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# Outburst thresholds – misconceptions, criticisms and context

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# OUTBURST THRESHOLDS – MISCONCEPTIONS, CRITICISMS AND CONTEXT

Mark Blanch<sup>1</sup>

**ABSTRACT:** This paper describes the origins of outburst thresholds and considers the role gas content and gas desorption rate measurements play in outburst management systems employed in the Australian underground coal industry. It considers and provides context around criticism of simplicity, conservatism and the scientific basis of gas content thresholds and desorption rate indices. The validity of increasing thresholds based on reduced advance rates is questioned as is our ability to predict outbursts and the magnitude of those events.

## BACKGROUND

Up to 1994 there had been around 800 outburst reported across the Australian underground coal industry (Harvey, 2002), most of those occurring in the Bulli seam mines. There have been a total of 21 deaths associated with outburst, the most recent being the triple fatality at South Bulli Colliery on the 25<sup>th</sup> July 1991 followed by the single fatality at West Cliff Colliery on 25 January 1994. Following the South Bulli fatalities the industry adopted a risk management approach (Harvey, 2002), utilising prediction and prevention techniques with protection as a fall back in the event that an outburst did occur. In May of 1994 the NSW mines inspectorate issued a notice pursuant to Section 63 of the Coal Mines Regulation Act (CMRA) which placed restrictions, prohibitions and requirements on all coal mines operating in the Bulli seam:

- a. The gas content and composition ahead of the face was to be known (measured according to AS3980)
- b. Structure identification ahead of development roadways was required. Where structure was identified mining was only to be carried out under outburst mining procedures
- c. Normal mining was only to be carried out where:
- d. No structure had been identified and
- e. Where the total gas content was measured to be less than 9 m<sup>3</sup>/t CH<sub>4</sub> and 5 m<sup>3</sup>/t CO<sub>2</sub>
- f. Mining in gas contents higher than those thresholds was only permitted under full outburst procedures, or remote mining
- g. Where gas content was measured to be greater than 12 m<sup>3</sup>/t CH<sub>4</sub> or 8 m<sup>3</sup>/t CO<sub>2</sub>, only remote mining was allowed
- h. General body CO<sub>2</sub> readings were required at the working face of development panels every 2 hrs
- i. Training was required across the underground workforce in all aspects of outburst hazards (signs, dangers, rescue and escape)
- j. Refresher training was required every 6 months
- k. First response rescue and escape equipment was required in each panel
- l. The need to comply with design and operational requirements for machine operator protection as stipulated by the chief inspector of mines.

In the subsequent years Outburst Management Plans (OMP) were refined and systematic predrainage programs were implemented at all mines using directional drilling techniques. Integral to the success of the OMPs has been the Authority to Mine (ATM) procedure, outburst management committees and clear definition of roles and responsibilities. During the mid to late 90s the Bulli seam mine OMPs were adopted across the Hunter Valley and Bowen Basin mines where seam gas was

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identified as a hazard. Outburst thresholds for non-Bulli seam mines have been established by using desorption rate characteristic specific to each of those seams linked to the desorption rate of the benchmark Bulli seam gas content thresholds.

Over the ensuing twenty years:

- reased up to four fold
- coal production rates have incoutbursts have been acknowledged as a risk across all eastern seaboard underground coal mine districts
- there have been no fatalities or serious injury as a result of outburst since 1994
- the incidence of outburst have been reduced to less than a few per year. Those reported have occurred while remote mining or as a result of the failure to implement the OMP to design
- all outburst have occurred during development mining other than:
  - two reportedly low intensity outbursts on Longwall 23 at West Cliff Colliery on the 3<sup>rd</sup> of April 1998. The seam gas reported to be 98% CO<sub>2</sub> and up to 21 m<sup>3</sup>/t (Harvey, 2002)
  - three outburst on the face of Longwall 27 at Metropolitan Mine on the 23<sup>rd</sup> of December 2016, 3<sup>rd</sup> and 4<sup>th</sup> of January 2017
- and importantly the industries tolerance for outburst and gas related hazards has been reduced significantly.

### OUTBURST MECHANISM

Over the last three decades there have been numerous studies which have set out to improve our understanding of the outburst mechanism. Because of the wide variety of conditions under which outbursts occur, there is no single theory that can explain the phenomenon (Lama *et al*, 2002) The general accepted mechanism in Australia follows:

- outbursts in the Bulli, German Creek, Goonyella Middle and Bowen seams have generally always occurred on geological structure; or on mining induced cleavage in the Gemini Seam in the Leichhardt Colliery experience (Hanes)
- in the area surrounding the outburst prone structure, the permeability has been reduced to almost zero as a result of the high stress conditions around the structure. The high stress / low permeability conditions causing seam gas content in the area of the prone structure to remain high despite gas predrainage efforts
- also often associated with the structure are slickensides and the presence of mylonite - fine crushed coal
  - which makes drilling and coring conditions difficult
  - allows for gas desorption rates to be enhanced significantly once reservoir pressure has been reduced to desorption pressure levels and
  - takes no load, transferring stress to the surrounding coal
- as the mining face approaches the outburst zone:
  - the highly stressed coal between the face and the outburst structure takes on more stress and permeability is further reduced
  - the coal barrier between the mine face and the outburst zone is reduced to a critical thickness and fails as the effective stress exceeds the material strength of the coal
- upon failure of the coal:
  - the fluid pressure on the coal in and around the structure falls suddenly from above gas desorption pressure to atmospheric pressure
  - the seam gas desorbs rapidly, and
  - the free gas pressure in the coal increases rapidly
- the rate of pressure build up is dependent upon the rate of gas desorption and the volume of gas available:

- gas desorption rates:
- increase with increasing gas content
- have long been recognised to be greater for CO<sub>2</sub> than for CH<sub>4</sub>
- are enhanced by the presence of fine grained coal / mylonite.
- the volume of gas (and coal) available for ejection is defined by seam gas content and the extent of the structured zone
- the gas pressure generated by the rapidly desorbing seam gas promotes outward projection of the coal

### OUTBURST THRESHOLDS

Since the early 90s the Australian underground coal industry has used seam gas content levels as outburst thresholds exclusively. Prior to that gas desorption rates were employed as an indicator of outburst risk (Lama, 1995) using the desorption rate defined by Hargraves Emission Value (EV) desorption meter which measured the volume of gas desorbed over a 2 – 6 minute period from a 4 g sample of coal taken from drilling cuttings off short boreholes (2-3 m) drilled immediately ahead of the development face. Thresholds defined by Hargraves were typically employed:

- 1.5cc/g for CH<sub>4</sub> and
- cc/g CO<sub>2</sub>

Other than being unsuitable for high production mining the EV meter was unsuitable in a mixed gas environment and effected by moisture, variations in sample ash, and knowing where the sample was taken from.

#### Bulli Seam Thresholds

The gas content thresholds currently employed in Bulli seam mines were first defined by Lama (1995). Those thresholds developed with reference to:

- overseas outburst thresholds in mostly CH<sub>4</sub> rich coal seams o Poland, Russia, Germany, Bulgaria and China. In particular the 9.0 m<sup>3</sup>/t (CH<sub>4</sub>) threshold employed at Germany's Ibbenburen Colliery
- thresholds employed at Collinsville Colliery of 5 m<sup>3</sup>/t CO<sub>2</sub>, desorbable gas content.

Lama's original thresholds were defined for desorbable gas content as measured by the slow desorption method of testing:

- 8 m<sup>3</sup>/t (CH<sub>4</sub>) and 4 m<sup>3</sup>/t (CO<sub>2</sub>) where structure was present
- 10 m<sup>3</sup>/t (CH<sub>4</sub>) and 7 m<sup>3</sup>/t (CO<sub>2</sub>) in the absence of structure.

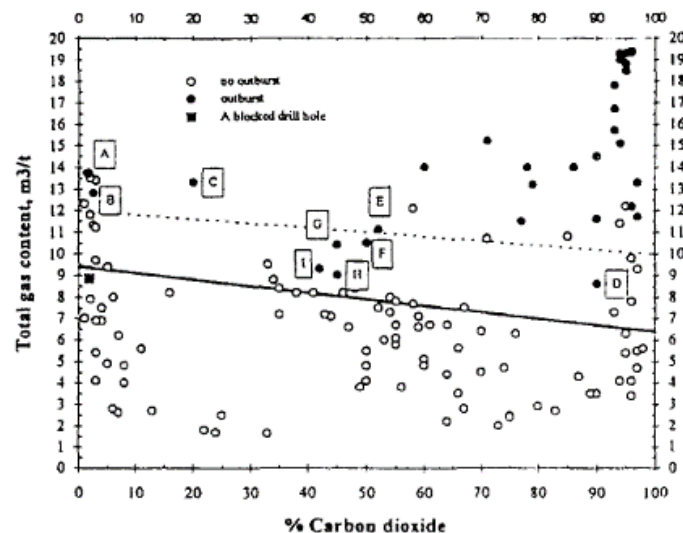
These were subsequently modified with the introduction of the fast desorption method of gas content testing for total desorbable gas content:

- 9.4 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.4 m<sup>3</sup>/t (CO<sub>2</sub>) where structure was present
- 12 m<sup>3</sup>/t (CH<sub>4</sub>) and 10 m<sup>3</sup>/t (CO<sub>2</sub>) in the absence of structure and accepting the occurrence of small outburst (< 20 – 40 tonnes).

In proposing the Bulli seam thresholds Lama (1995):

- makes reference to mathematical modelling which led him to conclude that the thresholds were appropriate for mine development rates up to 50 m /day

- suggested that for reduced development advance rates of between 10 and 12 m /day, the thresholds of 9.4 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.4 m<sup>3</sup>/t (CO<sub>2</sub>) could be raised by a factor of 1.2, to 11.3 m<sup>3</sup>/t and 7.7 m<sup>3</sup>/t respectively
- indicated the thresholds include a factor of safety 19%
- presented a chart (Figure 1) gas content and composition from a dataset of measurements derived from Tahmoor and West Cliff Collieries over a three year period. The chart includes:
  - the proposed lines of outburst thresholds for structured and unstructured coal
  - gas content / composition measurements where development mining had taken place indicating:
    - no outburst had occurred where the gas content was measured to be less than 9.4 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.4 m<sup>3</sup>/t (CO<sub>2</sub>)
    - a number of measurements were taken where the gas contents exceeded both threshold lines without the occurrence of outbursts
    - a number of outburst were recorded where the gas contents had exceeded the unstructured coal thresholds
    - ten outburst, varying in size (as defined by the amount of coal ejected) from zero up to between 30 to 40 tonnes where the gas content was measured to be between the two threshold lines. Lama indicating these outbursts were “too small to cause any major damage or endanger life of personnel”



**Figure 1: Measured gas content close to outburst prone structures – Tahmoor and West Cliff mines (Lama, 1995)**

Since their introduction mines operating in the Bulli seam have applied the thresholds with some differences:

- Appin Mine operates under a single threshold of 9.4 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.0 m<sup>3</sup>/t (CO<sub>2</sub>).
- Tahmoor Colliery now employs three threshold lines based on the original work of Lama:
  - 1) For unrestricted mining in structured coal the gas content has to be measured to be below 9.4 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.4 m<sup>3</sup>/t (CO<sub>2</sub>)
  - 2) Where the gas content is greater than the base thresholds but less than 11.3 m<sup>3</sup>/t (CH<sub>4</sub>) and 7.7 m<sup>3</sup>/t (CO<sub>2</sub>), normal mining is employed but with development advance rates limited to 12 m/day in structured coal
  - 3) Where it is proven that the coal is unstructured, thresholds of 12 m<sup>3</sup>/t (CH<sub>4</sub>) and 10 m<sup>3</sup>/t (CO<sub>2</sub>) are applied.

- Metropolitan Mine have recently modified their threshold limits to have two lines:
  - 1) 9.5 m<sup>3</sup>/t (CH<sub>4</sub>) and 6.4 m<sup>3</sup>/t (CO<sub>2</sub>) for unrestricted mining and
  - 2) 11.3 m<sup>3</sup>/t (CH<sub>4</sub>) and 7.7 m<sup>3</sup>/t (CO<sub>2</sub>) at development advance rates limited to 12 m/day.

### Other seams

Gas content thresholds for non-Bulli seams have been set using the desorption rate of the specific seam being assessed relative to the desorption rate defined for the Bulli seam “bench mark” coals following the work undertaken by Williams and Weissman (1995) and Williams (1997). During gas content testing of Bulli seam samples from dominate CH<sub>4</sub> and CO<sub>2</sub> areas of West Cliff Colliery it was found that the desorption rate for coal having a measured gas content of 9.5 m<sup>3</sup>/t (100% CH<sub>4</sub>) was the same as that where the gas content was measured to be 6.2 m<sup>3</sup>/t (100% CO<sub>2</sub>). GeoGAS’s fast desorption method of gas content determination has been subsequently used to set gas content thresholds using desorption rate index of 900 (DRI900). The DRI900 defined as the quantity of gas desorbed after 30 seconds of crushing a 150 g sample normalised to the total desorbable gas content of the full sample. The DRI900 has been used to define gas content thresholds for outburst mitigation for the:

- Wongawilli seam in the Illawarra Coal Measures to be circa 5.5 m<sup>3</sup>/t (98% CO<sub>2</sub>)
- West Wallarah and Fassifern seams in the Newcastle coalfields to be about 10 m<sup>3</sup>/t (98% CH<sub>4</sub>)
- Seams in the Hunter Valley coalfields to be in the order of 9 - 11 m<sup>3</sup>/t (CH<sub>4</sub> rich) and 6 – 7 m<sup>3</sup>/t (for CO<sub>2</sub> rich coals)
- Hoskisson seam in the Gunnedah Basin has an outburst threshold of about 6 m<sup>3</sup>/t (predominately CO<sub>2</sub>)
- Goonyella Middle and Lower seams, the Harrow Creek Upper and Lower seams in the Moranbah Coal Measures are around 7 m<sup>3</sup>/t at 98% CH<sub>4</sub>
- Elphinstone and Hynds seams of the Rangal Coal Measures in the range of 7 to 8 m<sup>3</sup>/t (CH<sub>4</sub> rich)
- Newlands Upper seam of the Rangal Coal Measures to be about 9.5 m<sup>3</sup>/t at 98% CH<sub>4</sub>
- Rangal coal measures seams toward the south of the Bowen Basin to be around 6 m<sup>3</sup>/t CH<sub>4</sub> rich and 4.5 m<sup>3</sup>/t at 60% CO<sub>2</sub>.

### Outburst control zones

The 2014 NSW Coal Mines Regulations introduced the concept of mining in Outburst Control Zones (OCZ). OCZ defined as any area of a mine where either:

- a. The gas content of the seam was measured to exceed 9 m<sup>3</sup>/t (100% CH<sub>4</sub>) or 5 m<sup>3</sup>/t (100% CO<sub>2</sub>)
- b. Where the GeoGAS Desorption Rate Index (DRI) method is used—the desorption rate index of gas exceeds 900.

Where the area of the mine is defined as an OCZ mining in that area is deemed a High Risk Activity and the mine is required to submit a high risk activity application to the Department of Industry Resources and Energy prior to mining.

## OUTBURST THRESHOLDS – MISCONCEPTIONS and CRITICISMS

### Misconceptions

*Permeability and raising thresholds for reduced mining rates*

Though often referred to in technical papers and in OMPs, permeability like a number of other gas reservoir characteristics plays no direct role in outburst initiation. Assessing one mine as being more disposed to outburst due to a lower permeability regime (for the same gas content and structural fabric) is misleading. The lower permeability mine will take longer to predrain or alternatively cost more to predrain for the same drainage lead time. Once the gas content is reduced to target levels a seam with a permeability of 2 mD will be no more prone to outburst than one with a permeability of 200 mD. The catch is the change of permeability in and around prone structures; this is key to understanding outburst mechanics, the importance in defining structure and in developing compliance core testing strategies. It is also the reason why many consider the second tier thresholds proposed by Lama based on reduced development rates as flawed (Williams, 2011). The unsound logic of sneaking up on an outburst zone by way of reduced mining rates first proposed by Lama (1995) has been employed to lift outburst thresholds at Tahmoor and Metropolitan Mines. Those mines adopting Lama's 2<sup>nd</sup> tier thresholds of 7.7 m<sup>3</sup>/t (100% CO<sub>2</sub>) and 11.3 m<sup>3</sup>/t (100% CH<sub>4</sub>) in structured coal for development rates limited to 12 m/day (Wynn, 2011). That work has seen Black (2016) suggesting that miners operating in other coal seams might follow suit by employing a DRI of 1200. Whether seam permeability is typically in the range of 2-5 mD or 20-50 mD the permeability in and around an outburst zone on a prone structure such as a strike slip fault will approach 0 mD as a result of the stress associated with the structure. There are number cases through history where outbursts have occurred after crib breaks (Hargraves, 1975), during remote mining where advance rates are painfully slow, or on longwalls where the face has retreated less than 9 m over 12 days - a long way short of the 10 – 12 m / day proposed by Lama (1995).

There are numerous instances across the Australian underground coal industry where:

- borehole monitoring provides the first indication an area is not draining as per normal
- the first response is generally to infill the borehole pattern in an effort to promote gas drainage
- where there is prone structure present the permeability will be tight and gas production rates are typically as disappointing as those measured from the first array of boreholes
- cores are taken where drilling conditions permit and the gas content is often at virgin levels.

This is a scenario that is familiar to most that have mined in the gassy Bulli, German Creek or Goonyella Middle seams. The permeability will be approaching 0 mD in and around the outburst prone structure and hence the gas content remains high; where the zone can be drilled it can only be drained with boreholes at tight spacings (2-5 m) and long lead times (measured in months). Gas bleed off from these areas is so slow that any mining advance rate is too fast (Williams, 2011). Most mine operators will then navigate these areas using grunching or remote mining techniques.

#### *Predicting outbursts*

Through the 90's there was often debate regarding outburst size and then the terminology applied to define them. Terms used to describe outbursts included outbursts, bursts, slumps and bumps. The latter terms suggest low intensity events (albeit uncontrolled). There are a number of references in Lama's work (1995) suggesting outburst of less than 20 to 40 tonnes were harmless and possibly acceptable.

The industry has moved on and our tolerance to hazards associated with seam gas, particularly those involving an uncontrolled release of gas, has been reduced significantly since the 90's. Other than the obvious, the underlying concern with accepting any form of uncontrolled event is that we can predict the size of an outburst. Structures are regularly mined through at elevated seam gas contents without outburst, yet there is no way of saying that the next time the same structure is mined through an outburst will not occur; the most recent example being the Metropolitan longwall outbursts. The outburst could be 40 tonnes or hundreds of tonnes, the volume of gas released could be a couple of hundred cubic metres or tens of thousands of cubic metres. Our capability to identify and map

structure is improving but our ability to predict which structure will outburst and what the size the outburst might be with any confidence is not where we might like it to be.

### Criticisms

Criticisms of the current outburst gas content thresholds are few but typically they are critical of their simplicity or that they are overly conservative:

*“The concept of a single measurement being an indicator of whether a coal seam is outburst prone might be convenient but is not valid” (Gray and Wood, 2013).*

*“The attempt by the Australian mining industry to shoehorn all of our outburst risk assessment on to a single gas content measurement is a gross simplification” (Gray and Wood, 2013).*

*“The need for a better approach is brought about by the simplistic and indeed incorrect nature of what is being used in Australia at present. This generally, but not invariably, leads to overly conservative gas drainage practice” (Gray and Wood, 2013).*

These criticisms seem to disregard that the gas content thresholds employed across the industry are just one element of a risk management system which has unequivocally proven to be an effective mitigation strategy since implemented in the mid 1990's.

Other aspects often referred to by the critics as not being included in the threshold are in fact taken into account when either assessing a mine or an area within a mine of the risk of outburst and other seam gas hazards:

- during the initial mine feasibility studies – coal strength, stress, seam lithology, presence and type of structure, gas content and quality, gas desorption rate and permeability
- panel hazard management plans, longwall gas management plans and each of the outburst Authority to Mine notices consider – geological structure, stress, seam lithology, previous mining history and mine plan, drilling history, gas content and quality, gas drainage performance, gas emission history and forecasts.

Calls of conservatism need to be considered in line with the fact that most mines predrainage programs will target remaining gas content levels well below outburst threshold limits in either the Sydney or Bowen Basin mines to minimise gas exceedances on either gate road development (between 3 and 5 m<sup>3</sup>/t) or longwall extraction (< 3 m<sup>3</sup>/t).

The use of gas content thresholds in conjunction with the other essential elements of the management system has proven to be effective. Gas content measurements are practical within the mining process and provide a well understood indication of energy available (albeit a static measurement). It's relatively simple:

- remove the energy through gas predrainage
- measure the gas content to confirm the predrainage plan
- consider the seam geology, drilling and gas drainage performance, mining plan and history
- authorise mining where it is safe to do so.

It could be argued that outburst gas content thresholds employed in the Hunter Valley and Bowen Basin mines are unproven given their origins. Outbursts that have occurred in the Bowen Basin since the implementation of OMPs at Central Colliery (July 2001) and North Goonyella Mine (October 2001 and May 2012) have all been relatively low energy events and have each occurred as a result of the failure to apply the OMP as designed. Gas content measurements at each of these sites post outburst were at or above outburst threshold levels; and hence there is no clear evidence to raise or lower gas content thresholds as an outcome of investigations into these few outbursts.



Without the occurrence of a statistically reliable number of outbursts it is always going to be difficult to modify outburst thresholds, regardless of how good the science might be. While we continue to target higher longwall production rates and faster gate road development rates the only foreseeable movement in gas predrainage targets appears to be downward. The likelihood of a future carbon tax can only place more pressure on lower gas drainage targets.

Criticism of the use of gas desorption rate as a means of setting gas content thresholds in non-Bulli seams are similarly poorly founded:

*“Related to errors in gas content measurement“ (Gray and Wood, 2013)*

*“Based on pseudoscience fitting a straight line to some group of data without having thought through the measurement process and the errors it contains” (Gray and Wood, 2013)*

*“The outburst threshold limit for this dataset is the gas content value at the point where the DRI of 900 meets the average minus 2 x SD line” (Black, 2016)*

The limits of accuracy of gas content measurement are now well understood and accepted in their application in gas reservoir modelling and seam gas management. Gas desorption rate has long been acknowledged as being fundamental in the outburst initiation process. The measurement of gas desorption rate from a sample of coal during the fast desorption method of gas content testing is effected by the inaccuracies inherent in the gas content testing. Desorption rate is also effected by sample moisture and by the consistency of the crushing process; hence we see a scatter around the (mean) line fitted to the gas content / desorption rate data set for a particular seam and gas composition.

The mean line fitted through the data set is used to define the outburst threshold. The mean less two standard deviations was originally intended by Williams to define the gas content limit for which gas predrainage would be initiated for outburst mitigation. For example the outburst threshold for the Goonyella Middle (GM) seam is typically set at about 7 m<sup>3</sup>/t (100% CH<sub>4</sub>). The gas content for the GM seam defined by the mean less two standards deviation of circa 6.2 m<sup>3</sup>/t is for practical purposes is meaningless as all mines operating in the GM seam target remaining gas content levels of 3 m<sup>3</sup>/t and most mines in the same thick seam typically commence predrainage when the gas content is in the range of 4 to 5 m<sup>3</sup>/t.

Acknowledging the scatter in the correlation between gas content and desorption rate due to the effects of sample moisture and potential variability in crushing, Williams’s (1995, 1997) intended use of the DRI900 was only ever as a means of setting gas content thresholds based on the benchmark Bulli seam desorption characteristics. Once set, all outburst assessments for that particular seam should be based on the defined gas content thresholds with the DRI value that accompanies gas content measurements from GeoGAS used as supplementary data only.

The use of the DRI as prescribed in the 2014 NSW Coal Mines Regulations for defining Outburst Control Zones suffers from the same potential limitations as described above when using it as a standalone indicator of outburst proneness – sample moisture and laboratory processing limitations. For the Bulli seam the OCZ defined by gas content - method (a) in the regulations would be slightly different to that defined by the DRI 900 (method (b)). For non-Bulli seams the use of method (a) is not valid, and using method (b) DRI900 would give an OCZ the same threshold as the outburst threshold which is inconsistent with the difference in OCZ limits and outburst thresholds limits in the Bulli seam.

## **OUTBURST THRESHOLDS and OUTBURT MANAGEMENT – IN CONTEXT**

It is indisputable that the risk management systems employed by the industry to manage the risk of outburst since the mid 1990’s has been effective. During a period where mine production rates have

increased by millions of tonnes per annum, the number of outburst that occur has been reduced significantly. There have been no fatalities or serious injuries as a result of outburst in Australia since their implementation more than 20 years ago. Other than the outburst that have occurred during grunching or remote mining, where the elevated risk has been identified prior to mining, those outbursts that have occurred during normal development mining have been as a result of failure to implement the plan. The recent outbursts on the longwall face at Metropolitan are the only exception to this and provide an opportunity to revisit our outburst management strategy for that phase of mining.

Criticisms of the use of the gas content threshold seem to disregard the fact that it is just one element within a management system, and that the other factors that can be used to define the risk of outburst such a structure, stress, coal strength etc, are in fact taken into account throughout the different phases of mine planning and authorisation.

Given what we have learnt about seam gas and gas drainage over the last 30 years it evident that the original Bulli thresholds proposed by Lama were not scientifically based but borrowed from experience elsewhere and modified slightly based on Bulli seam experience. That said the thresholds are part of a risk assessment system that works. Arguments regarding conservatism of thresholds neglect to consider the gas drainage targets required to meet statutory limits on gate road development or to produce at longwall production rates of 2 – 10 Mtpa.

Accepting our current understanding of the outburst mechanism, and taking the lessons learnt from our gas drainage and mining experience, it is clear that there is no feasible mining rate slow enough to allow gas to bleed off from an undrained outburst prone structure in a time frame that would render the outburst structure benign. Employing a higher gas content threshold justified by a development rate reduced to 12 m / day is flawed.

Though the use of gas desorption rate to transfer proven gas content thresholds to non-Bulli seams may not satisfy the scientific requirements of a few, gas desorption rate has long been acknowledged as key in outburst initiation. For a given gas content and composition for coal samples from the same seam, reported desorption rates will vary slightly due to inaccuracies inherent in the gas content testing, sample moisture, variations caused by sample selection and by inconsistency of the crushing process. These shortcomings in determination of the DRI are understood; how it is applied is important. The use of the DRI should be limited to setting gas content thresholds and providing supplementary evidence only in assessment of outburst risk. A single measurement of DRI should not be used as a standalone indicator of outburst risk.

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