A REVIEW OF THE

APPROVED STANDARD FOR

VENTILATION CONTROL

DEVICES

QMD 967396

Joncris Sentinel Services
493 Cawarral Road
Cawarral Qld 4702
Phone :(07) 4934 4592
Fax: (07) 4935 4335
Email: john@joncris.com.au
michael@joncris.com.au
Web: www.joncris.com.au

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1.0 INTRODUCTION

Following the release of the Queensland Mines Department's Approved Standard for Ventilation Control Devices, a number of operators and other interested persons have raised a number of issues regarding the content, application, implications and the actual intent of this Standard.

At law, the intent or what the authors of the legislation or a particular rule or standard, actually meant, carries little weight in the application of that legislation. The real test is how that legislation is interpreted by the Court.

As a general rule, Judges will look carefully at what is written and give their decision based on the legality of this and not on what someone meant or meant to say or write.

Topical examples of this fact are the decisions made in relation to the Native Title Act and the Marbo and Wik decisions.

With this in mind I have reviewed this Standard and wish to comment on:

1. The content and implications of this Standard and,
2. The resources required if our underground mines are to comply with the requirements of the Approved Standard

2.0 REVIEW OF THE CONTENT

The aim and objectives of this Standard (Appendix 1) are to:

(a) minimise the risk of goaf gases escaping into the external atmosphere after sealing

(b) assist mines install infrastructure which assists the survival of persons underground by providing a ventilation system which would remain operational under most conditions likely to be encountered after an overpressure incident.

The standard goes on to state:

> This standard sets the broad parameters that are to be met by mine operators who are then able to adopt whichever technology or materials they wish to achieve the standard.

2.0.1 Comment

This would appear to be a noble aim however there are two clauses which would appear to contradict the above.

(1) The design criteria for ventilation control devices such as stoppings, regulators, overcasts etc, have yet to be developed by scientific testing and therefore, at this time, only act as a guide for installation.

(2) The design and specification of seals are to have been proven successful by a test program at an internationally recognised mine testing explosion gallery.

This appears to suggest that the only technology or materials that may be selected are those which have been successfully tested at an internationally recognised mine testing explosion gallery.

A mine operator could not have the option under this clause, to erect a seal by stowing, packing or any other method that could not be tested as required.

This clause effectively locks you in to a supplier who has had their technology and materials tested in the approved manner.

I am also concerned about the statement in clause (b) of the expected outcomes which states.

> *.... providing a ventilation system which would remain operational under most conditions likely to be encountered after an overpressure incident.*

What proven evidence is there from real coal mine explosions, that the overpressure generated, has been below the values stated in this standard?

No one, however can foretell what forces would be exerted on a bulkhead in the event of an explosion. In the Bureau's Experimental Mine, for example, propagating explosions have developed from 1 to 127 psi and on a few trials pressure piling caused higher, un-recordable pressures and considerable damage. Seldom however, do pressures 200 feet and more from the origin of an explosion exceed 20 psig unless coal dust accumulation is excessive and the incombustible content of the dust is less than required by law. ***D.W. Mitchell, Explosion Proof Bulkheads, USBM Report No 7581.***

Research by R. Cybulska of Poland suggests that an incombustible content of 95 percent can still allow an explosion to propagate readily and a fine layer of coal dust on top of a conveyor belt or sitting on top of a thick blanket of stone dust will allow the explosion to propagate readily.

This research indicates that for stonedust to be effective, it must be in the air at the time of the arrival of the flame. ***Madam Ruth Cybulska Coal Mine Explosions Workshop Notes, 1982.***

2.1 Location of Seals

Clause 2(b) of the Standard States

> *The geotechnical stability of the seal site over the period it is required to function. Issues such as floor heave, goaf abutment pressures will impact on the seal site and must be fully considered and engineered accordingly.*

This would strongly suggest that to comply with this requirement, a detailed geotechnical appraisal would have to be carried out at each seal site and that the design and construction of the seal be engineered to suit the prevailing or expected load.

I have been advised that seals of an approved type have failed due to floor heave and abutment loads therefore, it would appear that the standard approved type seal, would be inadequate for any location with a load above 1.0 Mpa.

At some mines a compressive load in excess of 7.5 Mpa has been measured and under Clause 2(b) the stopping or seal would have to be engineered and constructed to withstand this load.

This will increase the cost of each seal erected.

2.2 Over Pressure

The Approved Standard for Ventilation Control Devices states that:

> *All Ventilation Control Devices installed are to remain "fit for purpose" for the life of that area of the mine and always capable of withstanding an overpressure of:*

Type A	*14 Kpa*	*(2 psi)*
Type B	*35 Kpa*	*(5 psi)*
Type C	*140 Kpa*	*(20 psi)*
Type D	*345 Kpa*	*(50 psi)*
Type E	*70 Kpa*	*(10 psi)*

2.2.1 Over Pressure Defined

Overpressure is the term used to describe the excess pressure over and above normal atmospheric pressure.

This excess pressure may be caused by an explosion of flammable gas and or coal dust or a large wind blast due to the uncontrolled caving in a large goaf.

The approved standard, deals mainly with the overpressure generated by an explosion in the underground workings.

The term explosion, is defined as the sudden release of pressure and energy and the formation of a pressure wave which is followed by a flame.

This initial pressure wave, often referred to as the Static Pressure induces an air flow behind it which is converted to Dynamic Pressure when it is slowed or stopped by, for example, Ventilation Control Devices.

It is a combination of these two pressure waves, Static and Dynamic, which cause most of the damage in an underground mine.

An explosion of flammable gases and/or coal dust may be classified into two categories, namely:

- Deflagration, and
- Detonation

The deflagration of a flammable mixture may be defined as the subsonic propagation of the flammable mixture.

This subsonic propagation under ideal laboratory conditions generates a pressure rise ratio of 8 to 9 times atmospheric pressure.

The most severe type of explosion is the detonation of a flammable mixture. Here the detonation velocity reaches supersonic proportions and there is no lag time between the initial shock wave and the flame front.

This supersonic propagation under ideal laboratory conditions generates a pressure rise ratio of about 18 times atmospheric pressure.

There are many factors which influence the type of explosion and the extent and magnitude of the resultant overpressures.

What we do know is that an explosion of a flammable mixture of gas and coal dust, can under ideal conditions, generate overpressures of up to 18 atmospheres.

It is generally accepted that the most common explosion, the deflagration of methane, will generate a pressure rise under laboratory conditions, of:

30 psi	at the Lower Explosive Limit
110 psi	at the Stoichiometric Level ie. 9.8% CH_4 in Air
40 psi	at the Upper Explosive Limit

The facts are that we do not know what pressures are generated in a real coal mine explosion. Rarely do we have the opportunity to inspect a mine following a large explosion and there are rarely any survivors near the origin or point of ignition, who can describe what they saw and how objects behaved.

Many experts have attempted to quantify and qualify the nature and extent of the overpressures, blast waves and point of origin, by at best a brief examination of the workings if this has been possible, by the examination of photographs or by computer generated models.

Unfortunately, rarely do we get these experts to agree on the nature, extent and cause of the explosion.

It is agreed that many attempts have been made throughout the world to simulate explosions in testing galleries and there is no doubt that some excellent work has been done.

I would argue that the ignition of very small volumes of methane or methane and coal dust mixtures and their effects in a simple, uncomplicated roadway or gallery, bear little relationship to a real explosion in an operating coal mine with multiple roadways, intersections and liberal coal dust.

References

USBM Bulletin No 680 by J.M. Kuchta
USBM Report No 7581 by D.W. Mitchell
USBM Report No 9382 by N.B. Greninger, E.S. Weiss, S.J. Luzik, C.R. Stephan
Scientific Forensic Reconstruction of an Underground Explosion by A.R. Green

2.3 Pressure and Force

The approved standard refers to an overpressure of 14 to 345 Kpa.

What does this mean and how does it relate to the lateral force or load that a ventilation control device must contain?

On the lower end of the scale, stoppings or ventilation control devices must be capable of withstanding an overpressure of 14 Kpa or 2 psi.

On the metric scale 14 Kpa is equal to a water column of 140 centimetres or about 55 inches of water gauge.

The average atmospheric pressure is equal to 101.3 KiloNewtons/square metre or 14.7 psi.

Atmospheric pressure will therefore produce a column of water to a height of 10.36 metres or 34 feet.

By simple proportion, the pressure of a column of water of 140 centimetres is equal to

P	=	101.3 x (1.4/10.36)
	=	13.69 KiloNewtons per sq metre

Therefore the pressure on the ventilation control device, in this case the stopping would be:

Atmospheric Pressure	101.3
Plus 14 Kpa or	13.69
Total	114.99 KiloNewton/m^2

It is just as likely however, that due to the positive and negative pressure phases, that do occur during an explosion in multi-heading developments, that normal atmospheric pressure is not equal on both sides of the seal or stopping or other ventilation control device.

If this is the case, wouldn't the overpressure generated by an explosion, be magnified many times due to the lower pressure on the other side of the stopping?

This may explain some of the complex blast wave patterns and the displacement of objects and stoppings, that the author observed after the Moura No 4 explosion.

The facts are that we do not know the extent and nature of the overpressures generated during a real coal mine explosion.

If we take the best case and assume that atmospheric pressure remains equal on both sides of the stopping, the overpressure is equal to 13.69 KiloNewtons/m^2

The actual force on the stopping will be this pressure multiplied by the cross sectional area of the stopping.

Force	=	Pressure x Area
	=	13.69 x 6 metres wide x 3 metres high
	=	246.4 KiloNewtons
	=	about 25 tonne

Type A & B Devices, Stoppings, Stoppings with man door, Regulators and Double Doors with a similar cross sectional area would need to withstand a **lateral or shear load** of:

14 Kpa	(2 psi)	(55 inches WG)	=	25 tonne
35 Kpa	(5 psi)	(138 inches WG)	=	62 tonne

Type C Seals for Sealed Areas

140 Kpa	(20 psi)	(551 inches WG)	=	246 tonne

Type D Seals for Sealed Areas

345 Kpa	(50 psi)	(1358 inches WG)	=	607 tonne

Type E Surface Air Locks and Fan House Structure

70 Kpa	(10 psi)	(275 inches WG)

The cross sectional area of the top of the fan house at a typical mine is about 38 square metres.

70 Kpa or 10 psi over this area = 260 tonne

If we accept the fact, as stated in the Approved Standard, that overpressures of up to 1400 Kpa (140 psi) (5510 inches WG) have been recorded in testing galleries, then it is clear that the above requirements are on the lower end of the scale and would therefore contain only a minor event.

The Standards which govern the construction, testing and approval of Flame Proof Enclosures raises some interesting questions.

It is my understanding that Flame Proof Enclosures must be constructed in such a manner, that they can withstand without damage, the forces generated by an ignition of flammable mixtures contained inside the box.

To satisfy this requirement, flame proof enclosures must be Type Tested to withstand an internal static pressure of 150 psi.

Is the purpose of the test, designed to prove that the enclosure, can withstand the pressures that are possible during the ignition of the volume of methane that could be contained within the enclosure?

If we look upon a seal area, as a very large flame proof enclosure, then wouldn't we have to adopt the same standards for the construction of the seal?

Clearly, my calculations need to be examined by a structural engineer who could give some advice on the design and construction of ventilation control devices which would withstand the overpressures quoted in the approved standard.

References Applied Mechanics by George E Drabble

2.4 Application of the Standard

The Approved Standard, as written, contains no start date and it makes no reference to existing ventilation control devices.

We can only assume, after careful consideration of the wording of clauses (a) and (b) of the expected outcomes, page 2 of the Standard and the reference to "All Ventilation Control Devices" installed or constructed; refer Page 4 of the Standard under the heading, Purpose or Intent, that this Standard is meant to include all existing

Stoppings	Seals
Regulators	Overcasts
Main Doors	Double Doors

There is no specific reference to Conveyor Belt Segregation Stoppings however I believe that these would be covered by the broad statement under Ventilation Control Devices, Page 4 of the Standard which states:

> *..... of (or) other device used to control or direct the ventilating air currently underground in an orderly manner.*

I therefore conclude that this Standard applies, without exception to all new and existing Ventilation Control Devices throughout the entire mine.

3.0 DUTY OF CARE

You will note that the Approved Standard contains references to:

- Only act as a guide
- Recommended only

- Considered as objectives only
- The following guidelines are to apply

This type of wording leaves some with the impression that there is no real need or that no one is forcing them to comply with the recommendations or guidelines.

I would strongly advise, that under the principles of Duty of Care and the accepted meaning of the terms Reasonable and Practicable, a prudent employer would need to examine and pay particular attention to the Approved Standards, Expected Outcomes.

Where hazards exist and there are no relevant regulations, employers still have a duty to reduce, eliminate or control the hazards.

This type of Standard is designed to provide practical information on how to reduce, eliminate or control the hazards to achieve the desired outcome.

Normally, a standard or guideline does not represent the only acceptable means of achieving the desired outcome.

At law, it is acceptable to use alternatives that will achieve the same standard or expected outcomes.

In this particular case the Expected Outcomes deal specifically with the escape of goaf gases and the survival of persons after an overpressure incident and it nominates specific design, specification and testing criteria, which restricts the options available to develop and implement alternatives.

We would have had a much wider scope for the development and implementation of alternatives had the primary focus been on preventing an overpressure incident, rather than accepting that such an event is probable.

This Standard and the apparent general acceptance of the content, by the industry, now sets the parameters for what could be considered Reasonably Practicable.

3.1 Reasonably Practicable

Employers are expected under the principles of Duty of Care to take action which is practicable and reasonable.

If something is practicable it is physically possible or capable of being done. The question of whether it is reasonable takes some other factors into account:

1. The severity of any injury or harm that may occur to any person.
2. The degree of risk or probability of such injury or harm occurring.
3. How much is known about the hazard and ways of reducing, eliminating or controlling the hazard.
4. The availability, suitability and cost of the safeguards.

The cost has to do with the expense and inconvenience necessary to put the safeguards in place, measured against the consequences of failing to do so.

It is not a measure of whether the employer can afford to put the necessary safeguards in place.

Employers would be expected to incur greater expense and inconvenience in the provision of safeguards against those risks which have been proven to cause injury and loss of life.

Individual employers could not claim that they did not know what to do about certain hazards, if those hazards were widely known by others in the same industry and safeguards were in place at other mines.

I would recommend that a legal opinion be sought on this matter.

4.0 CONCLUSIONS

I have concluded that the Approved Standard for Ventilation Control Devices as written:

(a) Applies to all new and existing ventilation control devices, throughout and on the surface of the mine.

(b) That only approved technology and materials tested successfully at an internationally recognised mine testing explosion gallery may be used.

(c) That there is grave doubt about the accuracy of the statement in the expected outcomes that this standard would provide:

> *a ventilation system which would remain operational under* ***most conditions*** *likely to be encountered after an overpressure incident.*

(d) That this Standard does little to enhance the overall safety of the mine. By its very nature it assumes that an explosion is inevitable and it reacts to that belief.

I am of the firm opinion that the money spent on complying with this Standard would have been better spent proactively and that is, a firm concerted approach towards prevention of an explosion.

5.0 WHAT RESOURCES COULD BE REQUIRED AT A TYPICAL OLDER MINE (EXAMPLE ONLY)

5.1.1 Sealed Area Seals

South Side of the Mine	65
North Side of the Mine	11
Total Seals Required	76

We need to determine if any of these sealed areas contain or are likely to contain flammable mixtures in the explosive range. If this is the case then those areas will have to be inertised or Seals to withstand 345 Kpa (50 psi) will be required.

It could be argued that a sealed area containing 100% methane, has the potential to enter the explosive range, therefore, the seal would need to withstand 345 Kpa (50 psi).

If these sealed areas do not contain and are not likely to contain flammable mixtures in the explosive range, then 140 Kpa (20 psi) seals will suffice.

If we assume that only 140 Kpa seals are required, I would estimate the cost to be about $12,000 per seal, installed.

Estimated Cost **$912,000.00**

5.1.2 Intake to Return Stoppings 35 Kpa (5 psi)

South side of the Mine	60
North Side of the Mine	50

Total 110

Estimated cost including preparation and installation, say $8,000 each

Estimated Cost **$880,000.00**

5.1.3 Double Doors 35 Kpa (5 psi)

South side of the Mine	8 sets	=	6 doors
North Side of the Mine	4 sets	=	8 doors

Bear in mind that no doors have been tested as required to date therefore it is very difficult to provide a cost estimate.

However if we assume that the cost would be in the order of $15,000 each

Estimated Cost **$360,000.00**

5.1.4 Overcasts 35 Kpa (5 psi)

South side of the Mine	2
North Side of the Mine	2
Total	4

Bear in mind that no overcasts have been tested as required to date therefore it is very difficult to provide a cost estimate.

However if we assume that the cost would be in the order of $35,000 each

Estimated Cost **$140,000.00**

5.1.5 Conveyor Belt Segregation Stoppings 35 Kpa (5 psi)

South side of the Mine	92
North Side of the Mine	53
Total	145

Assume a cost of $8,000 each

Estimated Cost **$1,160,000.00**

5.2 Surface Air Locks and Seals

Man and Materials Drift	2
Second Egress Shaft	1
Main Fan Housing	1
Total	4

The design of a surface air lock which could be remotely operated at least once per year, over the drift conveyor system, head frame or winder ropes is a major challenge and will require a great deal of thought.

How do we remove the conveyor belting and structure without requiring persons to travel or work in the mine entrance?

An alternate may be an air lock over the entire man and material drift, head frame, conveyor gantry and ROM stockpile area. This may satisfy the requirements of the standard.

The standard states that surface air locks and the main fan housing shall be designed to be either stable or readily repairable if subjected to overpressures of up to 70 Kpa (10 psi).

These would have to be designed by competent structural engineers and I have absolutely no idea of the cost of such structures, however there is no doubt that the cost would be considerable and probably prohibitive.

It is difficult to understand how these structures could be tested at an Internationally recognised mine testing explosion gallery, as is required by the Approved Standard.

5.3 Total Cost Estimate

Sealed Area Seals	$912,000
Intake/Return Stoppings	$880,000
Double Doors	$360,000
Overcasts	$140,000
Segregation Stoppings	$1,160,000
Total	$3,452,000.00

Plus Surface Air Locks, Seals and Main Fan House

5.4 Authors Comment

The sole purpose of this Report is to stimulate discussion and thought on this very important subject.

There is no doubt that we all want safer mines and that every effort must be made to achieve this, however, I am not convinced that this Standard provides the tools, guidance and protection necessary to achieve this aim.

Your feedback on the content of this report would be appreciated.

J.P. Brady