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HEALTH & SAFETY LABORATORY

Development of a Fire and Explosion Risk Assessment Methodology for Underground Mines

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EXECUTIVE SUMMARY

Objectives

The aim of this report is to present the framework of a fire and explosion risk assessment developed for use in underground mines.

Main Findings

A risk assessment system for the study of fires or explosions in underground mines has been developed . This is based on past work/recommendations made during the course of this project and a number of fire risk assessment schemes, namely those developed by the National Fire Prevention Association (NFPA); the Australian Department of Mineral Resources and a joint HSE/Home Office document.

The final methodology uses a series of check sheets to identify potential fuels and ignition sources, preventative measures, fire/explosion mitigation systems, and items for inclusion in emergency plans.

Main Recommendations

The assessment system developed should be distributed to the mining industry to better enable them to comply with statutory regulations on developing fire or explosion risk assessments. The assessment method could then be used as published or be tailored to the mines individual needs.

1 INTRODUCTION

In order to meet statutory requirements, (Appendix A), it is necessary for mine managers to address the potential for underground fires or explosions and their impact on the workforce and the mine ventilation system. One such means of doing so is to undertake a risk assessment to identify probable fire or explosion/locations to allow quantification of their effects. Both fire and explosion should be considered as fires may well arise as a result of an explosion, or vice versa. Even a small fire should be regarded as being a major hazard from the point of view of explosion initiation should a combustible atmosphere arise.

This report presents a risk assessment methodology for the assessment of underground fire and explosion hazards and is based on known underground explosion hazards, fire engineering principles, the review of historical fire incidents and fire test criteria for potentially combustible materials used underground.

2 POSSIBLE RISK ASSESSMENT METHODOLOGIES

2.1 Earlier outline fire risk assessment methodology

An outline methodology for the assessment of fire hazards was identified in an earlier report for this project (Thyer 2000) and is set out below.

1) Identification of materials present and method of material selection

- identify and list materials present, quantity and location.
- review tests used as a basis for selection of such materials and their shortcomings.
- consider how fire resistance changes in use, for instance due to contamination with coal dust, other combustible material, or ageing of product.

2) Establish possibility of ignition

- review acceptance criteria, e.g. flame size or maximum permissible temperatures allowed under tests, to establish ease of ignitability.
- establish maximum permissible temperatures under regulations applied to the mine.
- review method of use of materials - consider possible fault conditions or other scenarios which may lead to higher temperatures being achieved.

Stage (2), above, will be assisted by the review of past underground fires which will provide information on the type of fires reported, the method of detection and possible causes.

3) Consider possibility of fire growth

- establish likelihood of fire spreading beyond source - to include:
- size of original fire and material involved; and,
- consideration of fire resistance data for items which may be subject to flame impingement.

4) Will a fire be detected

- will personnel be able to detect a fire - use of environmental monitoring
smoke detectors
IR detectors to look for hot spots, etc..

5) What fire suppression systems present

- are any fire detection systems in place, what is the method of warning control staff of a fire so emergency strategy can be started.
- will the fire be detected by personnel - what are the occupancy levels in the area.
- what type are the fire suppression systems, and how effective are they.
- consider nature of possible fuels and typical extinguishing media.

- how are extinguishants to be applied, e.g., injection into engine compartments, deluge etc..
- do any standards exist specifying details of fire suppression systems, if not how is the system to be installed.
- will the system work underground, e.g. foam plugs may be disrupted by high air flows.

6) Communication and evacuation

- are reliable communication systems in place to coordinate fire & rescue operations.
- are practice drills undertaken.
- how will the spread of smoke affect fire & rescue measures.
- can the ventilation system be used to assist fire & rescue measures.

By following the above stages it should be possible to identify the most common fire types and their causes, along with possible improvements.

2.2 Suggested NFPA fire risk assessment

A possible fire risk assessment methodology is included for information purposes in two NFPA standards relating to mining (NFPA 121 and 122), the layout, consisting of four phases, is as follows:

1. identification of fire potential;
2. assessment of consequences of fire;
3. determination of the need for fire protection; and,
4. selection of appropriate fire protection option(s).

The suggested areas of assessment are similar to those described in Section 2.1 above and are as follows.

1) Identify the fire potential
a) Ignition sources

1. High temperatures e.g. engines, exhaust systems, turbochargers, and faulty devices such as bearings, brakes, and gears.
2. Electrical e.g. batteries, generators, instrument panels etc..
3. Cutting and welding
4. Other e.g. smoking, spontaneous ignition.

b) Fuel sources

1. Class A e.g. combustible debris, wood, rags, electrical insulation, upholstery, hose lines, tyres.
2. Class B e.g. diesel fuel, some hydraulic fluids, coolants, grease, oil, cleaning solvents.

c) Probability of coexistence of fuel and ignition source

1. Proximity of fuel to ignition sources. Analyse equipment to determine areas where lubricants, hydraulics or fuel lines are in proximity to ignition source(s), e.g. engine

compartments. Note, possibility of pressurised sprays or electrical sparks which may spray/jump beyond initial source.

2. Study past fire incidents to indicate possible future problem areas.

3. Quality of maintenance.

4. Housekeeping.
5. Operational damage e.g. material may roll/fall on equipment at a face causing damage to hydraulic lines or electrical components/wiring.

2) <u>Assessment of consequences of fire</u>

a) Personnel exposure.

1. Direct exposure of operator or nearby personnel to heat, smoke, toxic fume.
2. Exposure of distant personnel to smoke carried by mine ventilation.
3. Increased fire severity by spread from equipment or point of origin to other combustibles such as timber supports etc..
4. Ventilation flow reversal due to fire induced ventilation changes.

b) Economic risks.

Determine the economic costs of a fire on a piece of equipment, including both property damage, business interruption costs, and costs if fire spreads beyond point of origin.

3) <u>Determine the need for fire protection</u>

If risk analyses in (1) and (2) show unacceptable risks to personnel, economic risks, or both, appropriate fire protection measures should be determined.

4) <u>Select appropriate fire protection</u>

a) Hazard reduction

1. Equipment design - evaluate design to determine if risk can be reduced through design change.
2. Operating procedures - threat of fire can be reduced through effective implementation of company policies and procedures.
3. Evaluation - Do fire risk reduction measures reduce risk ? If acceptable no further action required, if unacceptable, further action needed to reduce risks, or fix detection/suppression systems, or both.

b) <u>Fire detection equipment</u>

Possible detectors (or triggers for fire suppression systems) listed in NFPA guidance as being used in the mining industry are:

1. Fusible plastic tube - pressurised plastic tube fitted with a pressure sensor which triggers extinguisher discharge on loss of pressure.

2. Thermistor strip - A line-type device with a sensing element consisting of a thin tube containing two wires separated by a material whose resistance or capacitance changes with temperature.
3. Metal hydride - A device consisting of a tube containing a metal hydride wire. When heated the hydride decomposes liberating hydrogen, thus pressurising the tube. Detection is achieved by monitoring pressure within the tube.

The current position for fire detection in UK mines is given in Appendix A. Here reliance is placed on a combination of detection of fires to activate systems and notification of the operations room.

c) Detector placement

Consideration should be given to physical configuration of the area or equipment to be protected, its proximity to a fire, ambient temperature, degree of mechanical exposure of the detectors, possibility of shock or vibration, presence of dust, ventilation flows etc..

d) Control options

1. Consider the following questions.
2. How is the suppression system to be activated - automatic or manual, both ?
3. Notify control room of activation
4. Equipment shutdown on detection

e) Fire suppression equipment

Identify available fire protection and suppression equipment alternatives.

1. Portable protection
2. Fixed suppression systems

f) Fire suppression agents

Determine most suitable suppression agent for fire identified and equipment used for application.

2.3 Home Office/HSE guidance

The document "Fire Safety and Employer's guide" also provides useful insights into the requirements of a fire risk assessment and on how to go about undertaking one. The main steps of the assessment are identical to those discussed previously, the only difference being the consideration of the amount of air or oxygen available to the fire.

The five steps to the assessment are as follows.

1) Identify fire hazards

Sources of ignition
Sources of fuel
Sources of oxygen
Work processes

2) Identify the location of people at significant risk in the case of fire

3) Evaluate the risks

Are existing fire safety measures adequate?
Control of ignition sources / sources of fuel
Fire detection / warning
Means of escape
Means of fighting fire
Maintenance and testing of fire precautions
Fire safety training of employees

carry out any improvements needed

4) Record of findings and action taken

Prepare emergency plan
Inform, instruct and train employees in fire precautions

5) Keep assessment under review

Revise if situation changes.

3 RISK ASSESSMENT METHODOLOGY FOR FIRE AND EXPLOSION HAZARDS IN MINING

3.1 Combination of assessment methodologies

As fire is not the only underground hazard of significance the final methodology has been developed by combination of those outlined above, with additional consideration of explosion, and the addition of a scoring system to allow the user to determine when further actions are necessary. Economic considerations raised in the suggested NFPA procedure have been omitted as HSE's main concerns lie in life safety issues.

3.2 Methodology overview

The methodology involves completion of a number of check sheets to allow the user to establish the likelihood of fire or explosion, the number of personnel at risk, methods of evacuation and areas where a more detailed analysis is required. Having identified prime areas for investigation a more detailed examination should be undertaken as part of the mines emergency preparedness documentation. An overview is given in Figure 1. Guidance notes and check sheets for use in the assessment are included as Appendices B-D.

3.3 The risk assessment team

When undertaking a risk assessment it is of importance to consider the range of hazards proposed by personnel of all disciplines represented in the affected area. This may include the mine manager, with whom ultimate responsibility lies, electrical and mechanical engineers, mine safety personnel, and TU rep/s. Depending on the perceived severity of the hazard, difficulty in fire fighting, or the length of the escape route, it may also be prudent to consult the Mines Rescue Service, or other emergency service, who may attempt to undertake rescue or fire fighting underground.

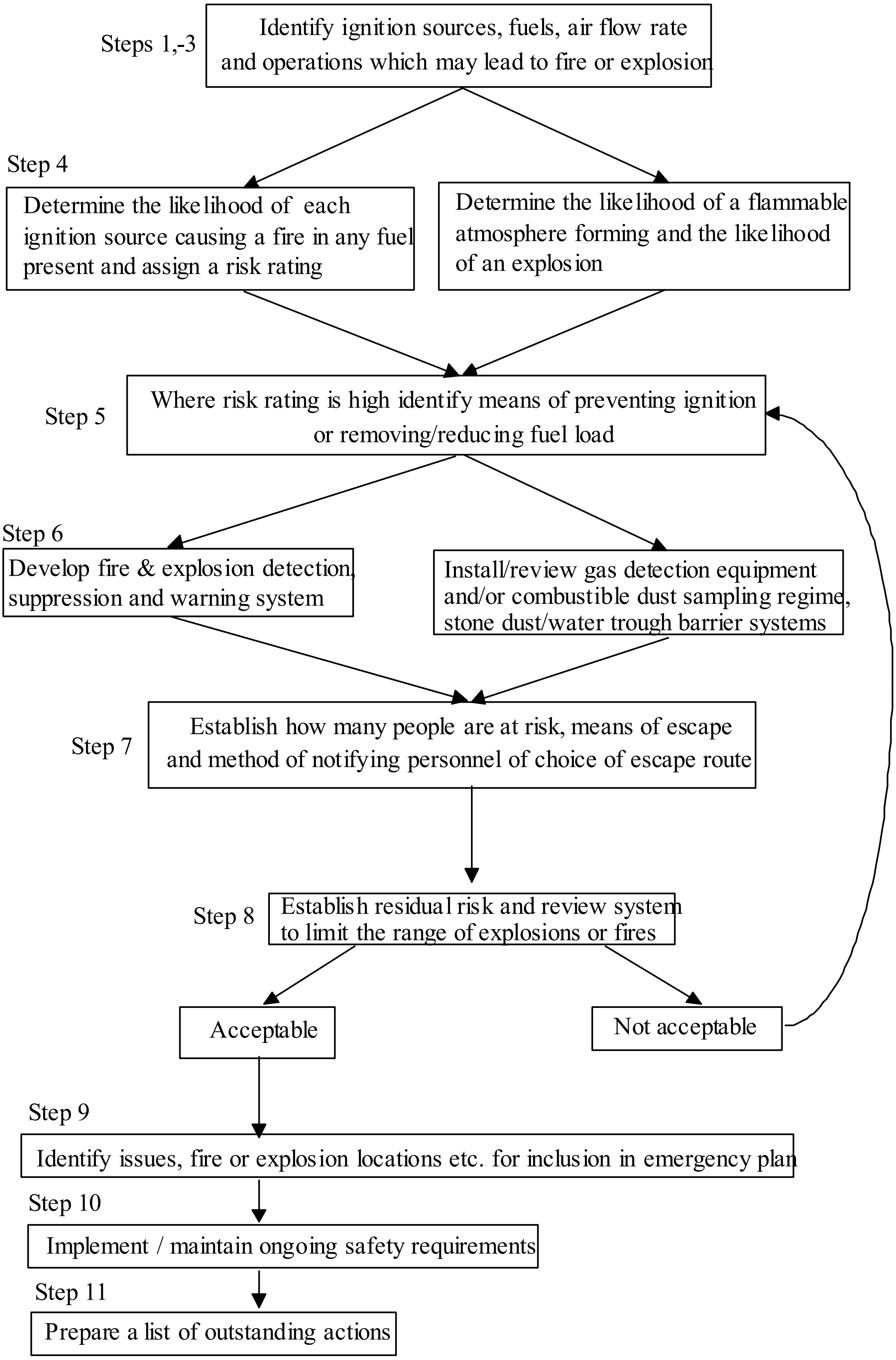

Figure1 Fire and explosion risk assessment flow chart

<u>Steps 1-3 Identification of fuels and ignition sources and consideration of workplace activities which may give rise to fire & explosion</u>

This stage is concerned with establishing the potential for fire or explosion, either through workplace activities, or accidental ignition of combustible materials.

The first stage is to study the area or operation of concern to identify combustible materials and potential ignition sources (either permanent or arising through fault conditions). The likelihood of fire/explosion is then evaluated by:

1. noting the coexistence of fuels and potential ignition sources;
2. noting the likelihood of an explosible atmosphere occurring;
3. study of past fire and explosion incidents in a particular operation as they may have a high probability of reoccurrence;
4. study of maintenance routines - are they being met, is maintenance of an adequate standard, could maintenance operations themselves lead to an increased fire/explosion risk, are there any changes in the frequency of faults which may indicate either inadequate maintenance or the equipment is coming to the end of its lifetime, are replacement parts those recommended by the equipment supplier etc.; and,
5. establish if the risk of fire/explosion is affected by standards of housekeeping.

Reference to the two examples presented in prEN1710 (see Appendix G)may be of use here as it provides a useful demonstration of possible thought processes in both identification of ignition sources and ways of preventing source being effective.

As stated above it is also of importance to give practical consideration of workplace activities which could cause a fire/explosion as well as identifying potential fuels and ignition sources.

Such activities may include obvious areas such as mineral extraction/cutting, hot works such as grinding, cutting, welding, or possibly smoking, along with less obvious hazards such as working on electrical equipment where electrical fires may result from accidental shorting or damage to equipment, or working on methane drainage systems, where methane leaks could result in fire or explosion.

Step 4 - Establishing the potential for ignition of fuels

Consider the likelihood of a fire or explosion occurring for all combinations of fuels and ignition sources identified and assign an overall risk rating. Also to be considered at this stage are any effects local airflow may have on hindering fire detection, or increasing the spread of fire.

Consideration must also be given to the movement of a body of gas by the mine ventilation system into areas where sparks or flames may be present. For example, around mineral cutting or drilling equipment, shotfiring, areas of coal seams undergoing spontaneous combustion, failed items of electrical or mechanical equipment generating sparks etc.

Risk reduction measures are required for any area having a combined risk rating over six.

Step 5 Risk reduction measures - reducing ignition probability

Methods for reducing risk in areas identified as having a high fire or explosion potential will include both means of reducing the likelihood of ignition and reducing in the quantity of fuel present. Such measures may include:

1. equipment design - evaluate design to determine if risk can be reduced through design change;
2. operating procedures - can the threat of fire can be reduced through effective implementation of company policies and procedures.

3. review of maintenance intervals;
4. increasing the frequency at which equipment is cleaned; or,
5. reduction in the amount of combustible materials through use of low flammability alternatives.
6. design, installation and maintenance of systems to limit the range of an explosion e.g. stone dust/water trough barriers, explosion doors etc..

Step 6 - Identification of fire/explosion protection and warning systems, installation and accessibility

This stage is divided into three parts.

Part (a) - consideration of fire/explosion types. This entails using information from Step 1 on fuel types and quantities to determine type of suppression system, how the agent is to be applied, the method of detection, and on the time in which the fire must be detected and the suppression system activated - areas where rapid fire spread may occur require rapid detection and system activation.

Part (b) - fire detection equipment. The purpose of this section is to ensure consideration of all relevant areas, not just siting of detectors. Also important is correct routing of signal cables from detectors, accessibility of enunciation panels etc.

Explosion detection equipment – environmental monitoring including fire damp measurements or hand-held instruments used by officials etc.

Part (c) - visibility and use of fire fighting equipment. Here the purpose is to ensure adequate signage of fire fighting equipment, ease of accessibility, that staff are trained etc.

At each stage a column is included to highlight areas where further action is required.

Step 7 - Means of escape

Consideration of means of escape given a fire or explosion, and the choice of self-rescuer given the nature/toxicity of smoke anticipated.

Step 8 - Establish residual risk

To be completed for those areas for which a high risk rating was derived.

Steps 9 - 11 issues for emergency plan ongoing requirements and outstanding actions

The final stages of the assessment are as follows.

Step 9 - Prepare a table summarising areas where fire or explosion is though possible, the main fuel and toxicity of smoke, evacuation routes considered and the effects of possible disruption of communications

Step 10 - Prepare a table or list of ongoing safety requirements which must be met for systems put in place to remain effective, e.g. staff training, testing of fire fighting equipment, regular stone dusting, maintenance of stone dust/water trough explosion barriers etc..

Step 11 - Prepare and act upon a list of outstanding actions identified during the assessment to ensure systems put in place are effective.

4 INFORMATION NEEDS FOR RISK ASSESSMENTS

4.1 Information sources

Apart from on-site surveys, information from suppliers, or internal company documentation/procedures, information required to perform a fire risk assessment can be obtained from the following sources.

Information on combustion in common fuels (smoke production, CO/CO_2, heat etc.) (SFPE Handbook 1988 and MFIRE users manual, 1995 - summarised in Appendix E).

Summary of mine fire incidents (Appendix F) reported to HSE between 1992-January 2002 (Thyer 2000).

Summary of fire test criteria for potentially combustible materials used underground (Thyer 2000)

Vehicle fires in non-coal mines, (Dabill, 2001)

Underground fire detection systems, (Walsh, 1997)

Placement of mine fire detection systems, (Jagger, 1997)

Systems to aid escape from smoke-logged underground workings (Weyman and Thyer, 1996)

Other notable information sources are:

NFPA 122 - Standard for fire prevention and control in underground metal and non-metal mines, 2000 Edition.

NFPA 123 - Standard for fire prevention and control in underground bituminous coal mines, 1999 Edition.

In addition to the above information sources, two example applications of the identification of ignition hazards for a mining conveyor and a shear loader are given in prEN1710*. These are reproduced in Appendix G.

* Note, this draft standard is being developed as an EU harmonised standard to support the ATEX Directive 94/9/EC, and thus also to support the implementing of regulations in the UK: i.e. The Equipment and Protective Systems Intended for use in Potentially Explosive Atmospheres Regulations, 1996. (Statutory Instrument 192).

4.2 Deficiencies in data

1). Very little quantitative data is available of fire frequency in mines. That which is available is mainly related to number of fires per year in a particular mining sector, or number of fires in mines using continuous miners, for instance. (Australian Department of Mineral Resources, (1997)) No quantified data could be found on fire frequency on operations such as transport of coal by conveyors, where, if a national figure was available for the number of kilometres of conveyors, a fire frequency of x fires/km/year could be derived. This figure would, however, be more of academic rather than practical utility.

2). The complex nature and toxicity of smoke produced in fires involving many modern plastics or composite plastic components is not known. For instance, in a recent study for HMIM by Dabill (2001) difficulty was experienced in establishing what plastics were used in vehicle manufacture, and as such only a broad-brush picture could be obtained on possible toxicity. This also applies to plastic packaging which has been widely used above ground for a number of years, and is now being encountered underground.

3) UK fire resistance test criteria.

In the majority of cases it has been found that acceptance criteria for materials are clear and well founded. There are a small number of situations, however, where areas for improvement have been identified. These are summarised in an earlier report, (Thyer 2000).

These deficiencies are compounded by the current lack of a national company/body to co-ordinate the maintenance and development of UK test methods.

4) European fire resistance tests

With the free European market foreign materials will become ever more common in UK mines. These materials may have been tested to national standards relating to the country of origin, rather than current UK specifications. A direct comparison between such standards is vital to ensure fire resistance criteria are comparable, and if any are to a lesser standard, appropriate fire precautions must be taken.

5 CONCLUSIONS

A methodology for the assessment of fire/explosion risk in underground mines has been developed by combination of earlier work on this research project and recommendations made by the NFPA, the Australian Department of Mineral Resources, guidance on fire risk assessment published by HSE and The Hole Office, and general fire risk assessment techniques. The system developed is divided into a number off steps with the output from each being documented using check sheets. The steps involved are summarised below.

Steps 1-3: identification of combustible materials, potential ignition sources, airflow in the vicinity of the possible fire, and workplace activities which may cause fire.

Step 4: establish the potential for each ignition source to ignite available fuels and assign a risk rating to each case.

Step 5: identify risk reduction measures for those cases with high risk ratings, and establish means of removing/reducing the likelihood of ignition or removing/reducing the quantity of fuel available.

Step 6: identify appropriate fire protection and warning systems.

Step 7: determine the number of personnel at risk and identify means of escape.

Step 8: establish residual risk.

Step 9: incorporation of findings in mines emergency plans.

Step 10: list ongoing safety requirements such as staff training, fire drills etc..

Step 11: Prepare a list of outstanding actions at the time of the assessment.

Steps 5-8 are iterative and should be repeated until risk can be demonstrated to be As Low As Reasonably Practicable (ALARP).

6 RECOMMENDATIONS

It is recommended that this report and assessment method be distributed to UK mines to better enable them to comply with statutory regulation. At present, however, as the assessment sheets are generic for underground fires/explosions as a whole considerable user modification is required to tailor them to individual needs. It is therefore recommended that they be distributed in electronic format to enable mines to more readily target the assessment process.

Such electronic format could take several forms:

a) distribution as a simple file e.g. MS Word;
b) conversion into a spread sheet to allow automatic totalling of hazard scores assigned to fire or explosion probabilities; or,
c) conversion into an 'expert system' coded computer programme.

It is thought that option (b), above, would be the more cost effective solution, as this could both automatically total hazard scores and prepare summary printouts for inclusion in the mines emergency plan.

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APPENDIX A REGULATIONS PERTINENT TO FIRE & EXPLOSION IN UNDERGROUND MINES

The regulations produced in the UK with particular reference to fire and explosions are:

The Mines and Quarries Act, 1954 (MQA)

Section 66: prohibition 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 73: means of escape from rooms....

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

Regulations 1-11

The Miscellaneous Mines (General) Regulations, 1956 (MMGR)

Regulations 31-35: precautions against fire

The Mines (Safety of Exit) Regulations, 1988 (SOE)

Regulation 7: places where it is not reasonably practicable to provide two ways out. (ACOP30)
Regulation 9: intake airways.

The Electricity at Work Regulations, 1993 (EAWR)

Regulation 4: systems, work activities and protective equipment: ACOP 9 & 14.
Regulation 6: adverse or hazardous environments: ACOP 3 & 6.
Regulation 23: oil-filled equipment.

The Coal Mines (Owners Operating Rules) Regulations, 1993 (CMOOR)

Rules on mine fires.

The Mines Miscellaneous Health and Safety Provisions Regulations, 1995 (MMHSPR)

Regulation 4: health and safety document, fire protection plan and explosion protection plan.
Regulation 8: hydraulic fluids.
Schedule 1 Part II,
3: smoking and use of open flame
4: fire-fighting equipment
6: flammable materials taken underground

The Coal and Other Mines (Locomotives) Regulations, 1956 (COMLR)

Regulation 25: housing stations
Regulation 26: filling stations
Regulation 27: fuel oil
Regulation 32: charging and changing batteries.

Provision and Use of Work Equipment Regulations, 1998 (PUWER)

Regulation 10: conformity with Community requirements

1. The Supply of Machinery (Safety) Regulations, 1992, Schedule 3, Clause 1.5.6: designed and constructed to avoid all risks of fire or overheating, clause 1.5.7: regarding risks of explosions).
2. The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations, 1996.

Regulations 12(2): protection against specified hazards – (c) work equipment catching fire or overheating, (e) explosion of work equipment or any article or substance reduced, used or stored in it.

All of the above being set within the general requirements of

The Management and Administration of Safety and Health at Mines Regulations, (1993) (MASHAM).

The Escape and Rescue from Mines Regulations, 1995.

APPENDIX B EXPLANATORY NOTES FOR RISK ASSESSMENT CHECK SHEETS

Some of the information relating to these check sheets is contained in the text of the report, but is repeated here for ease of use.

Two sets of check sheets are appended:

- Appendix C - Fire risk assessment check sheets
- Appendix D - Explosions risk assessment check sheets

A number of these sheets are generic. When appropriate those marked as relevant to fire risk should be substituted with the alternative explosions sheet.

Sheets requiring substitution for explosion assessments are listed below.

Step 2 - identification of explosible materials/atmospheres.
Step 3 - identification of airflow: not required for explosions unless fires may ensue.
Step 4 - risk of explosion prior to control measures being in place.
Step 6 - explosion prevention sheets a-c.

All other sheets are common.

Step 1 – Identification of ignition sources

These sheets are self-evident and require no explanation

Step 2 – Identify sources of fuel for fires or identification of potentially explosible atmospheres

Fires
Each potential fuel is assigned a score based on the ease of ignition or the possibility of rapid fire growth occurring, the production of toxic fumes (other than CO) and whether its flammability may be enhanced by contamination with other nearby materials. The final score is used to prioritise areas for early examination.

Explosions

The purpose of this sheet is to identify materials which may give rise to an explosion, what activities are being undertaken which generate the explosive atmosphere and whether fires may ensue.

<u>Step 3 – Identification of airflow in vicinity of fire</u>

This area is of significance as high airflows will promote smoke/gas dilution, allowing smouldering fires time to become flaming, or flamming fires time to grow to a large enough size to be detected. Obviously, there is a high ensuing risk of explosion should an explosible atmosphere develop if naked flames are present.

Step 4 - Establishing the potential for ignition of fuels

Consider the likelihood of a fire or explosion occurring for all combinations of fuels and ignition sources identified and assign an overall risk rating. Also to be considered at this stage are any effects local airflow may have on hindering fire/explosion detection, or increasing the spread of fire.

Consideration must also be given to the movement of a body of gas by the mine ventilation system into areas where sparks or flames may be present. For example, around mineral cutting or drilling equipment, shotfiring, areas of coal seams undergoing spontaneous combustion, failed items of electrical or mechanical equipment generating sparks etc.

Risk reduction measures are required for any area having a combined risk rating over the values indicated on the assessment sheets.

Step 5 Risk reduction measures - reducing ignition probability

Methods for reducing risk in areas identified as having a high fire or explosion potential will include both means of reducing the likelihood of ignition, decreasing the probability that an explosive atmosphere may develop, and reducing the quantity of fuel present. Possible measures to achieve these aims may include:

1. equipment design - evaluate design to determine if risk can be reduced through design change;
2. operating procedures - can the threat of fire/explosion can be reduced through effective implementation of company policies and procedures.
3. review of maintenance intervals;
4. increasing the frequency at which equipment is cleaned; or,
5. reduction in the amount of combustible materials through use of low flammability alternatives.

Step 6 - Identification of fire protection and warning systems, installation and accessibility

This stage is divided into three parts. Two forms of Part (a) are available depending on whether fire or explosion is being considered.

Fires assessment

Part (a) - consideration of fire types. This entails using information from Step 1 on fuel types and quantities to determine type of suppression system, how the agent is to be applied, the method of detection, and on the time in which the fire must be detected and the suppression system activated - areas where rapid fire spread may occur require rapid detection and system activation.

Part (b) - fire detection equipment. The purpose of this section is to ensure consideration of all relevant areas, not just siting of detectors. Also important is correct routing of signal cables from detectors, accessibility of enunciation panels etc.

Part (c) - visibility and use of fire fighting equipment. Here the purpose is to ensure adequate signage of fire fighting equipment, ease of accessibility, that staff are trained etc.

At each stage a column is included to highlight areas where further action is required.

Explosions assessments

Complete the alternative checksheet for Part (a), then Parts (b) and (c) as before. This should also included any systems to limit the range of an explosion, e.g. stone dust or water trough barriers, explosion doors etc..

Step 7 - Means of escape

As well as consideration of escape routes, consideration must also be given to the nature of fumes/smoke produced in the event of a fire/explosion. This will determine whether self-rescuers provided are adequate. It should be noted that some materials, especially plastics produce complex mixtures of combustion products which can contain toxic species such as HCl or HCN – neither of which would be removed by a normal filter self-rescuer. Details on smokes produced by materials commonly encountered are given in Appendix E.

Step 8 - Establish residual risk

To be completed for those areas for which a high risk rating was derived.

Steps 9 - 11 issues for emergency plan ongoing requirements and outstanding actions

The final stages of the assessment are as follows.

Step 9 - Prepare a table summarising areas where fire or explosion is though possible, the main fuel and toxicity of smoke, evacuation routes considered and the effects of possible disruption of communications

Step 10 - Prepare a table or list of ongoing safety requirements which must be met for systems put in place to remain effective, e.g. staff training, testing of fire fighting equipment, regular stone dusting, maintenance of stone dust/water trough barriers etc..

Step 11 - Prepare and act upon a list of outstanding actions identified during the assessment to ensure systems put in place are effective.

Appendix C risk assessment check sheets

The following are intended as examples of ignition sources which could arise in a range of mines. The list is not definitive and should be altered as appropriate

Step 1. identify ignition sources

	Potential ignition source (Insert below and delete those not applicable)		**Potential ignition source (Insert below and delete those not applicable)**
Permanent high temperatures	e.g. Diesel engines	High temperatures on equipment failure	e.g. Drive shafts/bearings
	Exhaust systems		Frictional heating through misalignment
	Brakes		Conveyor drive drums or idlers
	High intensity lighting		
	Compressors		
Workplace activities / hazards	Hot work	**Electrical**	Electrical equipment present
	Smoking		Batteries/generators
	Others – shotfiring, poor stemming etc.		Possibility of damage to cables/equipment causing fire
	Spontaneous combustion		Static discharge

Step 1. identify ignition sources

	Potential ignition source (Insert below and delete those not applicable)		Potential ignition source (Insert below and delete those not applicable)
Mechanical ignition sources	Friction through rubbing/dragging	**Contraband items**	
	Dropped loads / falls of ground causing sparking		
	Use / presence of light metals		
	Sparks or heating from cutting picks or drilling tools and material being cut or drilled		
	Lack of lubrication		
	Trapped debris under conveyors		

Step 2. identify sources of fuel

	Material (Insert as appropriate)	**Approximate quantity e.g. 1 kg, 10, kg, 100 kg, >100kg**	**Fuel easily ignited or possibility of rapid fire growth in this fuel**	**Produces toxic fumes other than CO/CO_2 when burning**	**Flammability affected by contamination with other materials nearby e.g. oil soaked wood/dust may be easier to ignite**	**Total score**
Class A	Timber		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Coal		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Electrical insulation		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Hydraulic hoses		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Conveyor belting		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Tyres		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Upholstery		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
	Litter/other combustible waste		Y: 1 N: 0	Y: 1 N: 0	Y: 1 N: 0	
Others (insert as appropriate)						

Treat fuels with highest score first.

STEP 3. Identify air/oxygen supply

For tunnels state airflow in locality(m/s)	
For compartments / underground rooms or spaces give compartment volume (m^3)	

High airflows in tunnels
1) Detection via atmospheric monitoring may be less effective due to smoke/gas dilution.
2) High airflow will spread smoke/gas through the mine more rapidly.
3) High airflow may also promote rapid fire growth.
4) Alternative means of detection to atmospheric monitoring may be required.

Low airflows in tunnels
1) Detection by atmospheric monitoring more effective.
2) Poorer smoke dilution in the vicinity of the fire could make escape more difficult.
3) Large fires could cause reversal of imposed airflows in tunnel systems.
4) Development of an explosive atmosphere is more likely as firedamp will be allowed to accumulate.

Compartment volume
Larger compartments can lead to larger fires before air is consumed. Treat as high airflow cases.

Summary of fire/explosion potential
(Insert fuels and ignition sources identified in steps 1 and 2 below)

Ignition sources	Fuels	Fuel types	Air/oxygen supply m/s

Step 4 Fire risk prior to control measures being in place

Risk rating = 1 x (2+3) (1) (2) (3)

Ignition source	**Fuel**	**Likelihood of ignition (from 1-5)**	**Severity (from 1-5)**	**Airflow Low 1, Medium 1, High, 2**	**Risk rating (Likelihood x severity + airflow)**
Insert ignition source e.g. naked flames, smoking	Insert fuel types				

Ignition source	**Fuel**	**Likelihood of ignition (from 1-5)**	**Severity (from 1-5)**	**Airflow Low 1, Medium 1, High, 2**	**Risk rating (Likelihood x severity + airflow)**
Insert ignition source e.g. hot work					

For any risk rating greater than six control measures to reduce the risk are required.

Step 4 Fire risk prior to control measures being in place

Ignition source	Fuel	Likelihood of ignition (from 1-5)	Severity (from 1-5)	Airflow Low 1, Medium 1, High, 2	Risk rating (Likelihood x severity + airflow)
Insert ignition source e.g. rotating machinery / friction					

Step 5 Fire or explosion risk reduction measures - reducing sources of ignition

Ignition source	**Prevention measure and relevant legislation**	**Further action required**	
		Y	**N**

Colour code prevention measures: Action complete - Blue; Action incomplete - Red

Step 5 Fire or explosion risk reduction measures - reduction in amount of fuel

Fuel source	Prevention measures and relevant legislation	Further action required	
		Y	N

Colour code prevention measures identified: Action complete - no further work required Blue; Action incomplete further work required - Red

Step 6: Fire detection and warning part (a) method of detection, quantity of fuel present and identification of extinguishant

Fuel type	Type and quantity	Extinguishing medium and quantity given amount of fuel present	Method of detection	How is control room notified	Fire fighting performed automatically, manually, or by fire fighting team ?
Class A (generally solids such as wood, coal etc.)					
Class B (generally liquids such as diesel etc.)					
Fires in electrical equipment					

See explanatory notes at the start of Appendix B for information on choice of suppression system

Step 6: Fire/Explosion detection and warning part (b) safeguarding detection equipment

Item/location	Control / enunciation panels likely to be affected by fire	Cabling routed through safe areas - safe from damage by fire or impact during normal working	Plan of fire zones / sensor locations displayed near local and main control panels ?	Maintenance / inspection programme in place	Further action required Y/N

Obviously one of the prime factors during the installation of a fire detection system is correct siting of detectors. The above is intended to serve as a reminder for areas which may not always be considered.

Step 6: Fire/Explosion detection and warning part (c) visibility and use of fire fighting equipment

Location of equipment	Clearly visible and adequate signage	Easily accessible	Likely to be obstructed during normal operations	Hose reels long enough to reach all areas	Staff trained in use	Maintenance / inspection programme in place	Further action required Y /N

Step 7: number of people at risk and means of escape

		Comments	**Further action required Y / N**
Number of people at risk close to fire or explosion			
Number exposed to smoke carried by ventilation system			
Length of escape route or dist. to fresh air, and time taken to travel route (given smoke filled tunnel)			
Self-rescuer of sufficient duration ?			
Self-rescuer of correct type for toxic gases produced in fire/explosion ?			
Escape route adequately signed and free from obstructions, falls of ground etc.			
Choice of escape route ?			
Method of notifying personnel of choice of escape route			
All personnel underground trained in use of rescue equipment			
All personnel underground trained/familiar with all escape routes			
Instructions on means of escape included in emergency plan ?			

Note. For complex tunnel networks computer modelling may be required to fully understand smoke behaviour in the workings and thus confirm the adequacy of escape routes. Such modelling could address the possibility of flow reversals with fires in low ventilation flows, flow recirculation and general smoke spread through the workings.

Step 8 residual risk after implementation of all control measures

Ignition source	Fuel	Likelihood (from 1-5)	Severity (from 1-5)	Airflow Low 1, Medium 1, High, 2	Risk rating (Likelihood x severity + airflow)
Insert ignition source identified e.g. rotating machinery/friction					
Ignition source	Fuel	Likelihood (from 1-5)	Severity (from 1-5)	Airflow Low 1, Medium 1, High, 2	Risk rating (Likelihood x severity + airflow)
Insert ignition source identified					
Ignition source	Fuel	Likelihood (from 1-5)	Severity (from 1-5)	Airflow Low 1, Medium 1, High, 2	Risk rating (Likelihood x severity + airflow)
Insert ignition source identified					

Step 9 - summary of issues for inclusion in emergency plan

Location of possible fires	Number of personnel at risk	Main fuel and toxicity of smoke	Evacuation routes considered	Possibility disruption of communications through fire damage or underground smoke ?

Step 10 summary of ongoing requirements

1) Staff training

	Staff training in place	
	Permanent staff	Contractors
Self rescuer		
Fire fighting		
Familiarisation with escape routes		
Involved in fire drills and interval		

2) Inspection maintenance

Inspection / maintenance scheme in place for detection / fire fighting equipment in place (give equipment and area below if appropriate)	System in place to ensure ongoing requirements of risk reduction measures are in place

Step 11 list of outstanding actions at time of assessment

ACTIONS IDENTIFIED DURING ASSESSMENT TO BE INSERTED BY USER

Appendix D Alternative check sheets for use with explosions risk assessment

Step 2. identify sources of fuel

Type of material	Quantity present and how often	Activity giving rise to potentially flammable atmosphere	Escalation possible on ignition	
			As fire	As explosion

Due to the considerable risk of escalation of underground explosions all potential explosible atmospheres should be studied and mitigation / detection measures put in place.

Appendix D Alternative check sheets for use with explosions risk assessment

Step 4 Risk of explosion prior to control measures being in place

Ignition source	Potentially explosible fuel	Likelihood of ignition (from 1-5)	Severity (from 1-5)	Risk rating (Likelihood x severity)
Insert ignition source e.g. naked flames, smoking	Insert fuel types e.g. methane			

Ignition source	Potentially explosible fuel	Likelihood of ignition (from 1-5)	Severity (from 1-5)	Risk rating (Likelihood x severity)
Insert ignition source e.g. mechanically generated sparks	Insert fuel types e.g. suspended coal dust			

For any risk rating greater than five control measures to reduce the risk are required.

Appendix D Alternative check sheets for use with explosions risk assessment

Step 6: Detection of potentially explosible atmospheres and warning systems required - (a) detection of flammable atmosphere

Fuel type	**Method of detection**	**Time elapsed before action taken to reduce levels**	**Further action required ? Y/N**
To be inserted by user e.g. Methane			
Raised coal dust			
Coal dust on surfaces			

For parts (b) and (c) of Step 6, complete generic sheets used for fires assessment

APPENDIX E SMOKE PRODUCTION DATA FOR MATERIALS TYPICALLY INVOLVED IN UNDERGROUND FIRES

Table 1E Smoke and toxics production figures for common fuels

Material	Yield CO (g/g)	Yield CO_2 (g/g)	Yield CH (g/g)	Yield smoke (g/g)
PVC	0.063*	0.46*	0.023*	0.172*
	0.078 **	0.89 **	Not determined **	Not determined **
Hydrocarbons e.g. diesel	0.019	2.64	0.007	0.059
Coal	0.2	2.9	-	-
Wood				
Rubber	0.13	2.8	-	-

* SFPE Handbook data for PVC in a well ventilated flaming fire.
** Average figure for cone calorimeter tests on an PVC conveyor belt. (private correspondence)

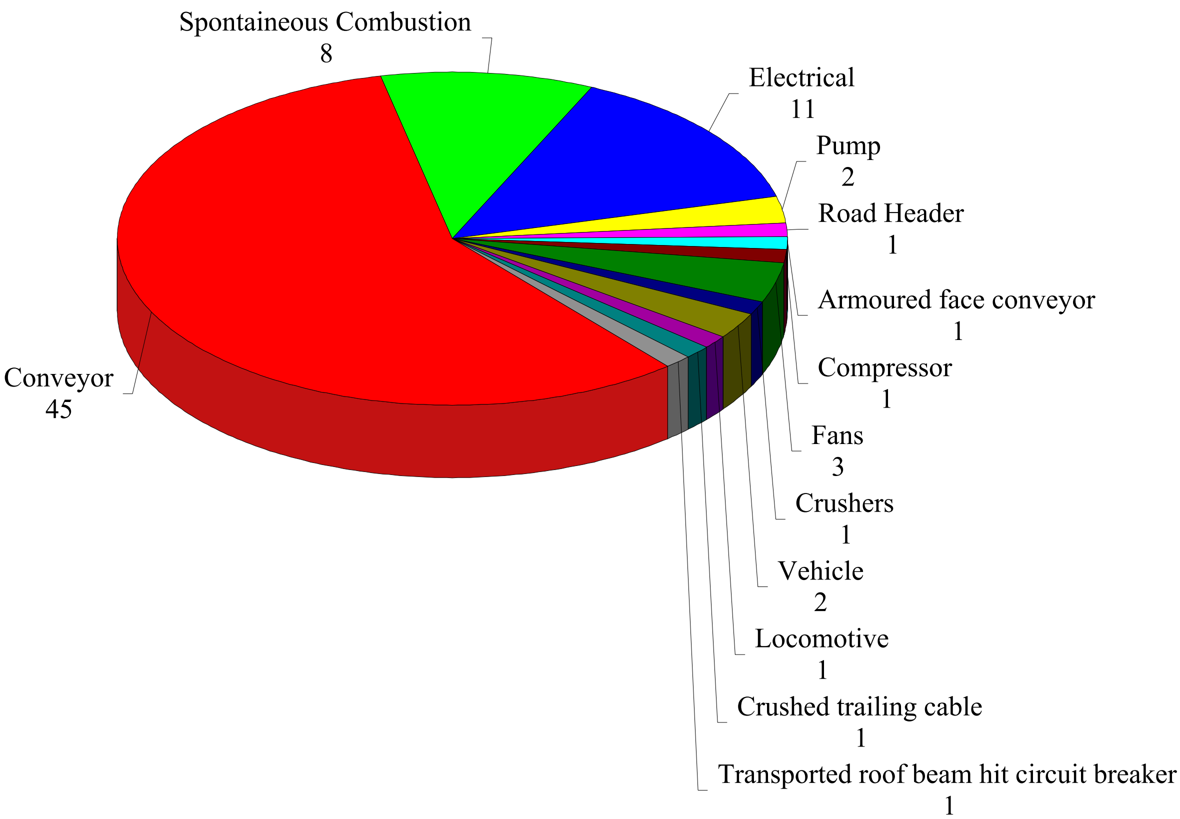
The following unpublished work relating to emission of toxic fumes by overheated electric motors is also available in addition to the above published figures: (Table 2E). As the quantity of each component varies widely from one motor to another it is not possible to quantify how much of each species would be produced. The figures presented should therefore be used to allow choice of suitable self-rescuer types.

Table 2E Decomposition characteristics for typical polymers used in electric motors

Polymer	Decomposition onset temperature (°C)	Decomposition products	Toxicity information (IDLH[c])
Epoxy resin	250-560	Mainly phenolic compounds	Phenol 250 ppm
Polyester resins	300	Acetaldehyde, CO plus acid and anhydride compounds	Acetaldehyde: 200 ppm CO: 1200 ppm
Polyurethanes[a]	200	CO, HCN, nitrogen oxides, nitriles, toluene di-isocyanate	HCN: 50 ppm NO_2: 20 ppm TDI: 2.5 ppm
Polyamides[b]	450	CO, benzene, HCN, toluene and benzonitrile (plus H_2 and NH_3 above 550 °C)	Benzene: 500 ppm Toluene: 500 ppm NH_3: 300 ppm Benzonitrile is a respiratory irritant
Polybutadiene	250	Butadiene (Yields up to 60% at 330 °C)	Low toxicity but potential explosion hazard
PTFE	500	Carbon tetrafluoride, hydrogen fluoride, hexafluoropropene and possible CO under certain conditions	HF: 30 ppm CF_4: no significant toxic effects

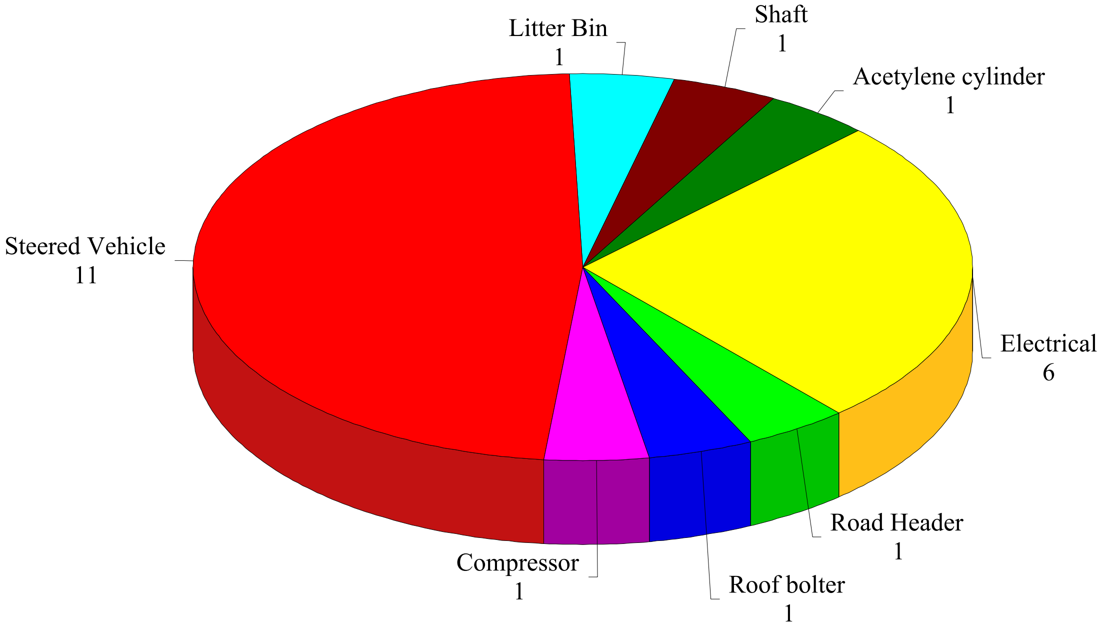
a. Generic information on polyurethanes.
b. Information based on Nomex material, widely used for electrical insulation duty.
c. Immediately dangerous to life and health (National Institute of Occupational Safety and Health, US). The IDLH is the maximum airborne concentration of a substance to which a healthy male worker could be exposed and still be able to escape without loss of life or irreversible organ damage.

APPENDIX F SUMMARY OF REPORTED UNDERGROUND FIRES DURING THE PERIOD 1992 – JANUARY 2002- COAL MINES



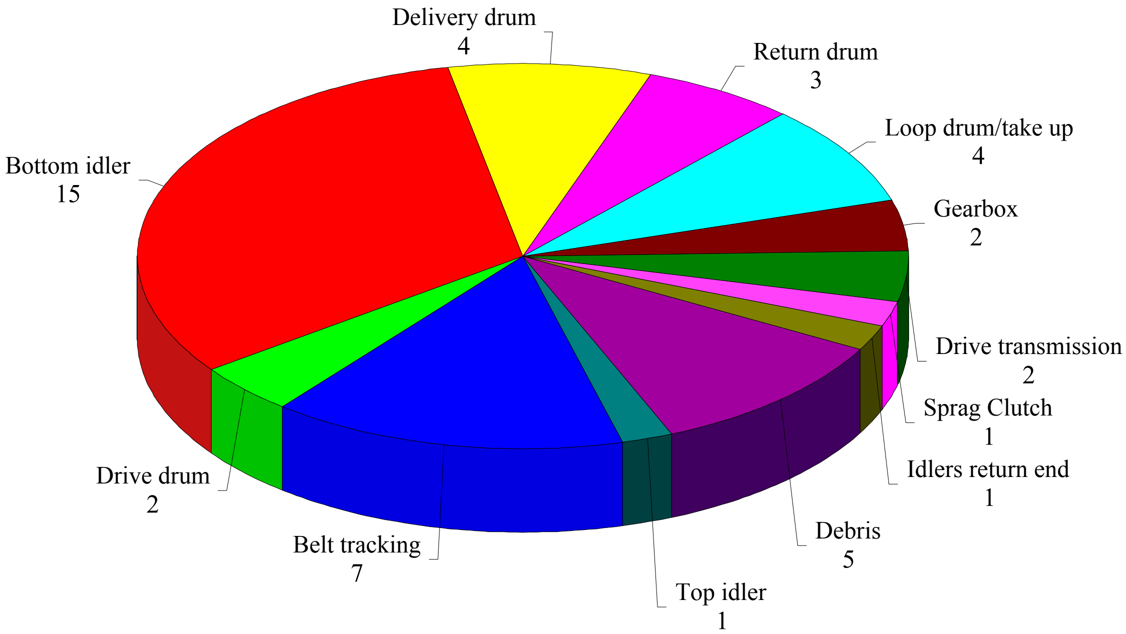
Total 78 fires

Appendix F summary of reported underground fires during the period 1992 – January 2002 - miscellaneous mines



Total 23 fires

Appendix F summary of reported underground fires during the period 1992 – January 2002 - coal mine belt conveyor fires



Total 47

APPENDIX G EXAMPLE RISK ASSESSMENTS FOR CONVEYOR INSTALLATION AND A SHEAR LOADER FROM PR-EN1710

These are generic requirements, not based on specific machines, they are not definitive and contain alternatives. Each manufacturer is required to carry out an ignition hazard assessment for each individual machine and determine the most appropriate control measures for that particular machine.

Example of an ignition hazard assessment for a conveyor belt intended for use in a coal mine

A.1 ATEX Category and Intended usage of the equipment

The equipment consists of components which are assembled to form a belt conveyor intended for transporting coal in a coal mine having a potentially explosive atmosphere of firedamp and coal dust. The manufacturer has decided to construct it to meet the requirements of Group I Category M2 equipment. It is therefore necessary to produce an ignition hazard assessment document for inclusion in the technical file in accordance with the requirements of EN 13463-1 for Category M2 equipment. This means the conveyor has to incorporate a high level of ignition protection, irrespective of the fact that it is intended to be de-energized in the event of an explosive atmosphere occurring. The reason being, that it might operate unintentionally 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, or if the occurrence of an explosive atmosphere at the place where the conveyor is located has not been immediately detected by the manual/automatic firedamp detection and monitoring arrangements and a shut down initiated.

Ignition protection will therefore have to be applied to some potential sources that are not present in normal operation, but the risk of them becoming effective cannot be discounted,

Potential ignition sources arising from rare malfunctions can however be neglected because the conveyor is not intended to operate in an atmosphere containing concentrations of gas/dust exceeding those allowed by national regulations (about 25% of the LEL for firedamp/air mixtures)

A.2 Construction / Description of the equipment

The conveyor consists of a continuous belt, made of fire resistant plastic coated textile material, mounted on a metallic structure incorporating drive and idler rollers. It is driven at the delivery end by a flameproof electric motor and an oil filled gearbox through a large diameter drive drum. The assembly has a drive-end tensioning roller on a moveable frame and a freewheeling return-end roller drum. The belt is supported throughout its length by top and bottom belt idler rollers forming part of the structure. A caliper type brake is provided on a brake-drum at the drive-end. The brake is gravity applied by weights and released by a flameproof electrically driven thruster-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 metallic belt 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.

A.3 Assessment

a) Electrical equipment

The drive motor and brake thruster-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.

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.

b) Non-electrical equipment

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 the table A.1 below:

Table A.1 - Example of an ignition hazard assessment for a mining conveyor, Group I, Category M 2

Potential ignition sources		Example of measures applied to prevent the sources becoming effective	Ignition protection used
Normal Operation	Faults that cannot be ignored		
Bearings		All bearings are lubricated by grease. Replenishment of grease is required every 6 months. 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 of use, after which time, they need to be replaced. This information will be included in the instructions to the user. 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 bearing housings need to be examined for signs of overheating, abnormal noise or discoloration on a daily basis. Where practical continuous temperature monitoring can be fitted and set to trip the drive power at 10 K above normal operating temperature.	EN 13463-1 (User instructions)
	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)
	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 in an unacceptable amount.	EN 13463-1
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.	EN 13463-1 (User instructions)

Table A.1 - Example of an ignition hazard assessment for a mining conveyor, Group I, Category M 2			
Frictional heat from the brakes		Verification of design calculations to be discussed with manufacturers.	EN 13463-5 Constructional safety ”c”
	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 IPXX 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”
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. 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”
Dust deposits on gearbox		Regular cleaning is needed to prevent dust deposits forming layers on gearboxes.	EN 13463-1 User instructions)

Table A.1 - Example of an ignition hazard assessment for a mining conveyor, Group I, Category M 2			
	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.
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)
	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”
	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”
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 conditions that cannot be ignored.	EN 13463-1

NOTE The ignition hazard assessment shows that the highest maximum surface temperature of a part of the conveyor is 140°C under conditions of use that cannot be ignored. The conveyor is therefore suitable for use in places where coal dust can form a layer on any exposed surfaces, because it is within the maximum allowable temperature of 150°C for such circumstances of use (see EN 13463-1 for maximum surface temperatures).

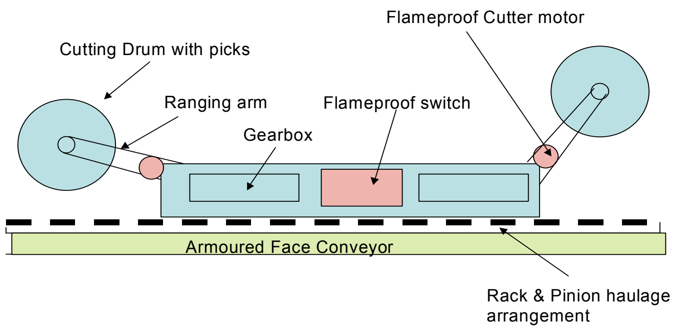
Example of an ignition hazard assessment for a shearer loader intended for use in a potentially explosive atmosphere of a coal mine

The following paragraphs are intended as an example of how a manufacturer would record the ignition hazard assessment for a coal cutting machine (shearer loader), intended for use on a coal face in a gassy mine. They are not based on any particular manufacturer's machine, they are not definitive and alternative ignition control measures could be applied to prevent the identified potential ignition sources from becoming active.

B.1 ATEX Directive category and intended use of equipment

The equipment is a Group I Category M2 shearer loader for cutting and loading coal onto an armoured face conveyor (AFC), installed beneath it. It will be used on a longwall face in a coal mine having a potentially explosive atmosphere of firedamp and coal dust. The shearer loader is powered by electricity. It has tungsten carbide tipped cutter picks fixed to a rotating spiral drum, used to extract coal from the virgin coal seam in front of it. During this process, the main body of the shearer loader moves along the top of the AFC, loading coal onto its moving flights. The main body of the shearer loader and AFC are sited in a continuously monitored and ventilated part of the coal face beneath hydraulically powered roof supports. If the firedamp / air concentration in the general body air of this continuously ventilated part of the face attains a level of 25% of the lower explosive limit (LEL) by volume, then according to member state law, the M2 equipment must be de-energised. Because the coal seam has a sandstone roof immediately above it, with more than 50% quartz content, there is a danger of localised ignitions of firedamp, if the tungsten tipped cutting picks make frictional contact with the sandstone roof. The shearer loader is therefore fitted with water sprays. These are interlocked to the cutting drum motors, so the cutter picks cannot be rotated unless the sprays are delivering sufficient cooling water and an associated induced air flow to dilute the firedamp / air concentration at the pick point.

B.2 Construction/ Description of the equipment with regard to ignition protection



Layout and construction of the coal face shearer loader

Figure B.1
Layout and construction of the coal face shearer loader

The shearer loader consists of a rigid steel frame, with steel enclosures in it for the electrical switchgear and gearbox compartments. The switchgear is protected by flameproof enclosure 'd' according to EN 50018 and the gearboxes are protected by liquid immersion 'k' according to EN 13463-8. There are ranging arms at either end of the main body, moved by hydraulic cylinders, both of which are also protected by liquid immersion ‘k’ according to EN 13463-8. Spiral cutting drums are mounted on the end of each ranging arm and driven by electric motors protected by flameproof enclosure ”d” according to EN 50018. A haulage unit is positioned on the main body of the shearer. This is used to move the shearer loader along the AFC using a rack and pinion system. The haulages motors may be powered by either electric motors protected by flameproof enclosure ”d” according to EN 50018, or hydraulic motors protected by liquid immersion ”k” according to EN 13463-8. The machine’s bearings and power transmission system’s sliding and rolling elements are protected by constructional safety ”c” according to EN 13463-5.

B.3 Ignition control and monitoring system

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 present normal operating limits stipulated in the instruction manual. In no case do those trip settings exceed the maximum surface temperature for Group I equipment (i.e. 150 ^{o}C). The water spray pressure and flow are also monitored by this system. Ignition protection for the system is achieved by a combination of control of ignition source ‘b’ according to EN 13463-6 and intrinsic safety ‘ia’ according to EN 50020.

B.4 Compliance with the basic methodology & requirements document EN 13463-1

The shearer loader has been checked for compliance with EN 1127-2 and EN13463-1 and meets all requirements. In particular, the following are recorded:

(i) 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,

(ii) No external part, exceeding 100 square centimetres surface area, is made form non-metallic material having a surface resistance greater than 1 Giga Ohm

(iii) External enclosures are capable of passing the 20 Joule impact test on any surface.

(iv) Non-metallic parts have been subjected to immersion in mining hydraulic roof support fluid and their ignition protection characteristics are not impaired

B.5 Ignition hazard assessment of the electrical parts of the equipment

All electrical equipment is certified by an EU Notified Body as Group I, Category M2, in conformity with the ATEX Directive. Further information, not required for the purpose of this non-electrical equipment assessment, can be found in the relevant ‘Certificates of conformity’ issued by the relevant Notified Bodies.

B.6 Ignition hazard assessment of non-electrical ignition sources

The ignition hazard assessment table required by EN 13463-1 for non-electrical potential ignition sources is appended overleaf.

B.7 Equipment marking

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 overleaf has determined this to be as follows:

CE Ex **I M2 c k b**

Where:

‘CE’ is the distinctive community marking,
epsilon-x 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

Table B.1 - Example of an Ignition Assessment for 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		
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 and metal parts	The ingress of unacceptable stones and metal parts is not possible, because covers are removeable by tools and the cover seals have ingress protection rating IP54.	EN 13463-5, 4.5 ”c”
Frictional heat from bearings		All bearings are lubricated by grease. The replacement of grease is addressed in the user instructions. The bearings fulfil the conditions specified in prEN 13463-5, section 6.1. The time of replacement of the bearings is listed in the user instructions	EN 13463-1, Clause 6 prEN 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. As an alternative, it is acceptable to use a continuous monitoring system that disconnects the power, if an unpermissible temperature is indicated.	EN 13463-1, Clause 6 (user instructions) or EN 13463-6 ”b”
Frictional heat from moving parts inside the gearbox		The gearboxes need to be prepared in a protection class IP54, that guarantees no ingress of stones, metal parts or water in an unacceptable amount. The moving parts inside the gearbox are submersed in lubrication, that acts as a spark quenching agent and coolant. 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.	prEN 13463-5, 4.5 ”c” prEN 13463-8, Clause 6 ”k” EN 13463-1, Clause 6
	a) Ingress of stones and metal fragments to the gear boxes	All openings are closed by covers or other closing facilities that are removable by tools only.	EN 13463-1, Clause 6 prEN13463-5, 4.5 ”c”

Table B.1 - Example of an Ignition Assessment for a shearer loader Group I, Category M2			
	b) Unacceptable loss of lubrication from the gearbox	Gear boxes 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. As an alternative, a monitoring system is provided that disconnects the power, if the lubrication level falls below a minimum level, or an unacceptable value for the pressure or the temperature.	EN 13463-1, Clause 6 (user instructions) or EN 13463-.. "b"
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. The surface temperature of parts, where no coal dust is involved, is less than 450 °C	EN 13463-1, Clause 6
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 prEN13463-5 "c"
	a)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 prEN13463-5 "c"
	b)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
	c) Moving of brakes, because of an electrical break down	The drive motor is disconnected by the monitoring device for the brakes.	EN 13463-1, Clause 6 prEN13463-5 "c"
Frictional heat at drums		The drums with circumferential speed of more than 1m/s are assembled with a drum spray system, that prevents unacceptable high temperatures at the drums, the picks and the cutting zone. An interlock is provided to ensure that the drums cannot rotate without the drum sprays operating.	EN 13463-1, Clause 6 prEN 13463-5 "c" prEN 13463-.. "b"

Table B.1 - Example of an Ignition Assessment for a shearer loader Group I, Category M2			
	a) 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 EN 13463-.. "b"
	b) Blocking of sprays	The periods or rechecking for the spray are determined in the users manual. As an alternate, the pressure and flow monitoring system is acceptable for automatic checking, if it is prepared to detect those faults.	EN 13463-1, Clause 6 (user instructions) EN 13463-.. "b"
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 7.4.5	EN 13463-5, 7.4
	Pollution of liquid	The kind of hydraulic fluid and the filter as indicated in the users manual has to be used. 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 EN 13463-.. "b"
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, 7.4
Removable parts		Removable parts of equipment, are removeable only by tools.	EN 13463-1, Clause 9
Materials used for cementing		For that cementing materials, that are responsible for the protection class, products with an acceptable temperature stability are used.	EN 13463-1, Clause 10
Connection facilities for earthing conducting parts		All conducting parts are connected with the protection core in the trailing cable. Outer isolated parts are provided with earthing terminals.	EN13463-1, Clause 11
Light transmitting parts		Used 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
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.	Clause 5