SkillPro Services Pty Ltd

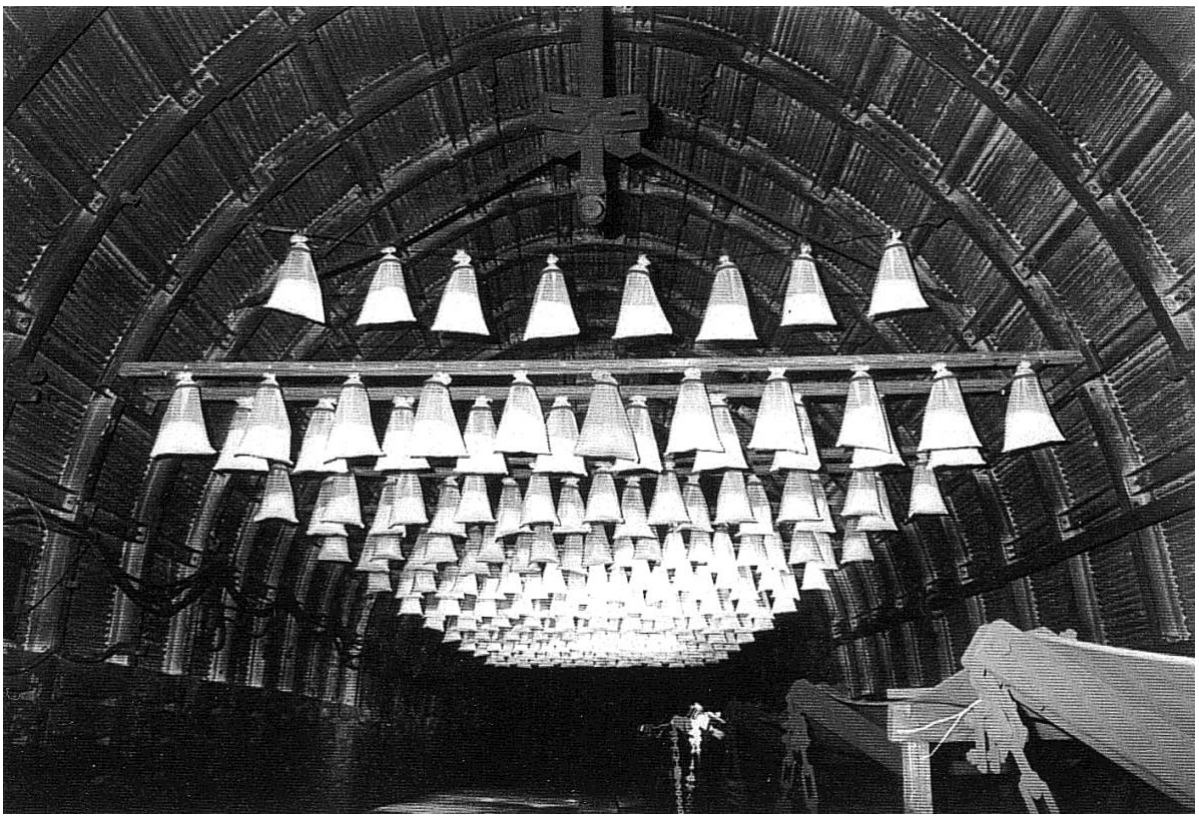
ABN 18 096 918 884

Installation Document

SkillPro Services Pty Ltd Bagged Barriers

NSW Underground Coal Mines

August 2024



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Disclaimer and Limitations

This document is intended to assist in the design, construction and installation of the SkillPro Services P/L bagged barrier system for stone dust explosion barriers. SkillPro Services P/L, its agents and its employees will not be held responsible for damages arising from inappropriate use of the product or errors or omissions in this document. It is the responsibility of the customer to ensure that any explosion barriers are designed, constructed, installed and maintained in a satisfactory manner, by suitably competent persons.

If there is any doubt in relation to the application of this document, independent professional advice should be sought. SkillPro Services P/L may from time to time make amendments to this document, in light of better knowledge of explosion protection from research it or others carries out, or in response to industry requirements. The responsibility rests solely with the mine to ensure that personnel who design, install and maintain explosion barriers have the necessary qualifications, training and experience to allow safe and compliant work practices to be followed.

The general location of barriers of any form is typically governed by State Legislation. This document, therefore, only attempts to describe how various types of barriers could be constructed. However, over-arching duty of care legislation requires mine operators to always be alert for risks that are not clearly covered by the specific legislation, in which case, guidance is possible based on extensive research undertaken world-wide over the past 100 years. Such situations might include (but are not limited to): a physical constraint to creating a continuous barrier large or long enough, barriers damaged by falls of ground and not being able to safely repair them, a new or emerging ignition risk a long way from existing barriers, roadway obstacles and/or layouts preventing barriers from being placed exactly as legislated and/or creating extensive turbulence more than ever considered by the original system designers, constricted single-entry drivage.

This document (including any appendices) applies only to SkillPro Services P/L barrier bags and hooks and cannot be applied to any other explosion barrier product other than those supplied by SkillPro Services P/L or its agents and which carry the SkillPro Services P/L and/or Becker logos as shown in this document.

Introduction

An alternative type of explosion barrier to traditional barriers made from stone dust loosely placed on shelves, or rows of water-filled tubs, is the SkillPro-Becker bagged barrier. Whilst the idea of bagged dust had existed for decades, the concept was refined and proven by CSIR of South Africa in the 1990s.

This installation document describes the components and various configurations of the bagged barrier as required for Australian coal mines. It is based upon the South African Guidelines with modifications to suit Australian conditions and mining practices.

This updated installation document specifically deals with the latest version of MDG3006 NSW TRG July 2024 on the use of SkillPro-Becker bags. In late 2016, SkillPro Services P/L undertook testing of a shortened version of the bagged barrier bags. The test results showed that the usual bag could be shortened by about 200mm while still holding 6kg of stone dust without affecting the suppression performance of a barrier constructed from short bags. Initially, a caveat was placed on the use of short bags that they could only be used to build the fixed distributed barrier. The reason for the original caveat was to provide a degree of conservatism in the introduction of the short bags due to the restricted test that had be undertaken at that time. After an approach by industry stakeholders, the caveat was relaxed to include construction of a "fixed concentrated" barrier. This version of the SkillPro Services P/L installation document describes the fixed concentrated barrier and relaxes the original caveat to allow its use in such a barrier.

The cover page photo shows a multi-layer barrier installed in the Tremonia test mine in Germany, prior to a full-scale coal dust explosion test.

Description of the SkillPro-Becker Bagged Barrier

The bagged barrier explosion suppression 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 parameters. In high workings, the bags of stone dust are suspended in horizontal layers.

The actual distances used in the layout of a barrier are determined by the requirement to achieve certain minimum levels of stone dust within the barrier, and by the roadway dimensions.

This document has been specifically developed around the SkillPro-Becker bagged barrier. Extensive large-scale explosion testing was undertaken in the development of the SkillPro-Becker bagged barrier components and this resultant document. Only bags clearly identifiable with the brand names SkillPro Services P/L or SkillPro- Becker can be installed utilising this document.

The SkillPro Services P/L supplied bags are easily identified by the logo shown below. This document cannot be used for the installation of any other type of explosion barrier system of any kind including alternative brands, type or designs of bagged barriers. Mining operations that may be using alternative products are advised to approach their supplier for appropriate installation instructions, based upon demonstrable research and large-scale testing.

becker
MINING SYSTEMS

Bag Supplied by;

SkillPro Services Pty Ltd

SkillPro Bagged Barrier Logo

Common Barrier Design Parameters

There are several common design parameters that apply to all types of barriers covered by this document. These define limits for the mass of dust needed, 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. Each plastic bag is marked with a horizontal line to indicate the approximate location of the hook's locking ring. It must contain dry stone dust complying with local regulations defining the acceptable specification for stone dust. The actual quantity contained in each bag is 6 kg and the number of bags in the barrier is designed upon the mass per bag determined by some weighing scheme. The bag is not designed to carry more than 6kg. The worked examples provided later in this document, are based on 6kg/bag as this is the default mass used by contract bag fillers in Australia.

2. 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 1).

3. The distance between the bags and the side of the roadway must not be greater than 0.5m (see Figure 1).

4. For roadways up to 3.5m high, each row must have a single level of bags suspended with the hooks not more than 0.5m from the roof. If required an additional layer can be suspended with droppers if loading demands more bags.

5. For roadways 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. SkillPro Services P/L droppers are recommended.

6. For roadways 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. SkillPro Services P/L droppers are recommended.

7. The distance measured along the roadway between rows of bags must be not less than 1.5m and not more than 3.0m.

8. Most importantly, the minimum total mass of stone dust used in the barrier is now based upon the values of either 200kg/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 220m, the stone dust mass will be calculated based on roadway volume i.e. 1 kg per m^3.

9. Bags should be suspended from a rigid structure or device, e.g., steel roof mesh. If a second or third layer of bags is needed due to the road height, then the lower layers of bags should utilize the SkillPro Services P/L dropper that can be used in one or two configurations.

10. Bags should be suspended so the hook and bag can swing freely inbye/outbye, ideally with the open part of the hook facing inbye. The hook should never be attached so it faces across the roadway.

11. Any barrier should only contain the one type of bag - other makes of bags should not be used.

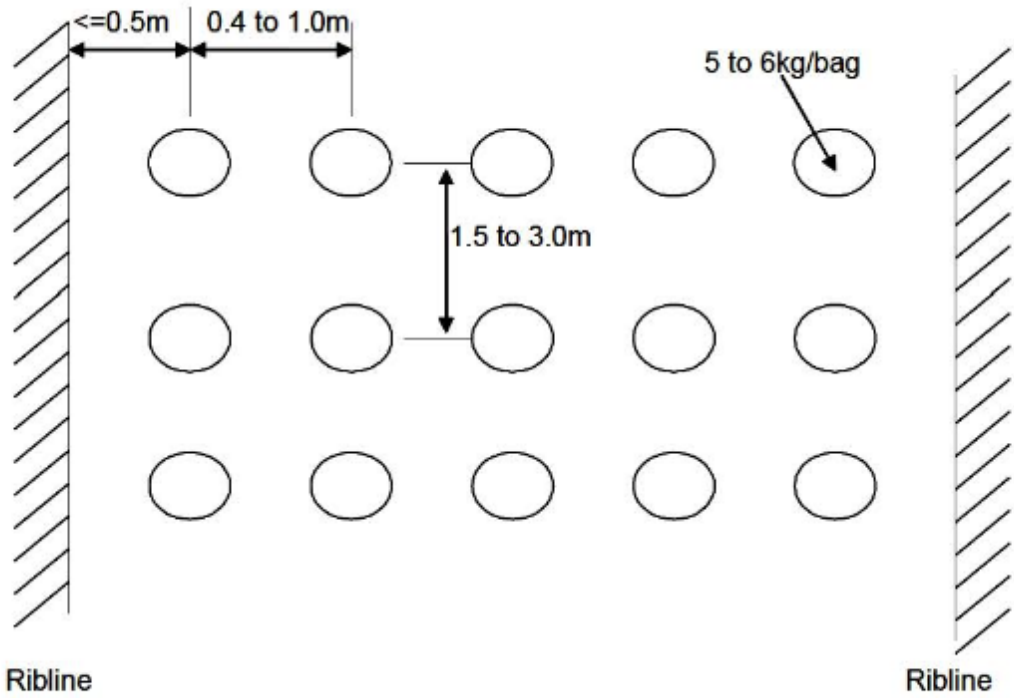


Figure 1 - Spacing of bags within a barrier – No significance should be placed on the number of bags shown across the roadway in this figure

Types of Barriers

The bagged barrier system can be configured in several different ways depending upon the application and the requirements of the mine and how they wish to apply the State Legislation. The four alternatives that can be applied are: -

1. an advancing distributed barrier after the original South African model,
2. an advancing concentrated barrier, or
3. a fixed distributed barrier, and,
4. a fixed concentrated barrier

All barriers must comply with the common barrier design parameters given above. A discussion on each type of barrier is given below.

(1) Advancing Distributed Barrier

An advancing distributed barrier consists of four sub-barriers, installed over a maximum distance of 120m of continuous roadway. Three complete sub-barriers must always remain in position, while the fourth sub-barrier is in the process of being moved ahead/back as the section advances/retreats. 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 always meets the required dust loading.

Historically, this layout has not been used in Australia due to the high labour costs, however it remains in this document for completeness.

The following distances must be maintained:

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

(b) the last row of the fourth sub-barrier, furthest from the last cut-through 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 2.

Some mines have found it is financially not worth advancing sub-barriers but build a new one at the front of the full barrier when space is available. This does not alter the requirement to adhere to the designs presented herein.

Example 1

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

Assume that a bagged stone dust barrier is to be installed in a bord-and-pillar section. Assume also that the first row of the first sub-barrier will be located 100m from the last cut-through and the last row of the fourth sub-barrier at 220m from the last cut-through. The belt road is 3.0m high and 6.5m wide.

The distance between the barrier extremities is 120m and the cross-sectional area is 19.5m2. The volume between the extremities of the full barrier is therefore 2340m3. Based on cross sectional area requirements of 200kg/m2 and roadway volume requirements of l kg/m3, the barrier will require either 3900kg or 2340kg of stone dust, whichever is the greater, in this case being 3900kg.

If each bag contains 6kg of stone dust, a total of 3900/6 = 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. If, say, 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. Taking the last cut-through as zero, the sub-barriers will be located as follows:

Last cut-through		0m
1st sub-barrier	start	100m
	finish	126m
2nd sub-barrier	start	130m
	finish	156m

3rd sub-barrier	start	160m
	finish	186m
4th sub-barrier	start	190m
	finish	216m

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

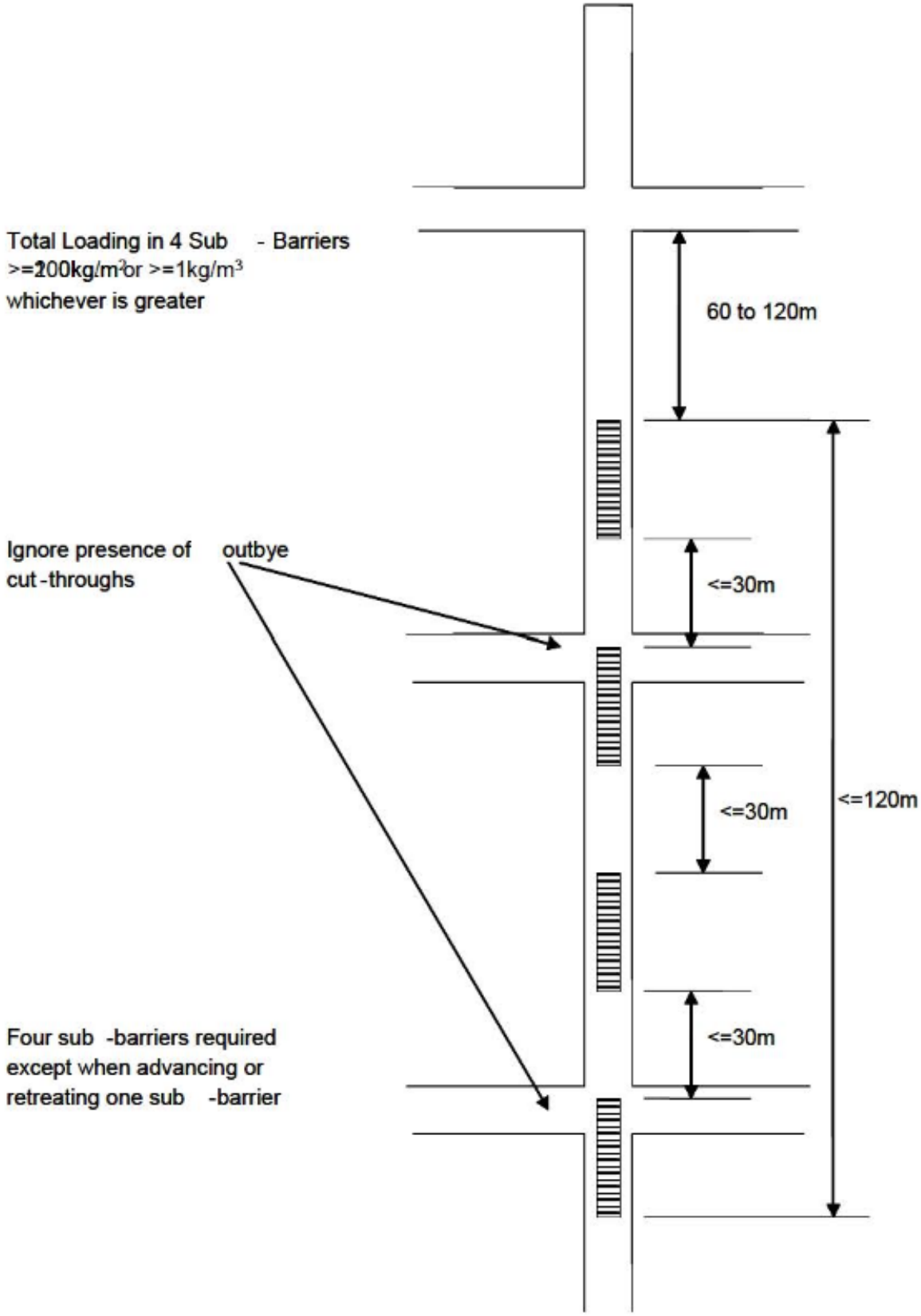


Figure 2 - Advancing Distributed Barrier (not to scale)

(2) Advancing Concentrated Barrier

An alternative to the advancing distributed barrier is the advancing concentrated barrier. Instead of the dust being distributed among four or five sub-barriers spread over about 120m of roadway, the stone dust is placed in two concentrated barriers 30 to 70m long. To facilitate panel advance/retreat, the second concentrated barrier is installed and used to leap-frog the first barrier to maintain the correct distance from the last cut-through. Each of the individual barriers is designed based on 200 kg/m^2 and therefore holds sufficient dust to act as a discrete explosion barrier. The two barriers are installed to allow removal of one for advancing or retracting as the face moves, without compromising the barrier dust loading.

Historically, this exact layout has not been used in Australia due to the high labour costs, however it remains in this document for completeness.

Despite the above comment, it is acceptable to advance a concentrated barrier by building a new barrier in front of an existing barrier when sufficient space is available rather than leapfrogging barriers. This does not alter the requirements to adhere to the designs presented herein.

The distance between the last cut-through or longwall face and the first row of bags must always be greater than 70m but less than 120m, 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 based on 200kg/m^2 of roadway cross-sectional roadway area.

The dimensions for an advancing concentrated barrier are illustrated in Figure 3.

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 3.6m and width of 6.5m. The area of the roadway is 23.4m^2 and the amount of stone dust required in each barrier is 4680kg. With 6kg of stone dust in each bag, each barrier will consist of 780 bags. For a 3.6m roadway height, there should be two layers of bags with the suspension hooks at not more than 0.5m and not more 1.0m below the roof. Allowing 0.5m between the ribs and the nearest bags and between adjacent bags, it is possible to install 12 bags in each row. The height of the roadway dictates the requirement for two layers of bags. Therefore, the final barrier consists of two layers of bags each of 33 rows and each row holding 12 bags (2*33*12 = 792 bags). Allowing a spacing of 2m between rows each barrier will be 64m long ((33-1) *2).

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. Both barriers, each consisting of 780 bags in this example, must always be in place, during the production of coal.

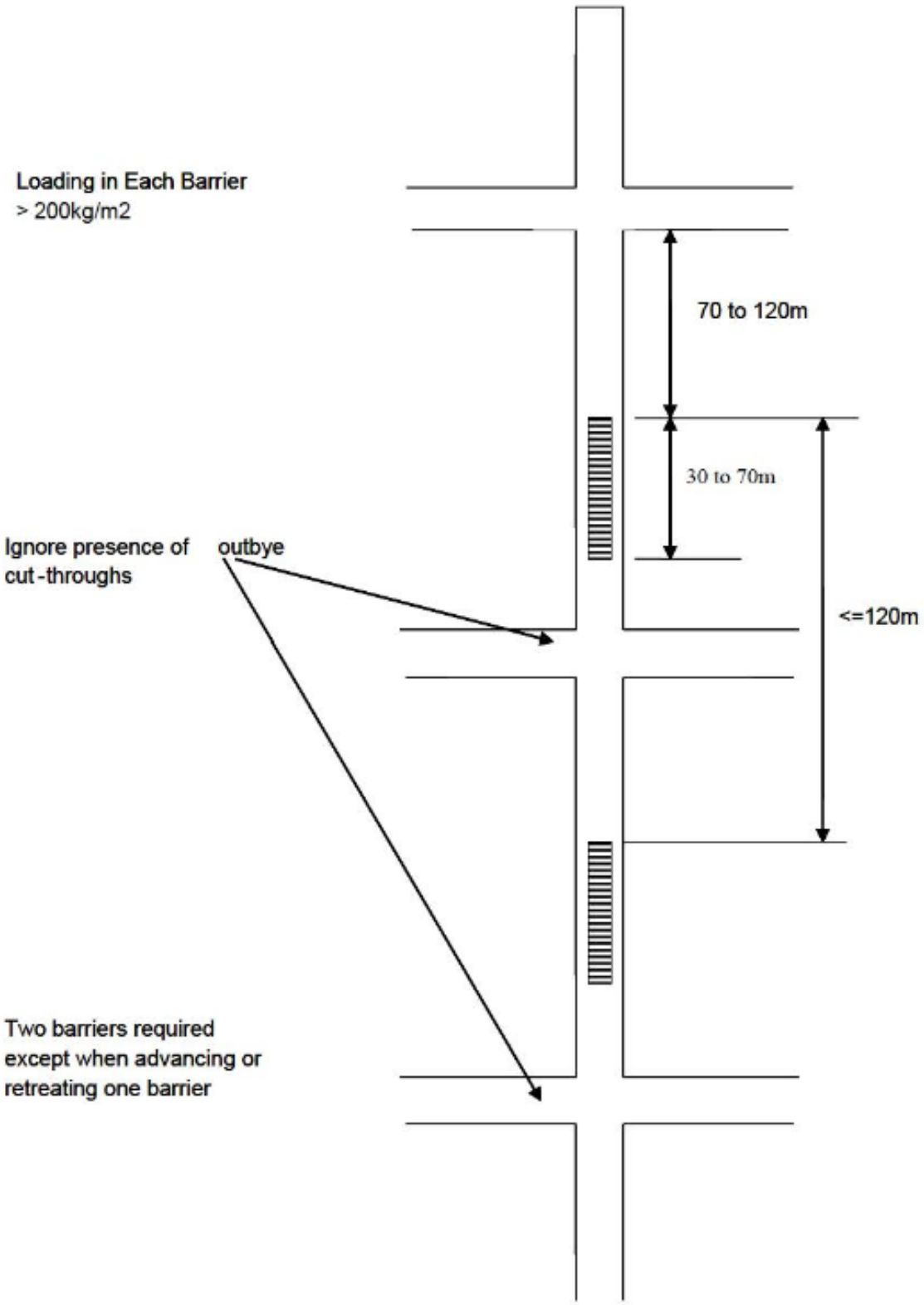


Figure 3 - Advancing Concentrated Barrier (not to scale)

(3) Fixed Distributed Barrier (continuous)

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, possibly 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 cut-through or longwall face must not exceed 120m. To be effective, the barrier must run for a minimum distance of 220m unless additional loading is used at this starting point.

It is not always possible to maintain the barrier length more than 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 gate road 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 is based on a minimum stone dust density of 1kg/m^3 in the mine roadway (see Figure 3).

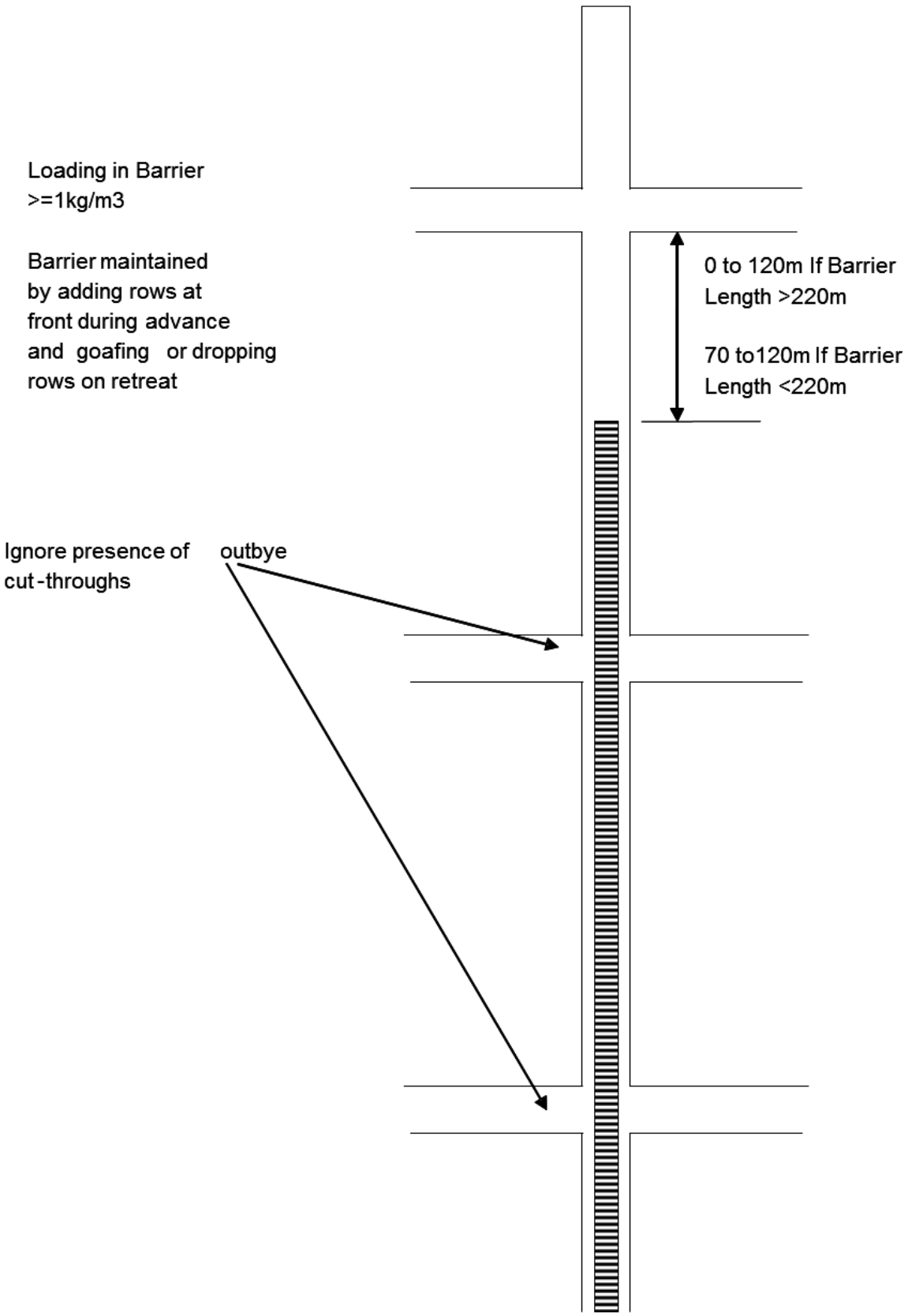
Whilst this arrangement is the most flexible, it is suggested that in cases of doubt, or circumstances not clearly covered by these guidelines, the mine should seek professional advice from SkillPro Services P/L or other competent parties, on the configuration of such barriers.

Example 3

An example of the design calculations undertaken to install a fixed distributed barrier.

Consider a longwall gate road that is 3.4m high and 5.2m wide 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 17.7m^2 and the stone dust requirements will be 17.7kg per metre of roadway length. At 6kg/bag this requires 2.95 bags/m. If the row separation is 2.5m each row will require 2.5*2.95 = 7.4 bags/row, which will be rounded up to 8 bags per row.

Figure 4 Fixed distributed barrier.



(4) Fixed Concentrated Barrier (continuous)

The fixed concentrated barrier is a variation on the advancing concentrated barrier in that instead of using only using two sub-barriers which leapfrog during the advance, a series of sub-barriers is built in accordance with the requirements for the advancing barrier but left in place as mining progresses. In this way, the fixed concentrated barrier achieves the same degree of safety associated with the fixed distributed barrier while possibly better meeting local requirements for sequencing of installation and alignment with pillars. The fixed concentrated barrier developed from the use of barriers in Australia as the use of bagged barriers matured over the years.

The design parameters for a fixed concentrated barrier are the same as those for an advancing concentrated barrier as per *Example 2*. The only change is that as each sub- barrier is built it is left in place so that ultimately there are many sub-barriers. In this way, the dust mass in the barrier increases and provides a high degree of protection.

Protection of Roadways with Obstructions

Where the bagged barrier is used to provide explosion protection in a conveyor belt roadway, **additional** stone dust bags must be suspended on the conveyor belt structure to provide protection against passage of an explosion under or between the belts, or between the belt and roadway side. This should take the form of one bag on either side of the belt structure for each row of bags suspended in the roadway. All hooks suspended along a conveyor belt **MUST** be free-hanging and be incapable of touching any moving part of the conveyor belt, even if accidentally bumped. These additional bags do not necessarily have to exactly align with the roof mounted row. Acceptable means of suspension from belt structure might include a looped cable tie or twisted flexible steel wire loop, so long as the minimum breaking strength of the loop/hanging device exceeds 30kg.

For suspended belt structure, wherever there is clearance to do so, **additional** bags must also be hung underneath the belt structure, below the level of the return belt for each row of bags suspended at roof level. This should take the form of one bag, either side of the belt structure, per metre of belt width for each row of bags suspended at roof level in the roadway. If there is insufficient clearance to suspend a bag, there can be no confidence in a bag simply placed on the road floor below the belt.

The same conditions apply whenever a ventilation duct or large pipe is suspended above the floor is used i.e. one **additional** bag is to be suspended under the vent duct/pipe for each row of bags suspended at roof level in the roadway.

There is no conclusive research into the exact mounting arrangement for attaching to belts or other such structures. Conceptually, provided the hanging system prevents the hook from dislodging as it rotates under explosion pressure, but still allows it to move under explosion pressures, then any reasonable hanging arrangement should be acceptable. There is some limited evidence that vibrating belt structures may prematurely fatigue the plastic hook, so mines with this application, need to periodically inspect and rectify as needed.

There is no direct research data showing the need or otherwise for additional protection around a longwall monorail system or a single pipe, that penetrates the barrier, other than that noted above, **but there should not be an unprotected "passage" between the rib and side of any large obstruction such as a suspended belt or vent duct, pipes or monorails-if there is space for a bag.**

Mines are alerted to research that indicated explosions can propagate in the narrow band of fine dust, commonly found under conveyor belts.

SkillPro Services P/L Short 6kg Bags

SkillPro Services P/L undertook testing in 2016 to assess the impact of reducing the length of the bag used for holding the stonedust upon the effectiveness of explosion barriers. It has been shown that a newly made short bag did not affect the behaviour of an explosion barrier and it is now the standard bag supplied to mines. Recent testing has shown that the short bags are as effective as the long bags in any barrier style.

The shortened bags are about 200mm shorter than a normal length bag with the normal hook. This provides greater clearance when mining height is restricted by seam height.

"Non-Compliant" or "Non-standard" Installations

There will almost certainly be circumstances in a mine that are not adequately covered by this document. It is impossible to anticipate every mine layout and configuration in which a bagged explosion barrier may be placed.

This is particularly so in a situation such as when a longwall panel approaches completion and is close to the main headings, or in the case of single-entry development, over about 100m. Similarly, the drivage of long face installation roads presents unique hazards as the face can be up to 300m away from the gate road where the barriers would normally be expected.

When a gate road or single entry drivage sets off, there will be times when it cannot easily comply with this installation document.

Increasing chain pillar lengths are making the use of either of the advancing systems more problematic, especially barrier separation distances, however the distributed barrier arrangement can usually rectify such issues. For any unusual or apparently non-compliant circumstances, the mine should seek professional advice. Please also refer to the Chapter, "Disclaimer & Limitations".

Hanging hooks and suspension systems

The role of the hook is to securely hold the bag in place so the explosion pressure can shred the bag of dust. Testing has included both types of hooks, though only the orange ABS hook is now sold. Figure 5 also shows how the specially made bag shreds and frees its payload of dust, when subjected to pressure impulse testing. Figure 6 shows hooks recovered from test explosions and the remnants of the bag can still be seen fused onto the hook, demonstrating the hook has totally fulfilled its function.

Figure 5 – SkillPro-Becker bag shredding

Figure 6 - Remnants of bag attached to hook post explosion

In mines with mesh against the roof, and limited height, the short hook is generally favoured, and this is the **default hook** for Australian customers. It also has a different hook shape to make installation easier in "tight" situations.

Hooks should be attached to fixings that run across the roadway so the hook can swing freely inbye and outbye. Hanging systems that unduly impede hook swinging, are unacceptable and this can be a challenge around belt structures etc. Ideally, the open part of the hook should face inbye, to lower the risk of it becoming dislodged when impacted by a pressure pulse.

Historical testing has shown the minimum pressure at which bags rupture may be related to the rigidity of the fixing system and all the testing which generated the fundamental designs used rigid frames or other similar steel supports for the hooks, equivalent to mesh commonly found on the mine roof. As such, this document recommends only rigid fixing systems such as mesh. In high workings where multiple layers of bags are needed, then the SkillPro dropper should be utilized.

Changes to the hook design, or adding additional straps, hangers etc. should not be undertaken without first contacting the suppliers or seeking professional advice.

Pre-filled bags

Pre-filled bags with appropriate hooks, can be supplied in palletised or pod mounted boxes, in some cases suitable for direct transport underground.

All prefilled bags sold in Australia are 6kg mass unless special arrangements are made.

Figure 7 - Bulk supply of pre-filled bags

Neither the bag nor hook is ultra-violet (UV) protected and as such, should not be stored outdoors or exposed to sunlight except during filling operations. Boxes of pre-filled bags, covered with shrink-wrap plastic should not be left exposed to the elements including during transportation or storage, nor should they have additional loads placed on top of them i.e. top load only, unless purpose-made packing crates are used.

Filling of Bags

It should be noted that the bagged barrier system is in part, reliant upon the proper filling of the stone dust bags that together form an explosion barrier. The individual bags are intended to hold 6 kg of stone dust, the exact amount is critical due to calculating the final barrier design (See worked examples above). The bag is not designed to hold more than 6kg.

All pre-filled bags sold in Australia contain 6kg unless special arrangements are made.

The horizontal line printed on the bag represents the approximate location of the hook locking ring and is a guide for those assembling them once filled.

Bag Closure

Once bags are filled with stone dust the hook is installed in the mouth of the bag and locked in place with the ring as shown in Figure 8(a) at about the position of the line on the bag. The excess plastic needs to be folded over the outside of the lock ring, to prevent the bag pulling through the lock ring in an explosion, and to prevent accidental water ingress (Figure 8(b)).

Figure 8(a) – Correctly fitted locking ring and position and (b) excess plastic folded over.

Broken or Defective Bags and Hooks

To preserve the integrity of the explosion barrier, the proportion of broken bags must not exceed 10% of the bags in any sub-barrier or in any 50m section of a continuous barrier. The proportion of broken bags must not be allowed to exceed this amount before steps are taken to replace them. This also applies to any additional bags hung under or around belts or other obstructions, as noted elsewhere in this document.

While in many situations, the life of the bagged barrier components may not be of significance, especially in an underground mine, it is expected that the component lives will be effectively indefinite. Some units have been suspended on the surface in South Africa for many years with little sign of degradation or moisture ingress. The safeguard against failing components in a barrier is to ensure compliance with the 10% rule stated above.

Broken and/or defective hooks or bags should not be used, and your supplier contacted.

Re-Cycling Bagged Barrier Components

There is no research data to support or refute the re-use of apparently undamaged bags and/or hooks. SkillPro Services P/L is aware that some mines cut bags to dump the dust and recycle some of the recovered hooks.

Auditing

SkillPro Services P/L expect contract fillers of bags and mine end-users, to both have processes in place to ensure all the measures in this document are observed, and if they appear to have a non-compliant situation, to take steps to adequately assess, then manage, those risks. SkillPro Services P/L can assist with such circumstances.

Consumer Feedback

Comments on any aspect of this guideline should be submitted in writing to: -

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Australia

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Email: admin@skillpro.au

Appendix A Risk assessment

SkillPro Services P/L bag barrier design risk assessment. To be expanded as needed by contract fillers, before going to mines				
Phase	**Problem, risk, Issue**	**Unwanted outcome**	**Current design controls**	**Additional controls needed by mine and/or contract fillers**
Filling	Under-filled	Inadequate dust density so the system does not work as intended in explosion	At 6kg, the dust is 135mm from the base of a bag that is 310mm wide, when the bag is suspended. Minor changes in bag width may occur. The exact mass/bag is covered by SkillPro Services P/L Installation Document and worked examples of barrier designs in this document, are based on 6kg/bag	Mines need to order bags filled to the mass required by their design. Contract fillers are expected to have an audited scheme to ensure bags are filled to 6kg. Bag filling mass and numbers are expected to be part of ongoing mine audits of major hazard management systems. Mine procedures should ensure any minor underfilling detected in service, is compensated for by hanging extra bags within the length of the barrier. Contract bag fillers should ensure their staff are trained to visually detect gross non-conformance.

	Over-filled	Minor economic loss only	The hook cannot be easily fitted in the marked location if it is drastically overfilled, so partially self-managed. This SkillPro Services P/L install document deals with fill levels.	Contract bag fillers should ensure their staff are trained to visually detect gross non-conformance. Bag fill level/weight is expected to be part of ongoing mine audits of major hazard management systems.
	Non-conforming dust used	Does not work as intended in explosion	All prior testing is with stone dust as used underground.	The mine/contract bag-fillers are expected to purchase dust that complies with the regulations of the Jurisdiction they are to be sold in. Mine purchasing systems should require proof of compliance with dust Standards. Correct dust usage/compliance is expected to be part of ongoing mine audits of major hazard management systems.
	Bag or hook damaged in handling/ packaging/freight/ storage (The bags are deliberately fragile by special design of the plastic).	No impact on performance - minor economic loss only	The load capacity of the hook is periodically tested by the suppliers. Hooks, rings and bags are all separately bulk packed and sealed in cardboard crates immediately upon production. The dust packs into the bags and very minor bag damage does not always result in loss of all the dust.	It is expected that technicians filling bags quickly work out how to handle them to avoid damage and put in place any necessary procedures/equipment. As-received condition is expected to be part of ongoing mine audits of major hazard management systems. Contract fillers should ensure crates of pre-filled bags are “top load” only.

			Purpose-made divided boxes can be supplied to hold/ship pre-filled bags and reduce likelihood of transport damage.	Mines and contract fillers should ensure neither bags nor hooks, or filled units, are left exposed to sunlight (UV radiation) for any time except that essential for filling and/or handling operations.
	Moisture/water gets into the dust or bag	1) Harder to fill 2) Does not work as intended in explosion	The bag is sealed against accidental water ingress provided the ring is correctly fitted and the top of the bag folded over it. The bag is made so that there is sufficient free material at the top to fold over the hook. The ring on the hook is a tight fit to maximize sealing capability. Wet dust will not flow easily through the hopper and into the bags.	It is expected that contract fillers will have a procedure to ensure bags are not filled with moist dust. It is expected that contract fillers will have a procedure to ensure bags that are accidentally damaged (torn/penetrated) during filling are rejected and not supplied to mines. It is expected that mines will have a procedure to ensure bags that are accidentally damaged (torn/penetrated) during hanging, or in-service are rejected and replaced. Mine procedures should include a check for workers to visually identify significant moisture ingress by way of hard-caked dust and/or visible moisture beading inside the bag and take remedial action in conjunction with the suppliers and or/contract fillers and/or hanging crews.

				Barrier/bag/dust condition is expected to be part of ongoing mine audits of major hazard management systems
	Wrong, different or sub-standard bag used.	Explosion not quenched because the bag does not rupture and disperse the dust as intended.	All bags sold by SkillPro Services P/L have that name and company logs printed on them. The installation document designs are based are numerous large-scale tests with these specific bags and hooks (they have been large-scale tested in real coal dust explosions). SkillPro Services P/L has a program and procedure to periodically re-test at large scale, a number of bags hooks to confirm rupture conditions. Test reports available to Mines Inspectorate and customers on request. The plastic bags have very special anisotropic properties so they will rupture under credible explosion pressures. SkillPro Services P/L show contract fillers how to confirm the bags have intended properties.	Contract fillers are expected to have a process to periodically check the bags have the intended properties. Correct bag in use is expected to be part of ongoing mine audits of major hazard management systems.

			SkillPro Services P/L routinely subjects the plastic bags to impact tear testing and the results are linked to large scale testing	
	Wrong, different or sub-standard hook	Explosion not quenched because the hook does not hold the bags or hold onto the mesh as intended	All hooks sold are specifically designed to retain the SkillPro Services P/L bags until they shred and dislodge the dust, under explosion conditions This installation document designs are based are numerous large-scale tests with these specific bags and hooks (they have been large-scale tested in real coal dust explosions). SkillPro Services P/L has a program and procedure to periodically re-test at large scale, several bags and hooks to confirm rupture conditions Test reports available to Mines Inspectorate and customers on request. SkillPro Services P/L routinely subjects the hooks to static load tests as per SP-2016-001	Mines and/or contract fillers should ensure SkillPro Services P/L bags and hooks are only used as "matched pairs" i.e., SkillPro Services P/L bag with SkillPro Services P/L hook and ring
	Hook wrongly placed post bag filling	May make hanging more difficult	There is an upper red line printed on the bags indicating hook placement to provide correct location with 6kg of dust in bag	Contract fillers are expected to have a process to check hook integrity as part of the packing process

	Hook locking ring not correctly secured post bag filling	Bag may slip out of hook when being handled or in an explosion. Minor economic loss to contract filler/mine	The outer plastic ring on the hook is designed to have a positive lock when correctly fitted SkillPro Services P/L instructs contract bag fillers on required processes	Contract fillers are expected to have a process to check lock ring integrity as part of the packing process
Transport to mine and underground	Broken bags with dust falling out	Inadequate dust density so the system does not work as intended in explosion	The SkillPro Services P/L Installation Document has a small allowance for damage. SkillPro Services P/L offers guidance to any mine buying product (via the retailer/bag filler if used)	Mines expected to use the SkillPro Services P/L Installation Document to design a compliant system. Mine workers are expected to replace damaged bags/hooks on-job to maintain compliance with guidelines Barrier/bag condition is expected to be part of ongoing mine audits of major hazard management systems Mines are expected to train their staff in requirements and have multiple levels of technical management that should assess installations routinely.
	Accidentally encounter water once installed	Water gets into the dust and explosion not quenched because dust does not disperse as	The bags are effectively sealed using the locking ring as part of the purpose-made hook and should not uptake water unless deliberately hosed or submerged, or otherwise damaged.	Barrier/bag condition is expected to be part of ongoing mine audits of major hazard systems.

		intended		Mines should periodically take particular note of dust state in any installations associated with water coming from the roof
Installation	Inadequate number of bags hung	Inadequate dust density or layout so the system fails to work as intended in explosion	SkillPro Services P/L Installation Document specify bag density for specific applications, all based on large - scale testing	Detailed Barrier design is expected to be part of ongoing mine audits of major hazard systems
	Excess bags hung	Economic loss only - not a system problem	SkillPro Services P/L Installation Document specify bag density for specific applications based on large-scale testing	Barrier/bag numbers are expected to be part of ongoing mine audits of major hazard management systems
	The hooks cannot easily be suspended from the roof line or around conveyors etc.	Explosion not quenched because dust bags cannot burst as intended (note, quality suspension hook is critical to them working)	Two different hooks designs allow for use in most modern mine situations (refer to SkillPro Services P/L for unusual situations including on or around belts - testing may be required) SkillPro Services P/L Installation Document suggest the hooks are optimally placed if they can swing inbye/outbye without jamming, so they should be placed on lines/mesh/rods etc. running across the roadway, not longitudinally	Bag hanging arrangements are expected to be part of ongoing mine audits of major hazard management systems
	The barriers are wrongly placed	Explosion not quenched because dust bag cannot burst as intended burst as intende (i.e. by pressure front	SkillPro Services P/L Installation Document specifies barrier layouts, and these should match legislated requirements	Barrier location is expected to be part of ongoing mine audits of major hazard systems

		ahead of flame front)		

	Crates/boxes of filled bags are excessive mass for the work platform	Overturning or toppling of the work platform or associated machine	No controls offered by SkillPro Services P/L	Mines buying cartons of pre-filled bags should work collaboratively with suppliers of filled bags to ensure all related mechanical risks are being appropriately considered and managed. Mines self-managing the bag filling operation should ensure all related mechanical risks are being appropriately considered and managed. It is expected that contract fillers note/advertise the gross mass of packages/crates they supply.
Operation	Bags fall or are hit/damaged (Note: Bags not designed to be deliberately hit by passing machinery)	Inadequate dust density so the system does not work as intended in explosion	SkillPro Services P/L Installation Document requires the mine to have some audit program to replace any damaged/missing bags. The SkillPro Services P/L Installation Document has an in-built safety factor of 10%, meaning up to 10% of the bags can be defective before the dust mass is inadequate for the application. SkillPro Services P/L provide a short hook and short bag specifically for improving clearance.	Barrier/bag damage is expected to be part of ongoing mine audits of major hazard management systems

	Bags fall due to premature hook failure (could be high ventilation speed causing swinging or vibration induced failure from belt structure)	Personal injury Non-compliant installation	Hook testing is part of large-scale system testing (note, the design intent is the hook remains intact until the bag commences to shred under the influence of an explosion pressure pulse). SkillPro Services P/L routinely subjects the hooks to static load tests as per SP-2016-001 SkillPro Services P/L can investigate alternate hook designs on a case-by-case basis	SkillPro Services P/L Installation Document requires the mine to have some audit program to replace any damaged/missing bags/hook. Contract fillers are expected to have some scheme to periodically test samples of hooks using 20kg static load and report any deficiencies Abrasive wear can occur and needs to be part of ongoing mine inspections/ audits of system
	Sprayed by water		Refer filling	
	Insufficient bags/dust to prevent an explosion		Several layouts have been designed based on full-scale explosion tests. Refer to SkillPro Services P/L installation document.	Barrier design against guidelines is expected to be part of ongoing mine audits of major hazard management systems
	Barrier is penetrated by a fixed installation such as a conveyor	Explosion can pass through or around the conveyor	The SkillPro Services P/L document refers to this.	Barrier design against guidelines is expected to be part of ongoing mine audits of major hazard management systems
	Bags rubbed through by being	Inadequate dust density so the	SkillPro Services P/L Installation Document requires the mine to have some audit program	Barrier design against guidelines is expected to be part of ongoing mine audits of major

	hung too close to a conveyor	system does not work as intended in explosion	to replace any damaged/missing bags	hazard management systems

	Static discharge from being placed in airstream	Gas ignition by electrostatic discharge	The filled bags have been tested and assessed as not posing an electrostatic discharge hazard. IEC 613440-4-4-2005 as reported in DNMR report no. 08/367	Mine Procedures should prohibit unfilled bags /hooks being stored underground Mine procedures control the absence of ignitable gas levels
	Incomplete protection as bags not correctly hung across the road	Inadequate dust density so the system does not work as intended in explosion	The SkillPro Services P/L installation document covers the arrangements needed for most common scenarios	The SkillPro Services P/L installation document advises the mine to have some audit program to ensure bags are hung as per this document. The SkillPro Services P/L installation document advises the mine to take special note of obstacles such as vent ducts, monorails, suspended belts etc.

References

1. Preliminary Report of the Dust Distribution with Stone Dust Bags, Margenburg, B., September 1995

2. Explosion Tests with the Stone Dust Bags (RSA) in the Explosion Gallery (20m^2) Tremonia Experimental Mine, Dortmund, Michelis, J., Margenburg, B., Vassard, P., December 1995.

3. Supplement to DMT Report Entitled "Explosion Tests with the Stone Dust Bags (RSA) in the Explosion Gallery (20m^2)", du Plessis, J., January 1996.

4. Explosion Tests with the Stone Dust Bags (RSA) in the Explosion Gallery (20m^2) Tremonia Experimental Mine, Dortmund, Continuation, Michelis, J., Margenburg, B., du Plessis, J., April 1996.

5. Explosion Tests with the Stone Dust Bags (RSA) in the Explosion Gallery (20m^2) Tremonia Experimental Mine, Dortmund, Final, Margenburg, B., du Plessis, J., July 1996.

6. Assessment of the Stone Dust Dispersed Barrier, du Plessis, J., Vassard, P., January 1997

7. Lunn, G.B., 1988. The suppression of dust explosions in coal mines, *Mining Technology*, 70(808): 35-43.

8. Michelis, J. and Margenburg, B., 1991. Operational explosion protection with mobile explosion barriers, in *Proceedings of the 24th International Conference of Safety in Mines Research Institutes, Part 1*, pp. 231-243, Donetsk, USSR Ministry of Coal Industry and State Committee for Safety in Industry and Atomic Power Engineering.

9. Cybulski, W., Coal Dust Explosions and Their Suppression, USBM Translation from Polish, 1975.

10. Humphreys D.R., 2000, Bagged Barrier Testing at Overseas Facilities, Final Report of ACARP Project C7030.

11. Guideline for the Compilation of a Mandatory ***Code of Practice*** for the Prevention of Coal Dust Explosions in Underground Coal Mines, Department of Minerals and Energy, Mine and Health Safety Inspectorate (of South Africa), November 1997.

12. du Plessis, J., personal communication, 1998.

13. Humphreys, D.R. and O'Beirne, T.J., Comparative Testing of Bag Barrier Components, SkillPro Report B000033, November 2016.