Department of Mines
Western Australia

No. 1

S A F E T Y B U L L E T I N

SULPHIDE DUST EXPLOSION HAZARD

PRELIMINARY

It is likely that the potential hazard of sulphide dust explosions in confined environments, particularly underground mines, may not be widely or fully understood throughout the industry. The purpose of this Bulletin is to re-iterate this hazard and to advise of current developments in evaluation and control of explosion potential which are taking place in Australia and Canada, in particular.

INTRODUCTION

The following extract from a paper by Dr George Lukaszewski of the CSIRO summarises the essential conditions which can lead to sulphide dust explosions:

> "Sulphide minerals oxidize rapidly when broken and exposed to air and, in operations where such minerals become dispersed as dusts, sparks or heat flash from blasting can initiate an explosion. The consequences can range from mine pollution by sulphurous gases to loss of life.
>
> The reactivity and ignitability of different sulphides can be determined in the laboratory. Iron-containing disulphides such as chalcopyrite and pyrite are the most reactive and have the lowest ignition temperatures, shortest thermal exposures for initiation and highest burning intensities. Their dusts are the most susceptible to 'flash' initiation and explosive propagation. While the metal monosulphides are less reactive, in the presence of moisture they may 'age' or weather to produce elemental sulphur in forms that dramatically lower dust ignition energies.
>
> In general, all sulphide dusts of fineness below about 50 um are flammable and can be ignited by thermal energies well below those commonly generated by blasting. Ignition events can thus occur frequently, but will not necessarily be propagated to produce an explosion.
>
> Assessments of the likelihood of explosions can therefore be made on the basis of ore composition and tendency to fragment into the dangerous size range. Monitoring of atmospheric dust content is vital in controlling the hazard. Such monitoring yields not only the dust composition, concentration and size distribution but also points to the occurrence of ignition events which show up through characteristic changes in chemical composition of the dust".

Explosions have been associated with development, primary stoping and secondary breaking, with blasting involved in all cases.

A considerable amount of test work, both laboratory and field based, has been carried out in an attempt to better identify the conditions which may lead to an explosion and also the effectiveness of various means of mitigation.

RECOGNITION OF THE POTENTIAL CONDITIONS FOR AN EXPLOSION

Dust explosions in metalliferous mines have generally been associated with mining operations in massive pyritic or pyrrhotitic ore bodies. Other minerals with an appreciable sulphur content may form an explosive dust cloud; laboratory tests have shown that sphalerite dust can sustain an explosion.

Sulphur Content of Common Sulphide Minerals

Mineral	Formula	Sulphur %
Pyrite	FeS2	53.3
Pyrrhotite	Fe1-xS	50-55
Chalcopyrite	FeS2	34.9
Sphalerite	ZnS	32.9
Arsenopyrite	FeAsS	19.6
Galena	PbS	13.4

Obviously, the common and extensive occurrence of pyrite makes it the most likely mineral to present this hazard.

Test work has shown that with faces containing greater than 20% pyritic sulphur, the possibility of a dust explosion exists.

Vigilance should be exercised where there is any significant showing of massive sulphides, as sulphide dusts may accumulate in headings from successive blasts, to be raised as a dust cloud triggered by a later blast, particularly where a burn cut and easers may be fired in a highly pyrite zone. It has been established that if the dust size exceeds 400 micron, explosions will not propagate.

The principal researcher into this subject in Australia (Dr Roger Enright of Sydney University), advises that since 1969 over 30 explosions associated with stope blasting and 200 in development headings have been reported. It is likely that there have been a further considerable number either not reported or not recognised.

To date, explosions in development headings have been more common, and although there are many factors to be taken into consideration, this is probably due to the high powder factor in such blasting generating finer dust (particularly in the burn cut) and ignition by the flame front from unstemmed holes. The volume of a development heading is limited and the delay interval between shots is usually more extended, resulting in a relatively high dust concentration.

EVIDENCE OF AN EXPLOSION - THE AFTERMATH

Following a dust explosion, the following are usually found:

- evidence of a flame front, charred plastic (vent, cables, bell wire etc) or other combustible material;
- red or black dust (haematite or magnetite) deposited in headings;
- residual gases, chiefly sulphur dioxide (SO2) and sometimes H2S;

- damage to installations or equipment due to the propagation of an air blast wave.

In the case of dust explosions deriving from large scale open stope blasts, the results have been devastating.

MEASURES RECOMMENDED TO PREVENT OR TO MITIGATE DUST EXPLOSIONS

General

1. Determine if there is a risk. Examine the mineralogy in all areas being mined. Note all areas where the sulphur content of the minerals exceeds 20%.
2. Formulate procedures to prevent and to minimise risk including:
   - written practices for prevention or confinement of dust explosions;
   - training of personnel (including retrain and follow up) in awareness and precautions;
   - firing procedures (evacuation of personnel, location of firing boxes etc);
   - records of dust explosions (notification of the Mines Inspectorate).
3. Control the potential exposure of persons to the effects of the dust explosion aftermath –
   - monitoring of SO_2, H_2S etc. if present;
   - clearance of the mine or part of the mine before blasting;
   - provision of fresh air bases, respirators or SCBA.

Summary of Preventive or Mitigating Measures which have been Employed in High Sulphide Areas.

The following techniques are available to prevent or inhibit a sulphide dust explosion:

- Inert the combustible dust produced during blasting;
- Reduce the temperature and volume of the gases generated by detonation of high explosives, and prevent ignition of the cloud produced during blasting;
- Remove or inert previously deposited dust which may contribute to a primary or secondary dust explosion;
- Quench the flame of an existing dust explosion;
- Limit the effects of the toxic gases (SO_2 and H_2S) following in the wake of an explosion;
- Reduce the oxygen content in an underground excavation with the inert gases produced during blasting.

It has been established that if the ambient atmospheric oxygen content is reduced to 13%, an explosion will not occur.

SPECIFIC MEASURES

No accumulation of sulphide dust should be allowed. Headings in which dust settles after blasting should be regularly washed down. Always wash down before blasting.

Development Blasting

- Ensure that no personnel are within range of any dust ignition blast which may result from any face being fired;
- Stem all holes with inert materials preferably limestone dust cartridges - suspend a bag of limestone dust in front of the burn cut;
- Minimise the spread of delays used in the blast;
- Use air water sprays (preferably a bank of two or three) at distances of 15 m to 45 m from the face;

- Remove all inflammable material from the blast area (to a point outside the air/water spray zone);
- Water down and wash away dust before blasting.

Secondary Blasting

- This should be restricted to 'pops' and the holes drilled and charged should be stemmed with inert material;
- 'Blister' or 'plaster charges' (such as 'pillow packs') should be avoided;
- All pops should be fired on the same delay, or preferably with instantaneous detonators;
- Water down the blast area and use air-water curtain sprays as for development blasting.

Open Stope Blasting (Large Scale)

- All large scale production blasting should be detonated electrically from the surface after a complete evacuation and check of the mine;
- All accessible development adjacent to and connected to the stope should be watered down before the blast;
- Air/water blast sprays should be set up in adjacent connected development to form a water fog;
- Delay scatter for the blast should minimised;
- Remove all inflammable material in the vicinity;
- Stem all charges with inert (eg. limestone) dust or water;
- Inert dust to be dispersed by charges with the blast may be set up;
- Check the mine carefully after the blast for evidence of a sulphide dust explosion; in particular check for residual toxic gas.

NOTE: test work to date has cast doubt on the effectiveness of dispersal of inert (eg. limestone) dust as a dilutant. It is likely to be more successful for development firings than for large open stopes.

SUMMARY

If there is any apprehension of the potential risk of a sulphide dust explosion, contact the Mining Engineering Division Inspectorate for advice.

If any evidence of a dust explosion is found, it must be reported to the District Inspector (Mines Regulation Act Section 31 (5)(e)). The Inspectorate will investigate and advise, and will pass the information to the Australian Sulphide Dust Association.

There is an on-going programme of research being conducted into this hazard, and links have been established with CANMET of Canada on the issue.

It is planned to have one day field seminars conducted in a number of mining centres in WA later in the year, probably near the time of the MINESAFE 1990 Conference in September.

A copy of a questionnaire prepared by the Sulphide Dust Association has been attached which will assist in appreciating the problem.

J M Torlach
STATE MINING ENGINEER
7 February 1990

QUESTIONNAIRE
OPERATING HINTS
PREVENTION OF DAMAGE AND INJURY FROM
SULPHIDE DUST EXPLOSIONS
A. INTRODUCTION

This questionnaire has been prepared following the meeting at the Hellyer Mine Tasmania, on 9 November 1989 of the Australian Sulphide Dust Association.

The aim is to pool the experiences of operators with a view to preventing injury to persons or significant damage to property, without necessarily waiting for an answer to the question of what mechanisms are important in these sulphide dust explosions.

Any answers from this questionnaire are not to be construed as regulatory requirements, nor used as evidence, etc.

B PREDICTION

1. Do you have a system for predicting sulphide dust explosions? (please explain)

2. Have you undertaken any analyses of:

    a. ore (eg. grain size and minerals) which has high dust explosion potential.
    b. products of the blast?

3. Have you developed any rules of thumb as to causes of dust explosions eg. why there may be more hematite formed on some occasions than magnetite?

4. Are you able to say which areas or types of firings are more likely to produce dust explosions?

5. How do you keep records of dust explosions?

C. PREVENTION

1. What is your standard procedure for preventing or containing a dust explosion? (If it is not written down, would you indicate the preventive measures).

2. Do you restrict the type(s) of blasting when a dust explosion is predictable - eg. cessation of firing in nearby open cuts, multiple heading firings, pops with stope blasts?

3. Do you use special explosives, or avoid certain explosives?

4. Do you use special stemming techniques? Please provide the specifications for your stemming material.

5. Please provide a drawing of your air/water spray. Can you indicate what air and water pressures and volumes you use?

6. Please describe how you set up your air/water sprays (eg. proximity to face, direction of spray).

7. How do you water down before firing ie. how particular are you and over what distance?

8. What issues are important in the training of:

   a. operators,
   b. supervisors, and
   c. ventilation officers?

D. CONTROL OF PERSONAL EXPOSURE

1. From where are shots fired when dust explosions are predicted (or possible)?

2. What evacuation procedure do you have for each principle type of blast?

3. Do you have a particular technique for checking whether the workings are clear for return to work?

4. Do you have any technique (other than smell) for sensing abnormal SO_2 production?

5. What special instructions are your operators given for detection of possible dust explosions?

6. Do you set up your ventilation equipment differently if dust explosions are possible?

7. Do you have any special fan re-setting procedures (if the forced ventilation fans are tripped by a dust explosion)?

8. Do you have fresh air bases and/or oxygen self-rescuers set up especially for dust explosions?

9. Do you have any special fire-fighting or rescue gear at the ready for dust explosions, or special notification of control centres?

E. OTHER MATTERS

Please describe.