still the possibility that an explosive atmosphere will occur, the explosion protection plan must set out the arrangements for ensuring that degassing operations are carried out safely. These measures include the:

- Manager's auxiliary ventilation rules;
- Provision of suitable equipment;
- Supervision and training.

328. The explosion protection plan should set out the management responsibilities for:

- Deciding when a degassing operation is necessary;
- Carrying out a risk assessment before each degassing operation;
- Supervision of the degassing operation, including a clear requirement that the degassing operation should only be authorised by the senior official at the mine after due consideration of the circumstances.

329. Where single entries are driven in seams with medium or high specific firedamp emission characteristics a purpose-designed degassing unit should be permanently installed as part of the auxiliary ventilation system.

330. Where equipment has been in an explosive atmosphere, the recovery procedures should include purging with fresh air any spark and flame protected electrical equipment.

331. The senior official at the mine should take overall control of the degassing operation. Only suitably trained and competent people should supervise degassing operations, and then only with the authorisation of the senior official at the mine.

332. Further information can be found in the Model Rules on the Ventilation of Blind Ends, part of the guidance to the Coal Mines (Owner's Operating Rules) Regulations 1993, and in the Approved Code of Practice to the Electricity at Work Regulations 1999 (regulation 19, paragraph 1, and regulation 20, paragraph 3).

## EXPLOSION MITIGATION MEASURES

333. Explosion mitigation measures are designed to slow and stop the spread of an explosion through the mine. They include barriers to the extension of flame (stone dust and water trough barriers) and roadway treatment with incombustible matter. The latter is dealt with in the 'Preventing explosive dust atmospheres' section of this guidance.

### Barriers

334. Regulation 10A of The Coal and Other Mines (Precautions Against Inflammable Dust) Regulations 1956 requires managers to provide and maintain 'barriers to the extension of flame' in coal conveyor roadways through which and explosion could propagate.

335. Regulation 10A(2) requires managers to prepare a scheme showing where barriers should be sited and what type they should be.

336. Such barriers have to be approved by HSE and a further annex to the Regulations lists current approvals for stone dust barriers. However, other barriers have been approved by HSE since the Regulations were made:

- Concentrated water trough barrier;
- Distributed water trough barrier;
- Stone dust bag barrier.

These approvals are posted on HSE's website at Annex 5

## Level of monitoring

1. The level of monitoring that it is reasonably practicable for a mine to install will depend on the levels of risk indicated by the fire risk assessment process.

## Types of Monitoring and Protection

### *Temperature monitors*

2. Mines should install temperature monitors where a rise in temperature of some component could ignite a flammable material or substance, including oil, grease and coal dust, or might lead to major mechanical damage that could adversely affect the health and safety of people. Such equipment includes:

- Motors;
- Gearboxes;
- Bearing housings;
- Brakes;
- Scoop and traction-type fluid couplings;
- Compressors;
- Loop take ups;
- Conveyor return, discharge end and deflector rollers;
- Anti run back devices on conveyors.

3. Monitors should be positioned so that they quickly detect any temperature rise; for example, probes inserted into purpose designed and manufactured pockets within a component, or surface mounted ‘stick-on’ sensors directly in contact with components or component housings.

4. Where mines use infrared detectors they should cover the equipment or components that potentially give rise to the higher risks.

### *Thermal Protective Devices*

5. Thermal protective devices either:

- Regulate the temperature of the item they are protecting, such as a thermostat protecting a cooling system; or
- Thermally protect it in some other way, such as a fusible plug protecting a fluid coupling.

6. Thermal protective devices are appropriate for:

- Scoop and fluid couplings;
- Brake mechanisms;
- Anti-runback devices;
- Cooling systems.

7. Thermal protective devices should be set to operate at no more than 10$^{o}$C above the maximum temperature reached during normal operation (including start-up).

8. Where fluid coolers are used, the thermal protective device should be fitted at a suitable point before the fluid is cooled.

9. A temperature probe set to alarm at a temperature lower than that at which the thermal protective device would operate should give adequate warning of an over-temperature condition.

***Brake Wear***

10. Brake wear devices should be arranged to detect the maximum wear allowable before adjustment of the brake linkage becomes necessary, to prevent maximum travel of the operating device being reached.

11. Where brakes incorporate automatic pad adjustment (as in disc brakes) it will only be necessary to detect maximum allowable wear on pads.

***Brake Position switches***

12. Arranging switches to monitor the 'fully on' and 'fully off' positions will reduce the likelihood of frictional heating from partly applied brakes. Where the position switches monitor the position of the brake operating pedal, handle or lever, those setting up or adjusting the brakes and brake position switches will need to ensure that not more that 80% of the total travel is used when moving the brakes from the 'full on' to 'full off' position.

13. Where hydraulically applied brakes are fitted switches which detect the respective pressures associated with 'brake fully on' and 'brake fully off' may be used.

***Low Oil Level***

14. These should be used where low oil level could lead to a potentially hazardous temperature rise or to mechanical damage.

**Protection Specific to Conveyor Belts**

15. Where there is a likelihood that a significant fire could develop, for example on coal mine conveyors, the following is the minimum recommended level of additional monitoring.

***Belt Alignment***

16. Belt alignment devices need to be fitted at either side of the top belt as it arrives at the drive head and at other locations where frictional heating may result from the belt rubbing against some fixed object e.g. loop take ups, return and delivery units. They should be interlocked to stop the conveyor if they operate.

***Belt Tear***

17. Belt tear detection devices should be fitted at a safe run down distance from the delivery end such that the conveyor would stop before the torn belting went around the delivery roller.

18. It may be necessary to fit additional devices at points along the conveyor such as air doors, where there is an increased likelihood of belt damage.

***Belt Slip***

19. A slip detector, arranged to stop the conveyor if belt slip leads to the belt speed falling below 75% of the speed of the conveyor drive drum, will help prevent frictional heating. Non-contacting types are better than contact roller types.

20. Any timer used to override a belt speed/slip transducer during start-up should be set to as low a value as is practicable for the drive concerned and the number of restart attempts limited to three before a local inhibit circuit is initiated to prevent further attempts to start the belt remotely.

21. Where mines provide a belt slip transducer override for the purpose of jointing or replacing conveyor belting, it should be protected against unauthorised operation. It should be arranged so it cannot be activated or operated unless someone is continually present; for example, a button needs to be kept continuously depressed.

***Sequence tripping***

22. Where one conveyor loads onto another it should stop automatically when the receiving conveyor stops.

***Blocked Chute***

23. Mines should use blocked chute probes to stop the delivery conveyor where a blockage in the chute could give rise to danger.

***Belt Overspeed***

24. Where the gradient is in favour of the load, a belt over-speed device should stop the conveyor if the conveyor belt speed exceeds the speed of the driving drum by more that 15%.

***Position Monitoring of Scoop and ATLC Couplings***

**Scoop position switches**

25. Scoop position switches should monitor the non-driving and the fully driving positions of the scoop mechanism and should be positioned to ensure that switch operation occurs as close as is reasonably practicable to the extremities of scoop operating lever travel.

**Scoop Trim Oil Flow**

26. The oil flow should be monitored and arranged to automatically stop equipment below a level specified by the manufacturer or supplier. Any equipment stopped in this way should not be restarted until a competent person has examined it and found it to be safe.

***Drive Units***

27. Drive units incorporating scoop control and scoop trim fluid couplings (excluding ATLC fluid couplings), should be provided with suitable devices to:

- Ensure that the main driving motors cannot be started unless the scoops are in the non-driving position and any brakes are in the fully 'ON' position;
- Stop all main motors, place scoops in the non-driving position and apply any brakes, if one motor (including ancillary items which are necessary for the safe operation of the conveyor) stops or fails to start;
- Ensure that the main motors are stopped, scoops are placed in the non-driving position, and the brakes are applied, if the scoops fail to attain the maximum driving position within a predetermined time or fail to remain in the driving position while the scoop control circuit is in the 'conveyor' run condition;
- Ensure that the main motors are stopped and any scoops are placed in the non-driving position if any brake fails to attain the fully 'OFF' position within a predetermined time or moves away from the fully 'OFF' position while the conveyor is running;
- Stop all main motors and apply the brakes if the scoops fail to reach the non-driving position within a predetermined time after the scoop control circuit is de-energised;
- Move the scoops to the non-driving position and apply the brakes if the main motors are stopped or electrical power is removed;
- Stop and latch out all main motors, place the scoops in the non-driving position and apply the brakes if the temperature of the fluid in the external circuit of the scoop control fluid couplings becomes abnormally high (Indication of this trip condition should be provided);

28. For drive units incorporating ATLC fluid couplings, traction couplings or solid drives, interlocks and/or other devices should be provided, as appropriate, to:

- Ensure that the main motors cannot normally be started unless the brakes are in the fully ON position. To prevent accumulation of slack belt or surging there may be circumstances on downhill conveyors where brakes need to release before motors are started;
- Stop all main motors and apply the brakes if one motor (including ancillary items which are necessary for safe operation of conveyor) stops or fails to start;

- Ensure that the main motors are stopped if the brakes fail to attain the fully OFF position within a predetermined time of initiating the release movement or if the brakes fail to remain in the OFF position while the conveyor is running;
- Apply the brakes if the main motors are stopped or the power is removed;
- Ensure that motor start-up cannot be initiated unless the scoop is fully inserted. Movement away from the fully inserted position after the acceleration period should trip the electric motor. A timer by-passing the interlock may be required to allow acceleration of the conveyor.

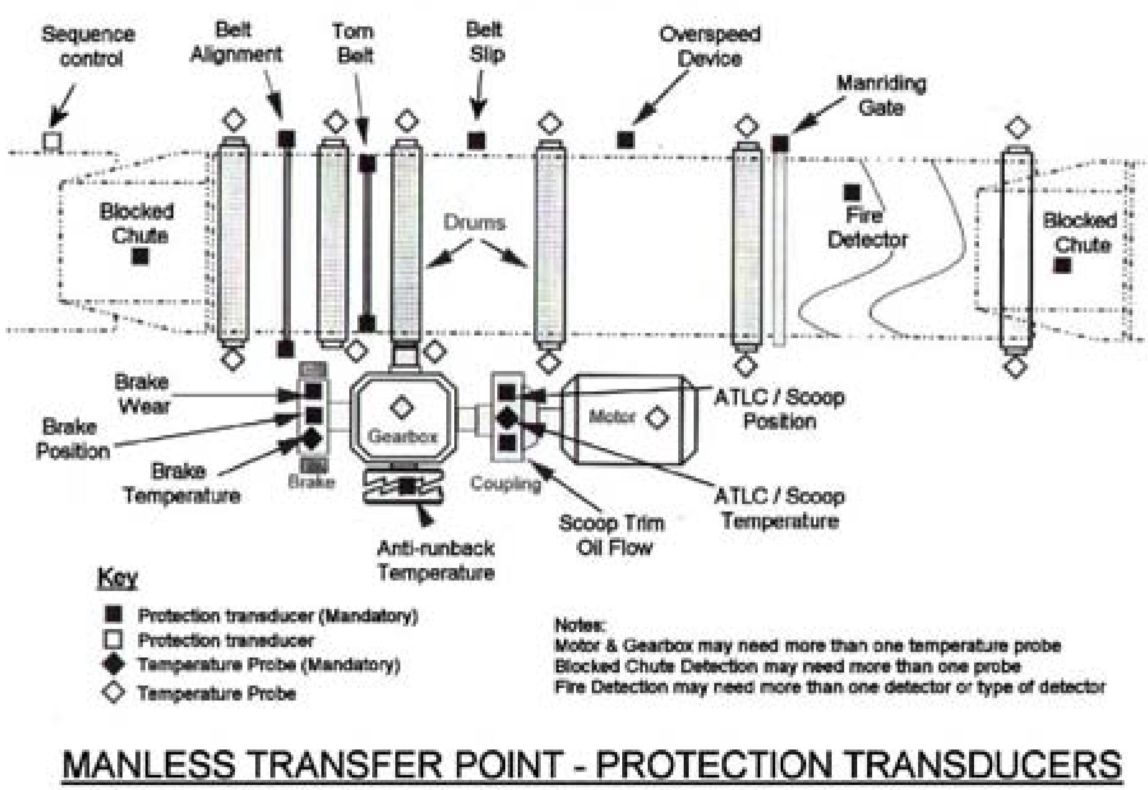



**Diagram showing position of transducers recommended for monitoring conveyors with unmanned transfer points. Environmental monitoring should also be used in the general body of mine air to detect fires at an early stage**

**Protection specific to fans**

***Booster fans***

29. Booster fans should be fitted with a vibration monitoring/control device that initially determines the vibration characteristic of the fan when it is installed and then initiates a warning or trip if the vibration levels exceed a pre-determined deviation from the initial installation level.

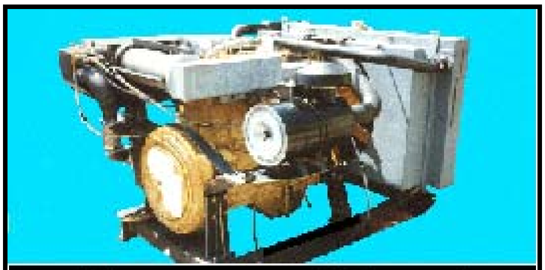
***Auxiliary fans***

30. Auxiliary fans that are not examined by a mine official at least every eight hours should be fitted with a vibration monitoring/control device similar to that fitted to booster fans but adapted specifically for auxiliary fans.

**Protection specific to internal combustion engines**

31. Monitoring and protective devices should ensure that engine oil pressure, coolant temperature and exhaust gas temperatures are within the limits set by the manufacturer.

32. For flameproof engines submitted by the manufacturer for ATEX certification for use in potentially explosive atmospheres, the Notified Body will test the protective circuits.



**Flameproof Diesel Engine**

33. Where internal combustion engines operate in potentially explosive atmospheres the monitoring and protection should automatically shut down the engine if it overheats or otherwise enters a potentially hazardous state.

## Classification of seams

1. The cross over temperature test has been used over the last twenty-five years or so to indicate the susceptibility of British coal seams to spontaneous combustion. The test simulates the slow oxidation process that is the precursor to a heating.

2. Air is passed through a sample of coal contained in an oven the temperature of which is increased at a pre-determined rate. At a certain point the temperature rise generated by the oxidation of coal will start to exceed the increase in oven temperature. This is known as the cross over temperature of the coal.

3. In practice mine operators tend to classify seams as high risk if the cross over temperature is less than $200^{o}C$ and low risk otherwise.

## Occurrence

4. Spontaneous combustion can occur in many places where low-velocity air flows through or over coal. For example:

- In coal left in the waste of longwall workings, particularly in advancing longwall workings;
- Above roadside packs in advancing longwall face workings;
- In narrow solid coal pillars;
- In broken coal along roadsides;
- In coal wedges in the floor in cross-measure drifts and sharp changes of horizon;
- Across the corners of junctions;
- At overcasts;
- In refuge holes;
- Close to faults;
- On salvage faces;
- Around booster fan sites and other locations with a high differential air pressure; e.g. air doors;
- In coal stockpiles.

5. Spontaneous combustion can also occur due to low velocity airflows over organic waste (wood, paper, oil-soaked rags etc.)

## Prevention

6. The following guidance is primarily for coal mines working high-risk seams, but owners and managers should remember that spontaneous heating can still occur in low risk seams and they should therefore have regard to this guidance.

### *Planning*

7. In planning mine layouts and mining systems mine owners and managers need to take account of the classification of seams liable to spontaneous combustion and the risks to people arising from spontaneous combustion, and balance these against other potential risks when designing preventative and protective measures.

8. Mine ventilation pressure has a strong influence on spontaneous heating. The higher the pressure differential between intake and return the greater the amount of low velocity air leakage. The stability of the air pressure is also important in avoiding varying low velocity air paths. Mines therefore need to balance the requirements for sufficient air to dilute any flammable gas entering the general body of mine air against the increased likelihood of spontaneous heating at higher

pressures. The ventilation system should also be designed to provide, as far as practicable, a stable air pressure distribution by, for example, minimising the number of connections between intake and return airways.

9. Booster fans, provided they are suitably sited well inbye, can reduce the intake-return pressure differential across a large area of the mine and consequently can have a beneficial effect on reducing leakage while at the same time increasing the overall air quantity. However, the roadways around the booster fan site will need to be well sealed to prevent low velocity air leakage in the coal around the site.

10. Longwall retreat workings are less liable to induce spontaneous combustion than longwall advancing faces. With an advancing face the ventilation flowing around the district creates a pressure gradient across the waste inducing leakage paths. As there is no pressure gradient across the waste of a retreating face the only leakage through the waste is limited to within a few metres of the back of the face supports and that deliberately induced by the back return system across the return corner to control flammable gas flows from the waste.

11. It may be possible to reduce the likelihood of spontaneous combustion by extracting the whole seam but this needs balancing against any increase in risks to workers from falls of ground, taking account of the thickness of coal that needs to be left in the roof of the face working for ground control purposes.

***Spontaneous combustion plan***

12. This should form part of the overall fire prevention plan for the mine and should include a description of preventative measures for each part of the mine at risk – further guidance on specific situations is given below. It should also include:

- Details of the spontaneous heating detection and alarm systems;
- The position of every stopping site, including details of any preparatory stoppings either built or planned and details of any pressure balancing arrangements;
- A roadway cross section and an inventory of materials and equipment needed to complete the stopping;
- Means of transporting materials and equipment to each of the stopping sites, together with an alternative route if the primary route is in a return airway likely to be contain unsafe concentrations of smoke or gases in the event of a fire;
- Nitrogen source(s);
- Pipe range(s) to deliver the nitrogen from the surface to the point(s) of use.

***Advancing faces – face start lines***

13. On advancing faces mines should:

- Remove any wood, paper and rags from the face start line;
- Solidly fill with a suitable cementitious material both ends of the face start line for at least 3m from either gate roadway, ensuring that these are sealed to the surrounding strata;
- Maintain 3m wide gateside packs for a minimum of 10m beyond the face start line;
- Where roof fragmentation is likely to be a problem, grout the strata:
    - Around the ends of the face start line;
    - Above the coal on the face side for 10m on the outbye side of the face start line;
    - Above the waste for 20m on the inbye side of the face start line;
- Seal the gate roadways for a minimum of 10m on the outbye side of the face start line to 20m on the inbye side of the face start line.

### *Advancing faces*

14. Mines should minimise air leakage through the waste by:

- Building solid waste-edge packs, tight to the roof, from pumped cementitious material;
- Ensuring there are no gaps between packs and between packs and the strata, including where necessary sealing between them using a suitable compound injected at low pressure;
- Strata grouting above the waste in high-risk seams where strata fragmentation is a problem.

15. While air leakage though the waste at a particular point will reduce due to consolidation as the face advances, monitoring may indicate that it is necessary to reseal the pack sides and the surrounding strata in certain areas as mining stresses cause the roadways to deform.

### *Salvage faces*

16. On worked-out coal producing districts the equipment should be salvaged quickly and the district sealed.

17. The period from the end of production to sealing should be as short as practicable and should not exceed three months.

18. To reduce the opportunity for spontaneous heating once production has finished mines should:

- Reduce the air quantity flowing around the district commensurate with the reduction in flammable gas emissions, ensuring that the concentration of flammable gas in mine air does not exceed 1.25%;
- At the same time, progressively reduce the flow in any firedamp drainage system and isolate unproductive holes to maintain average flammable gas concentrations in the drainage range;
- Seal waste edges on advancing faces to the front of the last pack;
- Erect gate roadway seals on retreat faces just inbye of the face finish line;
- Ensure that any excavation work associated with face salvage operations (face entry junctions, engine houses etc) are sealed so that they do not increase the likelihood of spontaneous heating.

### *Roadways (including gate roadways)*

19. Coal surfaces should either be left totally exposed or sealed to a depth of at least 15mm with a suitable sprayed lining.

20. Where roadway lagging is necessary, steel mesh should be used and not wood or corrugated sheets. If rock or coal starts to build up between the back of the mesh and any coal surface it should be injected and sprayed to remove any low velocity leakage paths.

### *Air crossings*

21. Mines should seal, and if necessary grout, any strata through which air leakage could cause spontaneous heating in coal for a distance of at least 5m to every side.

22. Prefabricated air crossings need gripping and sealing into the roof and sides at either end.

### *Junctions and other excavations in coal*

23. Mines should seal any exposed coal surface by fully packing the annulus between the junction steelwork and exposed roof and sides, for example with mini packing bags filled with cement.

24. The strata around refuge holes and other excavations in coal, and for 10m either side of fault intersection points etc, should be sealed by spraying and/or injection.

***Sealing off***

25. Worked out parts of the mine should be sealed off immediately upon completion of salvage operations. Stopping sites should be in good ground and built to the standards set out in the former Institution of Mining Engineers publication 'Sealing Off Fires Underground' (see reference at the end of this Annex).

***Pressure balancing***

26. Pressure balancing will reduce the likelihood of air leakage around any stopping and is particularly important where stoppings are unavoidably constructed in weak or broken ground, or ground that is still moving.

27. 'Sealing Off Fires Underground' (see above) contains comprehensive guidance on pressure balancing.

***Nitrogen injection***

28. Nitrogen injection can be an important control measure. Injected into advancing longwall wastes and into newly sealed off areas it will retard the rate of oxidation and reduce the likelihood of spontaneous combustion.

29. The spontaneous combustion plan will contain details of the means of delivering nitrogen from the surface to each point of use, either via dedicated ranges or via ranges normally used for other purposes, but which can be quickly converted in an emergency. The plan should also identify the nitrogen source, either storage tanks or a production plant on the mine surface, and any measures necessary to ensure that there is a sufficient supply.

***Detection***

30. The oxidation of coal generates a variety of products of combustion ranging from carbon monoxide and carbon dioxide, through to sulphur dioxide and, in the latter stages, hydrogen. It can also produce a variety of physical effects such as:

- Sweating – the oxidation process gives off water vapour that may condense as droplets or damp patches on metal or on rock surfaces;
- Smell – human detection of spontaneous heating relies on the recognition of the odours associated with the various stages of combustion, ranging from a 'musty' smell in the early stages, to a paraffin-like smell as the heating develops, and a petrol-like smell at higher temperatures.
- Haze – where moist air comes into contact with cooler air it can form a visible mist;
- Smoke;
- Hot surfaces.

31. Managers, supervisors and those working below ground in places liable to spontaneous combustion need sufficient instruction to be able to recognise and react to these physical changes.

32. An effective monitoring regime is necessary to detect at any early stage the onset of spontaneous heating. The best indication of spontaneous heating is the change in carbon monoxide concentration over time.

33. The level of monitoring will depend on the likelihood of spontaneous heating, which should have been determined as part of the fire and explosion risk assessment and be included in the fire and explosion prevention plans.

34. Mines should position carbon monoxide monitors where they are most likely to detect a heating at an early stage and connect their outputs into a multi-discriminatory alarm system. Paragraphs 174 and 175 in the main text contain further guidance on MDA systems.

35. On advancing faces, inserting sample pipes through the pack sides at intervals of about 20m and then sampling them regularly will enable mines to detect a heating and its approximate location at a much earlier stage and begin to take additional control measures. The sample pipes should be fitted with sample valves, and these should be closed when not in use so the pipes do not provide leakage paths through the waste.

36. On retreat faces mines should make arrangements to acquire deep waste samples at the return end. This is usually done by progressively leaving sample pipes in the return gate to allow the acquisition of a sample of gases from 10-25m into the waste at the return end.

37. On new retreat faces mines should arrange to acquire deep waste samples from the return end of the face start line until the face has retreated for 50m. The gates should then be stopped off immediately behind the face line.

38. Where firedamp drainage systems are installed, analysing the samples for carbon monoxide as well as firedamp content may give an earlier indication of the onset of a heating than the general body monitors. In high-risk seams, firedamp drainage ranges in each district should be continuously monitored for carbon monoxide.

**Mitigation measures**

***Preparatory stoppings***

39. In seams at high risk of spontaneous combustion mines should prepare stopping sites to enable the stopping off of a district or part of a mine in an emergency without the need for any further excavation.

40. District inspectors should report on the condition of preparatory stoppings as part of their statutory shift report, identifying in particular where remedial action may be necessary.

41. A supply of stopping construction materials and means of delivering it to stopping sites should be kept below ground in strategic locations ready for immediate use in an emergency to minimise delay while further materials and equipment are brought in from the surface.

42. When storing dry cementitious materials that might deteriorate over time, mines should check periodically that they remain fit for use and replace them if not.

43. Where the construction of a stopping is to rely on cementitious materials pumped from a remote station, the means of delivery should be checked periodically to ensure that it remains operable and that there are sufficient suitable hoses to deliver it from the cement range to the point of use.

***Injecting deep seated waste heatings***

44. Deep seated spontaneous combustion in longwall face waste areas is the most difficult to deal with as there is often no way to gain access to the heated area, although occasionally they can be located by long hole drilling either from the face or the gate roadway and the area around them injected with a suitable sealing compound to prevent air reaching it.

45. Water can be injected into the heated area to cool it, but the risk of a water-gas explosion in the waste is such that the control measures should include this only being done remotely with no one close to the injection point and no one on the return side.

***Dealing with near surface heatings***

46. Where spontaneous heating occurs above the pack or in strata close to the roadside, water can be applied to cool it, the affected area dug out from the intake side and the surrounding area injected at low pressure with a suitable sealing compound. Mines should also consider spraying the exposed surface surrounding the affected area with a strata sealer to prevent further air leakage and so reduce the chance of further heating.

**Further information**

47. The former NCB Publication ‘Ventilation in Coal Mines – A Handbook for Colliery Ventilation Engineers’ contains further information on spontaneous combustion, mine air sampling and mine gases.

48. The former Institution of Mining Engineers (now part of The Institute of Materials, Minerals and Mining) publication ‘Sealing Off Fire Underground’ is still widely available within the industry and contains much useful guidance on stoppings, pressure balancing, and mine air sampling, analysis and the interpretation of results.

## EXAMPLES OF IGNITION HAZARD ASSESSMENTS FOR MACHINERY AND EQUIPMENT INTENDED FOR USE IN A POTENTIALLY EXPLOSIVE ATMOSPHERE

1. Each manufacturer or assembler of machinery and equipment intended for use in a potentially explosive atmosphere is required to carry out an ignition hazard assessment for each individual item of equipment or machine and determine the most appropriate ignition prevention and control measures. These duties also apply to users if the user manufactures machinery or equipment for their own use.

2. Those using machines in potentially explosive atmospheres need to ensure that the manufacturer has carried out an ignition hazard assessment, and to undertake additional risk assessments dependant upon where the machine or equipment is to be used.

3. In the two examples below the manufacturer has designed the equipment to meet the requirements of Group I (mining) Category M2 equipment (for use in a **potentially** explosive atmosphere). To comply with the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996, the manufacturer has to:

- ensure that all electrical equipment is certified by a Notified Body
- produce for non-electrical equipment an ignition hazard assessment document for inclusion in the technical file lodged with the Notified Body in accordance with the requirements of EN 13463-1 for Category M2 equipment.

4. Category M2 equipment has to incorporate a high level of ignition protection, even though it is intended to be de-energized in the event of an explosive atmosphere occurring, because it might continue to operate for a short period of time in an explosive atmosphere if, for example, a sudden outburst of firedamp was to occur in the mine roadway.

5. Manufacturers will therefore need to protect against potential ignition sources, which may not be there in normal operation but which could occur due to a malfunction.

## EXAMPLE 1 - IGNITION HAZARD ASSESSMENT FOR A CONVEYOR BELT INTENDED FOR USE IN A COAL MINE

### Description of equipment

6. The equipment consists of components assembled to form a belt conveyor intended for transporting mineral in a coal mine having a potentially explosive atmosphere of firedamp and coal dust.

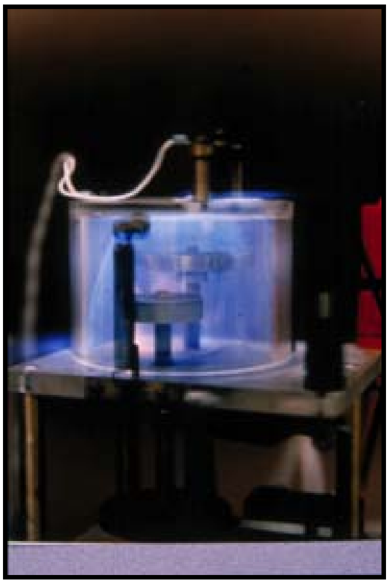
7. The conveyor belting is made from a fire resistant plastic coated textile material. It runs on a metal structure incorporating drive and idler rollers and driven close to the delivery end by a flameproof electric motor and an oil filled gearbox through large diameter drive drums. The assembly has a loop take-up system immediately behind the drive unit, and a freewheeling return-end roller drum. There is a calliper type brake at the drive-end. The brake is gravity applied by weights and released by a flameproof electrically driven thrust-motor that energizes five seconds after the main drive motor has applied drive power to the belt drum. This is to prevent runback of the belt on starting. The delivery chute is made of steel and is connected to the conveyor structure. Except for the fire resistant plastic coated conveyor belt, all other fixed and moving parts are made from steel. All metallic parts of the structure are connected together to provide an electrical bonding connection of better than one mega-ohm that will leak any unintentional electrical or electrostatic charging to earth.

## Assessment

### *Electrical equipment*

8. The drive motor and brake thrust-motors are ignition protected electrical equipment meeting the requirements of EN 50014 and EN 50018 as flameproof apparatus and have a certificate of conformity attesting compliance with EU Directive 94/9/EC issued by an EU Notified Body.

9. The signals, interlocks, conveyor control and monitoring equipment comply with EN 50014 and EN 50020 as intrinsically safe circuits and have a certificate of conformity attesting compliance with EU Directive 94/9/EC issued by an EU Notified Body.



**The Health and Safety Laboratory's break-flash apparatus used for testing intrinsically safe equipment. In this case the gas ignition indicates the equipment has failed the test**

### *Non-electrical equipment*

10. All exposed parts of the conveyor have been subjected to the impact tests in EN 13463-1. Any non-metallic parts on which the ignition protection depends have been subjected to environmental exposure tests described in EN 13463-1 and meet the requirements. The conveyor has no exposed light metals (aluminium, magnesium, titanium, zirconium) that could give rise to incendive sparking when struck by rusty iron/steel. The electrostatic ignition risk, user instructions, marking and other identified potential ignition sources are dealt with in Table 1 below.

**Table 1**

Example of an ignition hazard assessment for the non-electrical parts of a mining conveyor, Group I, Category M2

| **Potential ignition sources** | | **Example of measures applied to prevent the ignition sources being realised** | **Ignition protection used** |
|---|---|---|---|
| **Normal Operation** | **Faults that cannot be ignored** | | |
| | | **Bearings** | |
| Bearings | | All bearings are lubricated by grease. Replenishment required every 6months. The applied forces on the bearings are 50% of their rating. The calculated operating life of bearings on this conveyor is estimated as 25000 hours running, after which time they need to be replaced. This information will be included in the instructions to the user.<br>NOTE see prEN 13463-5:2000, 6.1 (regarding bearing rated life) | EN 13463-1 (User instructions) and EN 13463-5 Constructional Safety ”c” |
| | Bearing failure or loss of lubrication | The user should examine bearing housings on a daily basis for signs of overheating, abnormal noise or discoloration. Where reasonably practicable the user should fit continuous temperature monitoring and set it to trip the drive power at 10$^{o}$C above normal operating temperature. | EN 13463-1 (User instructions) |
| | | **Gearbox** | |
| Frictional heat from moving parts inside the gearbox | | The moving parts inside the gearbox are submersed in oil, which acts as a lubricant, spark quenching agent and coolant. | EN 13463-8 Liquid immersion ”k” |
| | Unacceptable loss of oil from the gearbox | A dipstick is provided on the gearbox. The oil level has to be checked weekly. This will be included in the instructions.<br>Transducers are available to continuously monitor gearbox oil level. | EN 13463-1 (User instructions) |
| Dust deposits on gearbox | | Regular cleaning is needed to prevent dust deposits forming layers on gearboxes. | EN 13463-1 User instructions) |
| | Ingress of stones or metal fragments to gear box | The gearboxes need to be prepared in a protection class IP54 that guarantees no ingress of stones, metal parts or water. | EN 13463-1 |
| | | **Brakes** | |
| Frictional heat from brakes | | Verification of design calculations to be discussed with manufacturers. | EN 13463-5 Constructional safety ”c” |

| Potential ignition sources | | Example of measures applied to prevent the ignition sources being realised | Ignition protection used |
|---|---|---|---|
| **Normal Operation** | **Faults that cannot be ignored** | | |
| | Brakes left on too long after the drive motor has started | The electricity supply to main drive motor is interlocked to the brake release thruster-motor to prevent the main drive motor driving through unreleased brakes after a period exceeding 5 seconds. The surface temperature of the brake was determined to be 140°C under this fault condition. | EN 13463-6 Control of ignition source "b" |
| Dust entering Brake housing | | An IP5X cover is provided to prevent deposits of dust entering the housing. | EN 13463-1 |
| | Brake disengagement fails | The brake operating linkage is fitted with a limit switch arranged to trip the conveyor main drive motor if the brake does not release correctly. | EN 13463-6 Control of ignition source "b" |
| **Idlers** | | | |
| Frictional heat from the belt idler rollers | | The idler rollers are sealed for life with fire resistant grease and the actual maximum loading on them is 50% of their rated maximum. | EN 13463-5 Constructional safety "c" |
| | Belt idler roller seizes and is rubbed by the moving conveyor belt | Weekly examination is required for signs of deterioration e.g. Abnormal bearing noise, visual discolouring and overheating.<br>The conveyor belt is made of fire resisting (self extinguishing) material to prevent flame propagation. | EN 13463-1 (User instructions) and EN 13463-5 Constructional safety "c" |
| **Belt** | | | |
| | Belt rubbing on spilled coal | The user must clean spilled coal away from contact with moving parts. This will be included in the instructions. | EN 13463-1 (User instructions) |
| | Slippage of conveyor belt on the driving drum due to loss of tension or stalling of the belt | The fire resistant belting has been subjected to a rotating drum friction test with a stalled belt and breaks before flames are produced. The belt tension needs to be checked weekly and visual control of starting is necessary. Protection against stalling by monitoring the belt tension and operating speed. The speed transducers are arranged to trip the motor if more than 10 seconds of abnormal speed difference (i.e. exceeding 25%) occurs between the drive roller and the belt. | EN 13463-1 (User instructions) or EN 13463-6 Control of ignition source "b" if fitted with monitoring. |
| | Belt driven at over-speed | The conveyor has been calculated at 20% over-speed without increase of temperature. Normally, the electric drive motor will prevent over speeding. Additional brakes are needed if conveyor fitted on a steep slope. | EN 13463-5 Construction safety" |
| Static electricity discharge | | Sufficiently conductive belting (i.e. less that 1 Giga-Ohm surface resistivity) is used to prevent charge build up. All other parts are metal and connected together to provide an electrically conductive path less than 100 Ohm. | EN 13463-1 (Electrostatic requirements and user instructions on belt replacement) |
| | Friction between the belt and fixed parts | Belt alignment monitors are fitted at the drive head. These are arranged to trip the drive motor if misalignment occurs preventing any temperature increase. | EN 13463-6 Control of ignition source "b" |

| Potential ignition sources | | Example of measures applied to prevent the ignition sources being realised | Ignition protection used |
|---|---|---|---|
| **Normal Operation** | **Faults that cannot be ignored** | | |
| Surface temperature of all moving parts | | All parts exposed to the potentially explosive atmosphere of both gas and dust have been tested and the maximum surface temperature has been found to be 120°C in normal operation and 140°C under fault conditions that cannot be ignored. | EN 13463-1 |

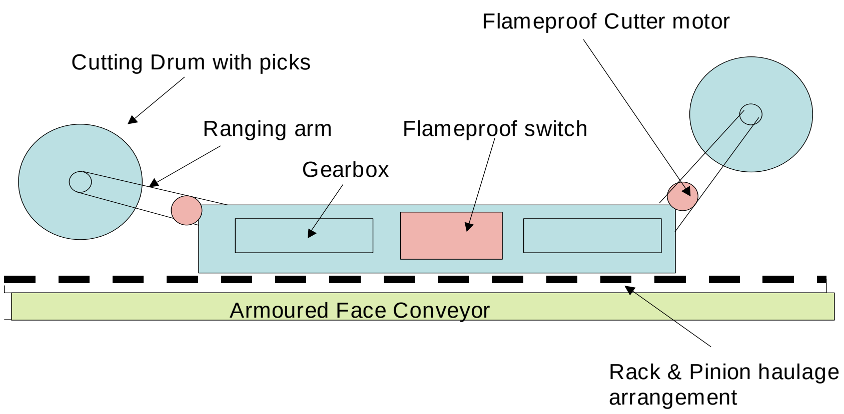
**NOTE**

Because the ignition hazard assessment has shown that the highest maximum surface temperature of a part of the conveyor is 140°C under fault conditions, the conveyor would be suitable for use in all mines, including coal mines. Even where a layer of coal dust formed any exposed surface the maximum surface temperature is lower than the maximum allowable temperature of 150°C for such circumstances of use (see EN 13463-1 for maximum surface temperatures).

## EXAMPLE 2 - IGNITION HAZARD ASSESSMENT FOR A SHEARER LOADER INTENDED FOR USE IN A POTENTIALLY EXPLOSIVE ATMOSPHERE OF A COAL MINE

### Description of equipment

The equipment consists of a shearer loader for cutting and loading coal onto an armoured flexible conveyor (AFC). The shearer loader consists of a rigid steel frame, with steel enclosures in it for the electrical switchgear and gearbox compartments. The manufacturer has decided that it needs to meet the requirements for Group I (mining), Category M2 as it is intended for use on a longwall coal face having a potentially flammable atmosphere of firedamp and/or coal dust. It is electrically powered by ATEX certified motors and has tungsten carbide tipped picks fixed to rotating helical drums to cut the coal. The main body of the shearer loader moves along the top of the AFC, loading coal onto its **moving flights (see diagram below).**




**Layout and construction of the coal face shearer loader**

11. The main body of the shearer loader and AFC are sited in a continuously ventilated and monitored part of the coal face beneath hydraulically powered roof supports. If the firedamp concentration in the general body of mine air exceeds 1.25% by volume (~25% of the lower explosive limit (LEL)), according to British law M2 equipment must be de-energised.

12. Because the coal seam has pyritic inclusions, and a sandstone roof with more than 50% quartz content, there is a danger of the localised ignition of firedamp from incendive sparking due to contact with the cutting picks, widely known as frictional ignition. To combat this, the shearer loader is fitted with water sprays and rotary air curtain (RAC) drums, both interlocked to the cutting

drum motors, so the cutter picks cannot be rotated unless the sprays are delivering sufficient water at the correct pressure to both the picks and the RAC drums.

**Assessment**

***Electrical equipment***

13. All electrical equipment is certified by an EU Notified Body as Group I, Category M2, in conformity with the ATEX Directive. Information can be found in the relevant 'Certificates of conformity' issued by the relevant Notified Bodies.

14. The switchgear is protected by flameproof enclosure ('d' according to EN 50018 – written as EN 50018 d). Helical cutting drums are mounted on the end of each ranging arm and driven by electric motors protected by flameproof enclosure (EN 50018 d). There is a haulage unit on the main body of the shearer used to move it along the AFC using a rack and pinion system. The haulage motors may be powered by either electric motors protected by flameproof enclosure (EN 50018 d) or hydraulic motors protected by liquid immersion (EN 13463-8 k).

15. Ignition protection for the system is achieved by a combination of intrinsic safety (EN 50020 ia) and control of ignition source (EN 13463-6 b).

***Non-electrical equipment***

16. The shearer loader has been assessed for compliance with EN 1127-2 and EN13463-1 and meets all requirements. In particular, the following are recorded in the manufacturer's technical file:

- Externally exposed parts are made from alloy containing not more than 15 % aluminium, magnesium, titanium and zirconium, and not more than 6 % magnesium, titanium or zirconium by mass;
- No external part, exceeding 100 square centimetres surface area, is made form non-metallic material having a surface resistance greater than 1 Giga Ohm;
- External enclosures are capable of passing the 20 Joule impact test on any surface;
- Non-metallic parts have been subjected to immersion in mining hydraulic roof support fluid and their ignition protection characteristics are not impaired.

17. The machine's bearings and power transmission system's sliding and rolling elements are protected by constructional safety (EN 13463-5 c).

18. The ignition hazard assessment table required by EN 13463-1 for non-electrical potential ignition sources is contained in Table 2 below.

***Ignition control and monitoring system***

19. The temperature of motor windings, gearbox oil and hydraulic oil are monitored for abnormal temperature rise by sensors connected to a control circuit. This is arranged to de-energise the electrical power supply to single motors on the machine if temperatures exceed values above the normal operating limits stipulated in the instruction manual. Trip settings do not exceed the maximum surface temperature of 150$^{o}$C for Group I equipment. The water spray pressure and flow are also monitored by this system.

**Table 2**

Example of an Ignition Assessment for the non-electrical parts of a shearer loader Group I, Category M2

| Potential ignition source | | Measures applied to prevent the source becoming effective | Ignition protective used and EEx symbol |
|---|---|---|---|
| **Normal operation** | **Faults that cannot be ignored** | | |
| | | **Covers and openings** | |
| Opening of enclosures that may expose hot components | | Openings giving access to enclosures, with surface temperatures higher than the temperatures specified in clause 6.1.1 of EN 13463-1:2001, are closed by covers or other closing facilities and, are provided with a warning label. The warning labels indicate the waiting time before opening the enclosure. | EN 13463-1, Clause 6 |
| | Ingress of stones, metal parts and water | The ingress of stones and metal parts is not possible, because covers are removable by tools and the cover seals have ingress protection rating IP54. | EN 13463-5, 4.5 ”c” |
| | | **Bearings** | |
| Frictional heat from bearings | | All bearings are lubricated by grease.<br>The replacement of grease is addressed in the user instructions.<br>The bearings fulfil the conditions specified in EN 13463-5, section 6.1.<br>The time of replacement of the bearings is listed in the user instructions | EN 13463-1, Clause 6<br>EN 13463-5, Clause 6 ”c” (user instructions) |
| | Bearing failure or loss of lubrication | The bearings need to be examined for overheating, discoloration or abnormal noise frequently, as requested in the user instructions.<br>As an alternative, it is acceptable to use a continuous monitoring system that disconnects the power, if a higher than permissible temperature is indicated. | EN 13463-1, Clause 6 (user instructions) or<br>EN 13463-6 ”b” |
| | | **Gearboxes** | |
| Frictional heat from moving parts inside the gearbox | | The moving parts inside the gearbox are submersed in lubrication, which acts as a spark quenching agent and coolant.<br>Because of the design, the surface temperature of the gearbox is limited to 150$^0$C, to take account of coal dust layers on the enclosure. | EN 13463-8, Clause 6 ”k”<br>EN 13463-1, Clause 6 |
| | Ingress of stones and metal fragments to the gear boxes | All openings are provided with covers or other closing facilities that are removable by tools only. | EN 13463-1, Clause 6<br>prEN13463-5, 4.5 c |

| Potential ignition source | | Measures applied to prevent the source becoming effective | Ignition protective used and EEx symbol |
|---|---|---|---|
| **Normal operation** | **Faults that cannot be ignored** | | |
| | Unacceptable loss of lubrication from the gearbox | Gearboxes have level monitoring devices (lubricant sight glasses or dipsticks). The period of rechecking and the type of lubrication is indicated in the user's manual. The sight glasses are in accordance with prEN 13463-1:2001, clause 12.<br>As an alternative, a monitoring system is provided that disconnects the power, if the lubrication level falls below a minimum level, or unacceptable values of pressure or temperature. | EN 13463-1, Clause 6 (user instructions)<br>EN 13463-6 b |
| **Power transmission systems** | | | |
| Frictional heat from the power transmission system | | The surface temperature of parts for the power transmission system, including the rack and pinion haulage system, is not higher than 150°C, where coal dust is intended to form layers.<br>The surface temperature of parts, where no coal dust is involved, is less than 450 °C. | EN 13463-1, Clause 6 |
| **Brakes** | | | |
| Frictional heat from the brakes | | The brakes are only fitted if the shearer operates on an incline. They operate as parking brakes. | EN 13463-1, Clause 6<br>EN13463-5 c |
| | Brakes are left on after the drive motor has started | To prevent loss of control of the shearer loader on an inclined seam, the drive motor runs against the brake for a short period. After that period, the signal for releasing the brakes is activated. If the brakes do not release after an additional period, the drive motor is disconnected. | prEN13463-1, Clause 6<br>prEN13463-5 c |
| | Interruption of electric power supply | If the brakes move during operation, at maximal speed of the shearer loader, and maximal incline of the seam, the surface temperatures of outer parts of equipment does not exceed unpermissible values, i.e. 150 °C, where coal dust is able to form layers, and 450 °C, where no coal dust is involved. | EN13463-1, Clause 6 |
| | Moving of brakes, because of an electrical break down | The monitoring device for the brakes is arranged to disconnect the drive motor. | EN 13463-1, Clause 6<br>prEN13463-5 c |
| **Shearer drums and picks** | | | |
| Frictional heat at drums | | The drums with circumferential speed of more than 1m/s are assembled with a drum spray system that prevents unacceptably high temperatures at the drums, the picks and the cutting zone.<br>An interlock is provided to ensure that the drums cannot rotate without the drum sprays operating. | EN 13463-1, Clause 6<br>EN 13463-5 c<br>EN 13463-6 b |

| Potential ignition source | | Measures applied to prevent the source becoming effective | Ignition protective used and EEx symbol |
|---|---|---|---|
| **Normal operation** | **Faults that cannot be ignored** | | |
| Frictional sparks at picks | | All picks are, where possible, provided with a spray system. The position of the particular sprays is behind the picks, and the spray beam cools down hot particles in the cutting zone. | EN 13463-1<br>Clause 5 |
| | Reduced water pressure | The drum spray system has a monitoring system, that monitors the pressure and the flow in the spray system, and disconnects the drive motor of the drums, if the values of pressure and flow of water are less than the limits indicated in the user's manual. | EN 13463-1, Clause 6<br>EN 13463-6 b |
| | Blocking of sprays | The periods or rechecking for the spray are determined in the users manual.<br>As an alternate, the pressure and flow monitoring system is acceptable for automatic checking, if it is calibrated to detect those faults. | EN 13463-1, Clause 6 (user instructions)<br>EN 13463-6 b |
| | | **Hydraulic systems** | |
| Hydraulic system for transmitting of energy | | Hydraulic systems for example, for lifting and lowering of the drums are operating with hydraulic fluids, that are in accordance with prEN 13463-5:2000 clause 7.5 | EN 13463-5, Clause 7.5<br>EN 13463-5 c |
| | Pollution of liquid | The kind of hydraulic fluid and the filter as indicated in the users manual has to be used.<br>In addition to this, if it guaranties that the drive motor of the hydraulic is disconnected, if a unacceptable temperature of the transmission liquid is detected. | EN 13463-1 user instructions or<br>EN 13463-6 b |
| | | **Electrostatic discharges** | |
| Electrostatic discharge | | For equipment with surface areas projected in any direction of more than $100cm^2$, materials are used with surface resistance less than 1GΩ, or materials that are checked in accordance with the test procedure in Annex C of EN 13463-1:2001. | EN 13463-1, Clause 7.4 |
| | | **Other** | |
| Removable parts | | Removable parts of equipment, are removeable only by tools. | EN 13463-1, Clause 9 |
| Materials used for cementing | | Cementing materials that are part of the ignition protection (e.g. gluing a window into a flameproof enclosure) have an acceptable temperature stability. | EN 13463-1, Clause 10 |
| Connection facilities for earthing conducting parts | | All conducting parts are connected to the protection core in the trailing cable.<br>Outer isolated parts are provided with earthing terminals. | EN13463-1, Clause 11 |
| Light transmitting parts | | Light transmitting parts are checked in accordance with clause 13.3.2.1 of prEN 13463-1 or protected by special covers. | EN13463-1, Clause 12 and 13 |

## Equipment marking

20. As the definition of 'equipment' in the ATEX Directive includes a complete machine, the shearer loader will be marked as a single item of equipment, with a single label, indicating the

ATEX Group, category and ignition protection. The ignition hazard assessment in Table 2 indicates the equipment should be marked as follows:

21. The European Standard relating to the construction of ATEX mining machinery - EN1710 - specifies that the machine will have a single label for all of the non-electrical parts and that it will include reference to that standard. An example of a label for a coal cutter that is ignition protected to EN13463 parts 5, 6 and 8, and constructed in accordance with EN1710 would therefore be as follows:

**COAL CUTTER – TYPE 123MKII**

CONSTRUCTED IN 2003

**CE Ex I M2 c k b**

**Isolate drum cutter picks at main switch before pick changing**

**MANUFACTURER LTD**

Somewhere Industrial Estate, Big City.

**Conforms to EN1710**

Where:

CE is the distinctive community marking,

Ex is the ATEX Directive symbol,

'I' is the ATEX Mining Group,

'M2' is the ATEX category and

'c', 'k', 'b' are the types of non-electrical ignition protection used to prevent non-electrical ignition sources becoming effective.

**Note 1**

In addition to be above, each individual item of electrical equipment will be marked according to EN50014 with its own type of ignition protection and certificate of conformity number.

**Note 2**

Non-electrical equipment manufacturers do not need to have their Quality Management System assessed by a Notified Body. Therefore, unlike electrical equipment, the marking does not include the Notified Body identification code.

**Note 3**

For electrical equipment the label will also include a four-digit code number for the notified body responsible for electrical certification and the EC-type certificate number (e.g. BAS 03ATEX2176).

**ANNEX 4**

## LAW RELEVANT TO FIRE AND EXPLOSIONS IN MINES

The following list contains the main provisions relevant to fire and explosion in mines. In the mining legislation section, principal provisions are referenced where appropriate.

### Legislation of general application

The Health and Safety at Work etc Act 1974

The Supply of Machinery (Safety) Regulations 1992

The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996

The Management of Health and Safety at Work Regulations 1999

The Provision and Use of Work Equipment Regulations 1998

The Dangerous Substances and Explosive Atmospheres Regulations 2002

### Legislation applying only to mines

The Mines and Quarries Act 1954 (MQA)

- Section 55 – adequate ventilation
- Section 56 – avoidance of danger from gas in waste
- Section 58 – means of ventilation
- Section 59 – prevention of leakage of air between airways
- Section 62: permitted lights
- Section 64: prohibition of taking into mines safety lamps not provided by the owner, or of an approved type
- Section 66: prohibition of possession of smoking materials in certain mines and parts of mines
- Section 67: prohibition of taking into certain mines and parts of mines, articles producing flames or sparks
- Section 74: dust precautions
- Section 79: withdrawal of workmen in cases of danger
- Section 83: restrictions on use below ground of certain engines, etc

The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956

The Coal and Other Mines (Fire and Rescue) Regulations 1956

Regulations 1-11: relating to fire precautions

The Miscellaneous Mines (General) Regulations 1956

Regulations 31-35: precautions against fire

The Coal and Other Mines (Locomotives) Regulations 1956

Regulations 11-16 – determination of firedamp content in locomotive roads

The Coal and Other Mines (Safety Lamps and Lighting) Regulations 1956

Part II (regulations 2-11): provision and maintenance of safety lamps and firedamp detectors.

Part III (regulations 12-16): re-lighting safety lamps underground.

The Mines (Manner of Searching for Smoking Materials) Order 1956

The Coal Mines (Firedamp Drainage) Regulations 1960

The Mines (Safety of Exits) Regulations 1988

Regulation 9: fire precautions in certain intake airways

The Electricity at Work Regulations 1989

Regulation 19: firedamp zones.

Regulation 20: cutting off electricity or making safe where firedamp is found either below ground or on the surface.

Regulations 22: means of cutting off electricity to circuits below ground.

Regulation 23: oil filled equipment

Schedule 1:provisions applying to mines only and having effect in particular in relations to the use below ground in coal mines of film lighting circuits

The Coal Mines (Owners Operating Rules) Regulations 1993

The Mines Miscellaneous Health and Safety Provisions Regulations 1995

Regulation 4: health and safety document, fire protection plan, and explosion protection plan

Regulation 8: hydraulic fluids

Schedule 1 Part II, paragraphs 3 (smoking and use of flame), 4 (fire-fighting) and 6 (flammable materials taken below ground)

The Escape and Rescue from Mines Regulations 1995

Regulation 4: emergency plan

**ANNEX 5**

HEALTH AND SAFETY AT WORK ETC ACT 1974

THE MINES AND QUARRIES ACT 1954

The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956

***APPROVAL OF A BARRIER TO THE EXTENSION OF FLAME***

1. The Health and Safety Executive hereby approves for the purposes of Regulation 10A(1) of the Coal Mines (Precautions Against Inflammable Dust) Regulations 1956 as amended,[1] a water trough barrier to the extension of flame of the type known as:

**THE PASSIVE WATER TROUGH BARRIER**

2. This approval is subject to compliance with the Specifications contained in the Schedule annexed hereto.

3. This approval shall come into effect on 1 March 1991.

*B. Langdon*

for and on behalf of the
**HEALTH AND SAFETY EXECUTIVE**

a person authorised to sign on behalf
of the Health and Safety Executive

Date: 7 February 1991
Ref: T.14.8/3
Barrier Approval No. 12/1

[1] *SI 1960 / 1738; SI 1974 / 2124 and SI 1977 / 913*

***SCHEDULE TO M&Q REGULATION 10A(1) BARRIER APPROVAL NO. 12/1***

***WATER TROUGH EXPLOSION BARRIERS***

***APPROVED SPECIFICATION FOR A PASSIVE WATER TROUGH BARRIER TO THE EXTENSION OF FLAME***

***GENERAL CONDITIONS***

1. The water barrier shall consist of water filled troughs, fixed or mounted in a roadway and shall be installed in approximately straight lengths of roadway where the cross-section remains approximately the same size and shape for 25m in length both upstream an downstream of the barrier. In the relevant length of roadway the effectiveness of the barrier shall not be impaired by installations and equipment.

**TROUGHS**

2. All troughs shall be fitted with lids to prevent the ingress of foreign material and minimise evaporation.

3. Troughs and lids shall be constructed from anti-static material of such design and composition as to be readily shattered by the action of the pressure wave in the event of an explosion.

4. Each trough shall contain the minimum quantity of water and an indication must be provided to show the corresponding minimum water level in the trough. If the troughs are not transparent and the water level cannot be readily seen, then a visual means of indicating the water level must be provided. The minimum quantity of water for large troughs (of 90 litres capacity) shall be 80 litres and for small troughs (of 45 litres capacity) 40 litres.

5. Troughs shall be placed with the longer side of the trough at right angles to the line of the roadway. Exceptionally one trough in a group of more than one trough may be placed longitudinally.

6. The specification and performance of water troughs should comply with DIN 21576 (A German Standard) or a suitable equivalent. A BSI Standard is being prepared.

7. The tests required to meet the specification broadly establish that:-

i) the troughs remain serviceable for as long as possible under the effect of heat

ii) the water contained in troughs is released and adequately distributed under the effects of the dynamic blast pressure of the explosion

iii) the trough material is flame resistant to a defined flame application. It must not continue to burn independently after removal of flame

iv) the material does not allow any static electrical charge, capable of igniting mixtures of air and methane or firing electrical detonators, to be built up or discharged from the surface of the trough

v) the material will not damage health in normal use.

**INSTALLATION OF TROUGHS**

8. Installation of the troughs can be achieved in various ways to suit particular requirements. They may be suspended from the roadway support, the strata or mounted on equipment within the roadway. The sides of any troughs suspended inside or mounted on cross members should not have more than 5cm of their height covered by the frame. When troughs are mounted on equipment a form of retaining lip should be provided not less than 3cm in height nor more than 5cm height (the latter in accordance with the first part of this paragraph).

9. The equipment used to secure the suspension or mounting of troughs shall be so designed, installed and maintained as to ensure, in the event of an explosion, the effective dispersion of water by shattering of the troughs.

**CONFIGURATION OF TROUGHS**

10. For roadways up to $10m^2$ in cross-sectional area at least 35% of the roadway width shall be covered by troughs. For roadways up to $15m^2$ in cross-sectional area at least 50% of the roadway width shall be covered by troughs. For roadways over $15m^2$ in cross-sectional area at least 65% of the roadway width shall be covered by troughs.

11. The sum of the spaces, measured horizontally, between troughs and between the nearest trough and the roadside shall not exceed 1.5m. The individual spaces measures

horizontally between adjacent troughs or between the nearest trough and the roadside shall not exceed 1.2m (Appendix I).

12. Where only one layer of troughs is required, the vertical downward distance from the base of each trough to the floor should not be less than 0.8m and not exceed 2.6m. The vertical upward distance from the base of each trough to the roadway roof must not exceed 1.2m.

13. Where more than one layer of troughs is required, for example in exceptionally high roadways, then the base of the troughs in the lowest layer must be not more than 2.6m above floor level nor less than 0.8m above floor level. The base of the troughs in the upper layer must be within 1.2m of the roadway roof support at its highest point. The internal between the bases of troughs in layers must not exceed 1.2m and there must be a clear space between layers of troughs of not less than 0.1m. (Appendix II, Figure 1).

14. If troughs are arranged in rows less than 1.2m apart, measured along the roadway, troughs in one row must not conceal troughs in the adjacent row from the blast effect of an explosion. In these circumstances, the requirement of paragraph No. 11 need not apply to each row of troughs, but must apply in the case of two adjacent rows closer than 1.2m when considered as a combined row. (Appendix II, Figure 2).

15. No trough shall have any part sheltered from the effect of a blast wave by a rigid installation in the roadway eg, a roof support.

16. In circumstances where proper distribution of water over the cross sectional area of the roadway might be obstructed by equipment, additional troughs shall be installed to provide adequate distribution.

***CONCENTRATED BARRIER CONDITIONS***

17. The minimum quantity of water contained in a barrier shall be 200 litres/$m^2$ of roadway cross-sectional area. Additionally, the quantity of water contained in the barrier shall be at least 5 litres/$m^3$ of roadway volume, spread over the length of the barrier. The distance between the first and last row of troughs shall not be less than 40m.

18. In roadways protected by concentrated barriers, the distance between adjacent barriers should not exceed 400m.

### *DISTRIBUTED BARRIER CONDITIONS*

19. Water troughs shall be arranged in groups. A group shall consist of all the troughs whose external edges are contained within a roadway length of 3m. (Appendix II, Figure 2). The minimum quantity of water in a group shall be 1 litre/$m^3$ of the roadway volume between adjacent groups.

20. If a roadway is protected by distributed barrier only, then the total quantity of water must not be less than 200 litres/$m^2$ of the roadway cross section. Such a barrier shall comprise at least three groups of water troughs. The maximum distance between groups shall be 30m.

21. In gate roadways and headings protected only by distributed barriers, the maximum distance of 30m between groups of troughs should be closed up initially so that a total quantity of water, equal to 200 litres per square metre of roadway cross section, is introduced as soon as is practicable. Thereafter normal spacing between groups of troughs can be followed. (Appendix III, Figure 1).

22. For both headings and faces the distance from the face to the nearest group of troughs in a distributed barrier should not exceed 35m. Should the presence of installed apparatus and equipment prevent this requirement being met, then either

a) The group of troughs nearest to the longwall faceline or face of the heading may be contained within a roadway length of 8m providing the nearest trough should not exceed 35m from the face, or

b) a triggered barrier to the extension of flame of a type approved by the HSE for the purpose of Reg. 10A(1) of the Coal Mines (Precautions Against Inflammable Dust) Regulations 1956 as varied by the Coal Mines (Precautions Against Inflammable Dust) (Variation) Regulations 1960 should be installed in accordance with such an approval, between the face and the group of water troughs nearest to the face which then may be up to 200m from the face.

### *JUNCTIONS AND SPECIAL CASES*

23. Concentrated barriers should generally be used for the protection of main roadways only. The sole exception envisaged is in the case of a new gate roadway or heading

being driven off a main roadway.  If a concentrated barrier is being installed in such a gate roadway or heading as it is being driven then it can be allowed to remain there.

24. The subsequent protection of the gate roadway or heading should be by a distributed barrier in conjunction with the concentrated barrier with the first group of troughs being not more than 30m from the concentrated barrier.  (Appendix III, Figure 1).

25. In the case of junctions where all the branch roadways in the immediate vicinity of the junction are protected by concentrated barriers, the maximum distance from the junction to the nearest trough of a concentrated barrier in each of the branch roadways should not exceed 50m.  Thus the maximum distance between concentrated barriers would not exceed 100m.  (Appendix III, Figure 2).

26. In the case of junctions where all branch roadways in the immediate vicinity of the junction are protected by distributed barriers, the maximum distance from the junction to the nearest group in each of the branch roadways should not exceed 15m.  Thus the maximum distance between groups would not exceed 30m, which is the prime objective to be met by requirement 20 (as shown in Appendix III, Figure 3).

***TRANSITION FROM ONE TYPE OF BARRIER TO ANOTHER***

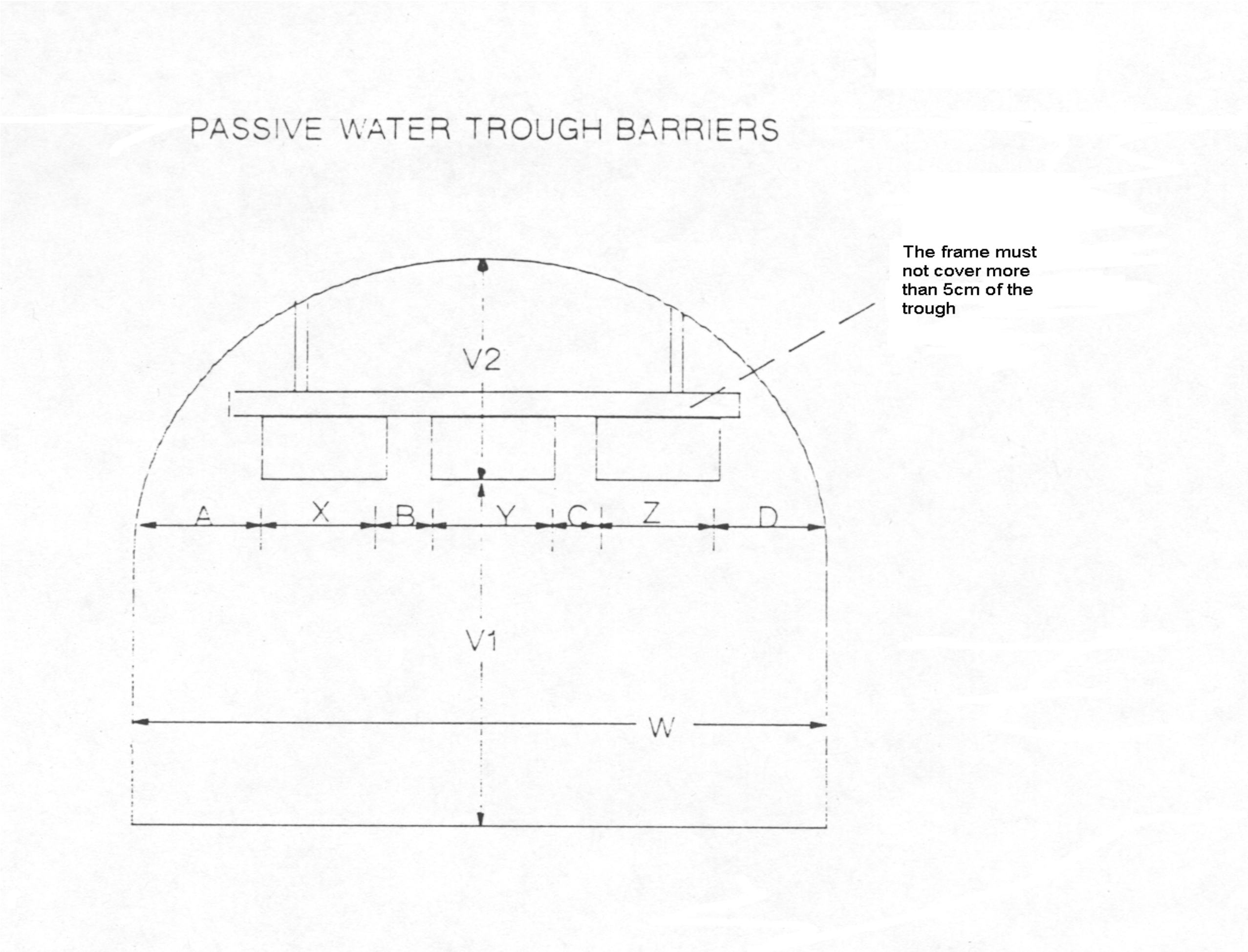
27. In the case of junctions where one or more of the branch roadways are protected by distributed barriers and the others by concentrated barriers then the maximum distance between adjacent troughs of the two types should not exceed 60m (as shown in Appendix III, Figure 4).

28. There should be a minimum distance of 100m between a water barrier and the nearest stone dust barrier (as shown in Appendix III, Figure 5).

29. If both concentrated and distributed passive water trough barriers are installed in the same roadway, the distance from the concentrated barrier to the first group of troughs in the distributed barrier should not exceed 30m (as shown in Appendix III, Figure 6).

**APPENDIX I**

PASSIVE WATER TROUGH BARRIERS




1. For roadways up to $10m^2$, X+Y+Z must cover at least 35% of W.
2. For roadways up to $15m^2$, X+Y+Z must cover at least 50% of W.
3. For roadways in excess of $15m^2$, X+Y+Z must cover at least 65% of W.
4. Distance A or B or C or d must not exceed 1.2m.
5. The total distance of A+B+C+D etc must not exceed 1.5m
6. Distance $V_1$ must not be less than 0.8m and not exceed 2.6m.
7. Distance $V_2$ should not exceed 1.2m. If this distance is exceeded, additional troughs shall be placed above and they may be in excess of 2.6m above floor level, but there should not be more than 1.2 between the base of layers of troughs.

ROADWAY SECTION

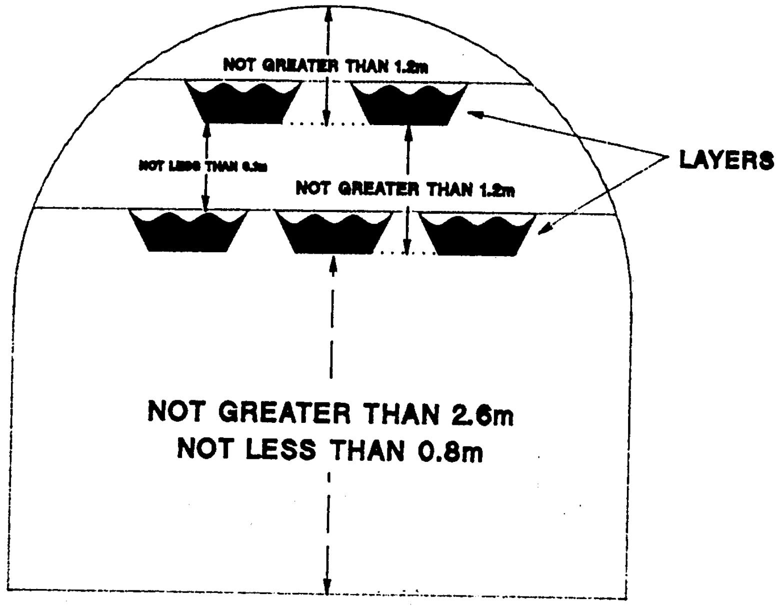



Fig 1

ROADWAY PLAN

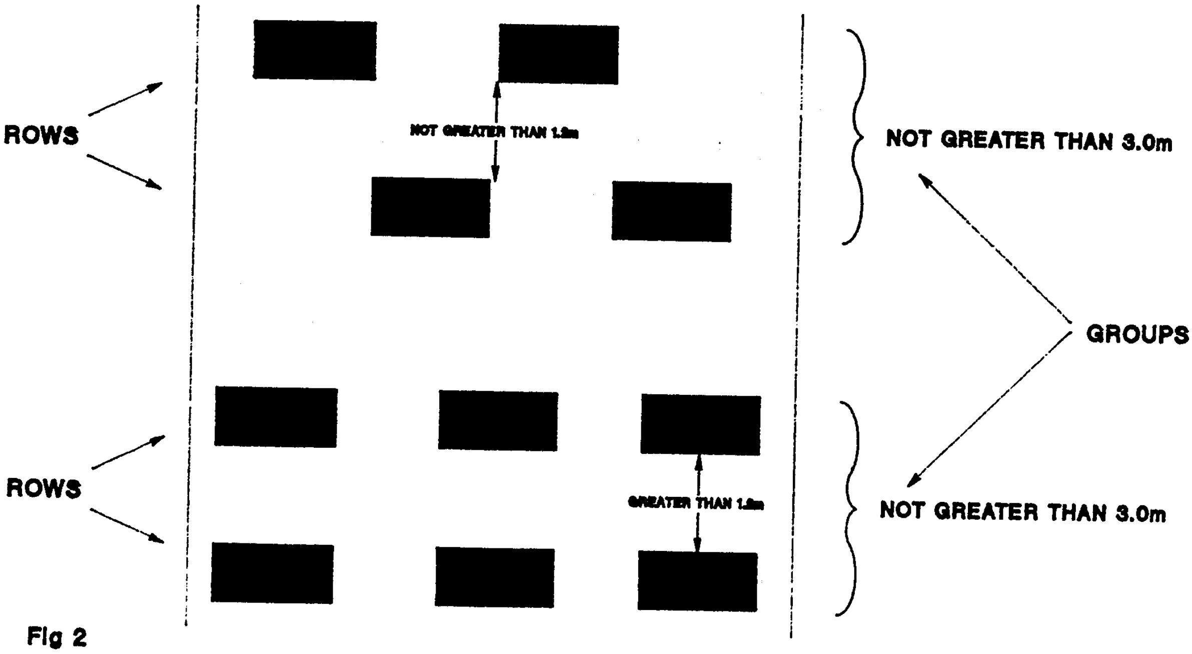



Fig 2

NOT TO SCALE

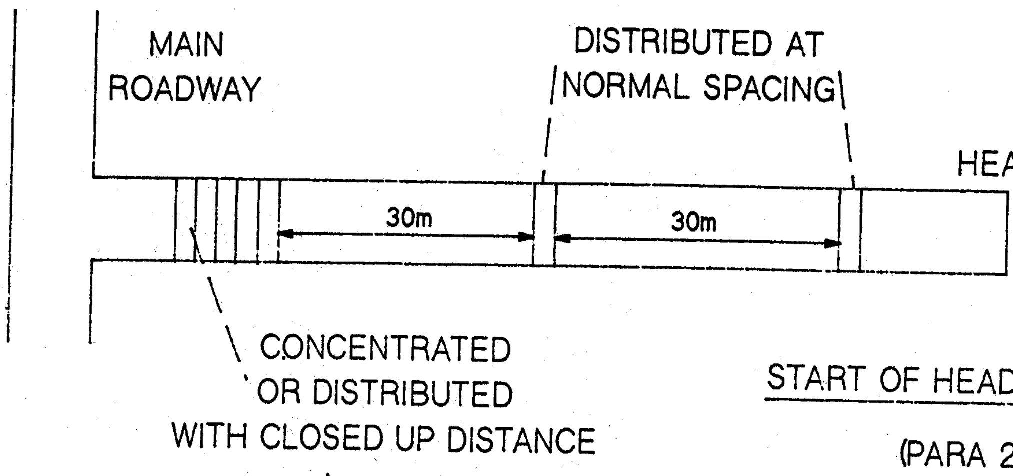



FIG 1

START OF HEADING

(PARA 21 & 24)

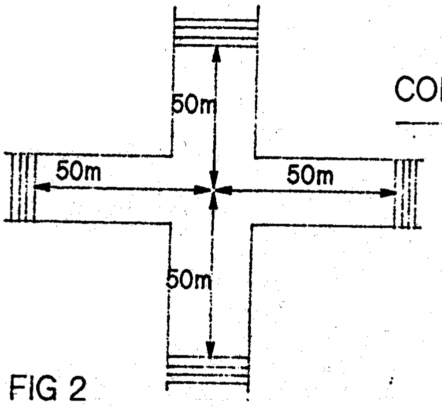



FIG 2

CONCENTRATED BARRIERS FROM A JUNCTION

(PARA 25)

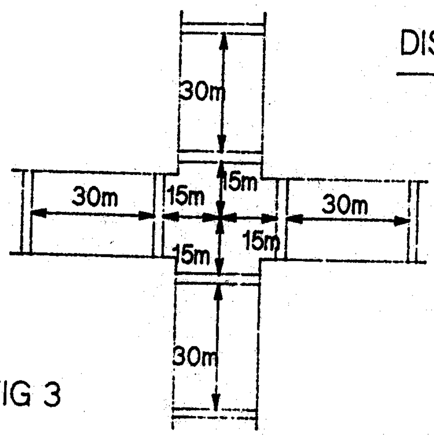



FIG 3

DISTRIBUTED BARRIERS FROM A JUNCTION

(PARA 26)

**ALL DISTANCES ARE THE MAXIMUM**

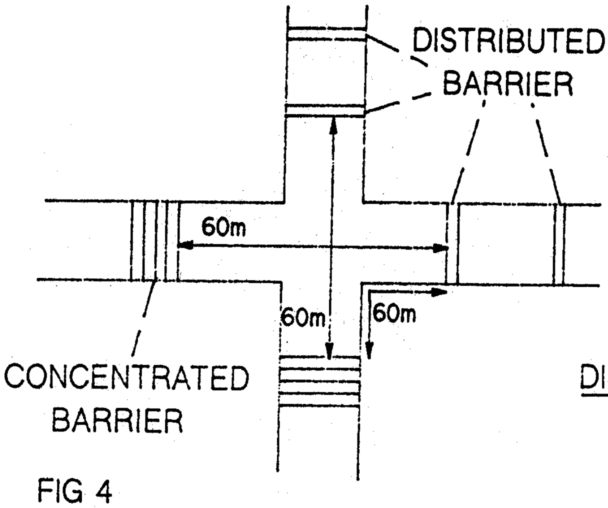



FIG 4

DISTRIBUTED AND CONCENTRATED BARRIERS FROM A JUNCTION
(PARA 27)

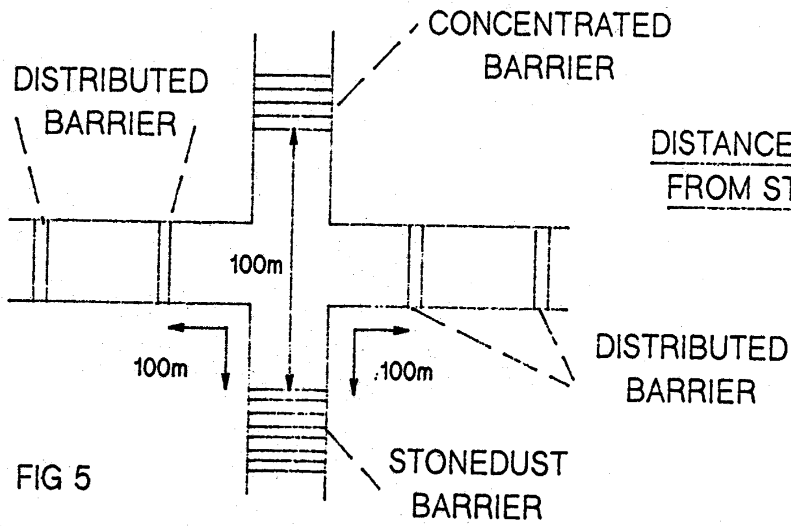
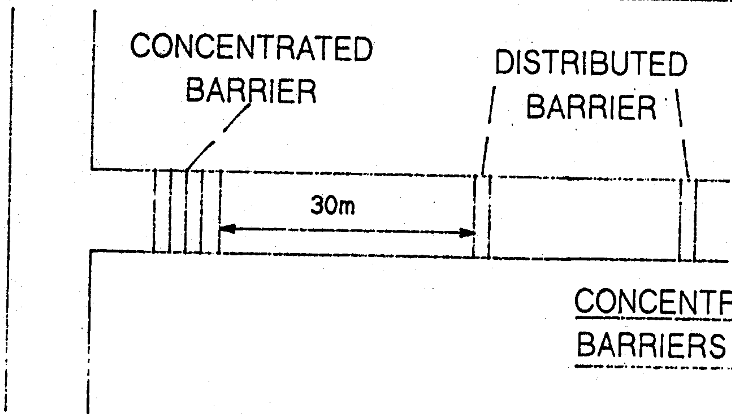



FIG 5

DISTANCE OF WATER BARRIERS FROM STONEDUST BARRIERS
(PARA 28)




CONCENTRATED AND DISTRIBUTED BARRIERS IN THE SAME ROADWAY
(PARA 29)

FIG 6

**ALL DISTANCES ARE THE MAXIMUM**

**ANNEX 6**

HEALTH AND SAFETY AT WORK ECT. ACT 1974

THE MINES AND QUARRIES ACT 1954

THE COAL MINES (PRECAUTIONS AGAINST INFLAMMABLE DUST) REGULATIONS 1956

**APPROVAL OF A BARRIER TO THE EXTENSION OF FLAME**

---

1. The Health and Safety Executive hereby approves for the purposes of regulation 10A(1) of The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956 as amended,[1] a stonedust barrier to the extension of flame known as:-

**THE BAGGED STONEDUST BARRIER**

2. This approval is subject to compliance with the Specifications contained in the Schedule annexed hereto.

3. This approval shall come into effect on 1 March 2004.

***D Mitchell***

For and on behalf of the
HEALTH AND SAFETY EXECUTIVE

A person authorised to sign on behalf
of the Health and Safety Executive

Date:

**Barrier Approval Number 2004/1**

---

1. SI 1960/1738; SI 1974/2124 and SI 1977/913

10. The distance between each row of bags within a sub barrier or within a distributed barrier shall not be less than 1.5 metres and not be greater than 3 metres.

11. Where any type of bagged barrier is used to provide explosion protection in a conveyor roadway additional bags (to those required for the standard barrier) shall be suspended beneath the conveyor structure to provide additional protection against passage of a flame under the belt. In circumstances where a conveyor is wider than 2m and there is more than 1m between the conveyor and the floor of the roadway, then one additional bag per metre width of the conveyor shall be installed beneath the conveyor for each row of bags suspended in that roadway.

12. Not withstanding paragraphs 7, 8 and 9 above where the bagged barrier is used to provide explosion protection in a roadway and a ventilation system (ducting, fans, regulators 'T' pieces etc) is suspended from the roof, the bags that would have been suspended from the roof where the ventilation system is suspended shall be suspended below the system at the specified intervals (see Diagram 3).

## TYPES OF BARRIER

### PRIMARY BARRIER

13. The primary barrier shall consist of four identical sub barriers installed over a distance of 120 metres of continuous roadway.

14. The first row of bags in the primary barrier shall not be closer than 70m and not be further than 120m from the coal face, face of heading or other potential ignition source (see paragraph 31), as appropriate.

15. The middle two sub barriers shall be spaced equidistant between the first and fourth sub barriers.

16. To ensure the minimum stonedust requirement is in place during retreating/advancing of the barrier an additional (fifth) sub barrier shall be used, this shall be installed before the first sub barrier is out of distance with the working place it is protecting.

17. The stonedust requirement for the complete primary barrier shall be calculated to achieve a stone dust density of 1.2 kg/$m^3$.

### *WORKED EXAMPLE*

Roadway size: 5m wide x 3.2m high.

Volume of roadway = 5m x 3.2m x 120m = 1920$m^3$

Therefore stonedust required in barrier is 1920m$^3$ x 1.2 kg/m$^3$ = 2304kg of stonedust in the barrier.

Number of 6 kg bags to barrier: 2304/6 = 384 bags

Number of bags per sub barrier: 384/4 = 96 bags

If bags are hung 0.5m from the sides of the roadway and 0.4m apart then each row can contain 11 bags.

This example shows each sub barrier shall contain a minimum of 96 bags, if each sub barrier consists of 9 rows of 11 bags a total of 99 bags will be used thus satisfying the minimum requirement.

If each row is spaced 1.5m apart then each sub barrier will extend over a distance of 12m (see Fig.1)

**SECONDARY BARRIER**

18. The secondary barrier shall consist of two identical sub barriers and be installed over a distance of 120m of continuous roadway.

19. The first row of bags in the secondary barrier shall not be closer than 70m and not be further than 120m from the last row of bags in the primary barrier.

20. To ensure the minimum stonedust requirement is in place during retreating/advancing of the barrier an additional (third) sub barrier shall be used, this shall be installed before the first sub barrier is out of distance with the working place it is protecting.

21. The stonedust requirement for the complete secondary barrier shall be double that required for a primary barrier in the same roadway.

***WORKED EXAMPLE***

Roadway size: 5m wide x 3.2m high

Volume of roadway = 5m x 3.2m x 120m = 1920m$^3$.

Therefore stonedust required: 1920m$^3$ x 1.2kg/m$^3$ x 2 = 4608kg.

Number of 6 kg bags to barrier: 4608/6 = 768 bags

Number of bags per sub barrier: 768/2 = 384 bags

If bags are hung 0.3m from the sides of the roadway and 0.4m apart then each row can contain 12 bags.

SCHEDULE TO BARRIER APPROVAL NUMBER 2004/1 MADE UNDER REGULATION 10A(1) OF THE COAL MINES (PRECAUTIONS AGAINST INFLAMMABLE DUST) REGULATIONS 1956.

***BAGGED STONEDUST BARRIERS***

## APPROVED SPECIFICATION FOR A BAGGED STONEDUST BARRIER TO THE EXTENSION OF FLAME

## COMMON BARRIER CONSTRAINTS

1. The barrier shall consist of a number of isotropic plastic bags containing 6kg of stonedust suspended in the roadway and arranged in accordance with this schedule.

2. All bags and hooks used in the construction of any barrier to the extension of a flame shall be of types that meet the specifications supported by UK Coal Mining plc Vocabulary number 13220225, or its equivalent.

3. Any stonedust used in the construction of any barrier to the extension of a flame shall be of a type that complies with The Coal Mines (Precautions Against Inflammable Dust) Regulations 1956 Regulation 6.

4. Each bag that forms any part of the barrier shall contain a minimum 6 kg of stonedust and be hung with the largest cross sectional area of the bag facing the potential blast wave (see Diagram 1).

5. The horizontal distance between hooks of bags in the same row must not be less than 0.4 metres and not greater than 1.0 metre.

6. The distance between the outer bags and the sides of the roadways must not exceed 0.5 metres.

7. For roadways up to 3.5 metres high one layer of bags per row is required, they shall be suspended with the hooks between 0 metres and 0.5 metres from the roof. The bags shall be installed to follow the roadway profile.

8. For roadways between 3.5 metres high and 4.5 metres high two layers of bags per row are required. The bags shall be evenly distributed between the layers with the hooks suspended between 0 metres and 0.5 metres from the roof in layer one and between 0.5 metres and 1.0 metres from the roof in layer two (see Diagram 2).

9. For roadways greater than 4.5 metres high three layers of bags per row are required. The bags shall be evenly distributed between the layers with the hooks suspended between 0 metres and 0.5 metres from the roof in layer one, between 0.5 metres and 1.0 metre from the roof in layer two and between 1 metre and 1.5 metres from the roof in layer three.

The sub barrier will consist of 32 rows of 12 bags. If each row is spaced 1.5m apart then each sub barrier will extend over a distance of 46.5m.

The second sub barrier will contain exactly the same number of bags and layout as the first (see Fig.2)

## DISTRIBUTED BARRIER

22. The distributed barrier consists of rows of bags being installed and being left in place until the mining operations it is protecting against are complete.

**23. The first row of bags shall not be closer than 70m and not be further than 120m from the working face. Bags may be hung closer than 70m but will not be deemed to form part of the barrier.**

24. The distributed barrier must be at least 360m long. The distance of 360m gives the same mass of stonedust as a primary and secondary barrier for the same cross sectional area.

25. The stonedust requirement for a fixed distributed barrier shall be calculated to achieve a stonedust density of $1.2kg/m^3$ of roadway volume.

### *WORKED EXAMPLE*

Roadway volume: 5m x 3.2m x 360m = $5760m^3$.

Therefore stonedust required in barrier is $5760m^3$ x $1.2kg/m^3$ = 6912kg.

Number of 6 kg bags 6912/6 = 1152 bags.

Number of bags per metre = 1152/360 = 3.2 bags.

If the rows are spaced at 3m intervals then 3.2 bags x 3m = 9.6 bags per 3 metres

1 row of 10 bags every 3m of roadway length (see Fig.3)

## LONGWALL WORKINGS, HEADINGS IN COAL AND BORD AND PILLAR WORKINGS

26. The conveyor roadway of any such working shall be protected by either:

a. primary and secondary barriers installed at the distances specified, (see also Fig. 4, 4a & 4b) or

b. a distributed barrier installed at the distances specified (see also Fig. 5, 5a, & 5b)

27. Where a coal face, a heading in coal or a bord and pillar working is advancing from or retreating towards a junction with an adjoining roadway, the primary and secondary barriers or the distributed barrier (whichever the case) shall be maintained within the distances stipulated in this specification (see also Fig. 6, 6a & 6b).

## ESTABLISHING NEW WORKING AREAS/COMPLETING WORKING AREAS (SEE ALSO FIG. 6, 6A, 6B, 6C )

28. When establishing a new working area explosion protection must be applied. This shall be achieved by erecting either a primary and secondary barrier or a distributed barrier on the appropriate side(s) of the working with the barriers set at the distances as stipulated in this specification.

29. These barriers shall be maintained and kept in place until a full barrier of the permitted specification can be erected in the gate roadway. This principle also applies in reverse. When working the retreat method a barrier as outlined above must be established in place prior to the position that a full barrier of the specified type cannot be maintained in the gate roadway. When two or more workings are either setting off or completing working from a common trunk conveyor in close proximity to each other the barriers for one working place can be deemed to offer protection for the other providing the above barrier specifications are maintained. (Fig. 6).

30. The above rules will apply to all headings in coal with or without a conveyor.

## OTHER CASES

31. Defined as any possible points of origin of an explosion which would be likely to lead to the spread of an explosion to a coal conveyor road. Examples may be certain scourings through goaf and stone drifts which are approaching or crossing coal seams or encountering faults or old workings and interconnections between mines.

32. In all these cases protection will be afforded by the installation of a primary and a secondary barrier. (Fig. 4).

## DIAGRAMS AND FIGURES

**<u>Diagram 1.</u>**
**<u>To show bags suspended facing the direction of any potential blast wave</u>**

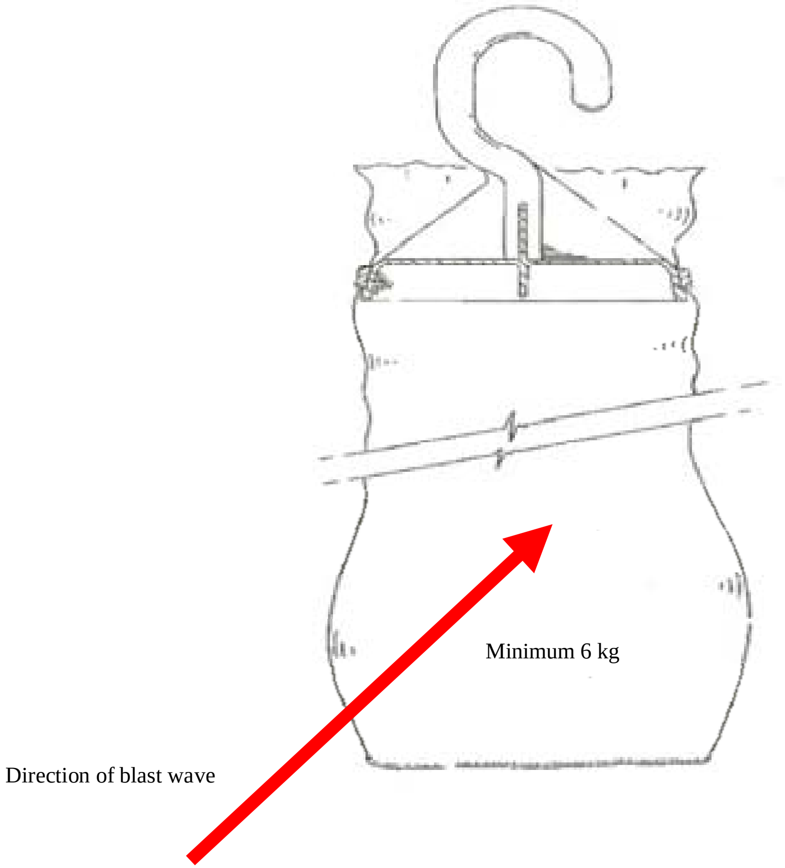


**Diagram 2 to show more than 1 layer of bags in a roadway between 3.5 & 4.5m high**

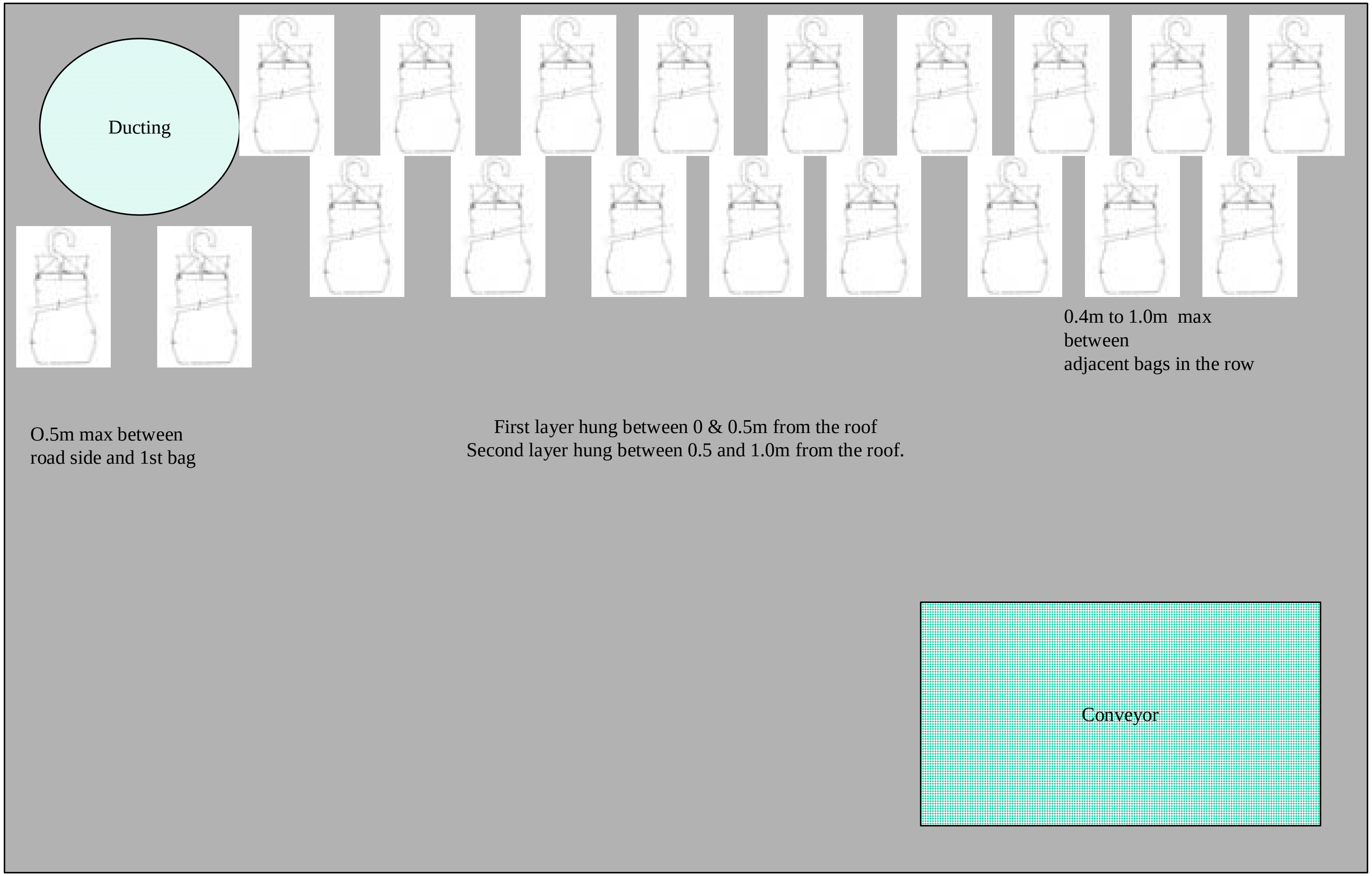


**Diagram 3.**
**To show bags suspended round a roadway obstruction**

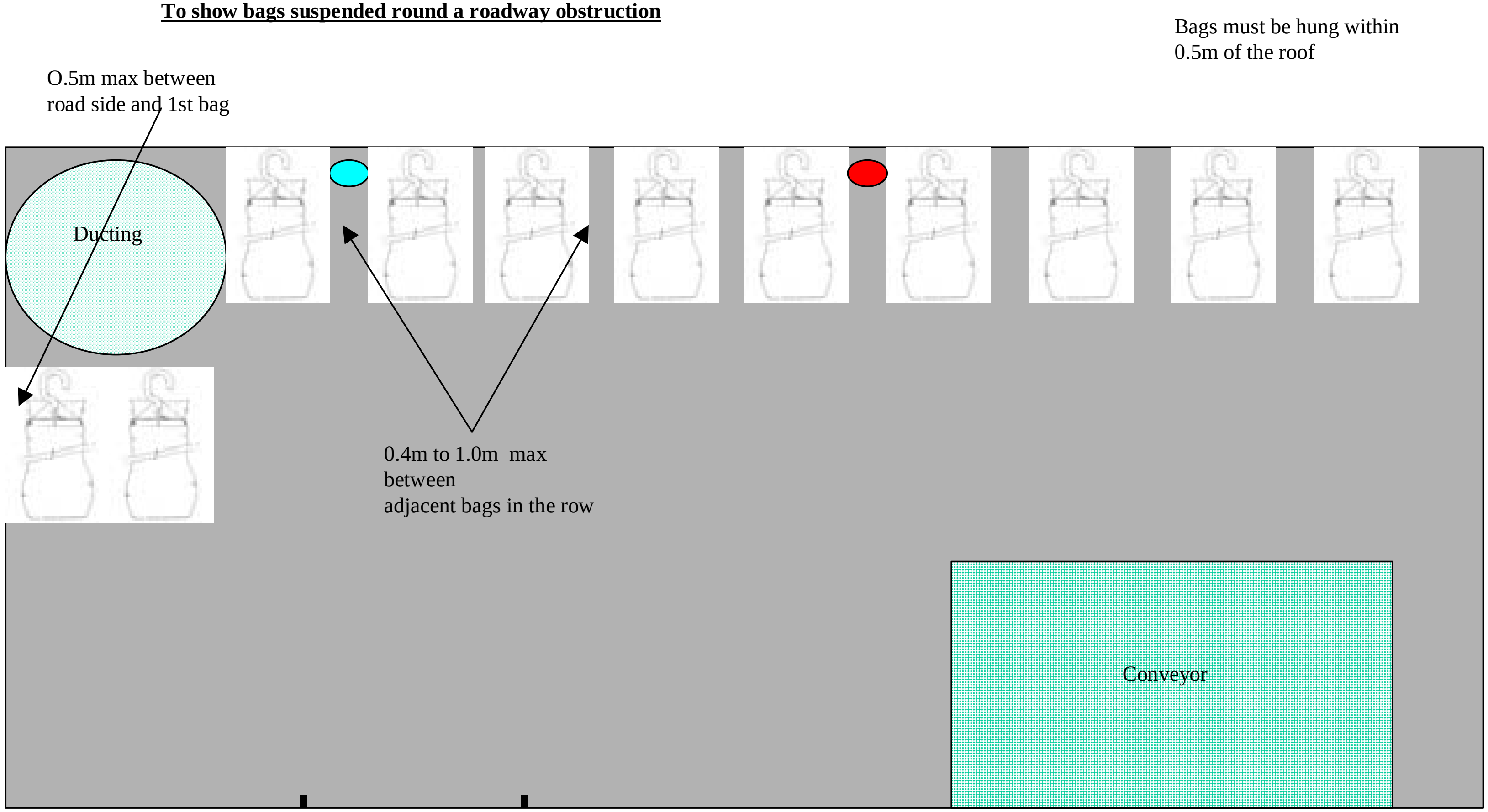


**Fig 1. To show distribution of sub barriers in a primary barrier as in the worked example.**

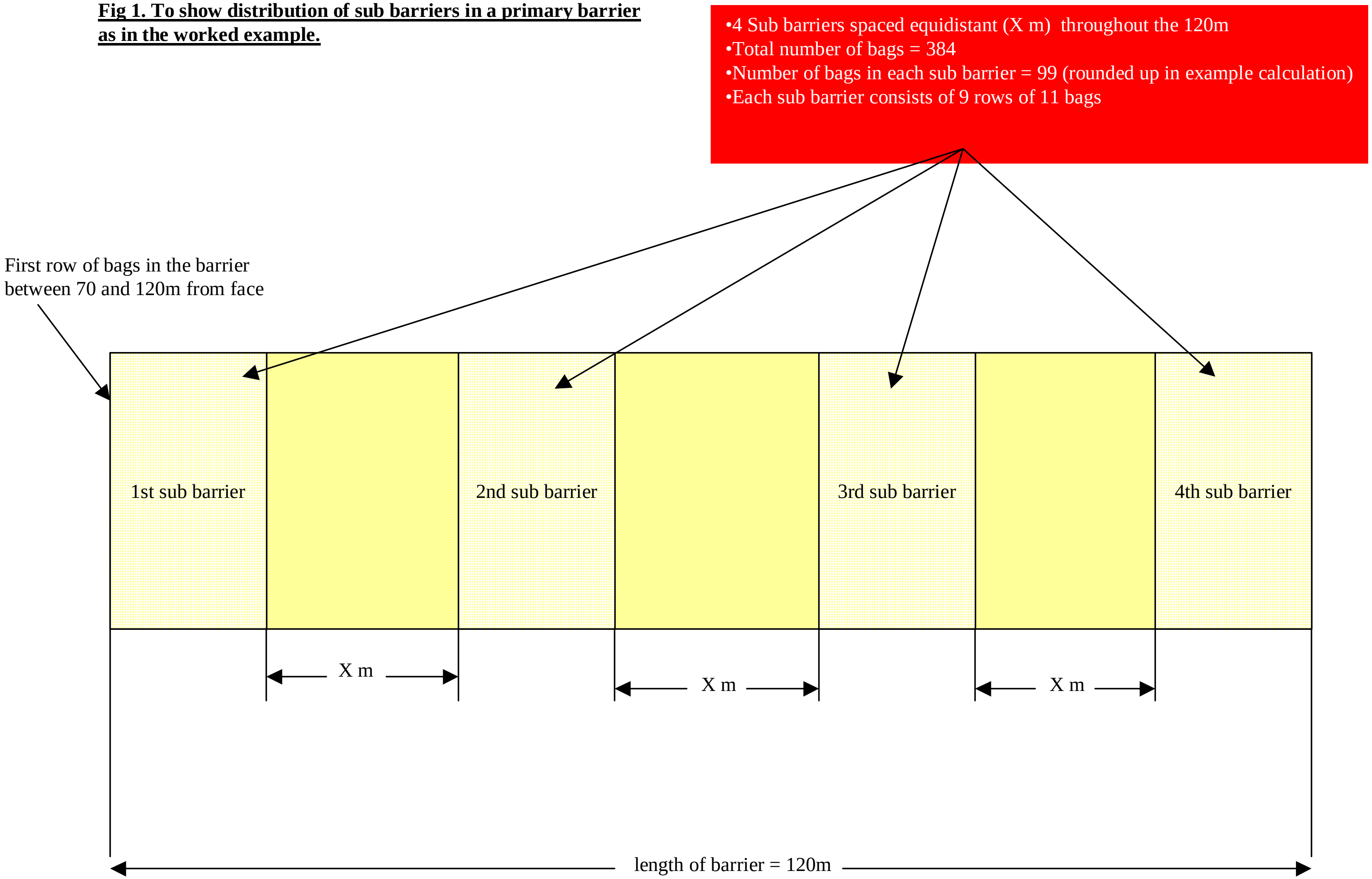


**Fig 2. To show distribution of sub barriers in a secondary barrier as in the worked example.**

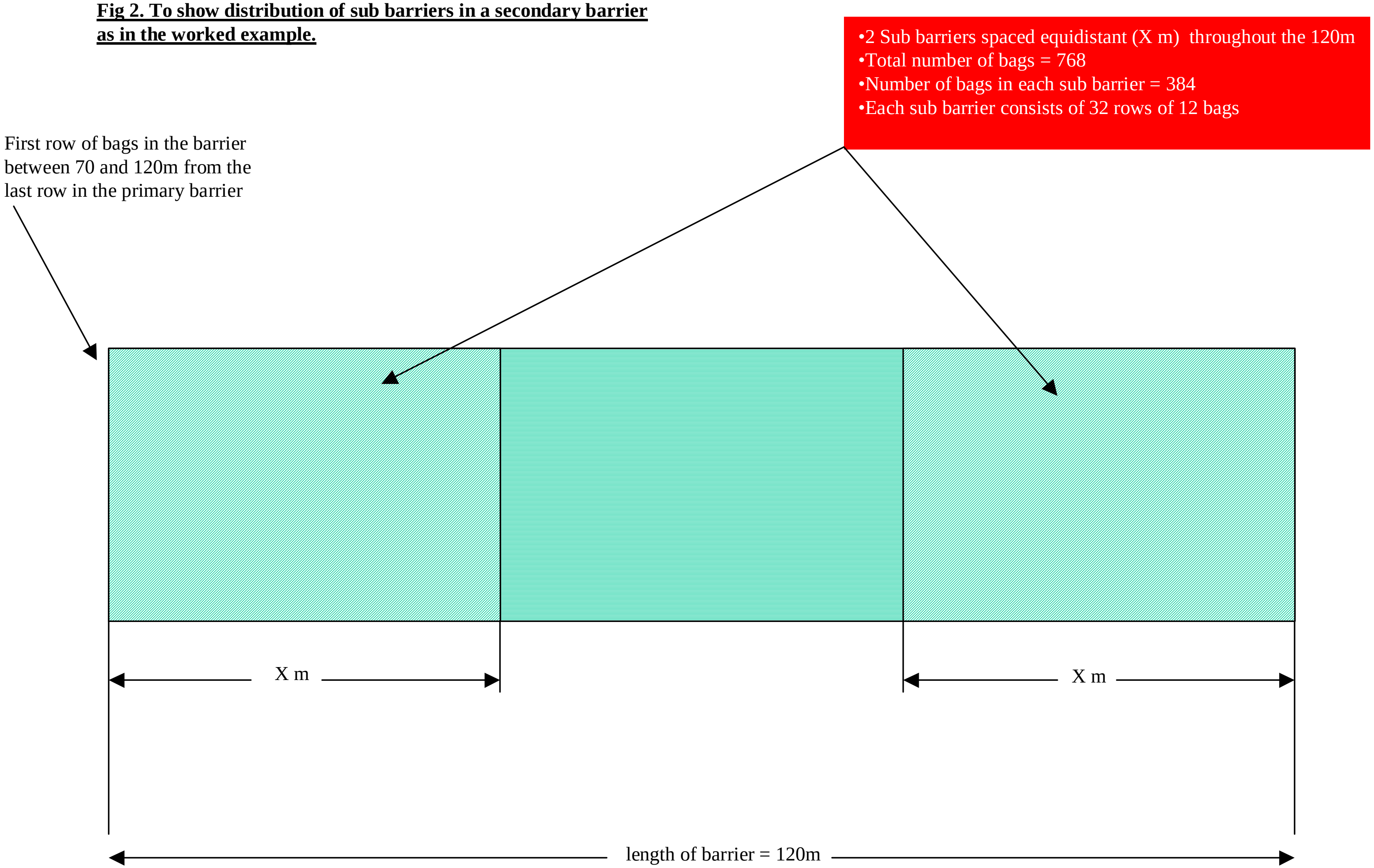


**Fig 3. To show distribution of bags in a distributed barrier as in the worked example.**

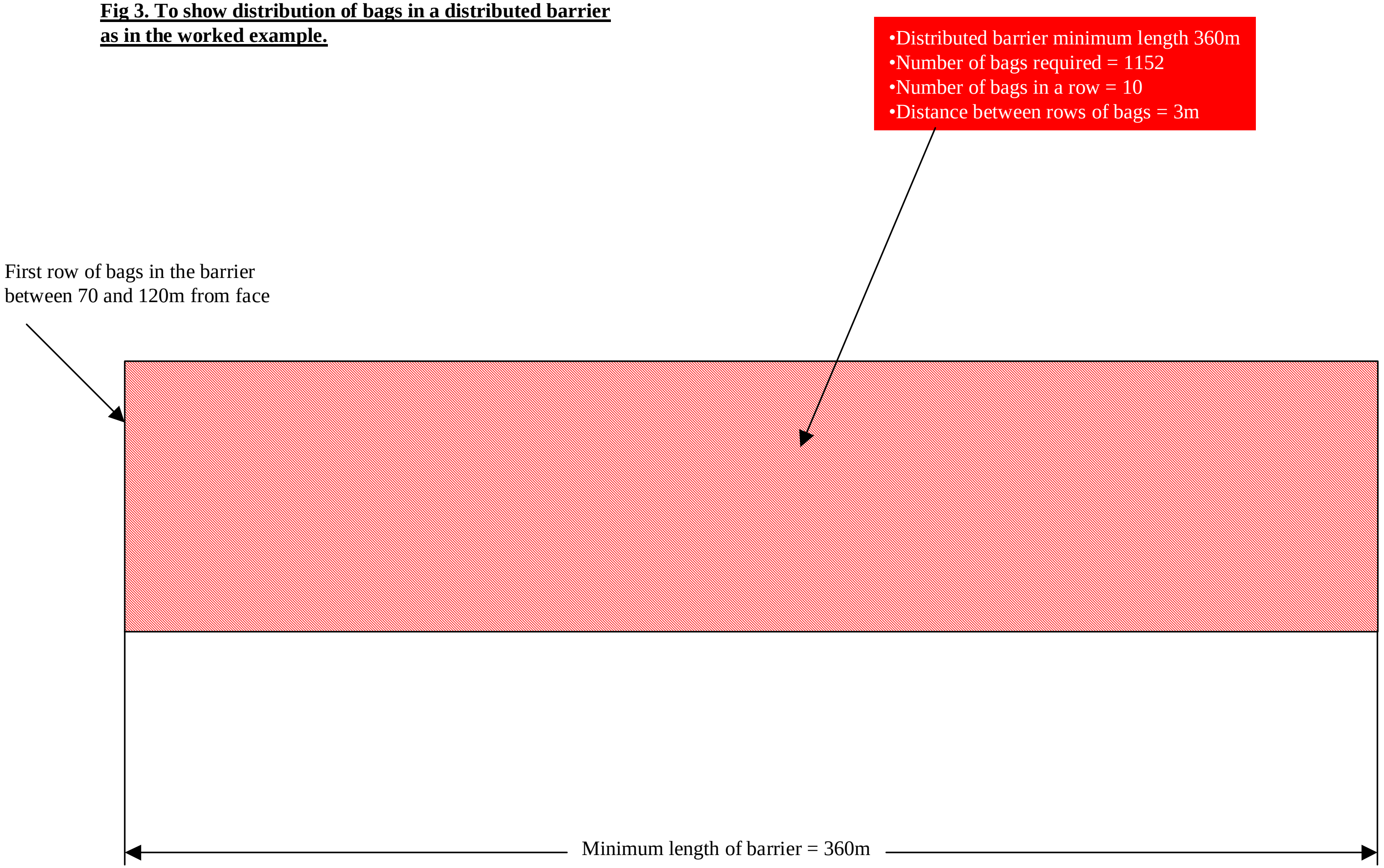


**Fig. 4**

**Protection of an established coal face using primary and secondary barriers**

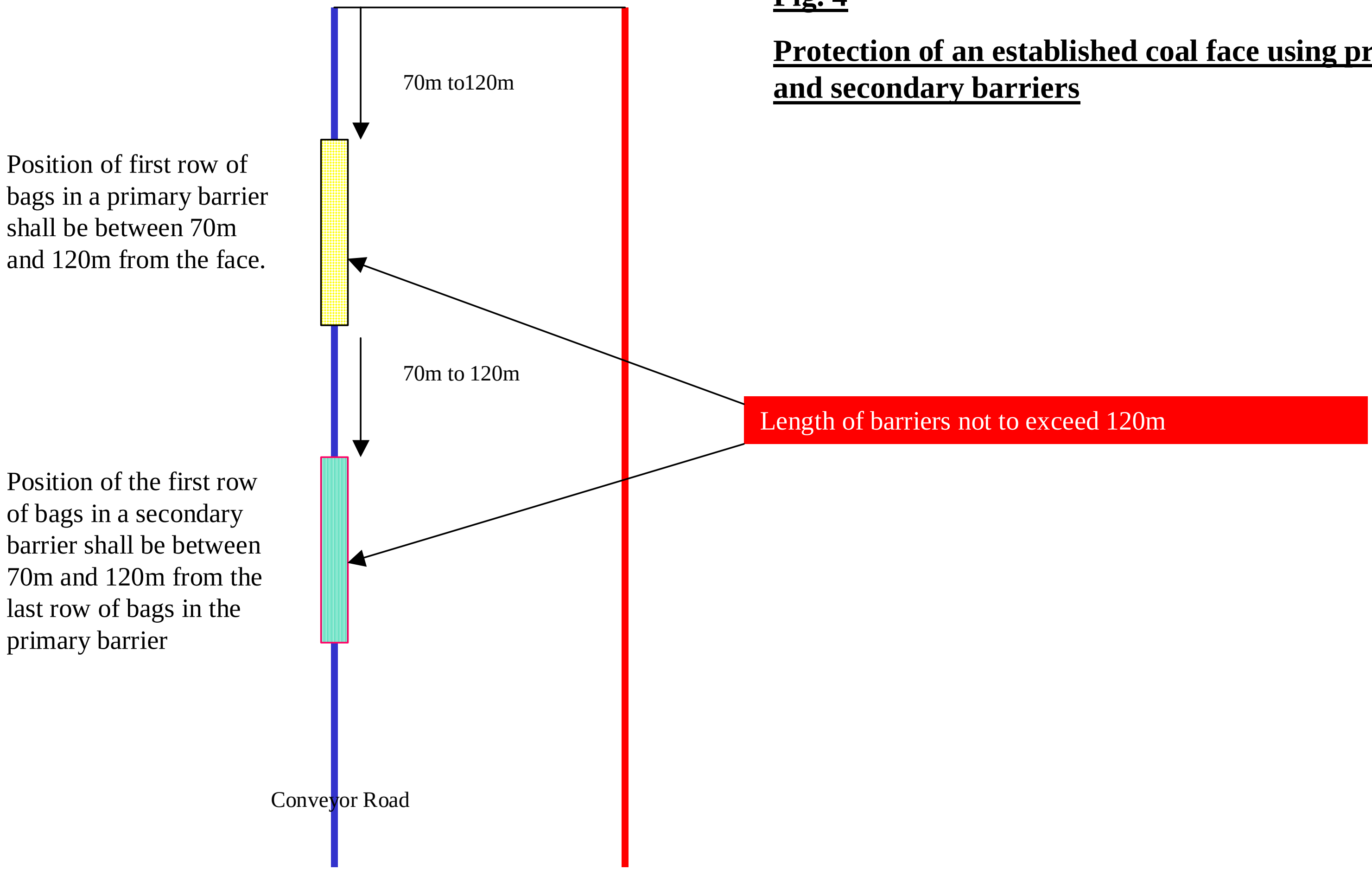


**Fig. 4a**

**Protection of an established heading in coal using primary and secondary barriers**

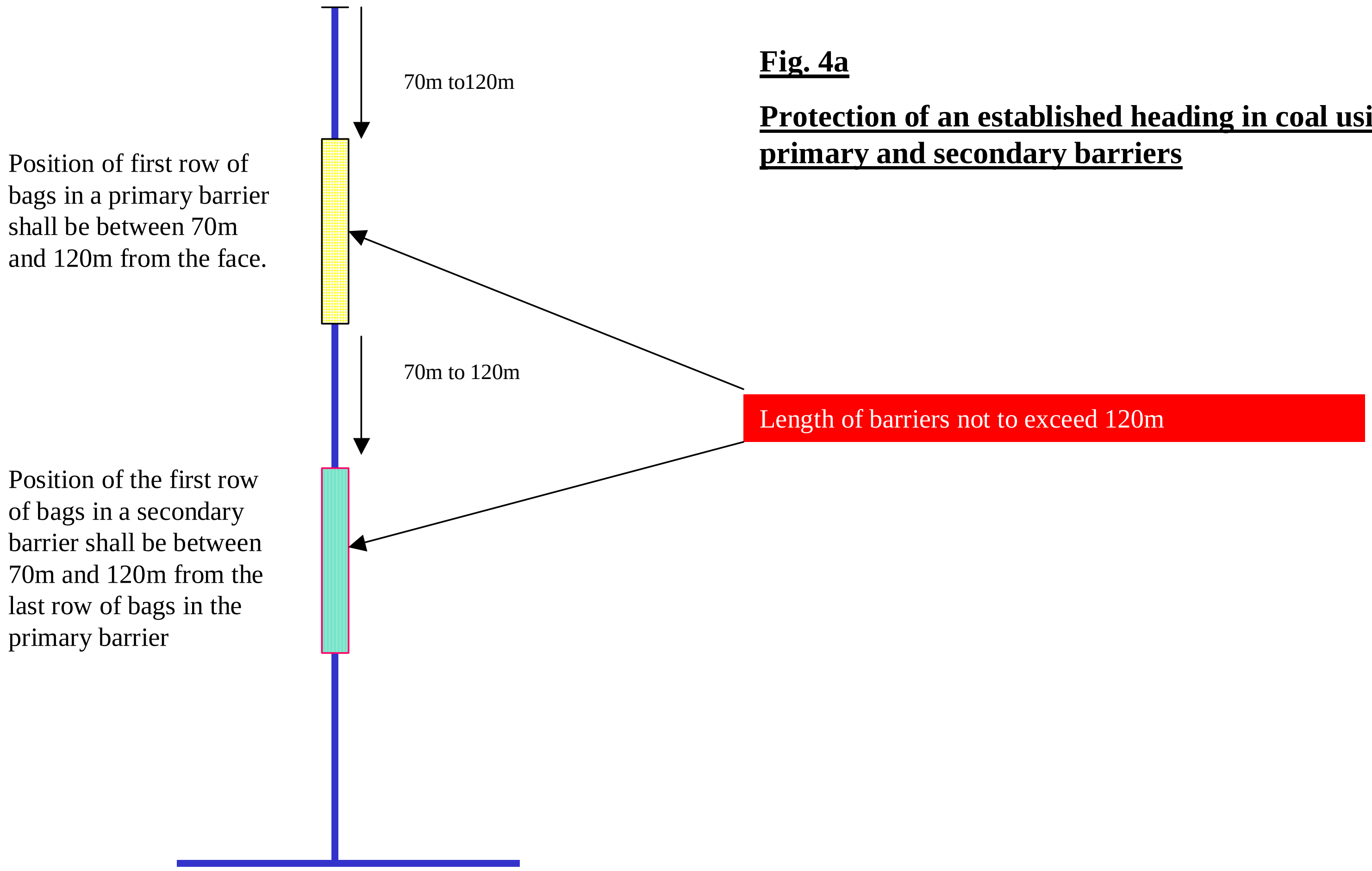


**Fig. 4b**

**Protection of an established bord and pillar working using primary and secondary barriers**

Position of first row of bags in a primary barrier shall be between 70m and 120m from the furthest working face.

Position of the first row of bags in a secondary barrier shall be between 70m and 120m from the last row of bags in the primary barrier

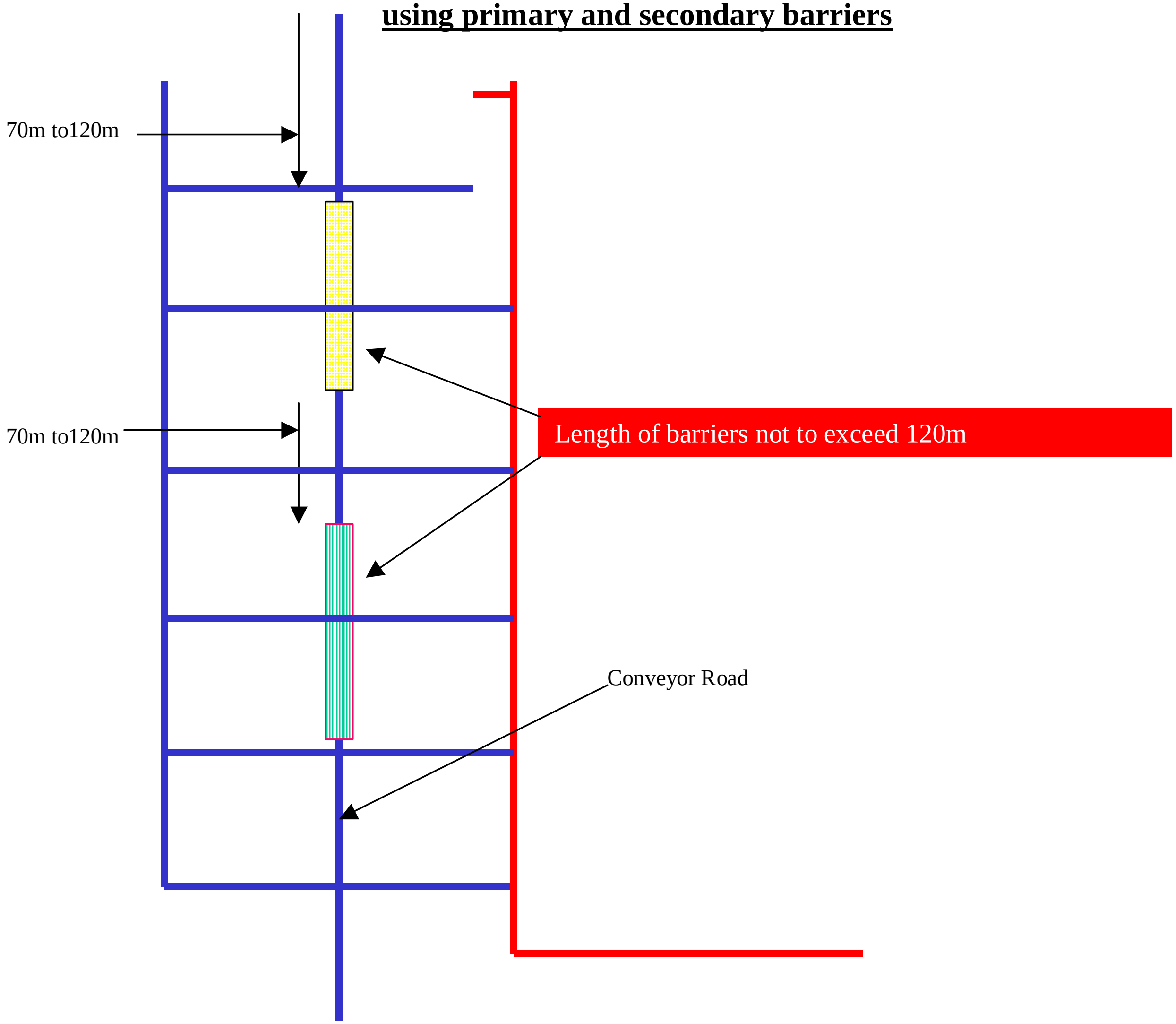
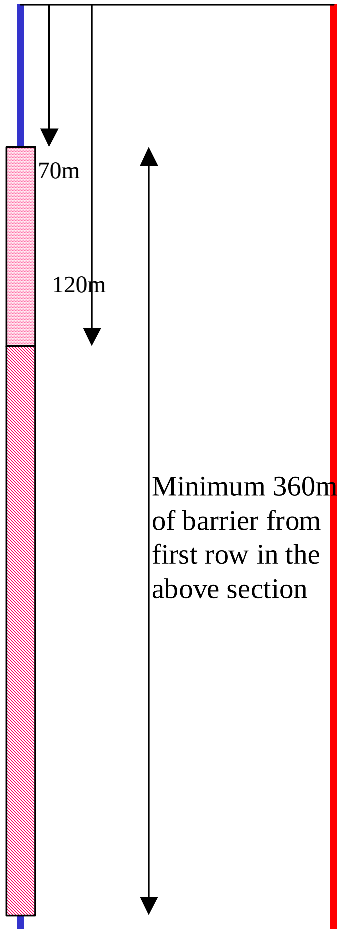


**Fig. 5**

**Protection of an established coal face using distributed barriers**

The position of the first row of bags shall be between 70m and 120m from the face.

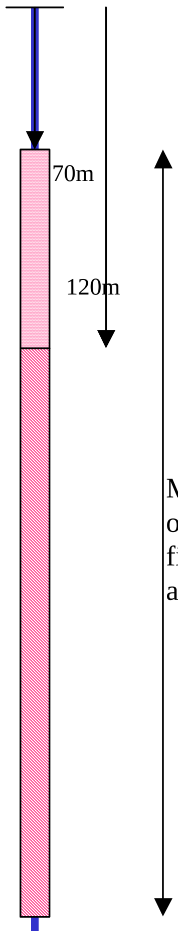



Any bags in a distributed barrier closer than 70m from the face shall not be included in the minimum 360m length of barrier required

**Fig. 5a**

**Protection of an established heading in coal using distributed barriers**

The position of the first row of bags shall be between 70m and 120m from the face.

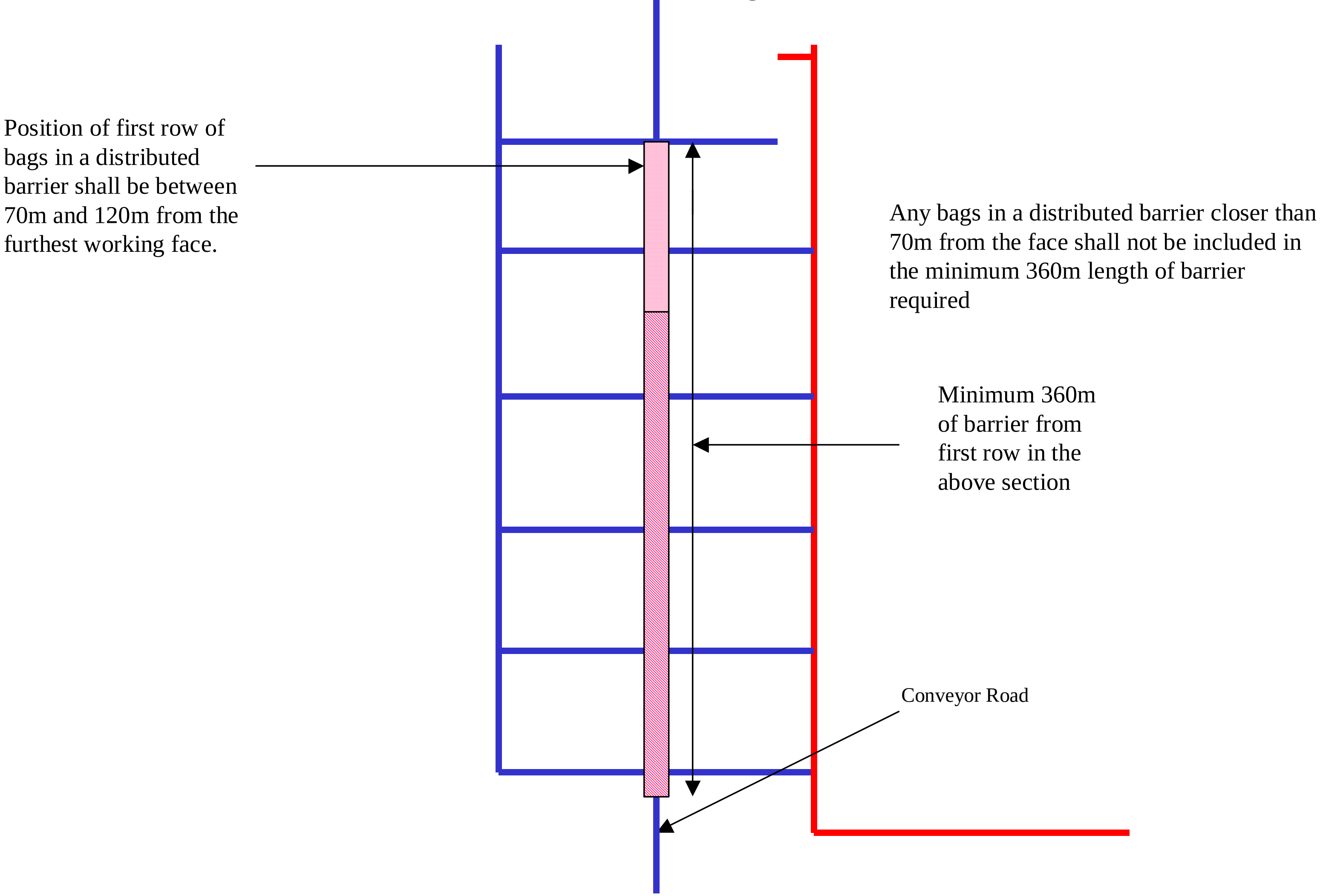



Minimum 360m of barrier from first row in the above section

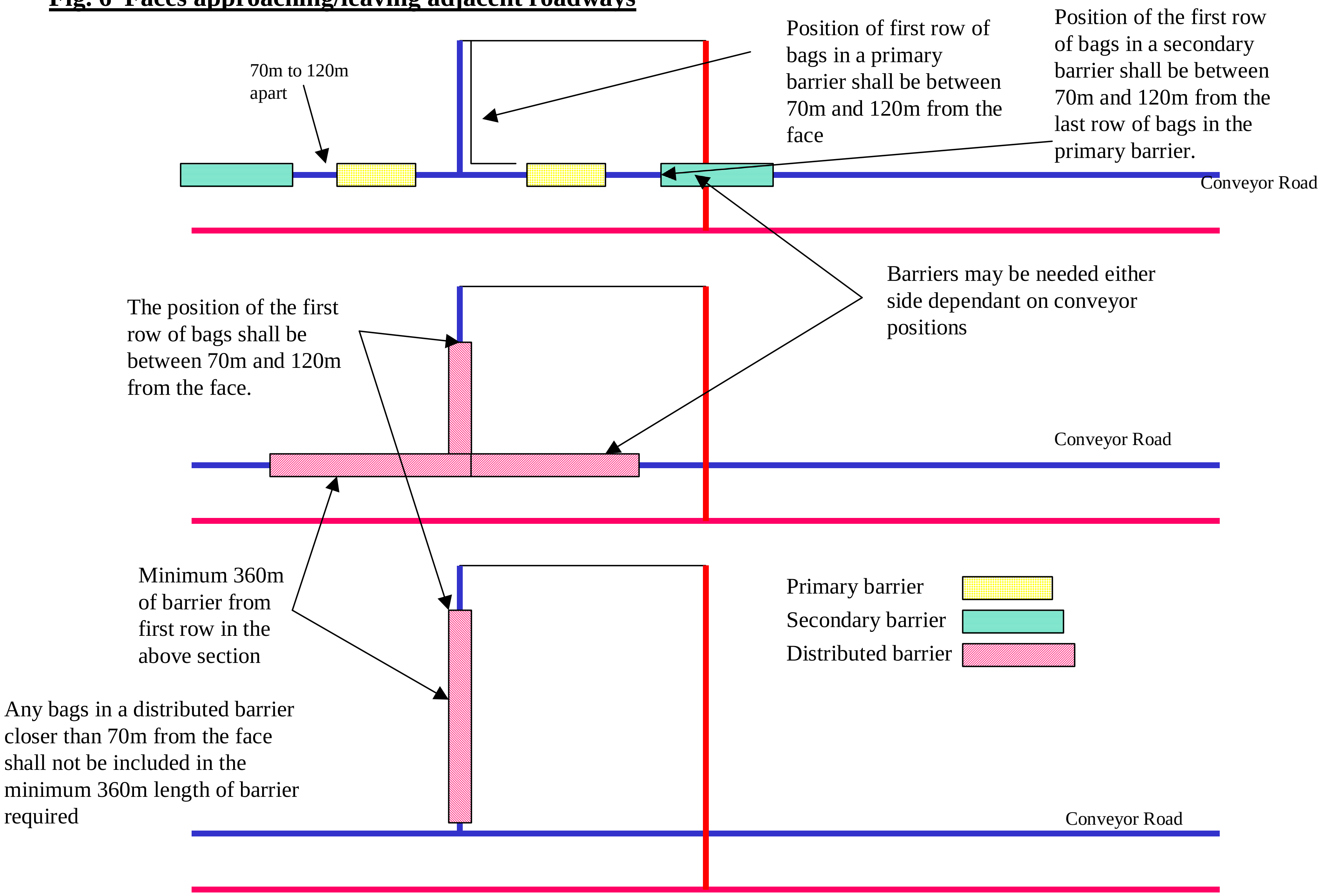
Any bags in a distributed barrier closer than 70m from the face shall not be included in the minimum 360m length of barrier required

**Fig. 5b**

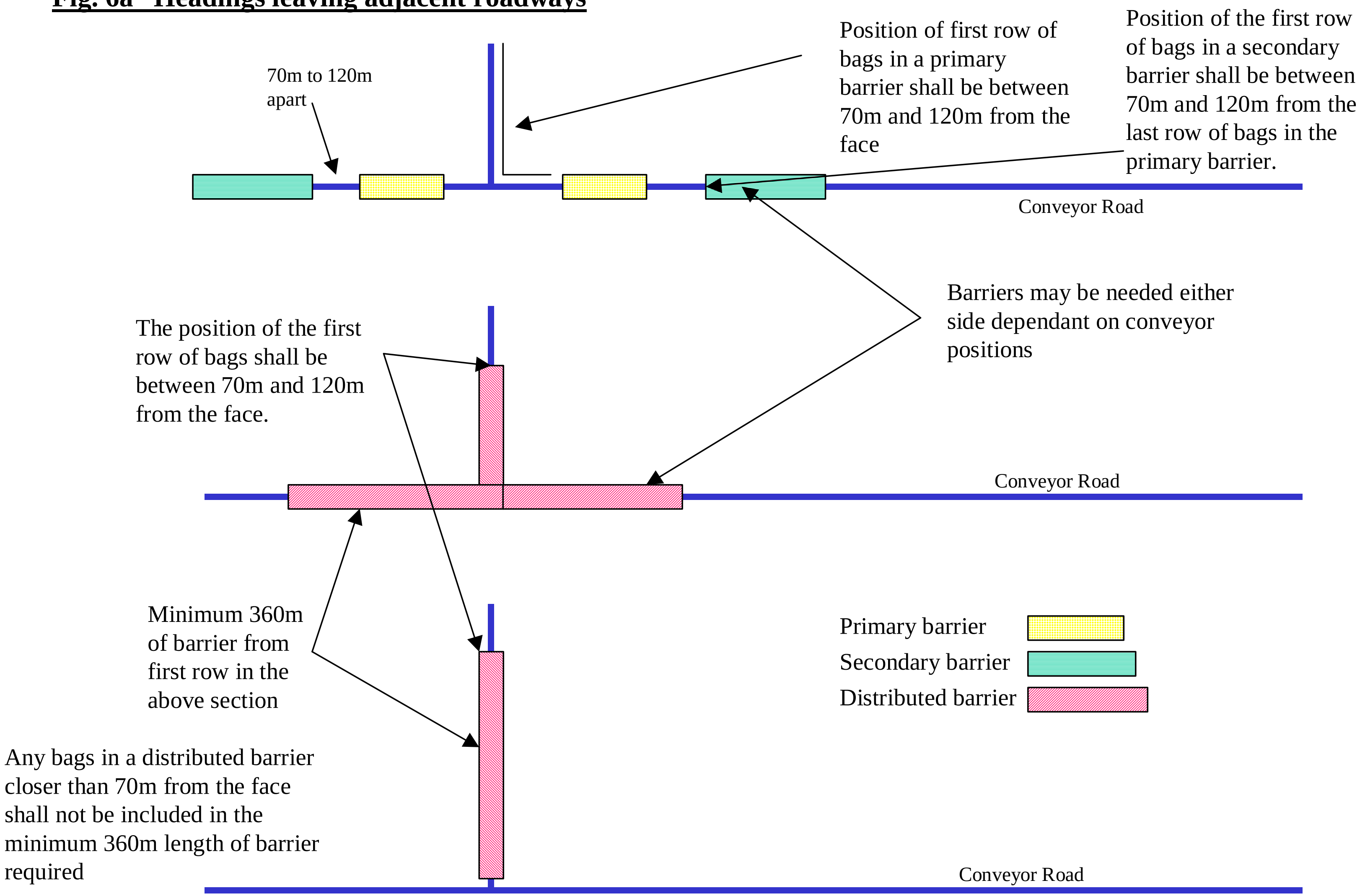
**Protection of an established bord and pillar working using a distributed barrier**



## Fig. 6 Faces approaching/leaving adjacent roadways



## Fig. 6a  Headings leaving adjacent roadways



## Fig. 6b

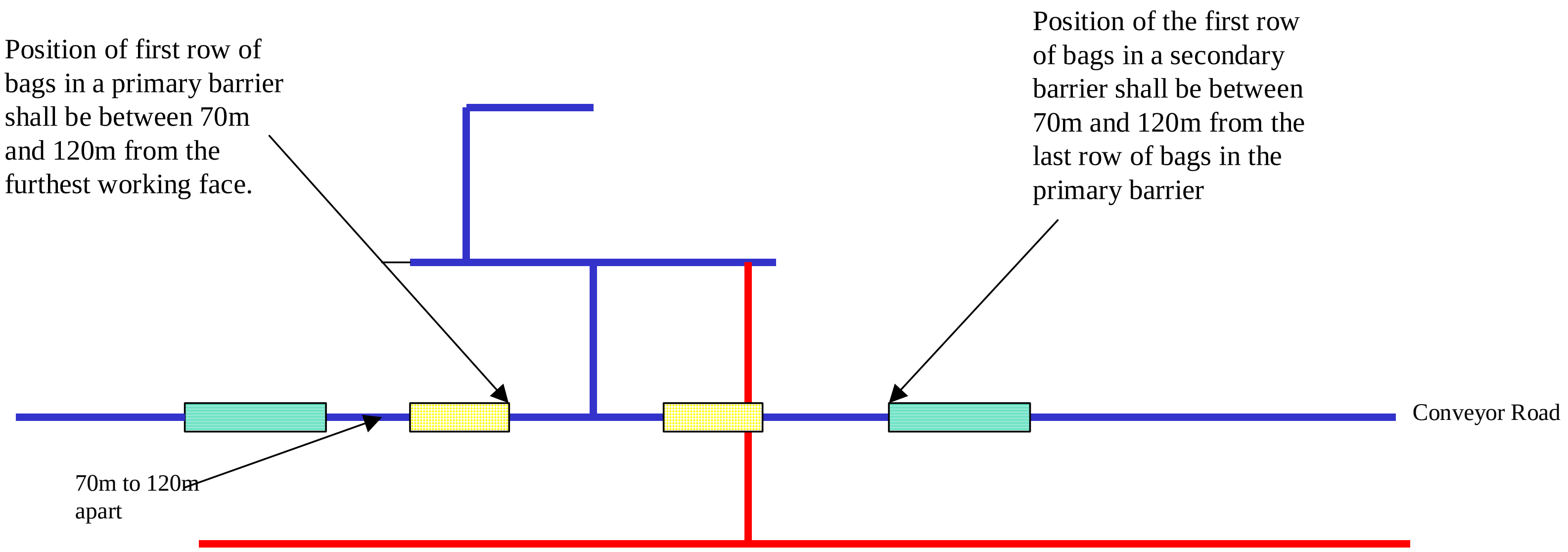
## Bord & Pillar working leaving adjacent roadways using Primary and Secondary barriers

Barriers may be needed either side dependant on conveyor positions

Primary barrier

Secondary barrier

Length of barriers = 120m



**<u>Fig. 6c</u>**

## <u>Bord & Pillar working leaving adjacent roadways using a distributed barrier</u>

Barriers may be needed either side dependant on conveyor positions