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MANAGEMENT OF EXPLOSION RISKS IN UNDERGROUND COAL MINES WITH THE USE OF BAG BARRIERS

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Presentation Outline

- Recent US Coal Dust Explosion History
- Countries Researched and Prevention Strategies
- Similarities and Differences (Regulatory)
- Specific Project Objectives Regarding Disparity in Practices
- Bag Barriers (Characteristics and Guidelines)
- Trial Installations in US Underground Coal Mines
- Conclusions

Recent Coal Mine Explosion Disasters

2001
Jim Walter No 5
13 Miners

2006
Sago
12 Miners

59 Miners
Since 2001

2006
Darby No 1
5 Miners

2010
Upper Big Branch
29 Miners

Other Coal Producing Countries Researched

- Australia
- United Kingdom
- Canada
- New Zealand
- Republic of South Africa
- Other regulations not readily available in English
  - China, Russia, Poland, Germany, more
  - Not Heavily Researched

Explosion Mitigation Strategies

Four Sided Approach to Explosion Suppression

Explosion Mitigation Strategies

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Removal of Coal Dust Accumulations

Explosion Mitigation Strategies

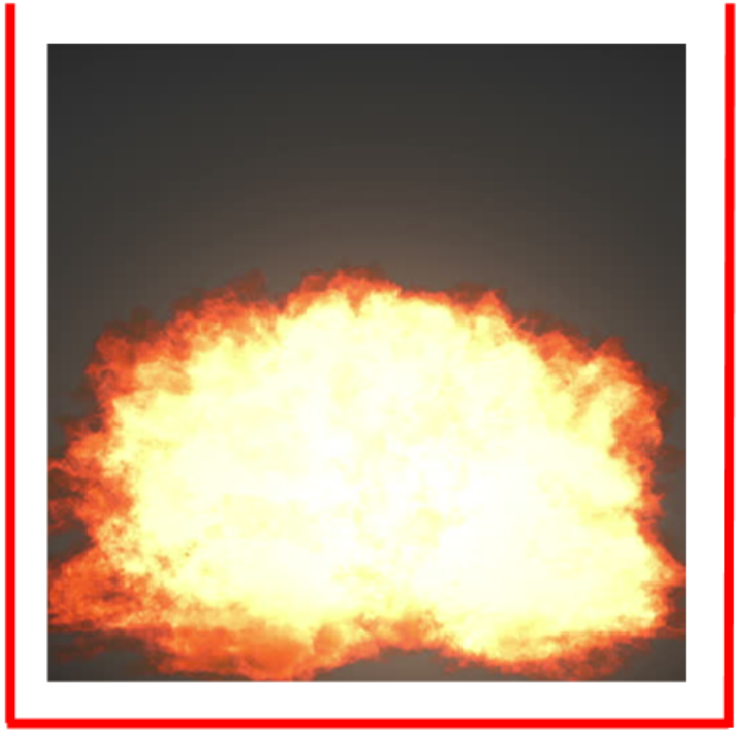
Four Sided Approach to Explosion Suppression

Removal of Coal Dust Accumulations

Wetting of Coal Dust

Explosion Mitigation Strategies

Four Sided Approach to Explosion Suppression



Removal of Coal Dust Accumulations

Inerting of Coal Dust via Rock Dusting

Wetting of Coal Dust

Explosion Mitigation Strategies

Four Sided Approach to Explosion Suppression

Install Explosion Activated Barriers

Removal of Coal Dust Accumulations

Inerting of Coal Dust via Rock Dusting

Wetting of Coal Dust

Regulatory Similarities and Differences

- **Similarities**
  - Strategies for prevention/removal of coal dust accumulations
  - Strategies for wetting of coal dust
  - Rock dusting required to within 12 meters (approx. 40 feet) of face
  - Increased rock dusting due to increased methane content
- **Differences**
  - U.S. CFR 30 does not require explosion barriers, all others do
  - Location, design, approval, and regulatory oversight of explosion barriers
  - Variable rock dusting incombustible content requirements (65% - 80%)

Disparity in Practices Raises Questions

- **What are the similarities/differences between barriers and regulations in countries that use them**
- **Are there significant differences in mines between U.S. and those using bag barriers?**
- **Can bag barriers be adapted/implemented in U.S.**
- **Can U.S. coal mining industry benefit from explosion barriers?**

How a Bag Barrier Works

- Coal dust explosions generally caused by methane ignition
- Explosion pressure wave travels faster than the flame front
- The pressure wave moves through ahead of the flame front and ruptures the rock dust bags
- The rock dust is dispersed and inter-mixes with the airborne coal dust
- The flame front is extinguished as it moves through due to higher incombustible content of the dust cloud

Typical Rock Dust Bag and Bagged Barrier

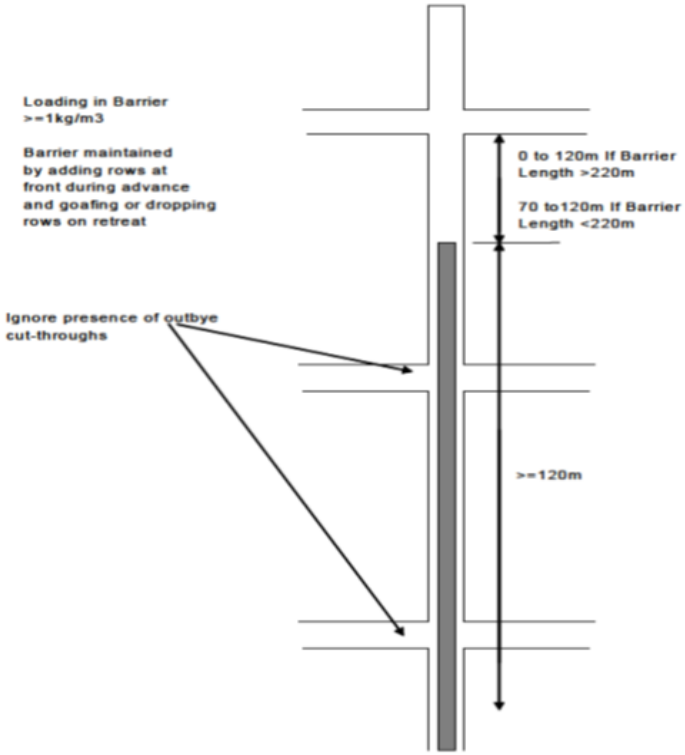
Comparison of General Guidelines for Bag Barrier Construction

General	UK	RSA	NSW
Minimum Bag Contents (kg)	6	5 (Low Seams) 6 (High Seams)	N/A
Stonedust Specs	Appropriate Type	*	**
Stonedust Amounts	1.2 (kg/m^3)	100kg/m^2 or 1kg/m^3 Whichever is Greater	≥200kg/m^2 within distance specs ≥400kg/m^2 outside specs
Bag Spacing	0.4 - 1.0	0.4 - 1.0	N/A
Bag Space to Rib	≤ 0.5	≤ 0.5	N/A
Row Spacing	1.5 - 3.0	1.5 - 3.0	$\frac{Stonedust\ mass\ in\ row}{cross\ section\ area}$
# of Layers (< 3.5m Height)	1	1	N/A
Spacing from Roof	≤ 0.5	≤ 0.5	
# of Layers (3.5-4.5m Height)	2	2	N/A
Spacing from Roof (Layer 1)	< 0.5	4m from Floor	
Spacing from Roof (Layer 2)	0.5 - 1.0	3m from Floor	
# of Layers (> 4.5m Height)	3	3	N/A
Spacing from Roof (Layer 1)	< 0.5	5m from Floor	
Spacing from Roof (Layer 2)	0.5 -1.0	4m from Floor	
Spacing from Roof (Layer 3)	1.0 - 1.5	3m from Floor	

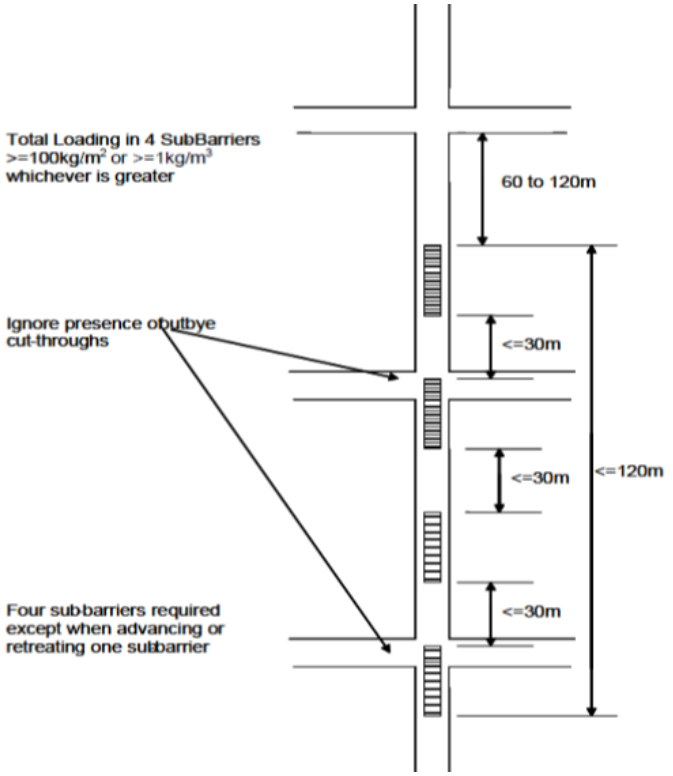
* = ≥ 95% by mass incombustible content density similar to pulverized limestone ≤ 5% by mass of free silica or other toxins 100% through 600 micrometer sieve 0% by mass through 75 micrometer sieve Does not cake unless directly wetted

** = < 3% by mass free silica ≥ 95% passes 250 micrometer sieve >60% but <80% passes 75 micrometer sieve

Distributed Barrier Designs in NSW and RSA

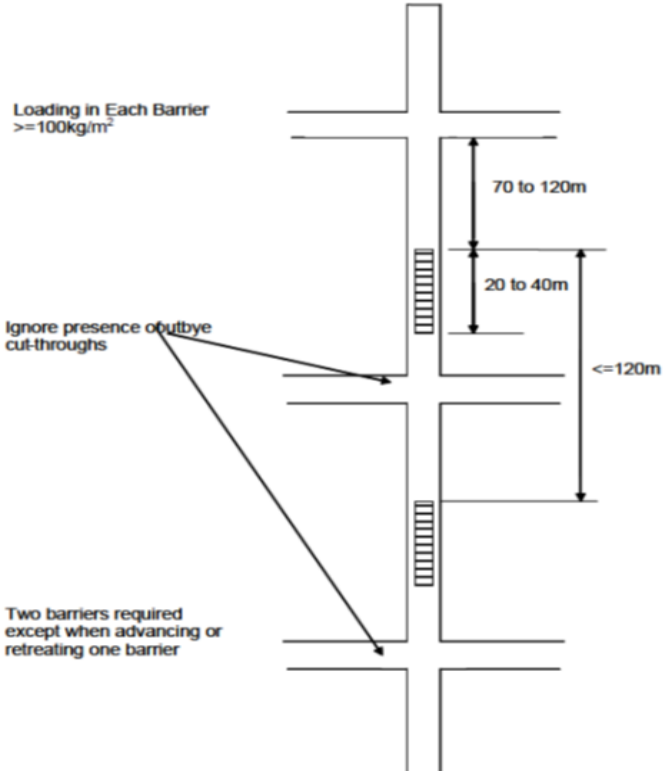


Continuous Distributed Barrier [1]



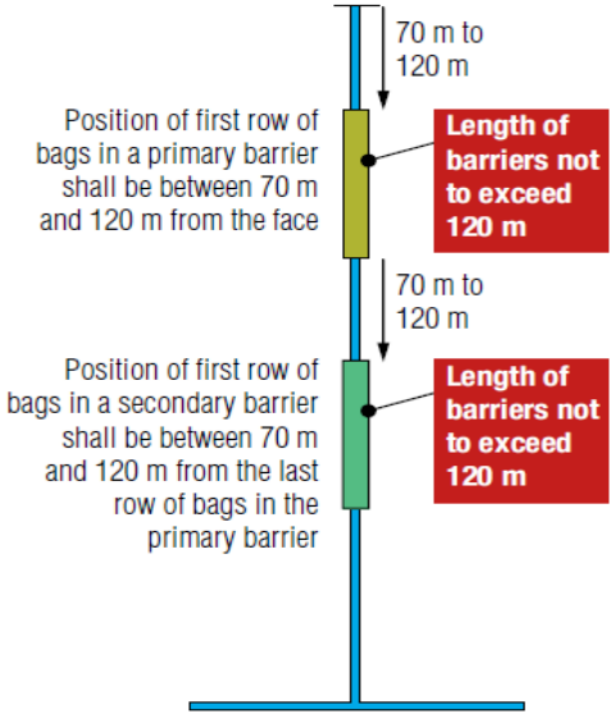
Discontinuous Distributed Barrier [1]

Concentrated Barrier Design in NSW and RSA

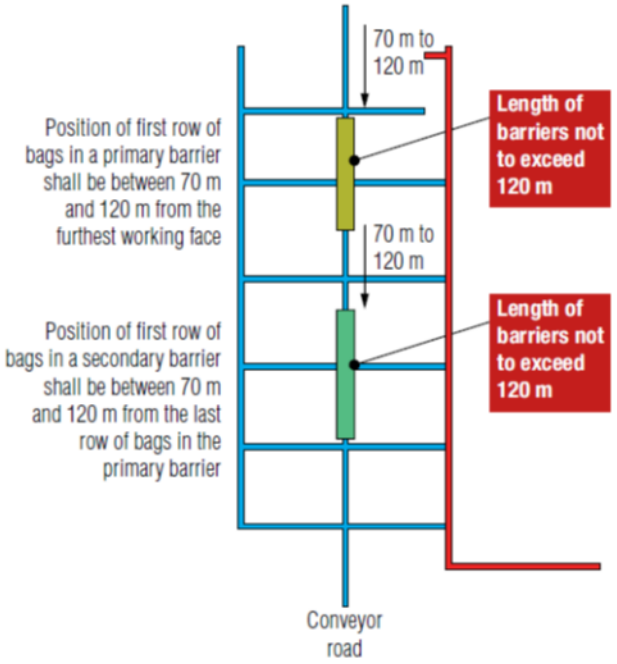


Concentrated Barrier [1]

Primary/Secondary Barrier Design in UK

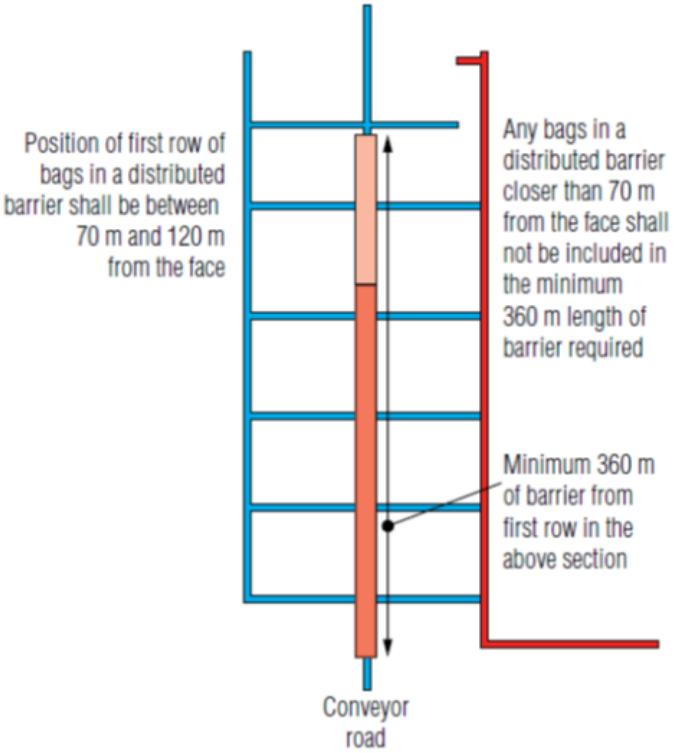


Coal Heading [2]

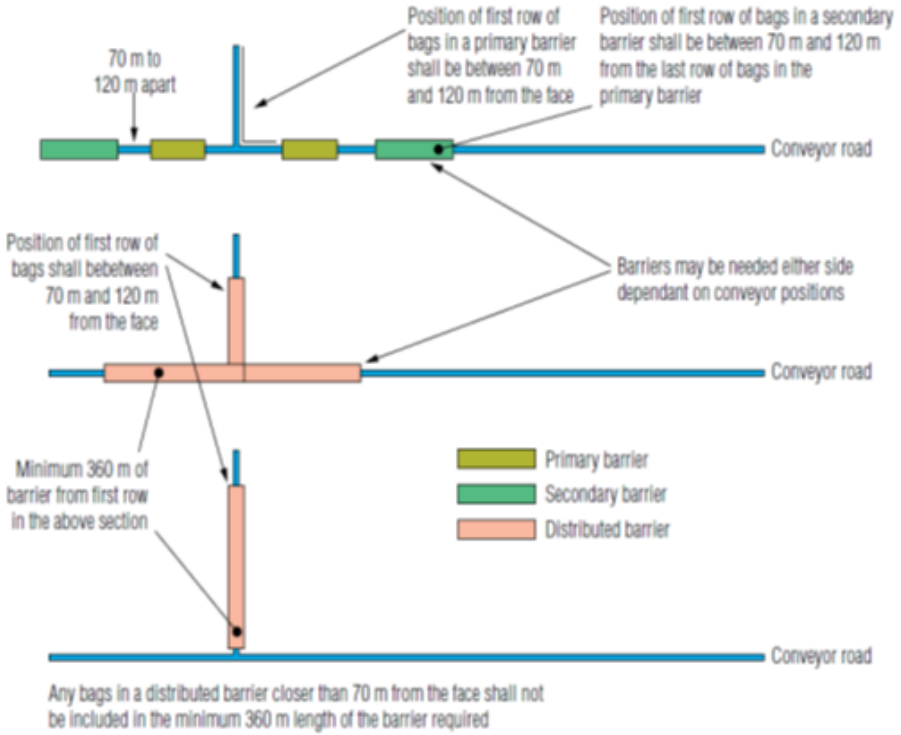


Bord & Pillar [2]

Other UK Barrier Design Considerations



Distributed Barrier Design in Bord & Pillar [2]



Typical Barrier Design when Intersection is Encountered [2]

Obstacles in Mine Entry

- **Suspended Obstacles** [2]
  - Ducting, piping, conveyors, & etc.
  - Bags must be hung around obstruction

- **Freestanding Obstacles**
  - Mainly conveyor structures
  - Additional bags must be hung from structure
  - Prevents flame propagation underneath structure

Main Differences in Foreign/U.S. Underground Coal Mines

- **Mining height**
  - **U.S. Mines typically shorter**
- **Ventilation**
  - **Bleeder type gob (goaf) ventilation not used in foreign mines**
  - **May require additional barrier installations**
- **Most differences due to technical specifics of individual mines**
  - **Can be carefully considered, organized, researched, accounted, and planned for with barrier design and placement**
  - **Similar process currently used in all foreign mines requiring barriers**

Bag Barrier Trials in U.S. Underground Coal Mines

- 5 Mine Sites Visited in Different Regions
- 2 Sites Selected in Eastern U.S.
- Representative of multiple entry medium height coal mines
- Different roof support methods
  - Roof mesh, bolts, straps, and plates
- Different locations
  - #2 (track) entry of 3 entry longwall section
  - #2 (power & piping) entry of 4 entry longwall section
- Left in Place for 5 weeks, returned for inspection and miner feedback

Conclusions

- **Similarities and differences in barrier designs due to regulatory, social, and technical differences between countries and mining (geologic) regions**
  - **All based off of same research and testing performed at Kloppersbos, Tremonia, Lake Lynn, and Barbara test facilities**
- **Differences in foreign and U.S. mines due to technical specifics of individual mine**
  - **Can be accounted for in barrier placement and design**
- **Bag Barriers can be adapted and implemented into medium height multiple entry underground U.S. coal mines**
  - **2 Trial installations completed**
  - **Positive feedback received**
- **Benefits to U.S. coal mining industry?**
  - **Preventing future fatalities in U.S. mines would be beneficial**

Questions

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Full reference list available