CANMET

Mining & Mineral Sciences Laboratory
Underground Coal Mining Safety Research Collaboration

Technical Information
Fact Sheet - Stone Dust

Fact Sheet on the Use of Stone Dust to Control Coal Dust Explosions in Underground Coal Mines

Background

The Underground Coal Mining Safety Research Collaboration (UCMSRC) is an ad-hoc association of stakeholders in the Canadian underground coal mining industry. It was established in 1998 after the closure of the federal government's CANMET Coal Research Laboratory in Sydney, Nova Scotia. The UCMSRC provides a forum for the discussion of safety and health topics in underground coal mines. Stakeholders include operating companies, Federal and Provincial government agencies, universities, unions and consultants.

The UCMSRC has commissioned studies on various aspects of underground coal mine safety and health as directed and supported by its stakeholders. To complement the earlier work on explosion barriers (Zou and Panawalage, 2001), the UCMSRC commissioned a review of international practice relating to the use of stone dust to control coal dust explosions after a request from several stakeholders.

Coal Dust Explosion Hazards

Coal dust explosions occur when fine coal particles become airborne and are ignited by some means. In a coal mine, the precursor to a coal dust explosion is usually the ignition and explosion of a quantity of methane (explosive in the range of 5% to 15%). Due to the confinement of the roadway a pressure wave is created which causes fine coal dust to become airborne. This is in turn, ignited by the flame that lags behind the pressure front, further driving the pressure front along and raising more dust ahead of the flame front. Until there is a break in this cycle of raising then igniting coal dust, the explosion continues to propagate generating destructive pressures and large quantities of irrespirable and toxic gases. Ultimately, a coal dust explosion could pass through the entire mine until it reached the surface. (Humphreys and O'Beirne, 2000)

Float Dust Hazards

Any accumulation of coal dust is hazardous. The finer the dust the more danger it represents. Float coal dust is the fine dust deposited on the roof, ribs and floor and presents a continuing hazard in coal mines. Campaign stone dusting can be ineffective as a combative measure, because float dust is continuously produced and dispersed into the air stream.

Measurements of the depth of dust layers involved in explosions has shown that only the top 2-4 mm of roadway dust is stripped off of the floor layer in a float dust explosion. For inerting purposes, any float dust deposited between campaign dusting, plus this layer, must have the requited total incombustible content (TIC). The TIC contribution required of floor dust increases with float dust thickness. Even if the underlying incombustible stone dust content is greater than 80%, an upper float dust layer will propagate an explosion since only the top 2 to 4 mm of floor dust is stripped away during a typical explosion event. Float coal dust can be deposited on the roof and sides of the roadway, as well as the floor, which makes it especially dangerous (Hartmann and Westfield, 1956).

Anatomy of a typical Coal Dust Explosion:

- Development of an explosive methane/air atmosphere
- Ignition of the gas
- Development of the primary (gas) explosion and acceleration of the flame displaced gasses outward
- Lifting of coal dust by airflow (the displaced gases), and creation of an explosive mixture
- Ignition of the dust / air mixture
- Further turbulent acceleration of the dust flame front, lifting more dust, mixing it with air, and creating an explosive zone in front of the flame
- Propagation of a dust explosion throughout the mine

Preventing Coal Dust Explosions

Prevention is based on eliminating one or more of the essential components: heat, fuel and oxygen.

Eliminating Heat - Eliminating heat sources in underground coal mines has been the goal of regulation ever since the discovery that methane explodes. The most common ignition source in modern underground coal mining is frictional ignition. Frictional ignitions can be controlled by effective cutter drum maintenance (replacing blunt picks and maintaining water sprays), and the use of water sprays directed behind the pick path to cool any metal smears. Other sources of ignition include electrical, flame, explosives and lightning.

Eliminating Methane - A frictional smear or spark will only ignite methane if it is present in explosive amounts. Consequently, the primary defence against accumulations of methane is effective ventilation. On longwall faces, ventilation of the face area, assisted by water venturis in the cutter drum and in some instances by methane drainage, is usually effective in dispersing and diluting methane. In room and pillar workings or in a single entry development in coal, where through ventilation isn't possible, fresh air has to be introduced to the cut to disperse the methane via auxiliary fans and ventilation ducts. A combination of well placed, well engineered and well maintained water sprays behind the cutting picks is also required. In addition to providing adequate ventilation most jurisdictions require methane monitors to be fitted to mining machines. Above a predetermined level of methane electrical power to the machine can be automatically or manually cut.

Eliminating Coal Dust - The production of coal dust is as inevitable as the release of methane in an underground coal mine. Much of the coal dust is entrained in the coal that is removed from the mine, however a significant portion of the dust is removed by the air stream. This dust can fall to the floor or cling to the roof and ribs. Washing the roof and ribs to remove accumulations of dust assists in reducing the amount of dust present. Removal of accumulations of coal dust after mining, or at other spillage points such as belt transfer points and belt tail ends, is good mining practice.

Suspension and Confinement - There are two approaches to preventing a suspension of flammable dust from forming in response to the initial ignition. Firstly, the dust can be kept on the roof, sides and floor by ensuring that it is sufficiently wet. Secondly, the most widely used approach to elimination of the coal dust problem is to add stone dust to the roof, ribs and floor to render the coal dust inert. In addition, many mines use explosion barriers which are designed to be activated by the pressure wave in front of an explosion, and flood the area with either water or stone dust, which renders any suspended dust inert.

Explosion Barriers - Explosion barriers control, and hopefully extinguish, coal dust explosions by removing the "fuel" from the explosion by engulfing the area of the barrier in an incombustible cloud of inert material or water, thus extinguishing the flame. Passive barriers, and most of the active barriers so far developed, use water or inert dust as the quenching medium. In the case of passive barriers, the explosion shock wave travelling in advance of the explosion disturbs the barrier. This causes the area of the barrier to be deluged with either water or inert dust, which quenches the flame. In the case of active barriers, sensors detect the approach of the flame, and a positive pressure system deluges the area with water or inert dust, again quenching the flame. Explosion barriers do have their limitations, such as in multiple entry room and pillar sections where the force of the pressure wave preceding the flame front is required for the barrier to deploy.

Stone Dusting - Stone dusting involves the application of an inert dust to the roof, ribs and floor of the mine roadway to render coal dust inert. Stone dust can be applied in any one of several ways, however automated stone dusters are now commonly use.

Stone Dust Properties

Stone dust is a pulverized inert material such as limestone, marble, dolomite, or anhydrite. Light colored material is preferred due to its light reflective characteristics (ASA, 1960). Limestone and similar carbonates produce the best rock, as their tendency to cake is low, and they have a light color, which aids illumination.

The particle size of stone dust deployed to reduce the Total Incombustible Content (TIC) of roadway dusts is an important consideration. Stone dust is denser than coal dust, and is therefore harder to raise into suspension. The optimum fineness (Jensen and O'Beirne, 1997) is 70% passing 75 micron, and the same authors report evidence that a mean particle diameter of 20 microns presents significant advantages. Further reduction of size does not improve effectiveness because very fine stone dust tends to agglomerate and will not be lifted into suspension by the explosion pressure wave as effectively.

Stone Dust Application

Stone dust can be applied in any one of several ways. Campaign stone dusting is usually accomplished by mechanical means. Tanks or other bulk stone dust carriers are used to spread stone dust on the roof, sides and floor to the required density. Because of the dust entrained in the mine air, this is difficult to do during operational shifts, and is usually done only once subsequent testing indicates a need for it. Over small areas, stone dust can be distributed by hand. If the surface of the roof and ribs is wetted prior to the application of stone dust, the adherence is substantially increased (Hartmann and Westfield, 1956).

Wet dusting is practised in some areas, especially when it must be done during production shifts. The application of wet stone dust reduces the ability of the dust to prevent propagation until the dust is completely dry.

Mechanized rock dusters, or trickle dusters, are employed in return airways to dilute float dust entrained in the air from the production face. They are also deployed in belt roadways to inert dust generated by the operation of the belt.

Incombustible Content

The ultimate test of the effectiveness of an inertization program is that it quenches an explosion when one occurs. Quenching will not occur if the incombustibles content of the roadway dust is not maintained at a safe level. The definition of a safe level is legislated in all mining jurisdictions, and ranges from 50% in intake roadways in the low volatile coal seams of Alberta to 85% in all roadways within 200 m of the last open cross-cut in Queensland, Australia.

Sampling Methods

Roadway dust sampling is conducted to determine whether or not the total incombustible content (TIC) of the roadway is high enough to prevent or suppress an explosion. The sampling method must have:

- adequate coverage, to ensure that all parts of the mine meet the appropriate standard,
- appropriate frequency, to ensure that time dependent deterioration of TIC's do not present a hazard to the mine, and
- a methodology that allows accurate determination on the success or failure of the roadway dusting program

Stone Dust Analysis Methods

There are four recognized methods for the analysis of mine roadway dust samples:

- High temperature ashing
- Low temperature ashing
- Volumetric
- Colorimetric

Both high and low temperature ashing are chemical methods enabling a precise measure of the inert content of the roadway dust. Volumetric and colorimetric methods have been preferred because they are faster (hence less expensive) than the chemical methods. However, automatic coal analyzers have greatly improved the ability to conduct assays quickly and accurately by chemical methods.

Recommendations

1. Avoid and/or remove accumulations of coal dust, including 'float' dust. Frequent examination, sampling and testing of roadway dust is required.
2. Stone dust standard should require, as a minimum, a dust fineness of 70% passing a 75 micron sieve.
3. Ideally, total incombustible content (TIC) of roadway dust should be 80-85% in the face area, in excess of 80% in return roadways and 65% - 70% in other areas (e.g. intakes).
4. Frequent stone dusting is required in order to maintain total incombustible content (TIC).
5. Separate samples of dust from the top 6mm of dust on the roof and sides, not just the floor should be taken. Water on the floor should not be assumed to render dust on the roof and ribs inert.
6. The use of explosion barriers is recommended as a minimum on conveyor roads within 180 meters of the face.
7. Eliminate potential sources of ignition.
8. Eliminate or reduce hazards due to methane gas accumulations.
9. A code of practice should be developed which would cover the above, including minimum standards for the application, examination, sampling and testing of roadway dust and the use of explosion barriers and QA/QC measures.
10. Additional research into explosion suppression systems and more testing of Canadian coals.

Please refer to the report "The Use of Stone Dust to Control Coal Dust Explosions: A Review of International Practice" by P.Cain. A copy of this fact sheet and P. Cain's report can be obtained at http://www.ugcoal.ca .

References

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[3] Hartmann, I. and Westfield, J. (1956); "Rock Dusting and Sampling", US DOI Bureau of Mines IC 7755 June 1956

[4] ASA (1960); "American Standard Practice for Rock Dusting Underground Bituminous Coal and Lignite Mines to Prevent Coal Dust Explosions", US Department of Interior, Bureau of Mines IC 8001, 1960.

[5] Jensen, B., and O'Beirne, T., (1997); "Design and Efficiency of Dust & Water Explosion Barriers in Modern Australian Mines", Final Report on ACARP Project C5430, January 28, 1997

[6] Cain, P. (2003); "The Use of Stone Dust to Control Coal Dust Explosions: A Review of International Practice", ROKDOK, Prepared for Underground Coal Mining safety Research Collaboration (an association of stakeholders in the Canadian underground coal mining industry). Paper available at: http://www.ugcoal.ca