Resources Safety & Health Queensland

Recognised Standard 21

Underground Explosion Barriers

Coal Mining Safety and Health Act 1999

December 2021

Version: 2.0

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Recognised Standards

This document is issued in accordance with PART 5—RECOGNISED STANDARDS and Section 37(3) of the *Coal Mining Safety and Health Act 1999.*
PART 5 - RECOGNISED STANDARDS

71 Purpose of recognised standards

A standard may be made for safety and health (a “recognised standard”) stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations.

72 Recognised standards

(1) The Minister may make recognised standards.
(2) The Minister must notify the making of a recognised standard by gazette notice.
(3) The CEO must publish on a Queensland government website each recognised standard and any document applied, adopted or incorporated by the standard.
(4) In this section -

Queensland government website means a website with a URL that contains ‘qld.gov.au’, other than the website of a local government.

73 Use of recognised standards in proceedings

A recognised standard is admissible in evidence in a proceeding if—
(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and
(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and
(c) the recognised standard is about achieving an acceptable level of risk.

PART 3- SAFETY AND HEALTH OBLIGATION

37. How obligation can be discharged if regulation or recognised standard made

37(3) …if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person’s safety and health obligation in relation to the risk only by—
(a) adopting and following a stated way; or
(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.”

Where a part of a recognised standard or other normative document referred to therein conflicts with the *Coal Mining Safety and Health Act 1999* or the *Coal Mining Safety and Health Regulation 2017*, the Act or Regulation takes precedence.

This recognised standard is issued under the authority of the Minister for Resources.
[Notified 17 December 2021]

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1 Purpose

The purpose of this standard is to provide a technical standard for selection, installation, maintenance and use of explosion barriers in underground coal mine roadways, to assist in reducing the risk of propagation of an explosion to an acceptable level.

This Recognised Standard does not reduce obligations to comply with stone dusting requirements as per Sections 300, 301,302 & 303 of the CMSHR 2017.

2 Scope

This Recognised Standard applies to an explosion barrier constructed, installed and maintained in underground coal mines in the State of Queensland.

Any active or passive barrier may be used that achieves a level of risk that is equal to or better than the level of risk achieved by the barriers mentioned within this Recognised Standard.

A physical test, or a combination of a physical and a laboratory test must be carried out by an independent recognised testing facility to prove the barrier can effectively suppress a coal dust explosion.

3 Application framework

A coal dust explosion is propagated by a failure to manage incombustible matter to a level that prevents this hazard eventuating. This presents a significant hazard in an underground coal mine, and has the potential to propagate to every part of a mine resulting in multiple fatalities.

Coal dust in suspension has flammable limits from approximately 35 g/m^3 to 1000 g/m^3. There are various environmental factors that will influence these flammable limits.

Coal dust explosions are usually a secondary explosion initiated by a methane explosion. The primary explosion creates shock waves that disperse coal dust into the air and the flame ignites the coal dust. These coal dust explosions are often self-propagating and extremely violent, affecting large sections of the mine.

Additional defences are needed to prevent the propagation of the primary ignition into a coal dust explosion. Explosion barriers are a last defence after an initial explosion has occurred.

Explosion barriers rely on the pressure wave or other means to trigger dispersal of the inhibitor (stone dust, inert material, water, etc.), to become airborne before the flame of the explosion arrives. This Recognised Standard states methodologies of achieving an acceptable level of risk.

4 Effective management and control of coal dust explosions

In developing the part of the safety and health management system for the management of explosion barriers, the site senior executive for the mine must -

- ensure the mine’s safety and health management system provides for the installation and management of explosion barriers.
- have regard to any criteria stated in a recognised standard for managing explosion barriers.
- apply the risk management process described in section 10 of the Coal Mining Safety & Health Regulation 2017 to develop the explosion barrier management plan.
- develop and implement a system to periodically inspect explosion barriers to be included in the part of the SHMS required by section 309 of the Regulation.

The UMM shall ensure that there is a person with the appropriate skills and competencies assigned the responsibility of developing and implementing explosion barrier management plans.

The management plan must include the following as a minimum:

- An explosion barrier, or part of an explosion barrier, installed within the ERZ where coal is being mined, must be inspected in line with section 309 and at least once per shift. Any part of an explosion barrier outside the ERZ where coal is being mined must be inspected in line with section 309.
- Confirmation that the installation of new barriers has been completed in accordance with the design criteria of the barrier.
- An up to date plan of the location of all of the explosion barriers shall be displayed at the surface of the mine where coal mine workers assemble before going underground.
- Details of the installation requirements should be displayed at the location where the explosion barriers are installed. For passive barriers the information board must include:
    - Cross-section of the road;
    - Total loading of the barrier;
    - Number and loading of rows;
    - The date of installation of the barrier.
    - Distance from the last completed line of cut throughs or longwall coal face.

5 Technical guidance

Explosion barriers shall be installed and maintained in locations as specified in section 303A Explosion Barriers of the Queensland Coal Mining Safety and Health Regulation 2017.

303A Explosion barriers

(1) The underground mine manager for an underground mine must ensure—

(a) explosion barriers are installed and maintained in the part of each of the following roadways within an ERZ1 in a part of the mine where coal is being extracted—

(i) a return roadway;

(ii) a single entry drive;

(iii) a roadway in which a coal conveyor is installed; or

(b) explosion barriers that are active barriers, devices or systems are installed and maintained on plant within an ERZ1 in a part of the mine where coal is being extracted in a way that would prevent the propagation of a coal dust explosion to a place mentioned in paragraph (a).

(2) The underground mine manager must also ensure explosion barriers are installed and maintained in a place in the mine, other than a place at which an explosion barrier is installed and maintained in compliance with subsection (1), identified by a risk assessment for the mine.

Examples of places for subsection (2)—

homotropal conveyor roadways and return bleeder roadways not within an ERZ1 in a part of the mine where coal is being extracted

(3) In this section—

explosion barrier means—

(a) a barrier, device or system constructed, installed and maintained in compliance with a recognised standard for barriers, devices or systems known as explosion barriers; or

(b) another barrier, device or system that achieves a level of risk that is equal to or better than the acceptable level of risk achieved by a barrier, device or system mentioned in paragraph (a).

6 Explosion barriers – Examples

Stone dust barrier	A device or system using stone dust erected at relevant locations in mine roadways for the purpose of arresting a propagating coal dust explosion.
Water barrier	A device or system using water erected at relevant locations in mine roadways for the purpose of arresting a propagating coal dust explosion.
Passive concentrated barrier	Either a stone dust or water barrier in which a series of loaded shelves are spaced at intervals of up to 3 metres.
Passive distributed barrier	Either a stone dust or water barrier in which a series of loaded shelves are more widely spaced than in a concentrated barrier, and further described within this document.
Active barrier	Is a transducer triggered device or system used to contain and suppress an explosion (methane and/or coal dust explosions) and a fire (e.g. conveyor fire). Typically such a device consists of a configuration of sensors, controller(s) and canisters filled with inert suppression material. The inert suppression material is able to disperse and create a gapless barrier to contain and suppress any propagating explosion flame. An active explosion barrier disperses the inert suppression material in the opposite direction to the movement of the explosion, thereby having the highest mitigation effect. An active explosion barrier is designed in such a way as to be functional in the least possible distance from any assumed ignition source.

7 Barrier design parameters

7.1 General

This section details the design parameters required for the different types of barriers described in this standard. The standard deals with both passive and active barriers.

7.2 Passive explosion barriers

7.2.1 Stone Dust (bagged barriers)

There are several design parameters that apply to all types of stone dust barriers (see Figure 1 and Figure 2) covered by this document. These define limits for the mass of stone dust required, distance between individual bags, for separation from the ribs (sides) of the roadway and the requirements for bags to be distributed in layers in high workings. These parameters are given below:

1. The number of bags in the barriers in the worked examples provided later in this document are based on the 6 kg per bag.

2. Unless specifically stated otherwise all distances (either between individual stone dust bags or between rows of bags) are measured from hook to hook.
3. The horizontal distance between the hooks of the bags in a row, must be not less than 0.4 m and not greater than 1.0 m, when measured across the roadway width (see Figure 5).
4. The distance between the bags and the side of the roadway must not be greater than 0.5 m (see Figure 5).
5. For nominal roadway height up to 3.5 m, each row must have a single level of bags suspended with the hooks not more than 0.5 m from the roof (see Figure 4).
6. For nominal roadway heights between 3.5 m and 4.5 m high, the bags must be distributed evenly amongst two layers, suspended with the hooks at not more than 0.5 m and 1.0 m below the roof level (see Figure 3).
7. For nominal roadway heights between 4.5 m and 6.0 m high, the bags must be distributed evenly in three layers suspended with the hooks at not more than 0.5 m, 1.0 m and 1.5 m below the roof level.
8. The distance measured along the roadway between rows of bags must be not less than 1.5 m and not more than 3.0 m (see Figure 5).
9. The minimum total mass of stone dust used in the barrier is based upon the values of either 200 kg/m^2 of roadway cross-sectional area, or 1 kg/m^3 of roadway volume between the extremities of the barrier, whichever amount is greater. It should be noted that for any barrier longer than 220 m, the stone dust mass will be calculated on the basis of roadway volume i.e. 1 kg/m^3.
10. Bags should be suspended from a rigid structure or device, e.g. steel roof mesh. If a 2nd or 3rd layer of bags are needed, due to the road height, then the lower layers of bags should be fixed onto a rigid device or structure. A loose or un-tensioned chain or cable across the roadway is inadequate.
11. Bags should be suspended so the hook and bag are unobstructed and able to move freely. The bags must be able to swing freely inbye and outbye (see Figure 1). The bags must be hung with the largest cross-sectional area of the bag facing the potential blast wave.
12. Where any type of bagged barrier is used to provide explosion protection in a conveyor roadway, additional bags (to those required for the standard barrier) should be suspended from the conveyor structure to provide additional protection against the passage of a flame under the belt (see Figure 4). At a minimum there must be one additional bag per row hung from the conveyor structure in the barrier.

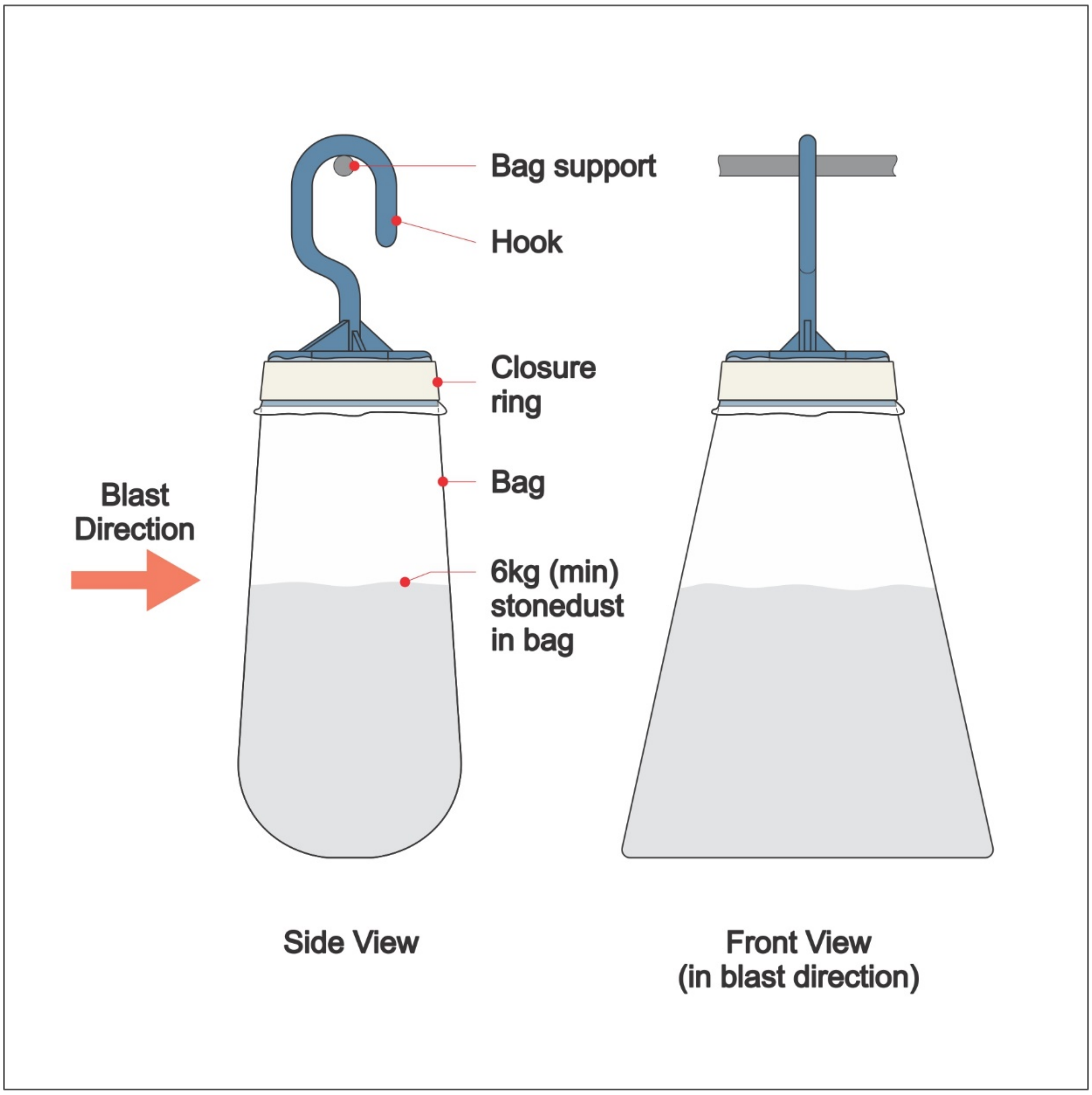

Figure 1 Bags suspended facing the direction of any blast waves

Figure 2 Typical barrier bag

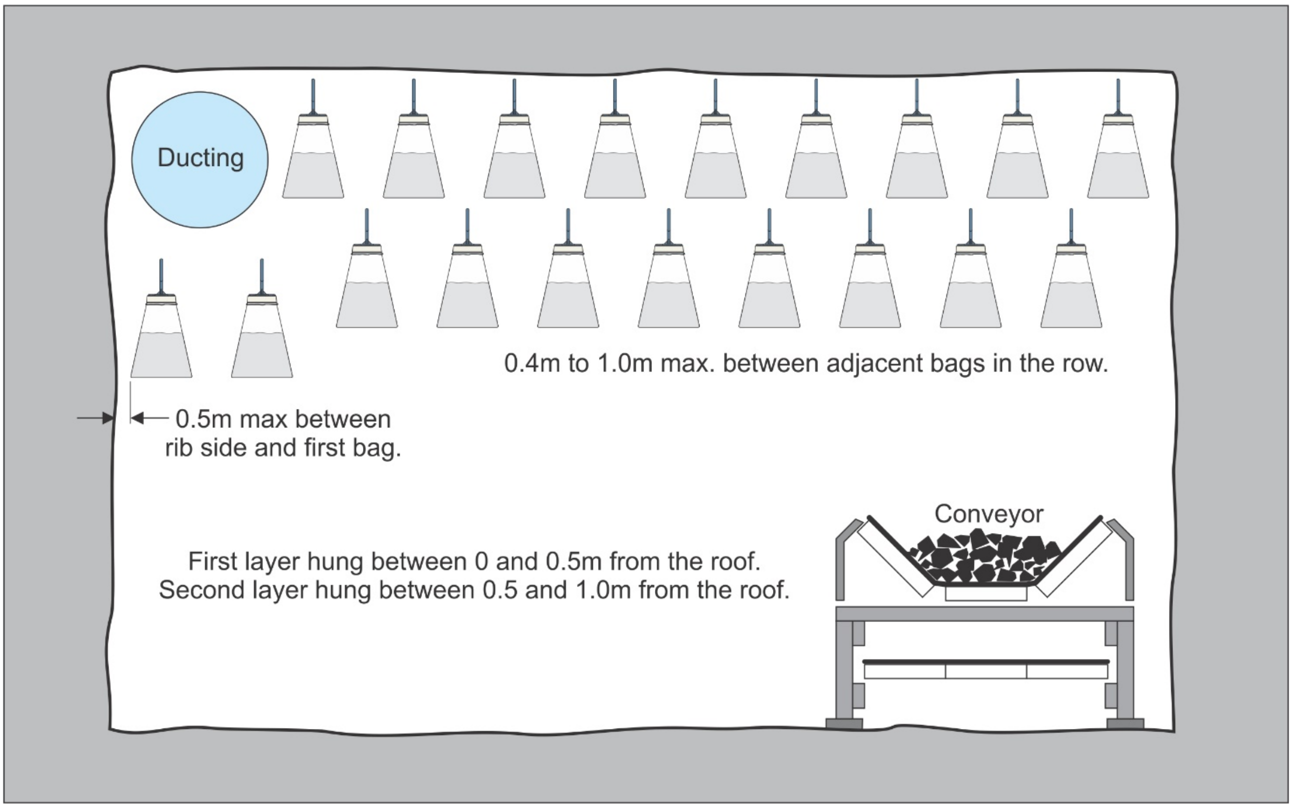

Figure 3 Typical bag placement in a roadway between 3.5 and 4.5 m high

13. Notwithstanding points 7, 8 and 9, where the bagged barrier is used to provide explosion protection in a roadway and a ventilation system (ducting, fans, regulators 'T' pieces etc.) is suspended from the roof, the bags that would have been suspended from the roof where the ventilation system is suspended should be suspended below the system at the specified intervals (Figure 4).

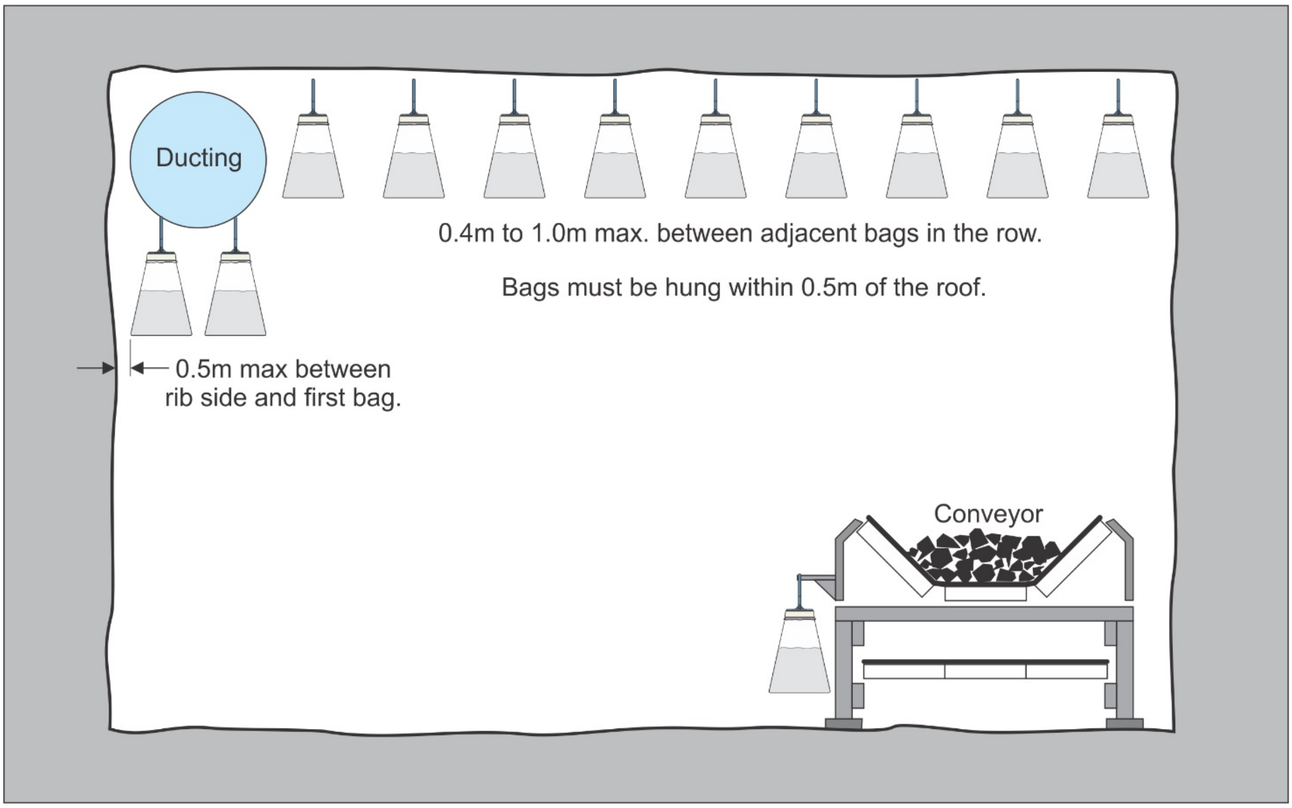

Figure 4 Typical bag placement suspended around a roadway obstruction

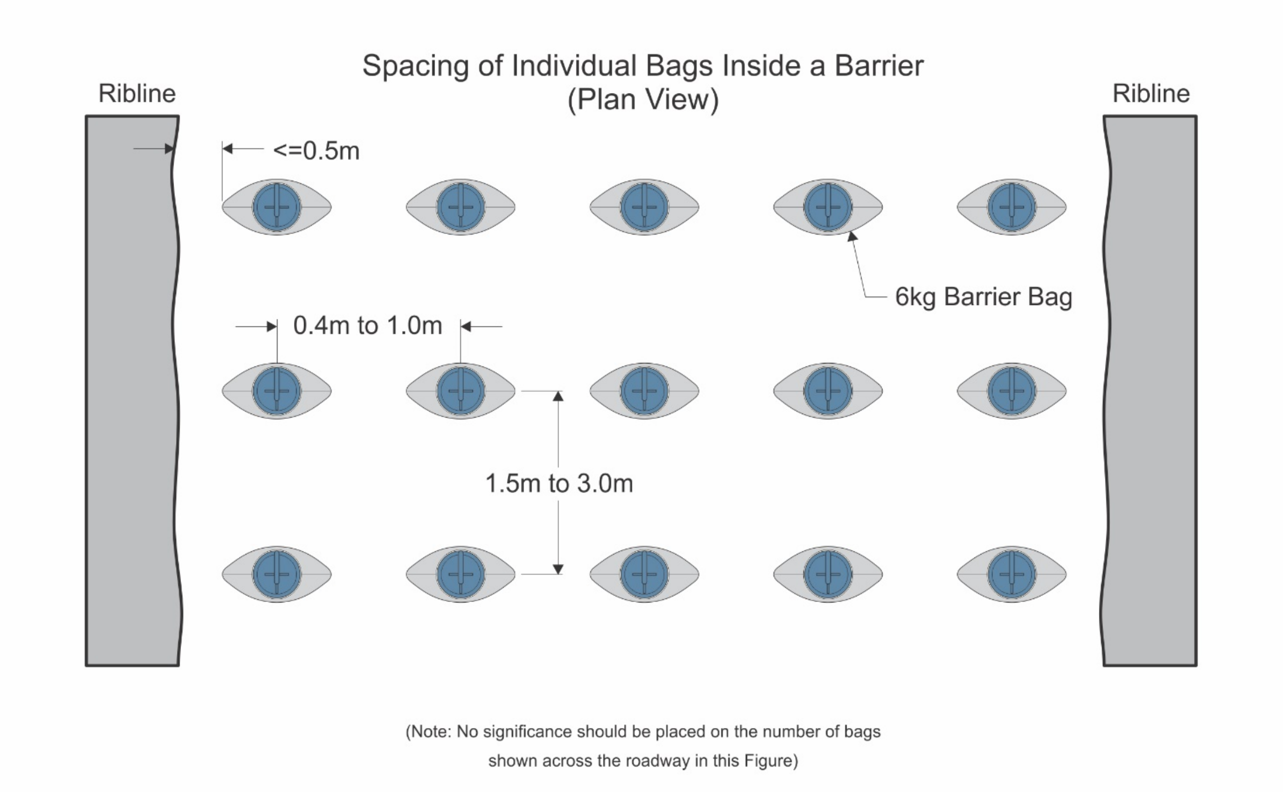

Figure 5 Spacing of Individual Bags

7.2.2 General types of stone dust bagged barriers

The bagged barrier system can be configured in several different ways depending upon the application, the requirements of the mine and how they wish to apply the Recognised Standard. Listed below are three alternatives that can be applied:-

1. An advancing distributed barrier,
2. A concentrated barrier, or
3. A fixed distributed barrier.

All barriers must comply with the typical barrier design parameters in Section 7. Relevant information on three types of stone dust bagged barriers is given in Section 7.2.3, Section 7.2.4 and Section 7.2.5.

7.2.3 Advancing distributed barrier

An advancing (or retreating) distributed barrier consists of four sub-barriers, installed over a maximum distance of 120 m of continuous roadway. Four complete sub-barriers must remain in position at all times. The original concept was that the fourth barrier would be moved only during non-production shifts when the probability of ignition is greatly reduced. If this is not the case, a fifth sub-barrier should be added, to have confidence that the barrier meets the required dust loading all times.

The following distances must be maintained:

(a) the first row of the first sub-barrier, must not be installed closer than 60 m and not further than 120 m from the last completed line of cut-throughs, or coal face of a producing longwall panel;

(b) the last row of the fourth sub-barrier, furthest from the last completed line of cut-throughs or face line, must be installed not more than 120 m from the first row of first sub-barrier;

(c) The two intermediate sub-barriers must be equidistant between the first and fourth sub-barriers;

(d) The presence of cut-throughs other than the last completed cut-through is not a consideration in determining distances;

(e) The maximum distance between the end of one sub-barrier and the start of the next sub-barrier must not exceed 30 m.

These dimensions are illustrated in Figure 6.

Example 1

A worked example of the required calculations will illustrate the design of an advancing distributed barrier.

This example describes a bagged stone dust barrier that is to be installed in a bord-and-pillar section. The first row of the first sub-barrier will be located between 60 and 120 metres from the last completed line of cut-throughs and the last row of the fourth sub-barrier will be at 120 m from the start of the first sub-barrier. The belt road is 3.0 m high and 6.5 m wide. Thus the cross sectional area of the roadway is 19.5 m^2.

$$3.0 \text{ m} \times 6.5 \text{ m} = 19.5 \text{ m}^2$$

The distance between the barrier extremities is 120 m and the cross-sectional area is 19.5 m^2. The volume between the extremities of the full barrier is therefore 2340 m^3.

$$120 \text{ m} \times 19.5 \text{ m}^2 = 2340 \text{ m}^3$$

Based on cross sectional area requirements of 200 kg/m^2 and roadway volume requirements of 1 kg/m^3, the barrier will require either 3900 kg or 2340 kg of stone dust, whichever is the greater, in this case being 3900 kg.

Each bag contains 6 kg of stone dust, a total of 3900 kg / 6 kg = 650 bags are needed. With four sub-barriers, there would be 650/4 = 163 bags per sub-barrier.

Each sub barrier needs 163 bags which is best arranged as 14 rows of 12 bags, (using a distance of 0.5 m between bags).

14 x 12 = 168 (individual stone dust bags)

If only 10 or 11 bags can easily be hung across the road, then additional rows will be needed, possibly with additional bags in some rows to make up to 163 bags in the sub-barrier.

Assuming the 14 row x 12 bag arrangement, and if rows in sub-barriers are 2.0 m apart, then each sub-barrier will extend over 26 m.

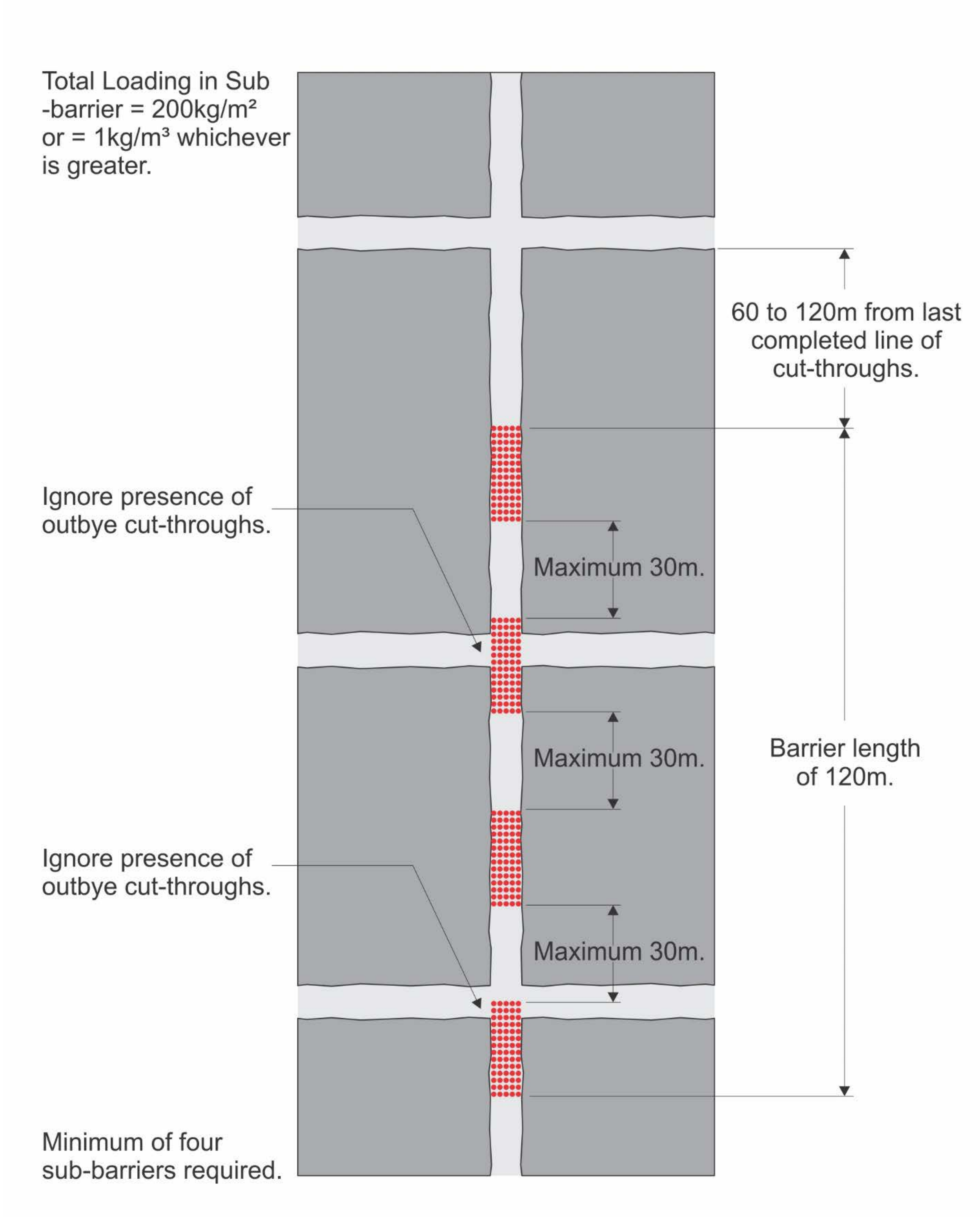

Figure 6 Distributed Barrier System

7.2.4 Concentrated barrier

An alternative to the advancing distributed barrier is the advancing or fixed concentrated barrier. Instead of the stone dust being distributed among four or five sub-barriers spread over about 120 m of roadway, the stone dust is placed in one concentrated barrier. To facilitate panel advance/retreat, a second concentrated barrier is also installed and used to leap-frog (or remain in place) the first barrier to maintain the correct distance from the last completed line of cut-throughs. Each of the individual barriers is designed on the basis of 200 kg/m^2 and therefore holds sufficient stone dust to act as a discrete explosion barrier. A minimum of two barriers are installed to allow removal of one for advancing or retracting as the face moves, without compromising the barrier stone dust loading.

The distance between the last completed line of cut-throughs or longwall face and the first row of bags must be greater than 60 m but less than 120 m at all times, both advancing and retreating.

The next barrier in the sequence must start no further than 120 m from the inbye end of the first barrier, so the exact distance between them will be dependent on the barrier length chosen.

The stone dust requirement in each barrier is calculated on the basis of 200 kg/m2 of roadway cross-sectional roadway area.

The dimensions for an advancing concentrated barrier are illustrated in Figure 7.

Example 2

An example of the calculations undertaken to design an advancing concentrated barrier follows.

Consider a roadway in which the barrier is to be installed and which has a height of 3.0 m and width of 5.2 m. The area of the roadway is 15.6 m^2 and the amount of stone dust required in each barrier is 3120 kg (15.6 x 200). With 6 kg of stone dust in each bag, each barrier will consist of 520 bags. Allowing 0.5 m between the ribs and the nearest bags and 0.4 m between adjacent bags, it is possible to install 11 bags in each row. Therefore, the final barrier consists of 48 rows and each row holding 11 bags (48 x 11 = 528 bags). Allowing a spacing of 1.5 m between rows each barrier will be 72.0 m long.

Two barriers are installed to allow removal of one barrier for advancing or retracting as the face moves without compromising the barrier dust loading. The design details of the second barrier will be the same as the first barrier. At least one of these barriers, each consisting of 528 bags in this example, must always be in place.

In the above examples, a distributed barrier (Example 1) would total 650 bags and a concentrated barrier (Example 2) would total 520 bags.

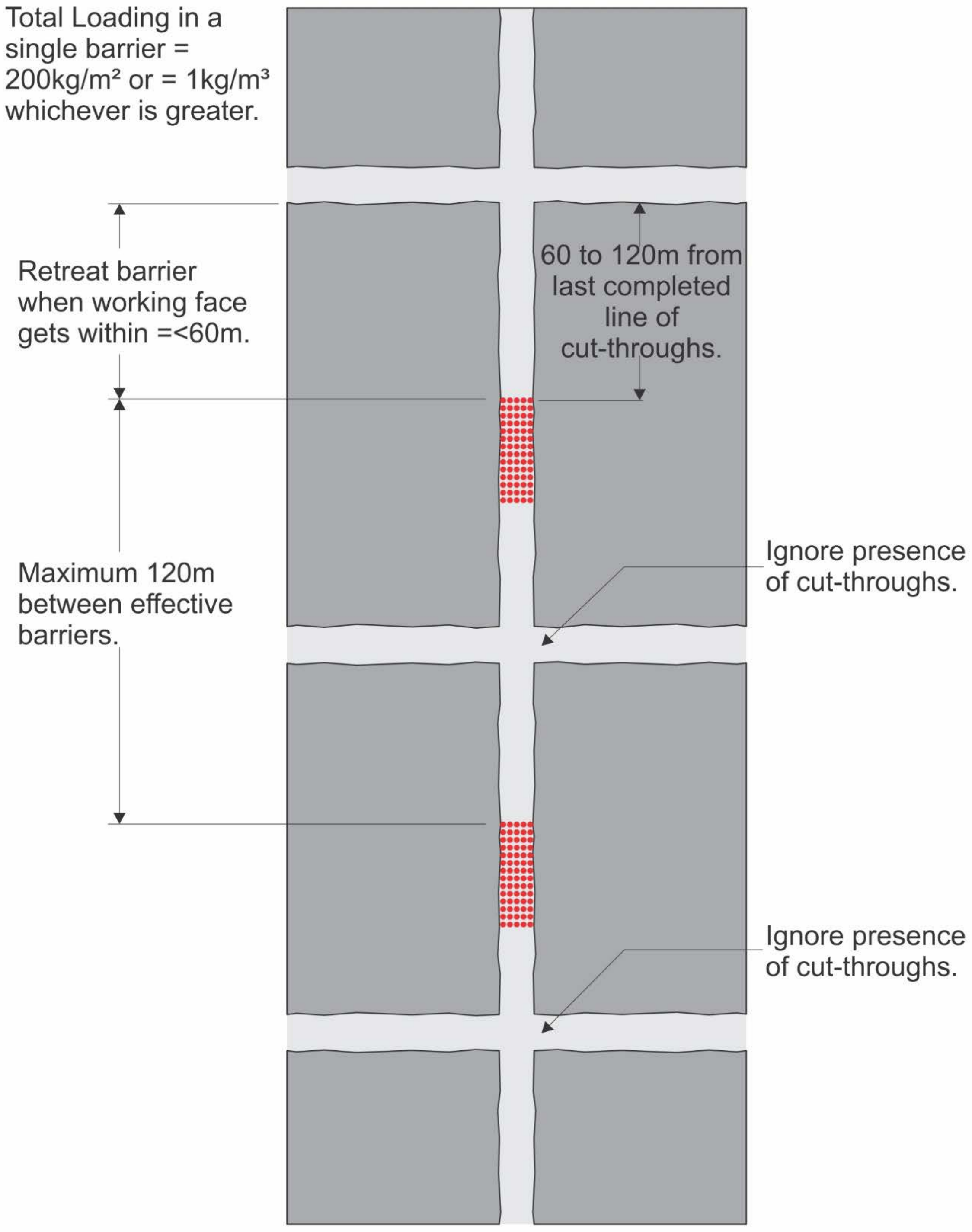

Figure 7 Concentrated Barrier System

7.2.5 Fixed distributed barrier

For mining situations in which there is rapid advance or retreat, and/or where mining sequence, and/or pillar sizes make either of the previous choices difficult, then a fixed distributed barrier can be used. This variation is typically applied in longwall extraction panels, to avoid safety risks and production delays associated with relocating sub-barriers used in either of the advancing barrier systems described above.

The fixed distributed barrier places a continuous array of stone dust bags in a roadway, potentially over its whole length. These would usually be installed during development and left in place for the retreat phase of mining. By leaving the bags in place, there is no requirement to advance or retreat barriers as described above, while providing a very high degree of explosion protection for that roadway.

The distance between the start of the fixed distributed barrier and the last completed line of cut-throughs or longwall face must not exceed 120 m. To be effective, the barrier must run for a minimum distance of 220 m.

It is not always possible to maintain the barrier length for 220 m as a longwall panel sets off or as a longwall face line approaches its end. For such cases, the mine can increase the density and convert the outbye end part of the barrier to the specifications given for an advancing concentrated barrier. Some part of this barrier may also have to project beyond the gateroad being protected, into the mains development roads, in which case the barrier may have to split and extend into a number of roadways to ensure the proper overall length.

The design of the fixed distributed barrier requires a stone dust loading based on a minimum stone dust density of 1 kg/m^3 in the mine roadway (see Figure 8).

Example 3

An example of the design calculations will illustrate the requirements for a fixed distributed barrier.

Consider a longwall gateroad that is 3.4 m high and 5.2 m wide. At a roadway height of 3.4 m, each row of bags requires only one layer with suspension hooks within 0.5 m of the roof. The roadway area is 17.7 m^2 and the stone dust requirements will be 17.7 kg/m of roadway length. At 6 kg/bag this requires 2.95 bags/m. If the row separation is 2.5 m each row will require 2.5 x 2.95 = 7.4 bags/row, which will be rounded up to 8 bags per row.

These can be installed immediately outbye of the face at a convenient position, but the first row location should not be more than 120 m outbye of the last completed line of cut-throughs or face line.

The total number of bags required are 220 m x 2.95 bags/m = 550 bags.

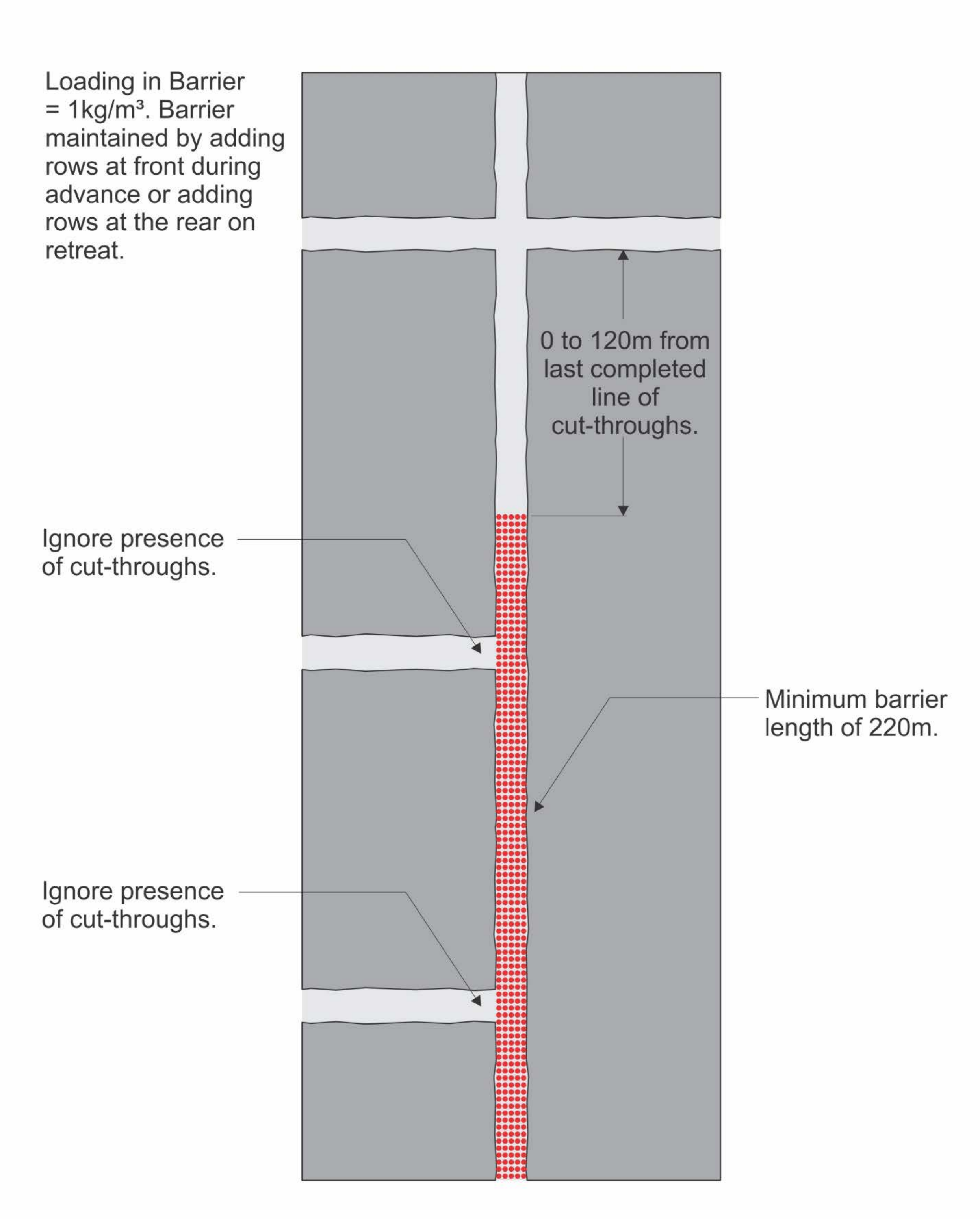

Figure 8 Fixed Distributed Barrier System

7.3 Active Barriers

7.3.1 General

Active barriers are triggered devices or systems used to contain and suppress the propagation of an explosion (methane and/or coal dust explosions). Typically, such a device consists of a configuration of sensors, controller(s) and canisters filled with inert suppression material. An active explosion barrier is designed in such a way as to be functional in the least possible distance from any assumed ignition source. Figure 9, shows an example of a typical active barrier mounted on a continuous miner.

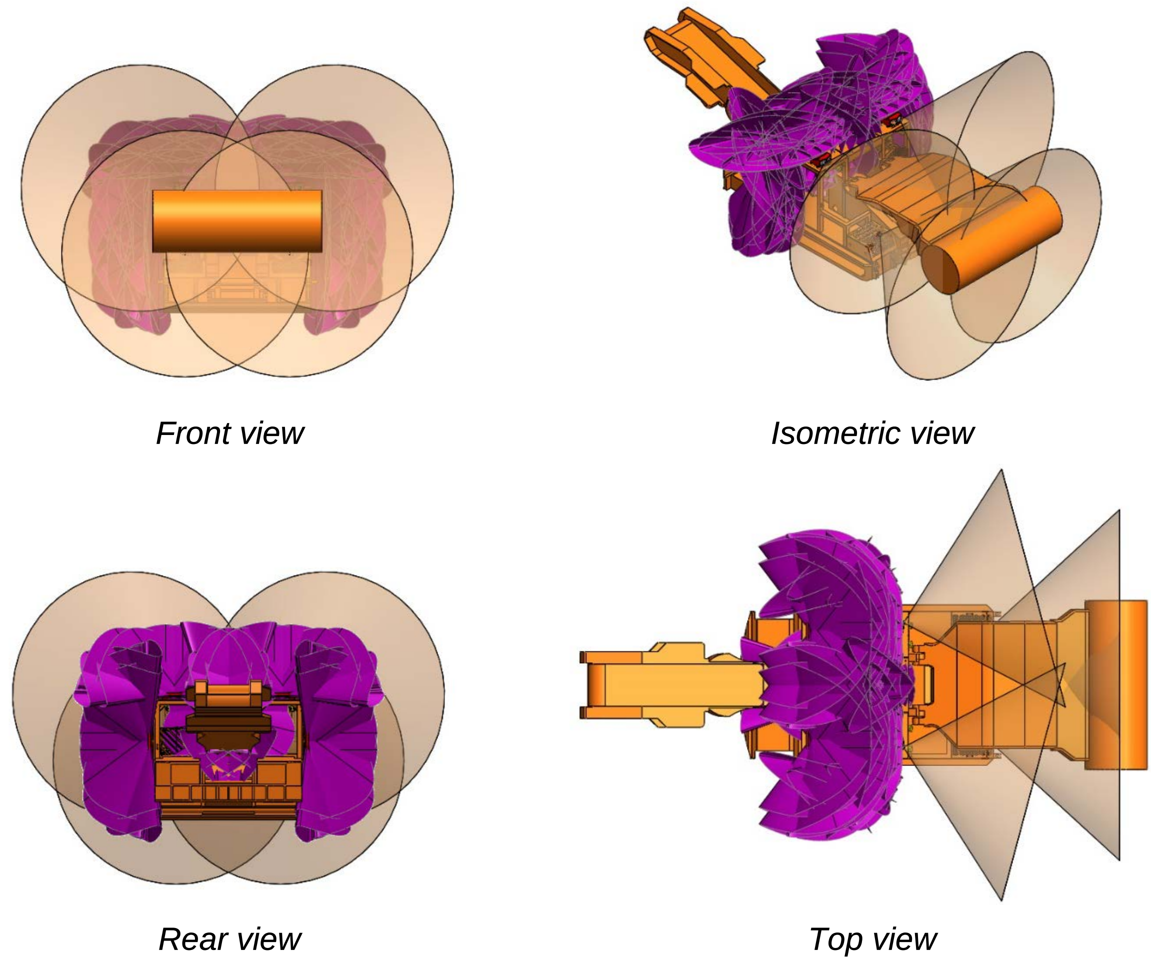

Figure 9 Active barrier – relevant plant

Figure 10 Homotropal maingate belt road active barrier installation example

7.3.2 Installation

The design and installation requirements that apply to active barriers are:

1. Return roadways. Active barriers that are placed in return roadways must be placed in the following locations:
    (a) Longwall return airways: within 150 metres outbye of the intersection with the longwall face
    (b) Development return airways: within 150 metres outbye of the last open cut through
2. Single entry drives within 150 metres outbye of the production face
3. Conveyor roadways within 150 metres outbye of the last open cut through or longwall face
4. Machine mounted active barriers must be designed and installed on plant in a way that would prevent ignition propagation to a place, as required by section 303A(1)(b) CMSHR 2017.

    Examples of plant include:
    (a) A continuous miner (including mounted roof and rib bolting equipment)
    (b) A road header (including mounted roof and rib bolting equipment)
    (c) Longwall shearer and face equipment e.g. AFC, shields

8 Validation and testing

The SSE must ensure that:

1. The explosion barrier system installed must be a proven system and method to suppress a coal dust explosion with evidence of testing conducted by an independent recognised testing facility. The design of an explosion barrier system must be based on peer-reviewed research and have been tested at a large scale explosion testing facility, such as those previously used in Germany, Poland, South Africa, UK, USA. Manufacturers are expected to provide documentary evidence they have either conducted such tests or that their system meets the original design of a system tested at one of these facilities.

2. The manufacturers of the explosion barrier system must maintain quality assurance and quality control for all systems installed at a mine. Documentary evidence as to the source and verification of the quality assurance and quality control (including test data) must be kept by the mine. Specifically, s44 of the Coal Mining Safety and Health Act 1999 apply to all designers, manufacturers, importers and suppliers of equipment for use at a coal mine. These include obligations to notify the Chief Inspector of Coal Mines (CIOCM) and any coal mine operator to which equipment has been supplied that has any hazards or defects associated with the equipment.

9 References

The following documents have been used as reference material for the development of this Recognised Standard:

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Späth, A. and Belle, B. (2021) Active roadway explosion barrier evolution in coal mining, in Naj Aziz and Bob Kininmonth (eds.), Proceedings of the *2021 Resource Operators Conference, Mining Engineering*, University of Wollongong, 18-20 February 2021 https://ro.uow.edu.au/coal/803.

Queensland Coal Mining Safety & Health Act 1999

Queensland Coal Mining Safety & Health Regulation 2017

10 Acronyms

AFC	Armoured Face Conveyor
CMSHR	Queensland Coal Mining Safety & Health Regulation 2017
CIOCM	Chief Inspector of Coal Mines
ERZ	Explosion Risk Zone
HSE	Health and Safety Executive (United Kingdom)
OEM	Original Equipment Manufacturer
PHMP	Principal Hazard Management Plan
SHMS	Safety and Health Management System
SOP	Standard Operating Procedure
SSE	Site Senior Executive
UMM	Underground Mine Manager