SAFETY MANAGEMENT OF UNDERGROUND COMBUSTIBLE SULPHIDE DUST

GUIDELINE

Department of Industry and Resources

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FOREWORD

This Department of Industry and Resources guideline has been issued to assist in identifying hazards and developing appropriate preventative strategies and training action plans to deal with the safe management of underground combustible sulphide dust. Adequate preventative strategies and the use and training of correct procedures is fundamental to the duty of care.

It is emphasised that this guideline is not totally inclusive of all factors concerning the "Safe Management of Underground Combustible Sulphide Dust," and that in some respects, it may not be totally suited to the individual requirements of susceptible mines.

Comments on, and suggestions for improvements to the guidelines are encouraged. The guideline will be revised as appropriate to accommodate comments, as well as reflect legislative changes, new information, improvements in technology and operational experience.

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1.0 INTRODUCTION

The Department of Minerals and Energy Safety Bulletin No. 1 “Sulphide Dust Explosion Hazard” February 1990, highlighted the concern for this problem. The hazardous nature of an uncontrolled Sulphide Dust Ignition (SDI), most likely an explosion, has been the subject of serious research only since the early eighties. It has also been the subject of a number of significant incident reports by mining inspectorates in Tasmania and New South Wales.

This guideline applies to underground metalliferous mines and recommends precautions to be taken where there is a possibility of encountering pyro-sensitive sulphide dust. Hazards created when a sulphide dust ignition occurs can include fire, toxic gases, oxygen deficiency and/or damage from an explosion.

In recent years considerable research on SDIs ("dusties" to some) has been conducted by Dr Roger Enright of Sydney University. During the nineties this research was carried out in conjunction with Australian Mineral Industries Research Association Limited (AMIRA). The focus being to; identify how an ignition develops, evaluate current control methods, and develop appropriate control measures where possible. The team involved was successful in most of these areas. A new research program is underway to identify more practicable methods of control.

The incidence of reported sulphide dust ignition occurrences in mines in Western Australia is very low.

World wide, over the last 20 years there has been an increasing incidence of SDI explosions which appears to coincide with the increasing use of larger hole diameter blasting. Of particular concern is vertical crater retreat (VCR) mining.

This guideline has been compiled from documents referenced in the Appendix, reviews of mining practice, and consultation and interaction between the Inspectorate and Industry. It should be noted that other mining dusts which may ignite and explode are not covered by this guideline.

2.0 LEGISLATIVE REQUIREMENTS (WA)

Regulations contained in the Mines Safety and Inspection Regulations 1995 which are relevant to underground mines subject to sulphide dust ignitions are:

Specific emergency precautions required to be taken for underground mines

4.36. (1) This regulation applies to any of the following potential incidents -

(a) a fire;
(b) an accidental explosion (including a sulphide dust or coal dust explosion);
(c) a failure of the primary ventilation system;
(d) flooding;
(e) an inrush of mud or tailings;
(f) an inrush or outburst of gas; or
(g) the extensive collapse of workings.

(2) The principal employer at, and the manager of, an underground mine must ensure that, so far as is practicable, the following things have been done to ensure the safety of persons working underground in the mine in the event of a potential incident to which this regulation applies -

(a) An alarm system has been installed and a procedure has been established for activating the system;
(b) A procedure has been established for the prompt notification of rescue and fire fighting teams;
(c) A procedure has been established for evacuating persons working underground;
(d) Fire refuge chambers and fresh air bases are provided for persons working underground;
(e) Provision has been made for the safety of drivers of winding engines at underground shafts;
(f) All employees are adequately trained and retrained in emergency procedures and the use of emergency equipment and facilities; and
(g) Emergency drills have been conducted on a regular basis.

Penalty: See regulation 17.1.

Self rescuers in underground mines

4.34. (1) The manager of an underground mine must ensure that any person who goes underground in the mine -

(a) Is provided with (at least) a filter self rescuer or (preferably) a self contained self rescuer; and
(b) Is fully trained in the use and limitations of the self rescuer provided.

Penalty: See regulation 17.1.

(2) If there is a risk of a dust explosion or an identified risk from naturally occurring noxious or asphyxiant gases in an underground mine, the manager of the mine must ensure that all persons who go underground in the mine are provided with self contained self rescuers.

Penalty: See regulation 17.1.

(3) A person in an underground mine must not -

(a) Wilfully damage a self rescuer; or
(b) Use a self rescuer for a purpose other than the preservation of life or to demonstrate how it works.

Penalty: See regulation 17.1.

Monitoring of toxic, asphyxiant and explosive gases

9.29. (1) Each responsible person at a mine must ensure that adequate precautions are taken to monitor, and control the risk from, the formation or emission of toxic, asphyxiant and explosive gases in the mine.

Penalty: See regulation 17.1.

(2) If gases such as hydrogen cyanide, hydrocarbons, carbon dioxide, radon, sulphur dioxide, hydrogen sulphide, carbon monoxide, or methane are likely, suspected or known to be generated or emitted in a mine, the manager of the mine must ensure that the district inspector and employees at the mine are notified of the precautions that have been taken to monitor, and control the risks from, those gases.

Penalty: See regulation 17.1.

(3) The manager of an underground mine must ensure that, in any workplace in that mine, the atmosphere does not contain more than 12500 ppm, or 1.25% by volume, of methane.

Penalty: See regulation 17.1.

(4) If in any operation at a mine toxic, asphyxiant or explosive gas is emitted into the atmosphere in any travelway or other workplace, the manager of the mine must ensure that, where practicable, a monitoring device or monitoring devices are installed in the mine to give adequate warning of when the peak or STEL level of gas concentration is being approached.

(5) If any monitoring device is installed as provided in subregulation (4), the manager of the mine must ensure that adequate notices are erected in or about the mine informing persons of -

(a) The meaning of the warnings given by the device; and
(b) What action is required to be taken in the event of any such warning being given by the device.

Penalty: See regulation 17.1.

Sulphide dust ignitions

10.29. The manager of an underground mine in which minerals in the form of sulphides are present must ensure that -

(a) The risk of sulphide dust ignition is thoroughly evaluated before mining operations commence at the mine;

(b) procedures and work practices are developed and followed that minimise the risk of an explosion; and
(c) procedures are developed and followed that prevent injury or harm to the health of any person in the event of a sulphide dust ignition following blasting.

Penalty: See regulation 17.1.

3.0 DUST EXPLOSIONS

Many common dusts are combustible and with the right set of circumstances are explosive. It is worth noting that dusts generated from a large range of agricultural products feature prominently on the list. Some mineral dusts are also a major concern and when encountered in an underground mine the hazard is an order of magnitude higher. Of particular interest in mining is the uncontrolled combustion of sulphide and coal dusts.

Dr Enright describes a dust explosion as "*essentially a very rapid combustion of a suspension of fine particles, during which heat is generated at a higher rate than is dissipated to the surroundings. This phenomenon is characterised by the sudden development of pressure and a flame front which can cause loss of life and extensive destruction of plant and equipment. The explosion leaves in its wake an atmosphere with reduced oxygen content and highly toxic gases*".

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 oxidise 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 μm 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".*

Dr Enright's work has shown that:-

1. Pyritic ores with sulphur content greater than 18% can support a dust explosion.
2. Ignition temperatures of pyritic ores vary between 320^{o}C and 365^{o}C.
3. Minimum oxygen concentration to support a dust explosion is 13%.
4. No significant difference has been observed in explosion parameters of pyritic and pyrrhotitic ore.
5. Minimum explosive concentration of a pyritic ore is around 200 g/m^3.
6. Reactive sulphide dust is dust that is less than 180 microns in size.
7. Sulphide ores have about 20% as much energy (fuel) as coal and if an explosion occurs it is somewhat less violent.

Oxidation of sulphur bearing mineral can be extremely rapid. The reactions are:

$$3\,FeS_2 + 8O_2 = Fe_3O_4 + 6SO_2\uparrow$$

(black magnetite)

and/or

$$4\,FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2\uparrow$$

(reddish haematite)

Note the significant amount of $S0_2$ given off in both reactions.

It is known that chemical composition affects the intensity of reactions that occur. Fortunately chemicals known for their volatile reactions are not part of the mining scene.

There is support to the theory that spontaneous chemical reaction in a confined space has a part to play in a dust explosion. Testing in Canada has shown that spontaneous oxidisation is greater for coarser sulphide dust particles (27μm) of lower S content (15%) than for finer particles (10μm) of higher S content (22%). The reasons are unknown.

4.0 MINERALS OF CONCERN

A number of sulphide minerals are encountered in mining, some of which produce combustible dusts. Others are questionable, however caution should be practiced when mining materials containing sulphide minerals.

Pyrite and pyrrhotite minerals are the main concern. Tests have shown that explosions may occur in dusts containing 18% sulphur as a pyrite mineral.

4.1 Sulphur Content of Common Sulphide Minerals

Mineral	Chemical Composition	Sulphur %
Pyrite	FeS_2	53.3
Pyrrhotite	$Fe_{1-x} S$	52 - 53.5
Chalcopyrite	$CuFeS_2$	34.9
Sphalerite	ZnS	32.9
Arsenopyrite	FeAs S	19.6
Galena	PbS	13.4
Pentlandite	$(Fe, Ni)_9 S_8$	32.7 - 33.8

5.0 HAZARDS

The hazards to be expected when a sulphide dust ignition (SDI) occurs will reflect the intensity of the event. Consequences can vary from minor burning of services to multiple fatalities. Explosions related to SDIs have occurred in development mining, primary stoping and secondary breaking.

Where sulphides are mined management needs to be diligent with regard to gathering any evidence related to an SDI occurring. Evidence of such events may be minuscule but in the right circumstances such evidence may help to prevent a major explosion occurring. Prediction is difficult. Therefore it is critical to develop a bank of data to assist with planning, and to develop an early warning system.

The main effects of an SDI can be:-

5.1 Heat

The heat generated may vary from that produced by the oxidising sulphide minerals, (leaving red oxide traces), to that produced by an explosion which may set fire to any combustible material in its path. Burnt ventilation ducting and electrical cables are often evident. Burning of timbers has not been reported, however this is probably because of the scarcity of timber in mechanised mines.

5.2 Air Blast

The energy developed cannot be quantified but can be significant. The air blast from a sulphide dust explosion has been known to propel diesel loaders along a level. What is more dangerous is that the air blast has the capacity to reverse air flow circuits in the mine. Ventilation doors can be demolished, and electrical cables to fans can be burnt or pulled apart.

5.3 Toxic Gases

The main gas produced in an SDI is sulphur dioxide ($S0_2$), some hydrogen sulphide (H_2S) may also be produced. All injuries (including fatalities) that have occurred following sulphide dust explosions have been attributed to $S0_2$. The toxic gas produced at such an event may be disbursed around the mine in a manner which is quite different to the normal ventilation flow. Where flows have reversed, secondary ventilation may draw from exhaust and deliver contaminated air to areas expected to have clean air. It is possible that contaminated air may be delivered to an end unrelated to the work place where the explosion occurred.

Sulphur dioxide has the following properties;

- Colourless with a strong suffocating odour
- TLV 2 ppm, STEL 5 ppm
- up to 5 ppm there is a noticeable odour for most persons
- 6 to 12 ppm can cause immediate irritation to nose and throat
- about 20 ppm causes irritation and inflammation to eyes
- 400 to 500 ppm is life threatening for short term exposure

Hydrogen sulphide has the following properties;

- colourless with an offensive odour (rotten eggs)
- TLV 10 ppm, STEL 15 ppm
- 15 to 100 ppm causes eye irritation and conjunctivitis
- 250 to 400 (prolonged exposure) may cause bronchial pneumonia
- 500 to 1000 ppm acts as systemic poison and ultimate death.

The effects on a person by both gases are time dependent.

5.4 Oxygen Deficiency

Reactions that occur during an SDI as well as producing $S0_2$, use up most of the oxygen in the area. Persons present in the mine will therefore not only encounter toxic gases but a serious oxygen deficiency. It is thus recommended that oxygen self-rescuers be carried by all persons employed in mines that may be subject to SDIs.

6.0 ADDITIONAL POINTS

The following points need to be understood if management is to establish effective safe working procedures in sulphide orebodies which have the potential of SDI explosions occurring.

1. The initiation of a single hole in a sulphide zone can trigger an SDI explosion.
2. The classic fire triangle is fundamental to SDI explosions which may be rated as "violent" fires.

3. For an SDI to occur then all three components of the fire triangle must be present; oxygen, fuel and an ignition source.

- Oxygen - the only source available is from the ventilation circuit. An atmosphere with an oxygen level as low as 13% has been known to support an SDI event.
- Fuel - sulphide dust is the fuel. For pyritic ore a dust concentration that exceeds 200 gm/m^3 with a particle size of less than 180 micron is conducive to an SDI.

  Primary. Dust from blasting. The proportion of dust generated per hole varies according to blasting techniques and mineralogy. In general the portion of dust less than 200 micron generated in a blast is about 8% of the total blast. This dust is generated hole by hole as the blast occurs. Some holes generate a higher portion of dust (eg a burn cut in a development heading).

  Secondary. Dust accumulations which have been allowed to buildup over time around loading bays, exhaust airways, development headings, etc.

- Ignition Source - any flame or spark with sufficient energy.

  Primary. Research into SDIs has shown that a flame is produced when a blasting agent is initiated. Photographs of single hole blasting in development headings taken by R J Enright (University of Sydney) support this research. His most recent work has shown that the flame from blasting will ignite sulphide dust generated by the blast. In some holes the flame is contained within the hole.

  Research by AMIRA has demonstrated that the ignition temperature of pyritic ore dust varies between 320^oC and 365^oC.

  Secondary. A recent report describes an incident where a front end loader bucket hit the wall of an underground drive and generated a spark with enough energy to ignite accumulated sulphide dust in the vicinity.

Other potential sources of ignition include electrical arcing (motors, switches, etc), vehicle exhaust systems, and friction from poorly maintained mechanical equipment. There have been no reports of SDIs attributed to these sources but they have caused ignition of other dusts in other industries.

7.0 CONTROL METHODS

The primary control measure is to evacuate **all** persons to refuge chambers or to the surface when firing any area where there is a potential for an SDI event.

The prevention of an SDI event relies on controlling at least one section of the fire triangle. The methods selected need to be practical and that is where the difficulty lies.

7.1 Oxygen

Tests done to isolate the blast from an external source of oxygen (ie in excess of 13% of air) have not been successful. This is not a practical method of controlling the fire triangle.

7.2 Fuel

sulphide dust needs to be isolated from other components of the triangle. The development of an SDI event is not spontaneous, the ignition is progressive and cumulative. This means the individual or collective particles of dust must be surrounded by inert material (ie isolated from the oxygen or ignition source).

Primary. Attempts have been made to use water and/or inert dust (limestone) to enclose the sulphide dust. Neither method has been successful because it is impossible to instantly isolate the particles of sulphide dust as each hole is blasted and the quantity of water or limestone needed is in the order of 10% of the total blast (by weight). It is not practical to handle that quantity of inert material for each blast.

No matter what method is attempted, a large quantity of fuel (dust of less than 180 micron) will inevitably be produced in the blast area making this means of containment unpractical.

Secondary. Regular wash down of the area will eliminate the fuel source. It is particularly important to wash down within 20 metres of the blasting site. It is also good practice to remove any other flammable materials from the vicinity of a blast in high sulphide material.

7.3 Ignition Source

Containment of the ignition source is the most practical method of control.

Primary. Research by R J Enright has demonstrated that effective stemming of a blast hole will contain the flame and prevent ignition of the sulphide dust.

The difficulty is in finding an effective, practicable stemming product to contain the flame produced in each hole Research is currently being undertaken by AMIRA in this area. Trials to date have included gels and swelling clays.

A further difficulty arises where hole break-out occurs. Good practice in drill techniques, hole layouts and explosives usage will improve control and may help to eliminate hole break-out.

Large blasts may require firing from the surface.

Secondary. Control in this area is easier to manage. Good practices require:-

- ♦ dust accumulations to be washed off walls and backs before handling with mechanical equipment;
- ♦ electric motors and switching not to be installed in areas subject to sulphide dusts. (If they are required then only intrinsically safe equipment shall be used);
- ♦ vehicles to be properly maintained and the fire risk kept to a minimum;

- ♦ mechanical equipment to be maintained to a standard which eliminates excessive friction.

During secondary blasting only drilled and stemmed holes should be fired. "Blister" or "plaster" charges should be avoided. All pops should be fired on the same delay or with instantaneous detonators, and good wash down practices should be followed.

8.0 PREVENTION

The earlier a prevention program is set up the more manageable the SDI problem. The premise that should be recognised is that where sulphide ores are mined there is a potential of encountering SDI events. Planning for these events should be included in the feasibility study and should be updated as the mine is developed.

Actions to consider -

- as part of the final feasibility study map the areas of sulphur content above 18%;
- where practical plan the mine ventilation exhaust to be located as close as possible to areas containing above 18% S;
- as the mine is opened up examine the mineralogy and update the working plans;
- write work procedures for all disciplines to interface with the safe management of SDI risk. The disciplines involved will include geologists, miners, samplers, ventilation officers, supervisors and other support staff;
- train all personnel involved (including retraining) in awareness of the hazard and the precautions to be taken;
- modify firing procedures to minimise the risk of an SDI in areas where the potential for SDI events exist. Particular attention should be paid to multiple firing and secondary blasting. In some circumstances these may need to be avoided;
- record and review the results of blasting in hazardous zones. Analysis of this data is critical to minimising the risk. These records should be kept. When a sulphide dust ignition occurs there is also a requirement to report the event to the district inspector; and

- ensure tag-in and tag-out procedures are followed, and if necessary use the tag board for establishing or confirming that all persons are out of the mine when blasting from surface.

9.0 EMERGENCY PREPAREDNESS

In mines that have a potential for sulphide dust explosions additional emergency preparedness training and facilities are required.

9.1 Mine Rescue

A mine rescue team must be established and equipped with gas detection monitors (for 0_2, H_2S and $S0_2$) and self contained breathing apparatus (SCBA) of sufficient duration.

The teams and the first aid backup need training in handling persons affected by a toxic atmosphere containing H_2S, $S0_2$ or an oxygen deficiency.
Evacuation procedures should be designed to account for primary airflow reversals. Also there is the potential for secondary fans tripping out because of an air blast, or for toxic gases being picked up and distributed to ends quite remote from the SDI event.

A rescue team entering a mine which has been subjected to a potential SDI explosion must test the atmosphere as they enter. If a toxic atmosphere is detected they should withdraw to a safe position, don SCBA and re-enter. They should also be aware that ground-conditions may have deteriorated, ventilation controls may have failed, and electrical wiring may still be active.

9.2 Facilities

Refuge chambers must be located near the sulphide zones and be easily accessible. Equipment provided in the refuge chambers must include oxygen self rescuers. Consideration needs to be given to having cylinder oxygen on standby. Refuge chambers and their requirements are explained in more detail in the Guideline "Emergency Preparedness for Underground Fires in Metalliferous Mines".

9.3 Workforce

In mines that have the potential for SDIs all persons who go underground should be issued with oxygen self rescuers and trained in their use.

The underground workforce should be trained in the use of associated oxygen equipment and receive training and practice in mine evacuation procedures.

First aid skills development needs to be cognisant of the effects of $S0_2$ and H_2S on a person.

10.0 MINE RE-ENTRY

Mine re-entry includes re-entry from underground refuges (fresh air bases) as well as from the surface.
The main concern with re-entry to the workplaces is the possibility of encountering an atmosphere contaminated with toxic gases ($S0_2$ and H_2S) or being oxygen deficient.

When an SDI explosion occurs there is the possibility of mine airflows being reversed, auxiliary fans tripping out and toxic gases being distributed to areas quite remote to where the blast occurred. It is difficult to ascertain that all the toxic gases have been removed from the mine until:-

- the air in the workplaces has been tested;
- normal ventilation circuits have been re-established; and
- an appropriate time has elapsed to allow for removal of the contaminated air.

A written procedure should be developed for re-entry to the mine where the workforce has been totally evacuated or where some or all of the workforce are occupying refuge chambers. The procedure should take into account ventilation predictions taken from computer modelling that has reviewed anticipated SDI effects on the ventilation system.

A planned reconnaissance into the mine following an SDI, or suspected SDI, shall include the following:-

- a visual judgement of the main surface exhaust plume (an SDI explosion generates more than normal amounts of "dust");
- an observation of the readings on any remote gas detection equipment;
- a reconnaissance party which has at least two persons equipped and competent in SCBA use and gas in atmosphere detection techniques;
- non-entry into zones of irrespirable atmosphere unless necessary, the purpose is to identify areas that are contaminated and where ventilation circuits have not returned to normal;
- a back up SCBA equipped rescue team on standby;
- a record of all findings and where possible a report by radio direct to the shift supervisor;
- plotting and assessing information from the reconnaissance party as soon as possible; and
- a final clearance given by the supervisor or competent person appointed by the manager.

If during normal mining operations any person underground believes they can smell or taste $S0_2$ or H_2S then the mine should be evacuated and the atmosphere tested.

Proactive management will ensure that mine rescue team members are used as the reconnaissance party.

11.0 REPORTS

The prediction of SDI events continues to be difficult. The collection of data is important to aid continuing research into the problem and to minimise the consequences of SDI events.

Details to be contained in reports include:-

- location and supporting plans,
- type of blast,
- blasting method (including initiation),
- explosives used and powder factor,
- stemming details,
- effects of the SDI event,

- mineralogy of the area, and
- an explanation of the wetness of area.

All SDI events should be mapped on a master plan for easy reference. This is particularly important for mines where SDI events are rare.

The reports should be circulated to at least the Mine Superintendent, Mine Foreman, Ventilation Officer and Mine Geologist.

For convenience it is appropriate that the same form is used when reporting the event to a district inspector.

In Western Australia, under Section 78 of the Mines Safety and Inspection Act 1994, the Manager must immediately advise the District Inspector of any SDI occurrence. The Manager must give the District Inspector such particulars in respect to the occurrence as the Inspector may require. The Manager is also required to record the particulars of an occurrence in the record book.

REFERENCES

1. Hall, A.E., 1988. Sulphide Dust Explosions, Proceedings of Special Session CIM & M. Vancouver May 1988.
2. Enright, R.J., 1994, Sulphide Ore Dust Explosions, Summary of Research Investigations, AMIRA Project 316, 316A.
3. Torlach, J.M. 1990, Sulphide Dust Explosion Hazard, Safety Bulletin No. 1, WA Minerals and Energy February 1990.
4. Enright, R.J. 1990, Hazards Associated with Sulphide Dust Explosions. Minesafe International Conference 1990.
5. Kochout B.W., 1992 Sulphide Dust Explosion and Subsequent Gassing Significant Incident Report M 92/15 Mineral Resources Queensland.
6. Ayre, M.W.D., 1993 Dust and Gas Explosions Significant Incident Report, Development and Resources Tasmania.
7. Standish, P. 1995 Sulphide Dust Explosion, Immediate Incident Notification Circular, Mineral Resources, NSW.
8. Australian Sulphide Dust Association 1994. Prevention of Damage and Injury from Sulphide Dust Explosions. Operating Hints 1994 Mineral Resources, NSW.
9. Enright, R.J. 1988, Practical and Theoretical Aspects of Sulphide Dust Explosions. CANMET Contract 23440-7-9046. Ottawa.

10. Australian Standards 2430.2 - 1986, Part 2 Combustible dusts.