



# Recognised Standard 21

Underground Explosion Barriers

*Coal Mining Safety and Health Act 1999*

October 2020

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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 Natural Resources, Mines and Energy.**

*[Gazetted 6 October 2020]*

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## 1. Purpose

The purpose of this standard is to provide a technical standard for selection, installation, maintenance and use of stone dust barriers or other 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. This testing must be verifiable.

## 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 50g/m<sup>3</sup> to 1000g/m<sup>3</sup>. 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 the methodology of achieving an acceptable level of risk.

## 4. Effective management and control of coal dust explosions

In relation to the management and control of explosion barriers the SSE must:

- Ensure the mine's safety and health management system provides for the installation and management of explosion barriers.
- Incorporate the applicable underground explosion barrier system requirements of this Recognised Standard into the permit to mine system.
- Develop and implement a system to periodically inspect explosion barriers in accordance with s309 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 elements that need to be addressed in the documented process for managing explosion barriers shall be in line with the current stone dusting requirements of the operation as per CMSHR 2017 S300 (3) and consider the following:

- Ensure an explosion barrier, or part of an explosion barrier installed within the inspection district where coal is being mined, must be inspected at least once per shift.
- Ensure all explosion barriers are inspected in line with the stone dust inspection requirements.
- Arrange for the repair of any damage to or defect in the barrier.
- Supervise the erection of new barriers as required.
- Reporting weekly and monthly on the inspections carried out, and on any action taken or required. Such reports shall be countersigned by the UMM or his representative.
- In addition, a plan of the location of all of the explosion barriers shall be displayed in one or more conspicuous locations at the mine in a way likely to come to the attention of coal mine workers at the mine including:
  - Cross-section of the road;
  - Total dust loading of the barrier;
  - Number and loading of rows;
  - Displaying the date of last installation of the barrier.

## 5. Technical guidance

Barriers shall be placed in roadways as specified in section 303A Explosion Barriers of the Queensland Coal Mining Safety and Health Regulation 2017.

For clarity a roadway with a single point of entry mentioned in 303A(1)(a)(ii) is a single entry roadway referred to in Schedule 9 of the Queensland Coal Mining Safety and Health Regulation 2017 (Dictionary).

### 303A Explosion barriers

(1) The underground mine manager for an underground mine must ensure explosion barriers are installed and maintained—

(a) 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 roadway with a single point of entry;
- (iii) a roadway in which a coal conveyor is installed; and

(b) in a place in the mine, other than a place mentioned in paragraph (a), identified by a risk assessment for the mine.

*Examples of places for paragraph (b) —  
homotropical conveyor roadways and return  
bleeder roadways not within an ERZ1 in a  
part of the mine where coal is being extracted*

(2) In this section—

**explosion barrier** means—

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

(b) another barrier that achieves a level of risk that is equal to or better than the acceptable level of risk achieved by a barrier 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). The 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 as 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.

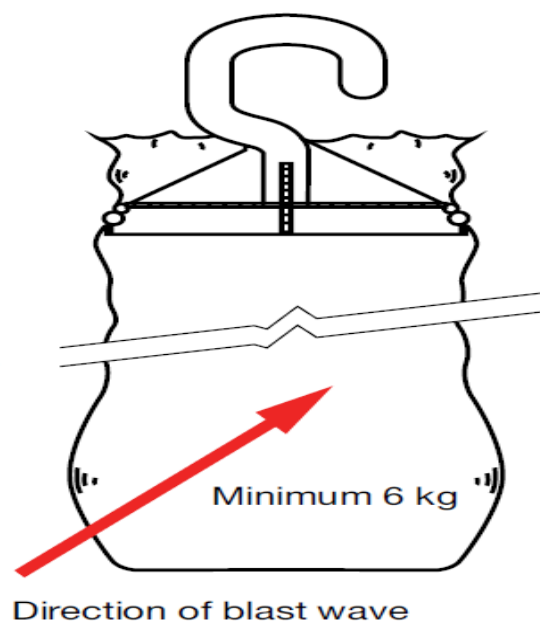
## 7. Barrier design parameters

There are several design parameters that apply to all types of barriers 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 6kg/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 0.4m and not greater than 1.0m, when measured across the roadway width (see Figure 4).
4. The distance between the bags and the side of the roadway must not be greater than 0.5m (see Figure 4).
5. For nominal roadway height up to 3.5m, each row must have a single level of bags suspended with the hooks not more than 0.5m from the roof (see Figure 3).



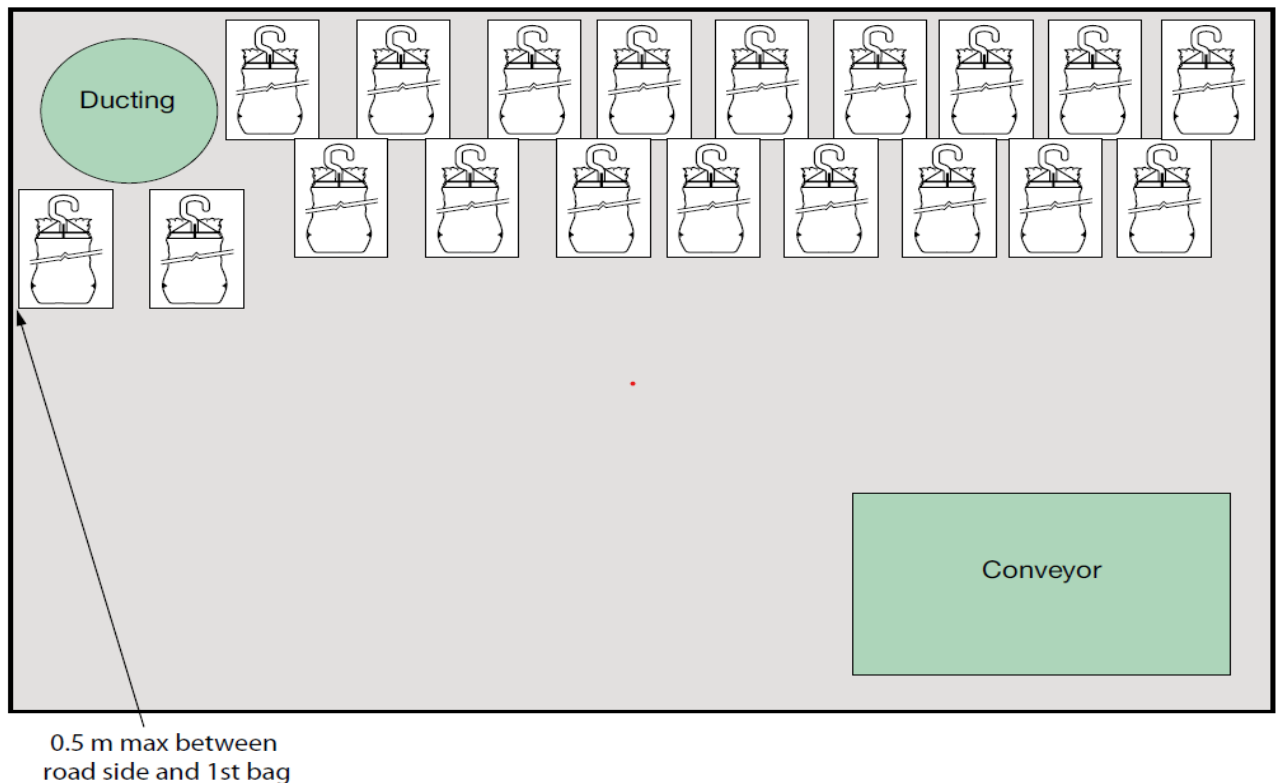
6. For nominal roadway heights between 3.5m and 4.5m high, the bags must be distributed evenly amongst two layers, suspended with the hooks at not more than 0.5m and 1.0m below the roof level (see Figure 2).
7. For nominal roadway heights between 4.5m and 6.0m high, the bags must be distributed evenly in three layers suspended with the hooks at not more than 0.5m, 1.0m and 1.5m below the roof level.
8. The distance measured along the roadway between rows of bags must be not less than 1.5m and not more than 3.0m (see Figure 4).
9. The minimum total mass of stone dust used in the barrier is based upon the values of either 200kg/m<sup>2</sup> of roadway cross-sectional area, or 1kg/m<sup>3</sup> of roadway volume between the extremities of the barrier, whichever amount is greater. It should be noted that for any barrier longer than 220m, the stone dust mass will be calculated on the basis of roadway volume i.e. 1kg/m<sup>3</sup>.
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).
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 beneath the conveyor structure to provide additional protection against the passage of a flame under the belt.



**Figure 1** Bags suspended facing the direction of any blast waves  
(Image source: HSE, 2020)

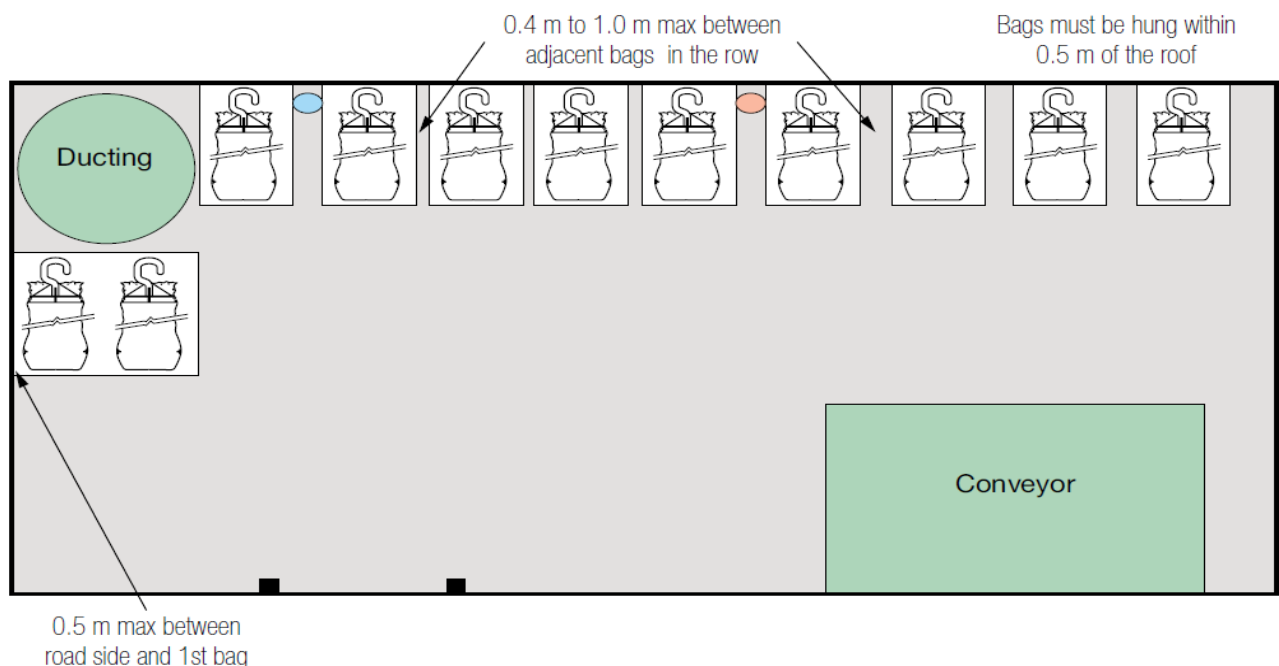
First layer hung between 0 and 0.5 m from the roof  
 Second layer hung between 0.5 and 1.0 m from the roof

0.4 m to 1.0 m max between adjacent bags in the row



**Figure 2** Typical bag placement in a roadway between 3.5 and 4.5 m high  
 (Image source: HSE, 2020)

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 3).



**Figure 3** Typical bag placement suspended around a roadway obstruction  
 (Image source: HSE, 2020)



- (a) the first row of the first sub-barrier, must not be installed closer than 60m and not further than 120m 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 120m 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 30m.

**These dimensions are illustrated in Figure 5.**

#### 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 120m from the start of the first sub-barrier. The belt road is 3.0m high and 6.5m wide. Thus the cross sectional area of the roadway is 19.5m<sup>2</sup>.

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

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

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

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

Each bag contains 6kg of stone dust, a total of 3900kg/6kg = 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 metres between bags).

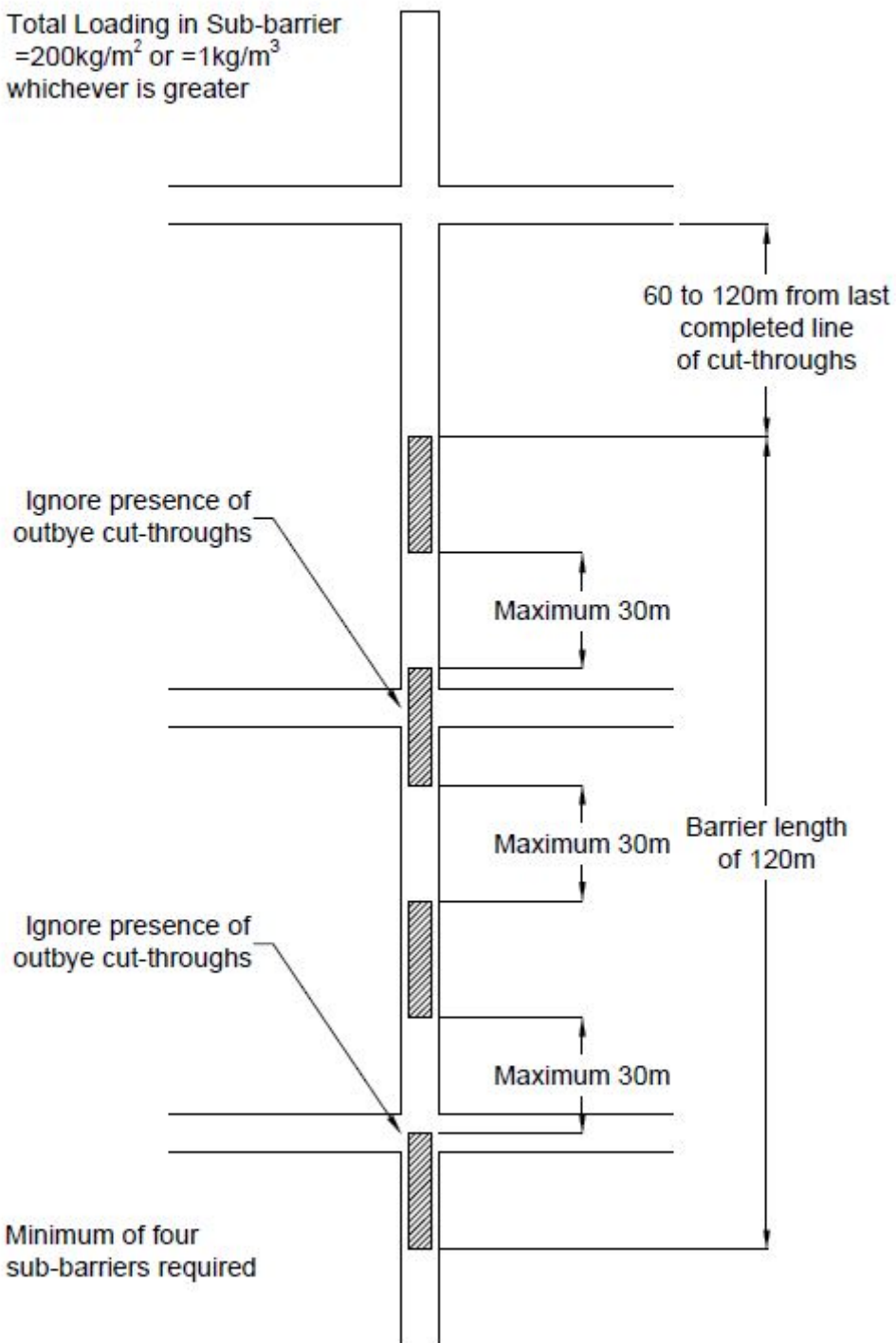
$$14 \times 12 = 168 \text{ (individual stone dust bags)}$$

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 2.0m apart, then each sub-barrier will extend over 26m.

## Advancing Distributed Barrier Showing Sub-Barriers

Total Loading in Sub-barrier  
=  $200\text{kg/m}^2$  or  $1\text{kg/m}^3$   
whichever is greater



**Figure 5** Distributed Barrier System

### 7.3 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 120m of roadway, the stone dust is placed in one concentrated barrier 20 to 40m long. 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  $200 \text{ kg/m}^2$  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 60m but less than 120m at all times, both advancing and retreating.

The next barrier in the sequence must start no further than 120m 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  $200 \text{ kg/m}^2$  of roadway cross-sectional roadway area.

**The dimensions for an advancing concentrated barrier are illustrated in Figure 6**

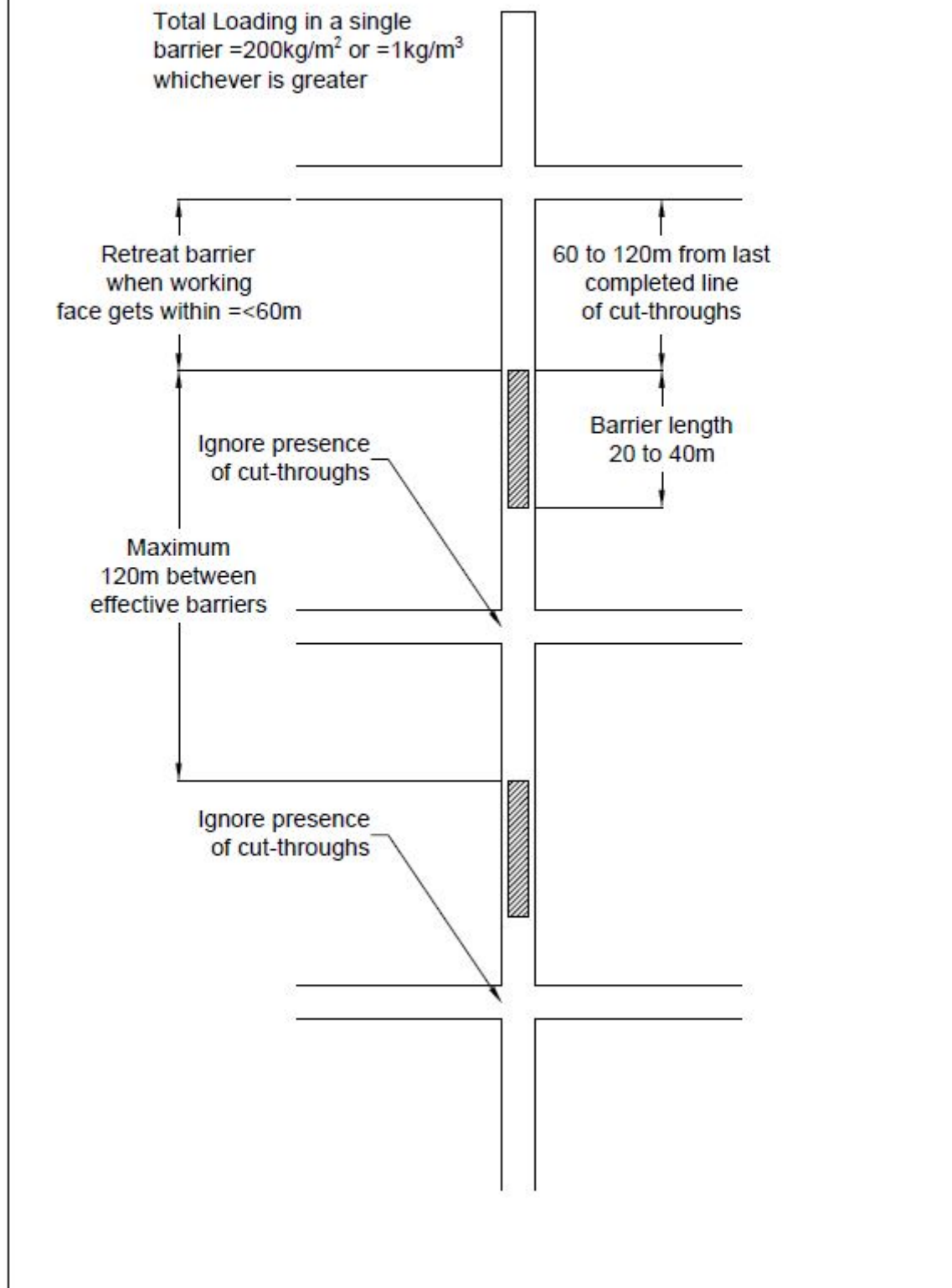
#### Example 2

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 3.0m and width of 5.2m. The area of the roadway is  $15.6 \text{ m}^2$  and the amount of stone dust required in each barrier is 3120kg. With 6kg of stone dust in each bag, each barrier will consist of 520 bags. Allowing 0.5m between the ribs and the nearest bags and 0.4m 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 ( $48 \times 11 = 528$  bags). Allowing a spacing of 1.5m between rows each barrier will be 72.0m 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.

## Advancing Concentrated Barrier



**Figure 6** Concentrated Barrier System



#### 7.4 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 120m. To be effective, the barrier must run for a minimum distance of 220m.

It is not always possible to maintain the barrier length for 220m 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 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  $1\text{kg/m}^3$  in the mine roadway (see Figure 7).

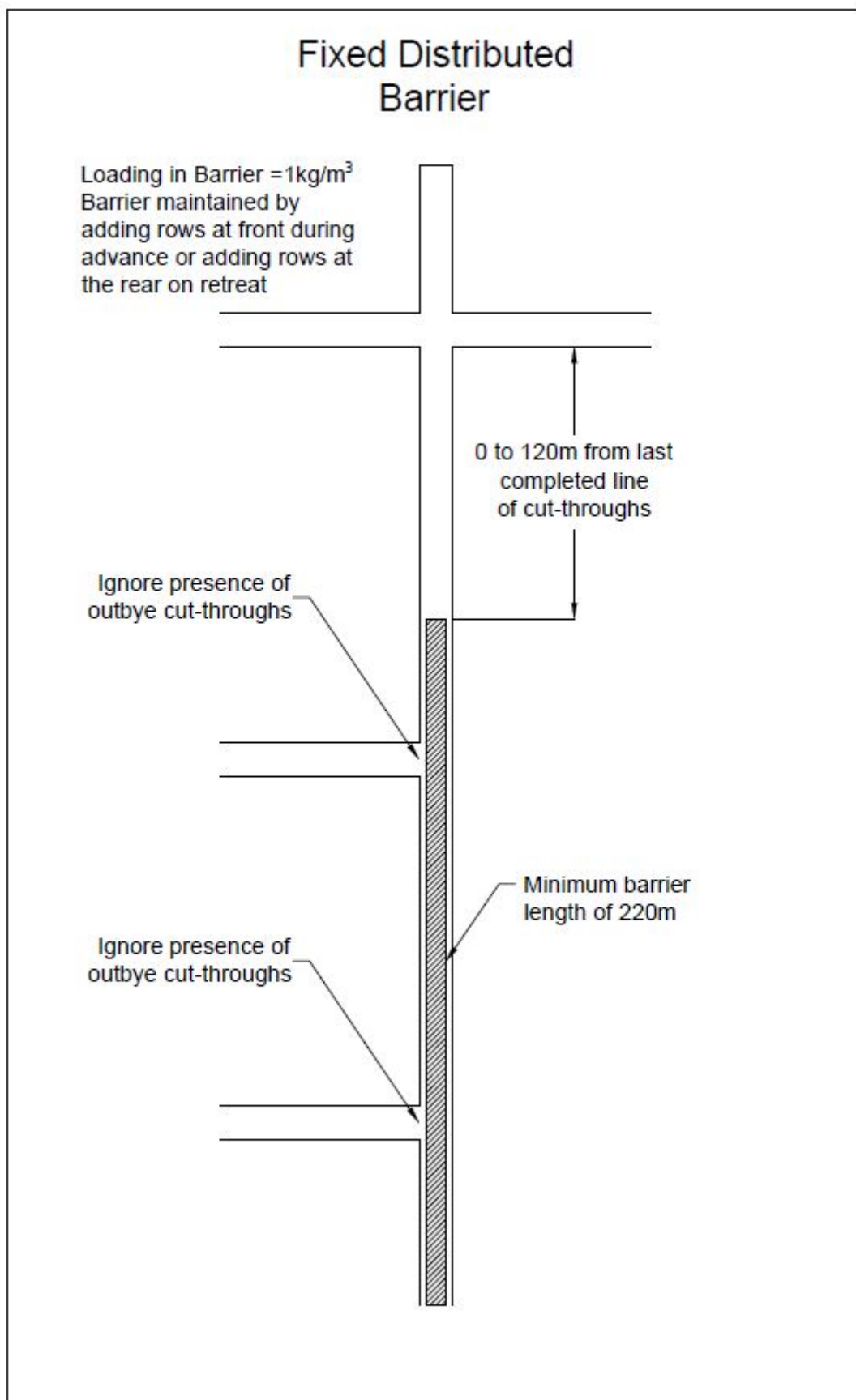
##### Example 3

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

Consider a longwall gateroad that is 3.4m high and 5.2m wide. At a roadway height of 3.4m, each row of bags requires only one layer with suspension hooks within 0.5m of the roof. The roadway area is  $17.7\text{m}^2$  and the stone dust requirements will be  $17.7\text{kg/m}$  of roadway length. At  $6\text{kg/bag}$  this requires  $2.95\text{ bags/m}$ . If the row separation is 2.5m each row will require  $2.5 \times 2.95 = 7.4\text{ bags/row}$ , 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 120m outbye of the last completed line of cut-throughs or face line.





**Figure 7** Fixed Distributed Barrier System

## 8. Validation and testing

The SSE must ensure that:

1. The 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. For example, stone dust barrier bags have been tested at several of these facilities. Manufacturers are expected to provide documentary evidence they have either conducted such tests or that their system meets the original design of a similar system tested at one of these facilities.
2. Verification of the quality of each batch of the bagged stone dust barrier components including the hook, ring and plastic bag rupture characteristics must be carried out by an independent recognised testing facility. The purpose is to ensure that ongoing manufacturing quality is maintained.
3. Documentary evidence as to the source and verification of the quality (including test data) of each batch of bags purchased 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 and any coal mine to which equipment has been supplied that has any hazards or defects associated with the equipment.

## 9. Review of this document

It is recommended this document is reviewed periodically. Reviews will be driven by new information, improved systems, research and new technology developments. For example:

- new information on float dust deposition in high productivity underground environments.
- the introduction of active barrier suppression technology.

## 10. References

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

Cybulski, W (1975) *Coal Dust Explosions and Their Suppression* Document. Volume 73, Issue 54001 of TT, United States National Technical Information Service. 582 pp

Du Plessis, Johannes Jacobus. (2000). *Development and evaluation of the bagged stone dust barrier*. 10.13140/2.1.1552.2084.

DMR (2020) *Guidelines for the compilation of a mandatory code of practice for the prevention of flammable gas and the coal dust explosions in collieries*. Mine Health and Safety Inspectorate. Mines Resources Department Mineral Resources Republic of South Africa.

HSE (2020) *The Mines Regulation 2014 (MR2014), Amended 2020*. Section 127, Page 34 – Guidance on explosion barriers (<https://www.hse.gov.uk/mining/bagged-stonedust-barriers.pdf>)

SkillPro (2017) Suggested Installation Guideline SkillPro-CSIR Bagged Barriers Underground Coal Mines, SkillPro Services Pty Ltd, November 2017.

Queensland Coal Mining Safety & Health Act 1999

Queensland Coal Mining Safety & Health Regulation 2017

## 11. Acronyms

CMSHR	Queensland Coal Mining Safety & Health Regulation 2017
ERZ1	Explosion Risk Zone No. 1
HSE	Health and Safety Executive (United Kingdom)
OEM	Original Equipment Manufacturer
PHMP	Principal Hazard Management Plan
SOP	Standard Operating Procedure
SSE	Site Senior Executive
UMM	Underground Mine Manager