International Journal of Mining Science and Technology 27 (2017) 749–753

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Investigations into the identification and control of outburst risk in Australian underground coal mines

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ARTICLE INFO

Article history:
Received 1 January 2017
Received in revised form 15 March 2017
Accepted 20 April 2017
Available online 10 August 2017

Keywords:
Outburst
Desorption rate
DRI
Threshold limit

ABSTRACT

Australian coal mines currently use gas content to assess outburst risk. The gas content threshold values for each mine are indirectly determined from measurement of gas volume liberated from 150 g coal samples during Q_3 residual gas content testing. It has been more than twenty years since this method, known as desorption rate index (DRI), was presented to the Australian coal industry, and in that time, there have been significant changes in mining conditions and the outburst threshold limits used at the benchmark Bulli seam mines. NSW Regulations list matters to be considered in developing control measures to manage the risk of gas outburst, and specifies that gas content, or DRI method, is used as the basis for determining outburst control zone. Whilst Queensland Regulations state that a coal or rock outburst is a high potential incident, there is no guidance provided to assist mine operators to define outburst prone conditions. A research project is planned at UOW to investigate the application of the DRI method and other potentially significant factors, such as gas pressure, coal toughness and permeability, which can be utilised by mine operators to assess outburst risk and determine appropriate outburst threshold limits and controls.

1. Introduction

Following the introduction of outburst threshold limits in Bulli seam mines in 1994, there was a significant decrease in the number of unexpected coal and gas outburst incidents. With the reduction in incidents, the attention of the mining industry has shifted away from outburst. There has been a reduction in support to conduct research to investigate the factors that define outburst prone coal and to develop new methods to identify and manage such areas to minimise the risk to mine safety and productivity. Current coal mining legislation in both Queensland and New South Wales provide little guidance in determining appropriate outburst threshold limits [1,2].

Various theories have been presented regarding the factors that contribute to the occurrence of coal and gas outbursts. In 1995, Ripu Lama listed the following factors as having the potential to contribute to an outburst: (1) tensile strength of coal, (2) gas emission rate, (3) gas pressure gradient, (4) moisture level, and (5) depth or stress level [3].

From studies conducted in the Bulli seam, Lama concluded that stress does not play a significant role and it is gas which is the major contributing factor to outburst occurrence. The use of gas drainage to reduce the gas content of the coal seam to a value considered safe for mining has been uncritically accepted by the mining industry. In the 20 years following the Bulli seam studies conducted by Lama, an increasing number of Australian coal mines has moved into areas with increased gas content and reduced permeability. The combination of these two factors tend to reduce the efficiency and effectiveness of gas drainage at reducing the gas content of the coal seam below previously defined outburst threshold levels.

Given that underground coal mining operations are carried out in coal seams that present a broad range of potential outburst factors, it is reasonable to question the validity of relying solely on the desorption rate index (DRI) to be transferable between all Australian coal seams and not consider other factors that may impact outburst risk [4].

2. Background

In 1995, Lama presented details of gas content and gas composition from nine separate locations in the Bulli seam where

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http://dx.doi.org/10.1016/j.ijmst.2017.07.006
2095-2686/

outburst incidents had occurred [3]. Lama also proposed outburst threshold limits, shown in Fig. 1, that he considered appropriate to control outburst risk in the Bulli seam. In this example, provided the gas content has been reduced below 9.5 m^3/t in 100% CH_4 rich coal and 6.4 m^3/t in 100% CO_2 rich coal, Lama considered there to be negligible risk of outburst regardless of mining rate and presence of geological structures. Lama also proposed two additional threshold levels that allowed mining to continue at a limited advance rate, capped at a maximum of 50 m per day, in areas with and without geological structures.

A number of outburst events have occurred in Australian coal seams in the years following the work completed by Lama. Details of those outburst events will be collated by the author to produce an outburst event database and reassess the threshold limits proposed by Lama, shown in Fig. 1.

Following the last fatal outburst that occurred in Australia, at Westcliff Colliery on 25th January 1994, a directive was issued to all Bulli seam mine managers detailing actions to be implemented to control the outburst risk [5]. The directive, issued by the Coal Mining Inspectorate and Engineering Branch of the New South Wales Department of Mineral Resources, included the prescribed outburst threshold limits shown in Fig. 2, and these threshold limit values were lower than the values recommended by Lama.

The introduction of the threshold limits resulted in a significant increase in the intensity of drilling and gas drainage in these mines for the purpose of structure identification and gas content reduction. Mine operators developed comprehensive outburst management plans which included standard drilling patterns and routine management controls to deal with the issue of gas content reduction.

3. Desorption rate index

Williams and Weissman presented data from gas testing CH_4 and CO_2 rich coal samples from the Bulli seam that showed the relationship between gas content and a newly defined desorption rate index (DRI) value [6]. The data presented in Fig. 3 suggest an approximately linear relationship exists between total measured gas content (QM m^3/t) and DRI and that the gas emission rate from CO_2 rich coal is greater than from CH_4 rich coal.

The relationship between QM and DRI for CH_4 and CO_2 rich Bulli seam coal samples, which was referred to as the Bulli seam benchmark, is represented by the following equations:

$$\mathrm{QM} = 0.01 \times \mathrm{DRI}\ (CH_4 \text{ rich coal samples}); \quad \text{and}$$
$$\mathrm{QM} = 0.0067 \times \mathrm{DRI}\ (CO_2 \text{ rich coal samples})$$

Williams and Weismann recommended that the Bulli seam benchmark and DRI provide a means of determining outburst threshold limit values given the Bulli seam outburst threshold limit values of 9.0 m^3/t for CH_4 rich coal and 6.0 m^3/t for CO_2 rich, when applied to the Bulli seam benchmark, both corresponded to a DRI value of 900, as shown in Fig. 4. Given the relationship indicated

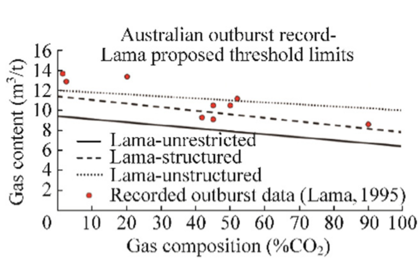

Fig. 1. Bulli seam outburst event details proposed outburst threshold limits.

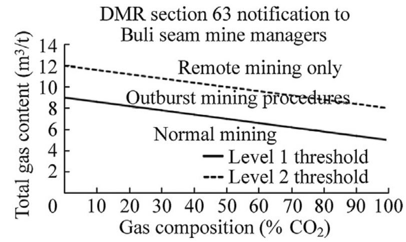

Fig. 2. Bulli seam outburst threshold limits.

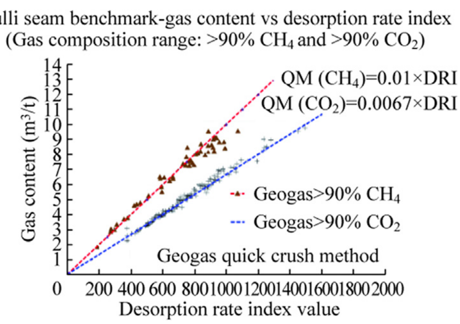

Fig. 3. Gas content and DRI relationship for CH_4 and CO_2 rich Bulli seam coal.

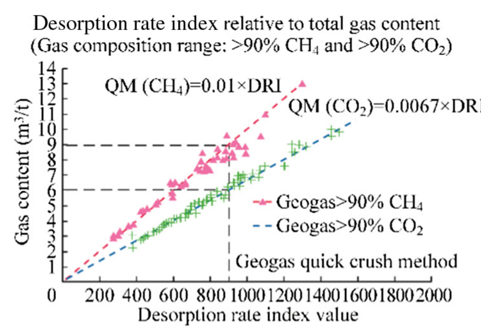

Fig. 4. Bulli seam benchmark and outburst threshold limits corresponding to DRI900.

in the Bulli seam, Williams and Weismann proposed that it would also be appropriate to use DRI900 to determine outburst threshold limits for other Australian coal seams.

It is now generally accepted that outburst threshold limits applicable to Australian coal mines are determined through a process of preparing a dataset of gas test results from the coal seam and plotting the reported gas content (QM) and desorption rate index (DRI) values, as shown in Fig. 5. Statistical analysis of the dataset is used to calculate the standard deviation (SD) of the QM values from the average of the dataset and a value of two

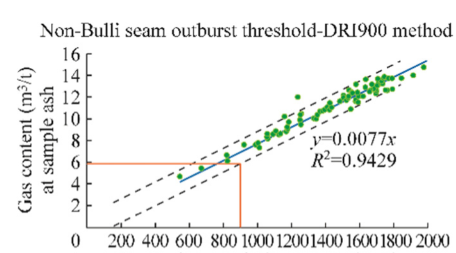

Fig. 5. Process of using DRI900 to determine the outburst threshold gas content value.