Guideline for the Compilation of a Mandatory Code of Practice for the Prevention of Coal Dust Explosions in Underground Coal Mines.

1. FOREWORD

Of all the risks inherent in coal mining, the one most feared is a coal dust explosion, since it is an event capable of almost instantaneously killing everyone below ground and destroying the entire mine. Coal dust explosions of such severity have occurred only twice in Southern Africa, namely in Durnacol in 1926 (125 killed) and Wankie in 1972 (427 killed). However, due to the increased use of mechanical miners, which increases the risk of frictional ignitions, the extent of the hazard has increased in recent decades, since these machines produce large quantities of dust in the potential presence of flammable gas.

Coal dust explosions are almost invariably initiated by an explosion of a flammable gas/air mixture or a flammable gas/air/coal dust hybrid mixture and so the first line of defence is to dilute flammable gas emissions by adequate ventilation and to ensure the total absence of ignition sources. However, these Guidelines and the Code of Practice to which they refer, deal only with the prevention and suppression of coal dust explosions. Other Codes of Practice will deal with good ventilation practice and the prevention of ignitions and explosions of flammable gas.

The role of coal dust in spreading the effects of flammable gas explosions was suspected in the 19th century, but it was only in the early 1900s that the use of water to keep roadways free of dust became a generally accepted practice. By 1920 the principle of adding stone dust to render a coal dust mixture inert had been researched. Upon implementation this had an undoubted effect on the number of coal dust explosions world-wide. However, to be effective, the stone dust must be intimately mixed with the coal dust and even the thinnest layer of superincumbent coal dust can cause an explosion to propagate. Strategically placed stone dust barriers can extinguish such explosions and they came into wide scale use, particularly in Europe, about 40 years ago. Since then more user-friendly barrier systems such as water troughs, active or triggered barriers and bagged stone dust barriers have been researched in a number of countries.

Following the Report of the Leon Commission of Inquiry into Safety and Health in the Mining Industry, the Mining Regulations Advisory Committee appointed a task group to advise on measures to be taken to minimise the risk of coal mine explosions in South Africa. A further task group was subsequently charged with investigating the application of bagged stone dust barriers, which recent research at both the G.P. Badenhorst Research Facility and the Tremonia experimental mine in Germany had indicated to be an alternative to other forms of barriers. The recommendations of both task groups are incorporated into this guideline.

2. TASK GROUP MEMBERSHIP

The original Task Group appointed by the MRAC consisted of:-

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The question of a Guideline for the Installation, Maintenance and Monitoring of Bagged Stone Dust Barriers was considered by a different Task Group consisting of:-

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3. THE GUIDELINE FOR THE COMPILATION OF THE CODE OF PRACTICE FOR THE PREVENTION OF COAL DUST EXPLOSIONS IN UNDERGROUND COAL MINES

3.1 Description

The purpose of this guideline is to assist those personnel at coal mines who are charged with the task of preparing a Code of Practice for the Prevention of Coal Dust Explosions. It provides guidance of a general nature on the required format and content for the Code of Practice and details sufficient technical background to enable the drafting committee at the mine to prepare a comprehensive and practical Code of Practice for their mine. It is not intended that it should be overly prescriptive in nature.

Coal dust explosions usually occur when a flammable gas/air explosion raises a cloud of coal dust, which is then ignited by the heat and flame of the original explosion. Since coal mining invariably produces coal dust, four strategies have been developed to combat the risk of coal dust explosions:

- Removal of coal dust and broken coal
- Wetting the dust to prevent it becoming airborne
- Mixing the coal dust with stone dust so that when airborne the mixture is inert
- Installing barriers in the mine roadways, which when activated by an explosion will use a heavy concentration of stone dust, water or other agency to make an entire zone of the roadway inert, thereby extinguishing all flame and preventing further propagation of the explosion.

All four strategies are dealt with in this guideline. These strategies embody various principles, techniques and methodologies that allow mine standards to be established. This guideline provides sufficient information and detail to ensure that the minimum required standards can be identified and compliance achieved. In this way it is anticipated that Codes of Practice can be written and implemented which will ensure that coal dust explosions no longer threaten the safety of persons in underground coal mines.2 Status

In accordance with Section 9(2) of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996), the Chief Inspector may require the manager to prepare and implement Codes of Practice. These Codes of Practice must comply with all applicable provisions of any guideline that the Chief Inspector has issued.

The Code of Practice is therefore a legal document and non-compliance with the provisions thereof in terms of Section 91(1)(a) is a criminal offence and is punishable by law.

The Code of Practice may be used in accident inquiries to ascertain compliance and to establish whether the Codes are suitable and sufficient.

The Code of Practice should be reviewed when the regular risk assessment shows that particular hazards are not adequately addressed.

Where the Code of Practice calls for a particular strategy which is not yet in place, the manager must provide a detailed timetable for the preparation and subsequent implementation of that strategy.

The Code of Practice will remain in force should the mine change ownership or close temporarily.

3.3 Format

The chapters must follow the sequence laid out under the heading "List of Contents". Numbering should be consistent to facilitate cross referencing. Each page must be numbered for easy reference. Wording must be unambiguous and concise.

Whenever possible, illustrations must be used to avoid long descriptions and/or explanations.

A glossary of terms and definitions is given in Appendix VI of this document. This Appendix must be attached to the Code of Practice. The definition of any other term, of which the meaning is not absolutely clear, must be added to those found in Appendix VI.

When reference has been made in the text to other publications or sources, a bibliography must be included as an appendix in which each reference is identified.

Appendices, which are considered to be the best current practice, provide additional information and form a part of the guideline. As such the various topics included under appendices should be addressed in the codes of practice. The standards reflected in

Appendicess III, IV, and V however, must be viewed as the minimum standard.

3.4 Access to the code of practice and related documents

The complete Code of Practice will be kept on file at the mine. Copies should also be kept by members of the Health and Safety Committee. A register must be kept of those persons/institutions who have copies in order that they can be supplied with any updates.

A procedure must be instituted by mine management to ensure that all employees are fully conversant with those sections of the Code of Practice relevant to their respective areas of responsibilities.

Relevant extracts must be translated into such other language/s as determined through consultation between management and the Health and Safety Committee and/or the health and safety representatives.

4. PREVENTION OF COAL DUST EXPLOSIONS IN UNDERGROUND COAL MINES

4.1 Title page

The title page of the Code of Practice must be brief, giving accurate information and all pertinent details about the colliery's name, date of issue of the Code of Practice, membership of the Drafting Committee and (where applicable) any revision date.

As an example, the title page could have the following information:-

ABC Colliery

Code of Practice For The Prevention Of Coal Dust

Explosions In Underground Coal Mines

December 1995 (revised December 1996 if applicable)

Reference No

Drafting Committee: Membership

4.2 Origin

It must be stated that this Code of Practice is mandatory in terms of Section 9(2) of the Mine Health and Safety Act, 1996 (Act No 29 of 1996).

4.3 Status and review

This section should contain statements with regard to the legal status and need for periodic review of the document, to the effect that;

- the Code of Practice is a legal document and that it is a punishable offence for any person not to comply with, or to falsely claim compliance with, the provisions of the Code of Practice,
- the Code of Practice may be used in an accident investigation/inquiry to ascertain compliance and also to establish whether the Code is suitable and sufficient,
- the Code of Practice is subject to review at least once per annum or at the request

of a stakeholder and the review should be based on a risk assessment and should incorporate any new strategies, techniques or methods which have become known to the industry,
- the Code of Practice should be subjected to organisational peer review and a statement to that effect should be included,
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- the Code of Practice supersedes all previous managerial instructions, recommended procedures and standards on the relevant topics from a legal viewpoint.

4.4 Members of the drafting committee

The manager must, in consultation with the Health and Safety Committee, establish a committee responsible for drafting the Code of Practice.

The members of the Drafting Committee, assisting the mine manager in drawing up the Code of Practice, must be listed on the title page giving their full names and designation, as well as professional qualifications and/or experience and affiliation. This committee must include a person who is suitably qualified in occupational hygiene techniques, and may make use of external consultants.

4.5 List of contents

5. Section A : Technical Information

5.1 General Information

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5.1.2 Coal Seams Mined

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5.2 Design and Control Considerations To Prevent Coal Dust Explosions

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6. Section B : Appendices

I Mechanism of a coal dust explosion

II Typical dust sources and some control measures to limit the formation dispersion and removal of coal dust

III Minimum stone dusting requirements

V Sealing of abandoned areas

VI Terms and definitions

VII Inertisation of coal dust

VIII References

IX Report of the task group on coal mine explosions

5. SECTION A -

TECHNICAL INFORMATION

The following minimum information must be provided:-

5.1 GENERAL INFORMATION

5.1.1 The mine

A brief description of the mine, its annual production, any sub-division into different areas, the physical distances between boundaries and workings and the general ventilation arrangements.

5.1.2 Coal seams mined

The seam/s being mined should be listed, together with relevant data, including seam width/thickness, flammable gas content, Kex value and proximate analysis.

5.1.3 Mining methods

The mining method or combination of methods used at the mine must be listed. This section should discuss the degree of mechanisation, taking care to identify the potential sources of coal dust.

5.1.4 Ventilation arrangements

Since the prevention of coal dust explosions rely primarily on the elimination of flammable gas explosions, a statement on the ventilation practice and standards at the mine should be included in the general information. This need not be a detailed statement and should, if possible, refer to any other Code of Practice that deals with ventilation and or explosion prevention.

5.1.5 Other codes of practices

Other Codes of Practice should be referred to in order to avoid conflict of requirements as laid down by the mine. The objective would be to have an integrated system.

5.2 DESIGN AND CONTROL CONSIDERATIONS TO PREVENT COAL DUST EXPLOSIONS

This section forms the principal element of the Code of Practice.

The Mine Health and Safety Act requires the manager to identify the hazards, to assess the health and safety risk to which workers may be exposed while they are at work, record these findings and implement reasonably practicable measures to

control the risk. Explosions and ignitions are such hazards and as such must be treated in accordance with the above.

When dealing with the aspect of hazard identification and risk assessment, the manager should refer to the SIMRAC reports as well as other publications on the subject.

Personnel involved must be trained in hazard identification/risk assessment prior to being involved in the process.

The measures required/taken to overcome the risk must be incorporated in the Code of Practice under the strategy headings 2.1 - 2.7.

Having identified a coal dust explosion as a major hazard associated with the underground mining of coal reserves, it is necessary to define strategies to manage these risks.

The department or persons responsible for the execution of the particular strategies or portions thereof must be stated in all cases.

Mine standards are derived from the strategies and are in essence not part of the Code of Practice. The Code of Practice specifies what is required.

Where a strategy is not yet in place, the mine manager must provide a detailed time table for the preparation and subsequent implementation thereof.

The mechanisms involved in a coal dust explosion are given in Appendix 1. The strategies for the prevention of a coal dust explosion are listed below, together with the mandatory requirement that the Code of Practice address each strategy.

5.2.1 Limiting the formation and dispersion of coal dust

Proposed measures of dust control must be reflected under this heading. The area of the mine in which these measures are to be applied must be specified and the persons responsible for carrying out this action as well as the persons responsible for monitoring the situation must be stipulated, by title.

Appendix II deals with this aspect.

5.2.2 Removal of coal dust

A programme for the regular clean up and removal of accumulations of coal dust from accessible workings, especially in the following areas, must be laid down:-

a) The face area before stone dust application.

b) Conveyor belt roads.

c) Tramming and travelling routes.

d) Return airways.

Refer to Appendix II.

5.2.3 Prevention of the initiation of coal dust explosions

Precautionary measures against flammable gas explosions are not addressed in this guideline. These are covered in the ventilation Codes of Practice. However, the role of flammable gas explosions must be acknowledged under this heading and cross-reference made to the ventilation Code of Practice.

Refer to Appendix I.

5.2.4 Inertisation of coal dust by the use of water

Where it is proposed that water is used to inertise coal dust the Code of Practice must specify the areas of the mine to be treated in this way, the method of applying water, times at which water is to be applied, maximum duration between application and the method to be adopted to check that sufficient water has been applied. The persons (by title) responsible for ensuring that watering down is conducted according to the Code of Practice must be stipulated.

Refer to Appendix VII.

5.2.5 Inertisation of coal dust by the application of stone dust

The Code of Practice must contain clear statements as to the required stone dusting standards in each of the eight identified areas mentioned in Appendix VII. The minimum percentage by mass of incombustible matter that will be maintained in dust samples retrieved from each of the areas, the quality control measures that will be adopted, and the way in which compliance monitoring will be carried out must be stated. Those responsible for stone dusting, sampling and compliance monitoring must be clearly identified. It is strongly advised that the

recommendations of the Working Party be adopted, as the minimum requirements of each mine’s Code of Practice. Should a mine deviate from these recommendations the Code of Practice must contain a statement of proof that the proposed deviations provide at least an equal protection against the possibility of a coal dust explosion.

Refer to Appendix VII.

5.2.6 The use of barriers to prevent the propagation of coal dust explosions

The Code of Practice must include the use of barriers to protect conveyor belt roadways. Return airways must also be protected by barriers, unless alternative methods are specified in the Code of Practice, to ensure that dust in the first 1000 m outbye of a working face in return airways will always contain at least 80% incombustible material by mass. If it is not intended to use barriers in return airways, the Code of Practice must specify in detail the arrangements for maintaining and monitoring stone dust levels at the required level/s in those roadways.

Refer to Appendix IV.

5.2.7 Prevention of explosions in abandoned areas of the mine

When workings of a mine are abandoned for any reason, they must remain adequately ventilated or be effectively sealed off. Before any area is sealed off the roof, sides and floor must, as far as is reasonably practicable, be stone dusted to ensure a minimum incombustible content of at least 80%.

The Code of Practice must specify the required actions before an area is sealed and also that a person, who is suitably qualified in occupational hygiene techniques, must certify that the stone dusting is adequate before the area is sealed.

To assist with the formulation of a Code of Practice refer to Appendix V.

The Code of Practice must address the sealing of abandoned areas in the mine. The use of risk assessment techniques to determine an appropriate type of seal must be specified in the Code of Practice. When seals other than explosion proof stoppings are to be used the Code of Practice must specifically refer to the need to suspend work in adjacent areas at periods when the atmosphere behind the seals is going through its explosive range.

6. SECTION B -

APPENDIX 1

THIS APPENDIX IS MERELY ATTACHED AS INFORMATION FOR CONSIDERATION IN THE PREPARATION OF THE CODE OF PRACTICE

1. MECHANISM OF A COAL DUST EXPLOSION

Finely divided coal will explode if a supply of oxygen is present and there is a source of ignition. The flame from a flammable gas ignition heats the atmosphere, causing a sudden rise in pressure. This rapid rise causes great turbulence, mixing the gases and exploding, resulting in a flame spread of up to five times the volume of the original mixture. The fast flow of air disperses dust from the roof, sides and floor of the roadway and the primary dust cloud is ignited by the flame front. The further rapid rise in the pressure caused by the heat of the burning coal and the turbulent flow of gases, lead to a pressure wave, raising coal dust which is subsequently ignited by the flame front lagging behind. These factors perpetuate and the mine with its contents can be destroyed in a few seconds.

Explosions can be divided into deflagrations and detonations.

In a deflagration the shock waves travel at the speed of sound (about 330 m/s) in the cloud of unburnt dust which has not yet contributed to the explosion, while the flame front follows at a slower speed. There is, therefore, a time lag between the arrival of the shock wave at a given point and the arrival of the flame. This interval can be used to advantage in that the shock wave can be made to trigger flame quenching devices which will arrest the progress of the flame. Obviously as the distance from the epicentre of the explosion increases, so does the interval between the arrival of the shock wave and the flame front. This, in part, determines the location of flame quenching devices, particularly those that have only a short duration efficacy.

The violence of an explosion depends on the maximum pressure generated and the maximum rate of pressure build-up. Dust explosions have produced maximum pressures of 1 Mpa and pressure build-up rates of 100 Mpa/s.

In a detonation the shock wave and the flame front travel together at approximately 1000 m/s in the gases produced by the explosion and will thus continue until all the available dust has been consumed. Most industrial dust explosions are deflagrations with flame speeds of up to 100 m/s, because the initial energy of the igniting source is small and the scale of operation is also relatively small. In coal mines, however, the igniting source is usually an explosion in itself

i.e. a flammable gas explosion, and flammable gas may continue to augment the effects of the dust. In a fully developed coal mine dust explosion, the speed of sound may be exceeded. Work by Landman, amongst others, has shown that, in the presence of only small concentrations of flammable gas, the minimum ignition energy, the minimum explosible concentration and the energy generated by a coal dust explosion all change.

Unlike dust explosions in surface plants, dust explosions in mines are confined in that the surfaces of the airways restrain the explosion and force it to travel along the airways. The pressure build-up is, therefore, compounded in all directions.

Rapid cooling of the heated gases and mine surfaces causes a vacuum, which leads to a reversal of forces that can be as destructive as the primary pressure wave. These phenomena are not as marked in bord-and-pillar workings as in concentrated longwall workings.

The ignition sensitivity of a type of dust can be expressed in terms of the minimum temperature or the minimum energy required to create an ignition. In practice the two are not independent and both must be taken into account. Most dusts also have different ignition sensitivities depending on whether the dust is in a cloud or a layer. Additional factors which will affect the ignition sensitivity are size distribution, volatile content, concentration, turbulence and moisture content.

2. INITIATION OF COAL DUST EXPLOSIONS

The most common initiator of a coal dust explosion is an explosion of flammable gas. Rare cases have, however, been recorded of coal dust explosions initiating and propagating in the absence of flammable gas.

Volumes of flammable gas/air mixture of as little as $4m^3$ have been known to initiate a coal dust explosion.

The best defence against flammable gas explosions is to dilute the flammable gas as soon as it is released, to below its lower explosive limit by ensuring sufficient ventilation. All places where flammable gas can accumulate must be adequately ventilated. Once mixed with air, flammable gas remains diluted.

In addressing this aspect in the code of practice reference should be made to the guidelines dealing with the ventilation code of practice and the prevention of explosions should form an integrated system.

APPENDIX II

SECTION 1 OF THIS APPENDIX IS MERELY ATTACHED AS INFORMATION IN THE PREPARATION OF THE CODE OF PRACTICE. SECTION 2 AND 3 MUST, HOWEVER, BE ADDRESSED IN THE CODE OF PRACTICE.

1. TYPICAL DUST SOURCES AND SOME CONTROL MEASURES

SOURCE	CONTROL MEASURES
DRILLING	* Adequate supply of water (pressure) * Duff collection * Dilution (ventilation) * Condition of tools
CUTTING	* Adequate supply of water * Conditions of tools * Dilution (ventilation) * Position and sequence of cut
BLASTING	* Second face * Burden/direction/length/spacing/tamping/timing * Watering down * Dilution (ventilation)
LOADING	* Wetting * Dilution (ventilation)
RIPPING	* Adequate supply of water * Surfactants * Dilution (ventilation) * Pick condition/Angle/type * Drum rotation speed * Scrubbers and dust retention aids * Method and sequence of cutting

TRANSFER SYSTEMS - INBYE SECTION	* Water sprays * Spillage prevention * Road treatment (wetting) * Cleaning
BREAKING/CRUSHING	* Siting * Wetting * Enclosing * Exhaust ventilation * Spillage prevention * Condition of picks * Method of tipping
CONVEYANCE/TRANSFERS OUTBYE SECTION	* Spilling prevention and removal * Belt cleaning mechanisms * Wetting * Belt/air velocities * Transfer heights * Chute design * Belt maintenance
VEHICULAR TRANSPORT	* Road surface treatment (wetting or binding) * Vehicle speed * Ventilation
SPILLAGE	* Prevention * Removal * Engineering design * Method of tipping

NOTE: This list is not exhaustive App II No 1 of 3

2. LIMITING THE FORMATION AND DISPERSION OF COAL DUST

It must be accepted that all coal winning operations involve the creation of coal dust. However, the quantity generated and its dispersion by the mine's ventilation network can be substantially reduced or controlled.

Dust is produced at the face, at conveyors, at transfer points and by the movement of persons and machines. Dust particles less than 100 micrometres in diameter may become airborne and be transported by the ventilating air current into the last through road and return airways where they are deposited onto exposed mine surfaces. The combustible portion of this dust, termed float coal, presents a greater explosion hazard than larger particle size coal dust.

A paper-thin dry layer of float coal dust on the floor of a roadway may be sufficient to propagate an explosion. It would be unrealistic to rely on dust suppression alone to bring about conditions such that the dust cloud raised into the air, by a flammable gas explosion, never provides a concentration of coal dust in the air capable of propagating an explosion. Dust suppression prolongs the period before dangerous dust conditions are reached and hence makes less onerous the task of treating the coal dust (by binding or stone dusting), by reducing the frequency with which such treatment needs to be applied. The amount of coal dust available as fuel is also reduced should an explosion occur.

The dispersibility of dust is the ease with which it can be raised into the air. Coal dust becomes a source of immediate danger when it is raised into the air in a cloud of sufficient concentration, generally accepted as approximately $50g/m^3$.

Coal dust loses its dispersibility with an increase in its free water content. Dry coal is not easily wetted, but coal with an inherent high moisture content, after having dried out, will readily absorb water again on being wetted down. Where the inherent moisture content of coal is low, surfactants can be used to decrease the surface tension of water.

It is of the utmost importance that dust on the roof and sides be washed down and the dust on the floor be wetted before work commences, or resumes, if dust has been created. When for safety reasons this is not possible, alternative measures must be adopted.

From the above, it is clear that an effective dust suppression programme is of paramount importance. Individual mines should evaluate their own circumstances and elaborate on them in their Code of Practice.

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3. REMOVAL OF COAL DUST

Supplementary to the dust suppression programme, a system for dust removal is essential.

By removing as much coal dust as is practicable, fuel for a possible explosion is reduced. An additional advantage is that the more coal dust that is removed from the workings, the less inerting material is required to make the dust safe.

Deposits of coal dust, loose coal and other combustible materials must be cleaned up and may not be permitted to accumulate in active workings. In longwall and shortwall mining, coal dust must be washed from face support and other equipment before the start of each production shift.

Dust and loose coal must also be removed from equipment and structures such as feeder breakers and conveyor belts. Details of how this will be achieved must be incorporated into this section of the Code of Practice.

APPENDIX III

THIS APPENDIX MUST BE INCORPORATED IN THE CODE OF PRACTICE

MINIMUM

STONE DUSTING REQUIREMENTS

1. STONE DUST

Stone dust is defined as pulverised limestone, dolomite or other approved incombustible dust subject to the successful testing at a research laboratory accredited by the Chief Inspector. It should preferably be light in colour.

The important properties used for the approval of stone dust are:-

a) It contains not less than 95% by mass of incombustible matter, and with a density similar or equal to approved pulverised limestone.

b) It contains not more than 5% by mass of free silica, or any other toxic substance in concentrations detrimental to health.

c) It is of such fineness that, when dry, all will pass through a sieve of 600 micrometres aperture and at least 50% by mass through a sieve of 75 micrometres aperture.

d) Unless directly wetted by water, it does not cake and will readily disperse into the air.

NOTE: It should be noted that other incombustible dusts which comply with the above requirements may not effectively suppress the flame hence the testing requirement.

2. EXTENT OF APPLICATION

In order to ensure that the underground workings of a coal mine are adequately protected, all underground areas of a coal mine producing bituminous coal, except those areas extending to the face from and including the last through road, in which the coal dust has been washed from the roof and sides, and the floor is too wet to propagate an explosion, should be stone dusted to within 10 m from all working faces unless such areas are inaccessible, or, unsafe to enter. Such areas must be timeously identified by hazard identification and risk analysis and addressed to reduce the hazard.

3. DEGREE OF INERTISATION

Any coal mine can be divided into different areas, with significantly different potential for experiencing a coal dust explosion e.g. intake airways far distant from a working face and return airways in the face area. Considering all available information the following minimum levels of inertisation by the application of stone dust are required:-

a) Intake airways

i) In the face area, a minimum percentage by mass of incombustible matter content of 80% must be maintained.

ii) Outbye the face area, intake airways must be maintained at a minimum of 65% incombustible matter content. Workshops, sub-stations, battery charging stations and other similar places where work is done or equipment is maintained, situated in intake air will nevertheless be maintained at a minimum of 80% incombustible matter content.

b) Return airways

i) A minimum percentage by mass of incombustible matter content of 80% must be maintained up to a minimum distance of 1000 m from the face. Beyond this distance, a minimum percentage by mass of incombustible matter content of 65% must be maintained. Provided that where approved barriers are installed, the incombustible matter content by mass, outbye the face area and outbye of the barriers must be maintained at not less than 65%.

ii) Return airways in close proximity to sealed areas or areas in the process of being sealed off, must contain a minimum percentage by mass of incombustible matter content of 80%, unless the area has been sealed off as required by Appendix V.

c) Conveyor belt roads

A minimum percentage by mass of incombustible matter content of 80% must be maintained up to a minimum distance of 180m from the face. Beyond this distance, a minimum percentage by mass of incombustible content of 65% must be maintained.

It should be recognised that conveyor belt roads constitute a particular hazard. Dust is liberated into the ventilation current at transfer points and during the conveying of coal. Spillage from belts also contributes to the problem. In addition, the conveyor structure itself provides an ideal location for the accumulation of coal dust. Stone dusting alone cannot, therefore, adequately protect conveyor belt roads and the use of barriers, as described in Section A, par. 2.6 and Appendix IV of these Guidelines must be considered essential.

d) Abandoned areas prior to being sealed off

Before any area is sealed off the roof sides and floor must, as far as reasonably practicable, be stone dusted to ensure a minimum percentage by mass of incombustible matter content of 80%.

4. FREQUENCY OF APPLICATION

Deposits of float coal can only be neutralised by an incombustible matter content of 80%, provided the coal dust and stone dust are well mixed. This can be achieved continuously by trickle dusting, or by frequent conventional applications of stone dust. Where continuous stone dusting is impractical, the principle should thus be that lesser quantities of stone dust be applied more frequently.

In the light of the afore-mentioned, Industry is urged to critically re-evaluate stone dusting techniques and equipment.

Establishing the rate of deposition of float coal will assist to determine the frequency of stone dust application.

Although the necessary frequency of application of stone dust will vary depending on a number of factors including production rate and method of mining, some general principles can be used in drawing up a Code of Practice.

a) Face area

Stone dust must be applied, and re-applied, as often as is necessary, to maintain the incombustible matter content by mass at a minimum of 80%. Although daily stone dusting is advocated, the frequency rate of application must not be less than once in every four production shifts, unless a risk assessment, including rates of deposition of float coal, or other sampling indicates otherwise. This applies to roads within the face area including roads carrying return air.

b) In pillar extraction operations, stone dust must be applied on a retreat basis at the same frequency rate as above.

c) In total extraction operations, sufficient stone dust must be injected regularly into the mined areas before the occurrence of the initial goaf, to inert the dust cloud that will be raised when it occurs.

d) The use of trickle dusters to facilitate effective stone dusting in return airways of bord-and-pillar workings, is favoured. However, in both longwall and shortwall mining, stone dust must be effectively introduced, during coal winning, into the return airways.

Finally, it must be emphasised that only the results of a rigorously applied sampling programme can indicate whether stone dust is being applied frequently enough.

5. STONE DUST SAMPLING PROGRAMMES

In order to ensure that the stone dusting programme complies with the standards set by the Code of Practice, several sampling programmes need to be set up and monitored. These will include quality of the stone dust, mine dust sampling, analysis of samples and reporting structures, as follows:-

A Stone dust specifications

The supplier must be responsible for testing each batch of incombustible dust delivered to the mine for reflectivity, incombustible matter content, fineness and have tests carried out by an independent authority to verify the silica content. A copy of a certificate showing the results of these tests, must be supplied to the manager on delivery of each batch.

The manager must verify all the above-mentioned specifications on an annual basis.

B Compliance sampling

For the purpose of determining the adequacy of the measures taken to comply with the requirements of incombustible matter content, samples must be taken as follows:-

i) Samples must be systematically collected from the roads of all accessible workings of a colliery.

ii) The workings of a colliery must be divided into the face areas and zoned back areas and these areas must be clearly demarcated on a plan, similar to the ventilation plan required by Regulation 10.18.

iii) The sample of the dust on the roof and sides must be taken separately from the sample of dust on the floor.

iv) In the case of dust on the roof and sides the sample must be taken to a depth not exceeding 6 mm and in the case of dust on the floor to a depth not exceeding 25 mm.

v) Every sample taken must be representative of the whole surface of the roof and sides, or the floor, as the case may be, of the length of road being sampled and must be collected by a method of strip sampling by which the dust is collected from a succession of transverse strips, 100 mm wide and equally spaced not more than 5 m apart. Intersections must be sampled diagonally across to include a sample from at least two pillar corners.

vi) Where it appears that the roof and sides or the floor, as the case may be, is wet, the sample must nevertheless be collected. Excess water must be drained off by placing the sample on a 2 mm aperture sieve, for at least one minute.

vii) Areas where water has collected in pools on the floor, need not be sampled but must be recorded as too wet to sample.

Since the rate at which dust is deposited, as well as the risk of an explosion being initiated differs considerably between the face area and back areas of a coal mine, these two areas should be treated differently.

viii) Face area:

(a) Samples from face areas must be taken at intervals not exceeding 7 working days.

(b) In the face area, a composite sample must consist of the combined material, collected from 5 equally spaced transverse strips (except where measurements are affected by diagonal sampling at intersections), over a measured distance of 20 m. Again the dust on the roof and sides must be taken separately from the samples of dust on the floor and the two sets of results reported separately.

(c) A series of 3 composite samples must be collected from all return airways, the belt road, and at least one intake airway, over a distance not less than

60 m length of roadway, commencing at a location approximately 15 m from the face. Similarly, a series of composite samples must be collected over the full length of the last through road.

(d) In the case of either longwall or shortwall mining, a series of 5 composite samples must be collected from all gate roads over a distance of not less than 100 m length of roadway, commencing at the face.

ix) Back area requirements:

(a) The workings of a colliery outbye the face area must be divided into zones not exceeding 600 m in length. These zones must further be divided into sub-zones, not exceeding 50 m in length, from which representative samples must be taken at intervals not exceeding 30 days.

(b) In the back area a composite sample must consist of the combined material collected from 11 equally spaced transverse strips (except where measurements are affected by diagonal sampling at intersections) over a measured distance of 50 m. Samples from the roof and sides should be treated separately from those obtained from the floor.

(c) Samples from sub-zones must comprise of composite samples taken from at least one return airway, the belt road and one other intake airway.

(d) Sampling of zones must be scheduled so that each sub-zone is sampled at least once per year.

C Analyses of samples

Samples must be analysed by either the colorimetric method or by a laboratory determination of mass of incombustibles or by both methods.

In either case samples of dust collected at a mine must without delay be processed and the incombustible matter content of the samples determined. Descriptions of the two methods follow:-

Colorimetric method

All samples may be analysed using the colorimetric method on surface or underground. In both cases the method described remains the same. If the underground option is chosen, drying facilities and adequate lighting must be provided. This option evaluates the degree of inertisation in the shortest possible time, permitting immediate remedial action. (Moisture correction is not considered in this option and is taken to be a safety factor).

i) The colour of a sample of dust must be compared with that of a scientifically prepared standard colour sample, known to contain eighty percent, or sixty five percent as the case may be, of incombustible matter content. When on such comparison, the colour of the sample is found to be the same colour or lighter than that of the standard sample, the incombustible matter content in the dust must be taken to comply with the prescribed percentage of the total incombustible matter content.

ii) Any sample that appears to be below the prescribed percentage of incombustible matter content must be analysed using the laboratory method described below.

iii) In addition to (ii) above, at least ten percent of the remaining samples must be analysed using the laboratory method.

iv) A separate standard colour sample must be prepared for each working area of a mine in the following manner:-

a) Grind some dry coal dust from the seam in each area for which the standard colour sample is being prepared so that it passes through a 250 micrometres sieve.

b) Determine the ash content of the sieved coal dust. The ash content must not exceed 20 percent by mass on a dry basis (this is to avoid the use of shale in the preparation of a standard colour sample).

c) Pass through a 250 micrometres sieve some dry stone dust of the type used in the mine.

d) Weigh quantities of the sieved coal dust and sieved stone dust in proportions which will give the desired incombustible matter content i.e. 65% and 80%.

e) Mix the dust thoroughly by stirring, shaking or rolling but do not grind the mixture.

f) Using the approved laboratory method, determine the incombustible matter content of the mixture and verify that it is not less than the required value.

g) Whenever there is change in the colour/reflectivity of the stone dust supplied to the mine, and whenever the colour of the coal seam changes distinctly, new standard samples must be prepared.

h) At intervals of not more than 3 months, re-test the standard and keep a record of the results of these tests. If the standard has an incombustible matter content which is less than that required, replace the standard with a new one.

vi) The procedure for the preparation and evaluation of collected dust samples is as follows:-

a) Split the sample and retain one half of the sample for laboratory analysis if required. Air-dry the portion to be compared if necessary. Sieve the sample through a 250 micrometres sieve and mix the sample thoroughly but do not grind it.

b) Compare the colour of the mixed sieved sample with that of the standard colour sample. The comparison must be made under conditions of good and even illumination. When conditions permit, and if by choice, this comparison is done underground, it must take place at a designated site. The comparison must be done in a suitably designed light box. The person performing this duty must be adequately trained to prepare the samples and to conduct the colorimetric test. Furthermore, his ability to distinguish between the colour ranges, must have been determined and his competence must be checked on at least an annual basis.

c) If any sample fails the comparison test, this must be reported without delay to the miner who must ensure that the area concerned is properly inertised timeously. The miner must report to the shift overseer or mine overseer on the corrective action taken. The dust sampler must report his findings to the environmental control officer or appointed person, who must ensure that the necessary remedial steps are taken.

Laboratory method

Analysis of samples in a laboratory must be carried out by the following method or by other approved methods:-

i) The residue of a weighed quantity of dust, after that quantity has been dried at a temperature not exceeding 140°C, and the loss of mass attributable to moisture ascertained, must be heated in an open vessel to a temperature not less than 480°C, and not more than 520°C, until the coal is completely burned away. The incinerated residue must be weighed.

ii) The sum of the masses of moisture and incinerated residue must be recorded as incombustible matter and be expressed as a percentage of the total mass of the dust.

iii) Where samples were air dried before analysis by the laboratory method, a correction may be made to the incombustible matter content of the dust sample analysed by laboratory method. The corrected total incombustible content is equal to M+I (100-M/100) where M is the percentage loss of mass during air drying and I is the percentage of total incombustible matter in the dust as determined by the method described in the preceding paragraph.

D Reporting of results and keeping of records

i) The certificates showing the quality of stone dust supplied to the mine must be retained for two years.

ii) A record must be kept of the date, places sampled and results of the analysis of the mine dust sampling programme. A return must be sent each month to the Principal Inspector clearly describing the places sampled and the results of the analyses obtained.

iii) Failure of more than 20% of the number of samples of a given area must be deemed totally unacceptable and requires immediate remedial action. Such remedial action must be reflected on the return referred to in (ii) above.

APPENDIX IV

SECTIONS 1, 2 AND 3 OF THIS APPENDIX MUST BE INCORPORATED IN THE CODE OF PRACTICE

DESIGN, INSTALLATION, MAINTENANCE AND MONITORING

OF BARRIERS TO PREVENT THE PROPAGATION

OF COAL DUST EXPLOSIONS

In the event that all safety precautions to prevent the initiation of a coal dust explosion fail, there is a very real prospect that the explosion can propagate throughout the entire workings of a mine. To prevent such an occurrence measures must be provided to arrest the explosion within the shortest possible distance. In intake roadways and return roadways remote from a working face, adequate stone dusting can prevent the passage of an explosion. However, where there is a chance that recently deposited float coal dust has formed a thin layer on top of a well stone dusted area, there is a severe risk that an explosion may propagate. Under these circumstances barriers must be installed.

Barriers may be either passive, in which case they are activated by the air blast which precedes the flame front, or triggered by either flame sensors or pressure transducers. In all cases the principle involved is that an inert zone is created by the barrier in which the heat of the explosion is absorbed and the chain reaction of the explosion broken.

Triggered barriers have been developed for specialised locations e.g. machine mounted. Passive barriers employing stone dust or water are used to protect roadways.

1. STONE DUST BARRIERS

In a typical coal dust explosion, a stone dust barrier is activated by the air blast which precedes the flame front. A dense cloud of stone dust is dispersed into the air which prevents further propagation of the flame. It is imperative that barriers are correctly installed and maintained to ensure their operation when required. Because much of the original research was conducted at the Experimental Mine Barbara in Poland, the most common type of stone dust barriers are referred to as the Polish design, constructed as detailed below:

Shelves consisting of loose, light weight boards are placed on a frame which is supported by suitable means. Frames must be installed horizontally in such a manner that the shelves will be readily displaced by the pressure wave.

App IV No 1 of 12

1. TIMBER/PROP SUPPORT

Support 10-30cm

Stonedust Frame

2. ADJUSTABLE BRACKET FROM ROOFBOLT

Roofbolt

10-30cm

Stonedust

Frame

The shelves must be installed as close as possible to the roof and sides, so that the apex of the stone dust on the shelf must be within 30 cm, but not closer than 10 cm, from the roof.

The height of the frame, supporting the boards, must be at least 20 cm and the width must not be more than 20 cm.

Lightly loaded shelves must be not more than 40 cm wide with a load of approximately 30 kg per metre of shelf length (average pyramidical height of 14 cm).

Heavily loaded shelves must be not more than 50 cm wide with a load of approximately 60 kg per metre of shelf length. (Average pyramidical height of 20 cm).

Distance Piece

Minimum 20cm

Maximum 40cm

(Light)

Maximum 50cm (Heavy)

Maximum

20cm

App IV No 2 of 12

The two types of stone dust barriers are referred to as "light and "heavy". Light barriers have a loading of 100 kg of stone dust per square metre of roadway. Heavy barriers have a concentration of 400 kg of stone dust per square metre of roadway and comprise of lightly-loaded and heavily-loaded shelves in the ratio 1:2. The lightly loaded shelves are sited before the heavily loaded shelves in relation to the probable direction of an explosion blast displacement.

The required loading and layout can be calculated as shown in the following examples:-

a) Light barriers

Area of roadway 6 m by 3 m = 18 m^2

Stone dust requirement is 18 x 100 kg = 1800 kg

Each shelf must have 180 kg (6m x 30kg/m shelve length)

Therefore 10 shelves must be erected and the spacing between each must be not nearer than 1,5 m and not more than 2 m apart to meet the specifications for a light barrier.

b) Heavy barriers

Heavy barriers must contain one third light shelves (180 kg) and two thirds heavily loaded shelves (6m x 60 kg/m shelve length = 360 kg each).

For roadway dimensions of 6 m by 3m i.e. 18 m^2 stone dust requirement is 18 x 400 = 7200 kg.

Let the number of light shelves be x then number of heavy shelves = 2 x and

180x + 360.2x = 7200

900 x = 7200

x = 8

so there will be 8 light shelves and 16 heavy shelves.

Again the design requires that shelves are to be spaced not closer than 1,5 m and not more than 2,0 m apart.

The Working Party considered that for conveyor roads and single entries, barriers should be mandatory while some flexibility exists in dealing with return airways.

(a) Conveyor belt roads

A barrier must be provided in every production section in the road carrying a conveyor belt. Either a light barrier or a heavy barrier, must be used.

i) Light barriers sited not closer than 80 m and not further than 180 m from the last through road, or

ii) Heavy barriers sited not closer than 120 m and not further than 360 m from the last through road.

(b) Single entries

Every single entry must be protected with a barrier, in exactly the same way as for conveyor roads.

(c) Return airways

Return airways must be protected by either high levels of incombustible matter i.e. a minimum of 80% incombustible matter content for the first 1000 m outbye of the face or by a light barrier, not closer than 80 m and not further than 180 m from the last through road. Outbye of the face area, the minimum incombustible matter could then be reduced to 65%.

2. WATER BARRIERS

Although water barriers can be either concentrated or distributed, the Working Party considers the use of distributed water barriers as impractical due to the continuous need to install additional units.

The use of concentrated water barriers is an alternative to employing stone dust barriers.

The minimum quantity of water must be $200l/m^2$ of cross-sectional roadway area, or $5l/m^3$ of roadway volume over the length of the barrier, whichever is the largest. The distance between the first and last row of troughs must be at least 20 m but not more than 40 m.

Passive water barriers function by allowing the pressure wave of an explosion to shatter the water troughs, dispersing water in the form of a cloud of droplets into the roadway cross section. The flame accompanying the explosion is extinguished by these water droplets.

Research has shown that a flame speed of at least 76 m/s is required to activate the barrier compared to 35 m/s required to activate a light stone dust barrier. Therefore a weak explosion may not activate a water barrier.

("Coal dust explosion barriers" by I. Liebman and J.K. Richmond)

The design, installation and maintenance of water barriers are critical if they are to work effectively.

App IV No 4 of 12

All troughs must be fitted with lids to prevent ingress of foreign material and minimise evaporation. Troughs and lids must be constructed from a material of such composition as to be readily shattered by the action of the pressure wave in the event of an explosion. The minimum quantity of water for large troughs (90 litres capacity) must be 80 litres and for small troughs (45 litres capacity) 40 litres. An indication must be provided to show the corresponding minimum water level in the trough. If the trough is not transparent and the water level cannot be readily seen, then a visual means of indicating the water level must be provided.

Troughs should be placed with the longer side of the trough at right angles to the line of the roadway. Exceptionally, one trough in a group may be placed longitudinally.

The design of troughs further require that:-

a) The troughs remain serviceable for as long as possible under the effect of heat.

b) The water contained in the troughs is released and adequately dispersed under the effects of the dynamic blast pressure of the explosion.

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

d) The material must not allow any static electrical charge, capable of igniting mixtures of air and flammable gas, or firing electrical detonators, to build up or be discharged from the surface of the trough.

e) The composition of the material in normal use will not have characteristics detrimental to health.

Since water is not so easily dispersed as stone dust and does not remain suspended in the air for any length of time, the installation and location of the troughs are critical if they are to extinguish an explosion.

Troughs may be suspended from the roadway support or mounted on equipment within the roadway. The sides of any troughs suspended inside or mounted on cross-members of frames must not have more than 5 cm of their height covered by such cross-members. Where troughs are mounted on equipment, a form of retaining lip must be provided which must be not less than 3 cm and not more than 5 cm in height. The equipment used to secure the troughs must be so designed, installed and maintained as to ensure the effective dispersion of water in the event of an explosion.

App IV No 5 of 12

With reference to the sketch, the following must apply with regard to troughs when installed in a single layer, if they are to be effective:-

The frame must not V 2 cover more than 5cm of the trough A X B Y C Z D

V 1

W

- For roadways up to 10 m^2, X+Y+Z must cover at least 35% of W.

- For roadways up to 15 m^2, X+Y+Z must cover at least 50% of W.
- For roadways in excess of 15 m^2 X+Y+Z must cover at least 65% of W.
- Distance of A or B or C or D must not exceed 1,2 m.
- The total distance of A+B+C+D etc must not exceed 1,5 m.
- Distance V1 must not be less than 0,8 m and must not exceed 2,6 m.
- Distance V2 should not exceed 1,2 m. Whenever this distance is exceeded, additional troughs must be placed above and they may be in excess of 2,6 m above floor level, but there should not be more than 1,2 m between the base of layers of troughs.

App IV No 6 of 12

Where more than one layer of troughs is required the following will apply:-

When troughs are arranged in rows less than 1,2 m apart, measured along the roadway, troughs in one row must not conceal troughs in the adjacent row from the blast effect of an explosion.

No trough must have any part sheltered from the effect of a blast wave by a rigid installation in the roadway.

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

Not greater than 1.2m

Not less than 0.1m Layers

Not greater than 1.2m

Not greater than 2.6m

Not less than 0.8m

Although concentrated water barriers can be considered as replacements for stone dust barriers in conveyor roads, single entries and return airways their siting is slightly different and their recommended location is as follows:-

(a) Conveyor belt roads

A barrier must be provided in every production section in the road carrying a conveyor belt. The barrier must not be sited closer than 120 m and not further than 360 m from the last through road.

App IV No 7 of 12

(b) Single entries

Every single entry must be protected with a barrier, sited as per (a) above.

(c) Return airways

Unless the incombustible matter content by mass of the dust is maintained at a minimum of 80% up to 1000 m from the face, a barrier must be provided in each road carrying return air. The barrier must be installed not closer than 120 m and not more than 360 m from the last through road.

3. BAGGED STONE DUST BARRIERS

Both the Polish design stone dust barriers and the water barriers are systems designed to be used in relatively slow moving longwall sections and their use in rapidly advancing bord-and-pillar workings could prove onerous.

Recently a bagged stone dust barrier was developed as a result of research undertaken at the GP Badenhorst facility and the Tremonia experimental mine operated by DMT in Germany. This barrier system has proven to be as effective in limiting explosions as some earlier barrier designs, but is easier to install and maintain.

Therefore it is preferred that these barriers be used.

A bagged stone dust barrier system consists of an array of clear plastic bags, containing stone dust, suspended in rows across the width of a coal mine road, installed in accordance with the following specifications.

The efficacy of a bagged stone dust barrier depends on several factors including;

- the physical characteristics of the plastic bags,
- the mass and quality of the stone dust in each bag,
- the method of suspending them below the roof of the roadway,
- the transverse spacing of bags in each row in relation to the cross-sectional dimensions of the road; and
- the longitudinal spacing of rows.

App IV No 8 of 12

Bagged stone dust barriers must comply with the following minimum requirements:-

a) Quantity of stone dust

Each plastic bag must contain either 5 kg for low seams or 6 kg for high seams of dry stone dust complying with the specifications contained in Appendix III.

b) Plastic bags

The quality, hook and ring as well as the rupture characteristics of the plastic bags used in bagged stone dust barriers must comply to the specifications of the products tested at the GP Badenhorst research facility. Documentary evidence as to the source and quality at each batch of bags purchased must be kept at the mine.

c) Closure of bags

Codes of Practice must detail how plastic bags containing stone dust are to be closed so as to exclude water when bags are installed in operational barriers underground.

d) Suspension of bags

Codes of Practice must clearly specify how plastic bags containing the requisite mass of stone dust are to be suspended below the roadway roof. The system must ensure that the vertical distance between suspended bags and the roof, and the horizontal distance between bags and between the outer bags and sidewalls, are to be maintained at all times.

The following requirements on the construction of a bagged stone dust barrier apply:-

The horizontal distance between the hooks of the bags on a plane must be not less than 0,4 m and not greater than 1,0m when measured across the roadway width.

The actual distances are determined by the total mass of stone dust that needs to be incorporated into a barrier, which is itself determined by the roadway dimensions. To cover a range of workings heights, the following requirements apply:-

  - For roads in the height range of less than 3,0 m, each row must have a single level of bags suspended below the roof.

- For roads in the height range 3,0 m to 3,5 m, each row must have a single level of bags suspended not more than 0,5 m below the roof.
- For roads in the height range 3,5 m to 4,5 m, each row must have two levels of bags suspended at approximately 3,0 m and 4,0 m above floor level.
- For roads in the height range of more than 4,5 m but less than 6,0 m, each row must have three levels of bags suspended at approximately 3,0 m, 4,0 m and 5,0 m above floor level.
- The distance between the bags and the side of the pillar must be $\leq$ 0,5 m.

Since no test data is available for roadways greater than 6 m in height any Code of Practice covering such a roadway should be developed in consultation with the Chief Inspector.

The distance measured along the roadway between rows of bags within the barrier must be not less than 1,5 m and not more than 3,0 m.

The total mass of stone dust to be used in a bagged stone dust barrier is based on either the cross-sectional area of the roadway in which the barrier is to be installed, or on the total excavated volume of the road between the extremities of the full barrier.

If M_A is the mass of stone dust based on cross-sectional area and M_V is the mass based on volume, then M_A must be at least 100 kg per square meter of cross-section area and M_V must be at least 1 kg of stone dust per cubic meter of roadway volume between the barrier extremities.

The total mass of stone dust to be used in a barrier must be based on the greater of M_A and M_V.

For example, in a roadway 6,6 m wide and 3,5 m high, the cross-sectional area is 23,1 square metres and M_A would be 23,1 x 100, i.e. 2 310 kg. If in the same roadway the distance between the extremities of the barrier is approximately 120 m, the total volume would be 23,1 x 120,0, i.e. 2 772 cubic metres, hence M_V would be 2 772 kg. Therefore the greater mass of 2 772 kg would be used.

The layout of the barrier is a critical element in its design and the following is required:-

A full bagged stone dust barrier must consist of four sub-barriers installed over a minimum distance of 100 metres of continuous roadway. Three complete sub-barriers must be in position at all times, while the fourth sub-barrier may be in the process of being moved ahead as the section advances.

The following distances must be maintained:-

- the first sub-barrier, closest to the last through road, must not be installed closer than 60m and not further than 120m from the last through road;
- the fourth sub-barrier, furthest from the last through road, must be installed not more than 120 metres from the first sub-barrier;
- the two intermediate sub-barriers must be equidistant between the first and fourth sub-barriers;
- the presence of splits must be ignored in determining distances;

- the maximum distance between sub-barriers must not exceed 30 metres.

Since the concept of bagged stone dust barriers is new, the design is best illustrated by an example, as follows.

Assume that a bagged stone dust barrier is to be installed in a belt road in a bord- and-pillar section. Assume also that the first row of the first sub-barrier will be located hundred metres from the last through road and the last row of the fourth sub-barrier at two hundred and twenty metres from the last through road. The belt road is 3,0 metres high and 6,5 metres wide.

The distance between the barrier extremities is 120 metres and the cross-sectional area is 19,5 square metres. The volume between the extremities of the full barrier is therefore 2 340 cubic metres. Thus, M_A = 1 950 kg and M_Q = 2 340 kg, of which the greater mass will be used.

If each bag contains 6 kg of stone dust, a total of 2 340/6 = 390 bags are needed. Based on four sub-barriers, there would be 390/4 = 98 bags per sub-barrier.

The roadway height of 3,0 m requires a single level of bags installed below the roof. The width is 6,5 m, so assuming the outer bags are 0,5 m from the sidewalls and that the bags are 0,46 metres apart, there will be 7 rows of 14 bags in each sub-barrier.

Assuming that rows in sub-barriers are 2,0 metres apart, each sub-barrier will extend over 12 m. Taking the last through raod as zero, the sub-barriers will be located as follows:

last through road 0 m

1 st sub-barrier start 100 m

finish 112 m

2nd sub-barrier start 136 m

finish 148 m

3rd sub-barrier start 172 m

finish 184 m

4th sub-barrier start 208 m

finish 220 m

Position of first sub-barrier must not be closer than 60 m and further than 120 m from the last through road.

APPENDIX V

THIS APPENDIX MUST BE INCORPORATED IN THE CODE OF PRACTICE

SEALING OF ABANDONED AREAS

During the normal course of underground coal mining, it becomes necessary to seal off abandoned areas to eliminate the need to ventilate them, to isolate fire zones, or areas susceptible to spontaneous combustion and flammable gas build up. The type of seal required can be assessed by a risk analysis of individual situations.

1. MINE PLANNING WITH REGARD TO SEALS

Each section of a mine must be planned so as to ensure that the entry roads into a secondary panel lead through adequately designed barrier pillars. The number of such roads must be kept to a minimum, consistent with the requirements of ventilation and the passage of machinery.

These roadways must be of minimum practical dimensions and must not be increased in size by top or bottom coaling. The length of the roadways through the barrier pillar must be such that it will allow for the effective installation of containment walls and explosion proof seals when necessary.

2. SEALING AND MONITORING STRATEGY WHEN STOPPING A WORKING PLACE PERMANENTLY

The following requirements must be incorporated in the strategy proposed in the Code of Practice:-

a) The Environmental Control Officer or appointed person must be informed of the intention to withdraw so that adequate ventilation conditions can be planned, and be maintained during reclamation activities up until the sealing work has been completed.

b) Until the seals are installed, tests for flammable gas and air flow must be conducted daily by a competent person and recorded in a book provided for the purpose.

c) Prior to final sealing, all boreholes and shafts must have all conductors removed and in the case of boreholes, the casings removed and the holes plugged or sealed by filling with concrete. Where it is not possible to fill the hole completely, a 2 m concrete plug must be installed in the solid in the upper portion of the hole. Records must be kept in a book provided by the Manager.

d) Ensure that the total area to be sealed is adequately stone dusted and certified to this effect by the Environmental Control Officer or appointed person.

e) Containment walls must be installed complete with sampling pipes positioned in the upper portion of the stopping. The ranges must extend to beyond the first intersection in the panels and suspended against the roof. The atmosphere behind and at the roof of the seal must be monitored according to a formal strategy until the manager is satisfied that he has enough information to decide on his next action.

3. CHOICE OF SEALS

The monitoring of the atmosphere behind the containment walls provides the manager with input to the risk assessment of the abandoned area. Two conditions are likely to exist.

i) The atmosphere in the sealed area has stabilised above or below the explosive range of flammable gas.

As an explosion cannot occur under these conditions, the containment walls now only require regular monitoring in order to verify the safe condition.

ii) The atmosphere in the sealed areas remains within the explosive range of flammable gas. Further action is then required, e.g.:-

- Re-ventilate and monitor.
- Improve the seal to prevent leakage.
- Inertise the atmosphere with a suitable inert gas.
- Install a stone dust barrier on the accessible side of the containment wall.
- Install approved explosion proof seal.

It is a question of judgement as to how long a period should be allowed for the atmosphere to stabilise behind the containment walls. The Code of Practice must contain a statement on the risk of working near an abandoned panel during the period when it passes through the explosive range. If any doubt exists regarding the final condition of the atmosphere behind containment walls the Principal Inspector must be informed and a thorough hazard potential analysis of the situation conducted.

4. TYPE OF SEALS

Containment walls must be designed to withstand a static pressure of approximately 140 kPa on the assumption that the area being sealed has been adequately stone dusted and cleared of all possible conductors of lightning and other electrical charges.

The seals must be situated at least 2 m back from the inbye corner of the pillars forming the panel entry and constructed of solid brick blocks. (Extensive tests conducted by the U.S. Bureau of Mines on 2 m high walls, have shown that the only solid concrete block type seal which maintained its integrity when subjected to an approximate 140 kPa pressure wave, was one that used 406 mm thick blocks with mortared joints, a centre pilaster of 813 mm thick, and the entire seal keyed into the floor and sides. When an equivalent wall was constructed using cementitious foam, the wall had to be at least 1,2m thick and the compressive strength of the material had to be not less than 1,4 Mpa.)

The wall must be well keyed or anchored into the roof, sides and floor. If keying-in presents a problem, an anchored retaining frame must be used to achieve adequate support. The wall must be constructed using a strong 3:1 mortar mix. A staggered block pilaster must be provided in the centre for additional strength. Walls wider than 7m and higher than 4m require a second pilaster.

Many mines already have large areas of sealed workings, where the quality of the seals and the true state of the atmosphere behind the seals may not be fully known. The recommendation is that these areas also constitute a potential hazard and all old areas previously sealed with walls of unknown integrity and design must be inspected if possible, and assessed for stability. Should a wall be found to be suspect, a new wall must be erected or the old wall buttressed and if need be, protected by the installation of barriers.

Where access to an old area is not possible for whatever reason and inspection of seals therefore not feasible, a new seal line must be established and quality seals constructed.

Irrespective of the type or quality of the seals installed, the inbye and outbye areas of the seals must be well stone dusted as a final precautionary measure.

Each containment wall constructed after the Code of Practice has been produced must comply with the above 140 kPa requirement.

The use of explosion proof seals is dictated by the hazard potential of the area in question and the situation. For example they should be used when a fire has been detected and there is a possibility of an explosion occurring after the sealing off of the fire area. Another situation where these walls may be needed, is when the atmosphere of a sealed off area stabilises within the explosive range or will take so long to pass through the explosive range that it will cause an unacceptable hazard.

5. OPENING UP OF OLD AREAS

Many explosions have occurred during the removal of seals. The opening up of old areas for whatever reason, must be viewed as a highly dangerous operation. After an evaluation of the atmospheric conditions and all relevant parameters, a formal system of re-opening must be set out and approved in advance by the manager.

APPENDIX VI

THIS APPENDIX MUST BE INCORPORATED IN THE CODE OF PRACTICE

TERMS AND DEFINITIONS

Although every effort should be made in drafting a Code of Practice to write clearly and concisely and to avoid the use of jargon, there are always a number of terms which require to be defined. In addition to the definitions contained in the Minerals Act and Regulations and the new Mine Health and Safety Act, the following definitions must apply in any Code of Practice For The Prevention Of Coal Dust Explosions:

"Accessible Workings" means all workings other than:

i) Goafed areas, the limits of which must be defined by the manager.

ii) Abandoned workings that have had all entrances effectively sealed by stoppings.

"Active Workings" means workings of any kind which are primarily in use for travel or work in Connection with the production operations of a mine.

"Approved" means approved by the Chief Inspector.

"Bituminous Coal" means coal in which the percentage by mass of volatile matter content calculated on a dry ash-free basis, exceeds 14%.

"Explosive Range" means that as determined by the United States Bureau of Mines explosibility diagram.

"Face Area" means an area within 180 m from the coal face being worked.

"Float Coal" means the coal dust consisting of particles of coal that can pass through a sieve having an aperture of 100 micrometres.

"Last Through Road" must constitute the closest holing to the working faces between two companions, which carry a unidirectional flow of air from the intake to the return of the section.

"Too Wet" means that when a coal dust sample of finely divided material is placed on a 2 mm aperture sieve for at least one minute, to permit the drainage of excess water, the resultant material when squeezed in the hand exudes water.

"Explosion proof seals" means a seal which is designed to withstand a static pressure of typically 0,4 Mpa and requires an approved design endorsed by a Professional Civil Engineer.

APPENDIX VII

THIS APPENDIX IS MERELY ATTACHED FOR INFORMATION FOR CONSIDERATION IN THE PREPARATION OF THE CODE OF PRACTICE

INERTISATION OF COAL DUST

1. INERTISATION OF COAL DUST BY THE USE OF WATER

One of the earliest defences against coal dust explosions was the use of water to wet the dust and prevent it becoming airborne. Water neutralises the explosion hazard of coal dust when present in sufficient quantity, and when intimately mixed. A mixture content of at least 30% is a fluid mixture with a consistency of slurry. To effectively neutralise the explosion hazard in an active heading, all coal dust must have been washed down or wetted to this consistency.

It must be stressed that dampness does not afford protection against an explosion as float coal does not adhere to water. A practical way of determining whether the dust has retained sufficient moisture, is to place a sample on a 2 mm aperture sieve for at least a minute to allow excess water to drain off. If the resultant sample is then gathered in a ball and, when squeezed in the hand, exudes water, it is sufficiently wet to prevent the propagation of an explosion.

If stone dust is applied to a wet surface, it affords nearly the same degree of protection, after having dried out, as stone dust applied to a dry surface.

In addition to the above, the following must be borne in mind when relying on water as an inerting material:-

a) Visual observation is a poor method for estimating the moisture content of coal dust. The general tendency is to overestimate the moisture content.

b) Pools of water do not necessarily provide protection against explosions as float coal tends to deposit on the water surface. This is due to the high surface tension of water.

c) Coal dust, although not wetted by water, adheres better to damp than dry surfaces. Coal dust deposited by the air current will remain dry even though the under-surface is wet. Deposits of coal dust on the sides and roof should be washed down, or removed by an alternative method, prior to initial stone dust application.

2. INERTISATION OF COAL DUST BY THE APPLICATION OF STONE DUST

For the past 75 years it has been known that the inerting of coal dust by the application of stone dust is the singular most important measure to guard against coal dust explosions. As a flammable gas explosion usually originates at the face, the standard of inertisation in the face area is normally the decisive factor as to whether the gas explosion remains localised, or develops into a coal dust explosion.

The quantity of dust generated, its transmission and deposition, the risk of an ignition source being present and the practical difficulties of stone dusting all vary in different areas of a coal mine. Eight such areas were identified:-

1) the areas extending to a working face from and including the last through road

2) intake airways within 180 m of a face

3) intake airways outbye of this face area

4) workshops, sub-stations, battery charging stations and other similar places

5) return airways within 1000 m of a working face

6) return airways more than 1000 m from a working face

7) return airways in close proximity to sealed areas

8) conveyor belt roadways

Minimum stone dusting requirements for each of the above areas, together with frequency of application, methods of sampling and compliance monitoring are contained in Appendix III of this Guidelines.

APPENDIX VIII

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APPENDIX IX

REPORT OF THE TASK GROUP

ON

COAL MINE EXPLOSIONS

This report is reproduced here as Appendix IX since it contains background information not found elsewhere in the Guideline.

1

1. INTRODUCTION

Following the Report of the Leon Commission into Safety and Health in the Mining Industry, the newly formed Mining Regulations Advisory Committee appointed a task group to advise on measures to be taken to minimize the risk of coal mine explosions. The terms of reference were;

* to consider the effectiveness of existing legislation, to recommend new legislation, amendments and additions to existing legislation

* to consider the existing standards, directives and guidelines

* to scrutinise a representative number of codes of practice and their application

* to consider appropriate SIMRAC issues

* to consider any other pertinent matter and to make recommendations to MRAC

* To consider how legislation is being complied with, monitored and enforced

The task group consisted of the following people:

M F du Plessis - DMEA (Chairman)

B A Doyle - DMEA

J Guthrie - Employers

N J J von Rönge - Employers

T C Muntingh - Employees

The group commenced its work on 10 July 1995.

2. HISTORICAL REVIEW

Records show that to date 1035 mine workers have died in 334 gas/dust explosions in South African Collieries.

Only in the case of Durnacol in 1926 (125 killed) did a coal dust explosion propagate through the entire mine. Analysis, however, of explosion records done recently by Flint, indicates that coal dust contributed to the severity of several other explosions. These explosions are indicated in Table 1.

Table 1

YEAR	COLLIERY	FATALS
1908	GLENCOE	77
1908	CAMBRIAN	0
1926	DURBAN NAVIGATION NO. 2	125
1935	MARSFIELD	78
1943	NORTHFIELD	78
1952	HLOBANE NO. 2	0
1952	HLOBANE NO. 2	1
1985	MIDDELBULT	34
	TOTAL	393

2.1 Explosion occurrences

Coal mine explosions vary from a flash at the face to an explosion involving the whole mine.

Table 2 shows the number of occurrences, injuries and deaths due to explosions in South African coal mines, during periods of 5 years, since 1950. (The last period covers the six years from 1990 to 1995.)

Table 2

PERIOD	EXPLOSIONS	INJ	KILLED	APPROX ROM UG PROD (MT p.a.)
1950-54	7	11	36	36
1955-59	4	14	23	40
1960-64	9	12	25	54
1965-69	18	9	7	58
1970-74	8	61	29	71
1975-79	13	28	1	79
1980-84	35	66	109	107
1985-89	16	28	70	121
1990-95	30	26	60	122
TOTALS	140	255	360	

The average annual explosion frequency during the period 1950 to 1979 was 2,0. This figure increased alarmingly to 5,4 during the period 1980 to 1995.

The increase in the occurrence of explosions must be considered against the background of the rapid rise in production, mainly due to the increasing use of mechanical miners.

Table 3 shows the number of continuous miners provided by the major supplier.

Table 3

YEAR	NO. OF UNITS	YEAR	NO. OF UNITS
1980	25	1988	124
1981	37	1989	134
1982	61	1990	145
1983	72	1991	145
1984	83	1992	149
1985	100	1993	151
1986	107	1994	171
1987	116	1995	186

2.2 Explosion severity

Even more disturbing than the increase in the frequency rate of explosions, is the rise in the severity of explosions. In the last 45 years there have been 17 explosions with 5 or more fatalities. Eight of these happened during the 14 year period 1980 to 1993. Two hundred and thirty nine workers died in explosions since 1980, while 121 fatalities occurred during the 30 years which preceded 1980.

Dr. G.v.R. Landman, in his dissertation "Ignition and Initiation of Coal Mine Explosions" interprets the increase in the fatalities as follows - "The risk in fatalities increased in recent years mainly due to two factors. Firstly, increased exposure as a consequence of improved productivity and secondly, the greater severity of explosions. Greater severity was brought about by the increased frequency of major explosions, rather than all explosions becoming more severe."

2.3 Location of ignitions/explosions

The location of explosions is categorised into three broad classes:

i) Explosions originating in the working face or close to it.

ii) Explosions in accessible areas which include non-face areas.

iii) Explosions originating in sealed-off or goafed areas.

Table 4 shows the location of the explosions during the period 1950 to 1995.

(The percentage explosions per area is shown. The numbers of explosions are shown in brackets.)

Table 4

AREA	1950-1959	1960-1969	1970-1979	1980-1989	1990-1995
FACE	64 (7)	57 (16)	62 (13)	75 (38)	86 (26)
NON-FACE	27 (3)	40 (11)	10 (2)	8 (4)	7 (2)
ABANDONED	9 (1)	0	28 (6)	14 (7)	7 (2)
UNCLASSIFIED	0	3 (1)	0	3 (2)	0
TOTAL	100 (11)	100 (28)	100 (21)	100 (51)	100 (30)

(Four incidents could not be categorised. The sub-category abandoned areas also includes, apart from sealed areas, all explosions that occurred in pillar extraction sections where the explosion was associated with the goaf).

4

2.4 Sources of ignition

Sources of ignition are divided into five categories.

Table 5 shows the percentage of explosion source of ignition during the period 1950 to 1995.

(The percentage explosions per source is shown. The numbers of explosions are shown in brackets.)

Table 5

SOURCE OF IGNITION	1950-1959	1960-1969	1970-1979	1980-1989	1990-1995
FRICTIONAL	0	4(1)	33(7)	61(31)	97(29)
LIGHTNING	0	7(2)	19(4)	6(3)	-
ELECTRICITY	27(3)	11(3)	14(3)	10(5)	-
EXPLOSIVES	46(5)	57(16)	29(6)	12(6)	3(1)
NAKED FLAME	27(3)	15(4)	5(1)	2(1)	-
UNCLASSIFIED	0	6(2)	0	9(5)	-
TOTAL	100(11)	100(28)	100(21)	100(51)	100(30)

Clearly, the main source of ignition during the last 25 years, by far, is frictional. A small number of these ignitions is associated with goafing whilst the majority originated at the face where mechanical miners were used. Three ignitions occurred at shearers in wall mining (no casualties), 1 occurred at a coal cutter (no casualties), with the remainder occurring at the cutting drums of continuous miners and, in a few instances, road headers.

(The friction ignition problem does not only exists in South African collieries. The USA, during the period 1980 to 1989, experienced 830 underground coal mine ignitions/explosions (mostly due to friction), resulting in 95 injuries and 75 fatalities. Although the American occurrence rate is appreciably higher than South African coal mines, the severity rate is substantially lower.)

3 CURRENT LEGISLATION

Evaluation of the South African legislation indicated the following:-

a) The degree of inertisation required by the regulations is insufficient to prevent the propagation of a coal dust explosion in the face area.

b) The frequency of the application of stone dust in the face area is insufficient to safeguard coal dust from participating in a gas explosion if sufficient methane is ignited in a poorly ventilated heading.

c) No means are prescribed to arrest a coal dust explosion which could arise if all other safety measures fails.

d) The current high rate of coal production renders the present required sampling interval of 30 days, to determine the efficacy of stone dust application, insufficient.

The inadequacies listed in paragraphs (a) to (d) pertain to coal dust explosions and these were reported to the MRAC during the initial progress report meeting. These shortcomings compromised the safety of persons and, consequently, the task group was instructed by the MRAC to draft a guideline for the prevention of coal dust explosions. This task has been completed and the guideline has been submitted to the MRAC.

The evaluation also revealed that the current regulations pertaining to explosion prevention are scattered throughout several chapters of the regulation book. Some issues recommended in the International Labour Office's manual, on the prevention of accidents due to explosions underground in coal mines, are also not catered for.

Records of investigations of past explosions do not indicate that explosions were caused by ineffective regulations. It is not envisaged that new regulations would prevent explosions from occurring. However, all regulatory requirements for the prevention of explosions should ideally be grouped together and regard should be given to the ILO's recommendations, where relevant.

It is thus recommended that when the regulations are revised, the regulations pertaining to the prevention of coal mine explosions be contained in a single chapter in the regulations book.

The existing South African regulatory requirements for explosion prevention were compared with those of other coal mining countries. The comparison has been summarised in a matrix form. A proposed index and the comparison are available as guides when new regulations are considered.

The task group is in full agreement with the recommendation contained in the report of the Leon commission that a task group should visit other coal mining countries to investigate their explosion prevention programmes.

4 EXPLOSION PREVENTION

With regard to an explosion, legislation and/or codes of practice should provide for; (1) its prevention at source (2) sufficient ventilation to dilute any explosible gas which may be liberated into the atmosphere (3) inertisation of coal dust to prevent coal dust from participating should an explosion of gas occur, and (4) means to stop a coal dust explosion within the shortest possible distance.

4.1 Sources of ignitions.

(a) Frictional ignitions

Frictional ignitions involve a metal cutting tool striking sandstone, or onto a pyritic material. Frictional ignitions occurring less frequently involve sandstone on sandstone, or sandstone on steel, abrasion during the fall of a sandstone roof, often associated with the goaf. Although in the majority of incidents the ignition is contained as a flash in the face where mechanical miners are in operation, thirteen fatalities and eighty workers injured have resulted from nineteen such ignitions since 1968. (The explosion which occurred at the Middelbult Colliery in May 1993, in which 53 people were killed, is still sub judice. Indications are, however, that the ignition was frictional.)

(i) Frictional ignitions by mechanical miners

As stated previously, frictional ignitions resulting from the use of mechanical miners are currently by far the most frequent source of ignition of methane explosions. The ignition process commences with the pick tip being heated by friction until the softening temperature of either the metal or rock, depending on which is the lowest, is reached. The molten material is then smeared by the forward motion of the pick and a thin filament is left on the rock. As the pick moves on, the hot spot is exposed and, if methane is present within the explosive range, an ignition may occur - depending on the area, temperature and lifetime of the hot spot.

Research into the frictional ignition hazard in the USA and UK have resulted in the following findings to decrease the frictional ignition hazard:-

° Application of water

An effective guard against frictional ignitions, is pick-path spraying. A solid-cone water spray impacting onto the surface of the freshly cut rock directly behind the pick, very significantly reduced the likelihood of frictional ignition. This proved true even with very worn pick tips, by promptly cooling the hot streak. The application of water in a spray form to reduce airborne respirable dust, has become a standard mining practice in South Africa. Laboratory tests, however, indicate that this method has negligible effect in reducing frictional ignition.

A continuous miner cutting drum where water is applied directly behind the pick is currently in the experimental stage in the USA. It is however unlikely that such system will be available in the South African market in the near future.

° Cutting drum speed

A decrease in the cutting speed leads to a decrease in the length of the hot smear and hence, a decrease in the ignition hazard. Currently continuous miners cut at a pick speed of approximately 3 m/s. Pick speeds should be in the region of 1,5 m/s to have a significant influence on the ignition hazard. (A speed below 1 m/s is unlikely to cause an ignition.). For existing continuous miners such large reduction in cutting speed is improbable as major drum and machine modifications would be required. A recent USA study concluded that the likelihood of ignition is not significantly decreased with a lower cutting speed in the range considered to be of practical interest.

° Pick design

Tungsten carbide can produce ignitions but the steel body of the pick produces ignitions far more easily. For this reason it is preferable that the tungsten is "oversize" (mushroom-shaped) to a