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Improved TARP development based upon mine specific data

B. Belle [a,b,*], D. Cliff [c]

[a] Anglo American Coal, Brisbane, Australia
[b] Department of Mining Engineering, UNSW, Sydney, NSW 2052, Australia
[c] University of Queensland, Queensland, Australia

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A B S T R A C T

The trigger action response plans (TARPs) are inherent to managing the multiple hazards such as: high gas content with multiple coal seams, high spontaneous combustion (sponcom) propensity, heat and ventilation. TARPs aim to provide assurance and guidance when the situation deviates from the original plan or there is a change conditions that could be hazardous. Over the years, learnings from various incidents has continuously required the coal operations to re-visit the TARP trigger values that were based on historic data or based on guidance values from the industry. In most cases, the background to the basis of TARP statistical data, viz., average, maximum, hourly, daily for the monitoring or sampling location is also unknown. Introduction of real-time monitoring devices to monitor the gases and airflows has provided greater understanding of the hazard scenarios and their controls. This paper analyses the carbon monoxide data from operating longwall mines and compares these with the historic trigger values to understand the changes and determine improvement opportunities while setting trigger levels in the TARPs. As an example of setting trigger values, those used in during the sealing of a panel are explored in terms of setting values based upon the sampling location and the level of risk. It is envisaged that the learning's shared herein would further enhance the understanding and management of multiple hazards in Australian coal mines.

1. Introduction

The principal hazard management plans (PHMPs) are fundamental to the various Australian State mine health and safety legislation to manage the major hazards effectively. Trigger values in TARPs are intended to be inherent non-emotional guides to mine operators. They are a fundamental element of the PHMPs aimed to initiate control actions at various levels of deviation from normality aimed at eliminating or mitigation of hazards. With relation to underground operations, TARPs have been set for mine ventilation, gas, spontaneous combustion of coal (sponcom) and heat. This paper provides sharing of experiences and discusses aspects of TARPs development and, in particular specific elements associated with sponcom/fire linked to trigger values used for the carbon monoxide (CO) hazard element.

Historically, sponcom PHMPs and associated triggers have identified the respective sponcom management hazard TARPs. The basis for these trigger values are often not easily traced to the specific mine. They may instead be based upon literature values or borrowed from other mines without taking into consideration the particular conditions at the mine. CO make in the return from a longwall panel is one of the key parameters used to set triggers. In order to improve the understanding and for timely response, measured CO data from the various longwall panels were analysed. Previously, in the absence of continuous real-time ventilation monitoring, monthly manual airflow data were used to establish the CO make. The granularity of such monthly data, detracts from the accuracy of any conclusions drawn therefrom since this will not indicate hourly fluctuations in airflow that will influence the measured CO data. Continuous air velocity monitoring is now a practical reality in high production coal mines, which provides major benefits in assisting to better understand the historic triggers in the TARPs and their validity [1]. Therefore, extensive data analyses can be made to establish the CO make for various longwall panels using real-time mine data and link this to trigger values based historically on single, monthly airflow data for sponcom management of an active longwall panel.

NSW MRS Handbook notes that manual methods alone do not provide an adequate system for protecting modern mines where continuous monitoring of the ventilation circuit at strategic locations is required, particularly where a significant risk of

* Corresponding author at: Anglo American Coal, Brisbane, Australia.
E-mail address: bharath.belle@angloamerican.com (B. Belle).

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spontaneous combustion is known to occur or be suspected of being a potential hazard [2]. For example, some TARPs refer to bag sample results. Some use the tube bundle data and some may have continuous real-time data. Is bag sample the best indicator? What is the frequency and population of bag sample data used to set triggers? Which sample location should be used? Most mines collect bag samples at strategic locations and their TARP triggers use bag sample results to validate the hazard levels. Bag samples take time to collect and analyse and it would not be appropriate to rely on bag samples in a situation where and when the sample was taken, the atmosphere was already above the trigger level. The delay in identifying this condition may have serious consequences as the scenario would have continued to change in the interim. It is rare to find explanations for the derivation of the trigger values in the TARPs. Typically, the documentation does not provide the background to the data used or the sampling methodology that is used to arrive in such values. For example; a proposed TARP that is being used in South Africa (SA) suggests on donning of rescue pack at 400×10^{-6} CO at Level 3 evacuation. The reason behind the SA proposed level is that the level equates to the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of Carboxyhaemoglobin level to 3.5% after one hour of exposure, which equates to the first signs of significant impairment [3]. The 400×10^{-6} CO is purely a health based trigger and not safety based indicator trigger value or based on measured CO value during normal mining operations. It would be rare to find more than 2×10^{-6} or 3×10^{-6} CO longwall return. Therefore, it is obvious to most that to have 400×10^{-6} CO in a well ventilated area would mean a massive uncontrolled fire outbye of workings. Finding more than 30×10^{-6} in a bord and pillar section areas with 50 m^3/s of fresh air would be certainly a large uncontrolled fire. For a typical bord and pillar coal mining operation, measured level of CO in the section return air using hand held gas measuring devices is zero.

On the other hand, New South Wales (NSW) requires donning of self-contained breathing apparatus (SCBA) when CO levels exceed 50×10^{-6} [2]. Similarly, Queensland Mines Rescue guideline suggests that the breathing apparatus will be worn in all circumstances when the atmosphere contains more than 30×10^{-6} CO, or 1.25% CO_2, or 10×10^{-6} H_2S or 2×10^{-6} SO_2 or 3×10^{-6} NO_2 or less than 19% O_2, or if other toxic fire products are likely to be present, as defined by legislation CMSHR 2001 and Schedule 6 [4,5]. These examples demonstrate the need for complete confidence on the trigger values, and the tools to be used monitor the environment and compare them to the trigger values to respond accordingly.

1.1. Tarp background

Cliff has summarised fundamental principles that TARPs should conform to following elements: the TARPs must be simple and robust; they must be adequately resourced both in terms of personnel and equipment; their focus should be on prevention and control through early detection; setting trigger values require detailed knowledge of what is normal, they need to be regularly reviewed and revised as necessary and experience dictates; there is no substitute for high quality mine environment monitoring systems; they should be set based on the best available advice-both on site and off site, and If a TARP mandates an action, then that action must be carried out, properly and promptly [6].

2. Development of TARPs based on operational data

What are the implications of generating a certain magnitude of CO expressed in Litre of CO in ventilation airflow per minute (L/min) mean for an operation? Laboratory tests done on sponcom propensity have to be used contextually when applied to an operating longwall panel. For example, Mitchell suggested a rule of thumb whereby burning of 453 g of coal lead to 14.15 L of CO per minute (L/min) [7]. Different coals may react differently to produce different rates of CO. Similarly, coal oxidation may produce different rates of CO at different temperatures, volume of available coal, and amount of fresh air available for oxidation. The measured levels of CO is also impacted of by the location of sample and status of the work area such as active goaf or a longwall return air. It is therefore possible for one to observe 2×10^{-6} of CO in a longwall return air against measuring 600×10^{-6} of CO in an active goaf inbye, the response triggers will be different. Correct application of such data would provide valuable information relating to the extent of a fire or on the development of a sponcom event and enable mine management to implement the controls needed to react to this effectively.

In the underground mines, it was noted that it was common practice to use the anecdotal method in the use of standard values of 10 L/min CO make from LW panel returns without any field evidence and therefore it should be challenged [8]. The issue with using only a generalised or common approach (rule of thumb) in relation operating longwalls is that this approach ignores the interpretation of the measured gas levels to provide a better understanding of the actual sponcom hazard that may be gleaned by analysing data from nearby longwall panels. For example, in advancing LW faces in German coal mines the following common approach triggers were based on CO make: less than 10 L/min CO was deemed to be normal, between 10 and 20 L/min CO required investigation, and greater than 20 L/min CO suggested the existence of a serious situation.

At a NSW Colliery, CO make could be as high as 150 L/min due to large air quantities across the longwall face (about 90 m^3/s) and to the presence of large amount of broken coal in the goaf [9]. Since CO make is related to ventilation circuit properties, any change to these factors is likely to influence directly the level at which different response actions would be triggered. For example, average (5×10^{-6}) and maximum (10×10^{-6}) CO concentrations in an airflow of 60 m^3/s result in a CO make variation between 18 and 36 L/min.

Mine ventilation engineers are faced with the challenge of defining effective sponcom TARPs for new coal mining operations. Currently, these are either "extrapolated" from the neighbouring mines or are obtained from published literature or from consensus based on rules of thumb. Little attention is given to the inherent bias brought about by the type of mining operations, rate of production or type of ventilation systems employed all of which will influence the levels and choice of triggers employed.

The use of real-time data facilitates the development of realistic triggers. Data obtained from various previously developed sections or longwalls, can be used to determine and distinguish between normal and abnormal situations. Typically data sets would include simultaneous gathering of both ambient and mining factors. The obtained data may be analysed statistically to determine what are normal and abnormal conditions based on parameters such as mean values and standard deviation of sample sets representing both factor types. Further data analysis could also establish any inter-dependence between some of the parameters collected, e.g., barometric pressure changes, mining, air leakage, etc. A data set acquired and correlated in such a way would therefore incorporate inherent, site specific characteristics that impact on the gas make or generation.

Fig. 1 shows an example of trigger values used for CO make in a sponcom TARP. Ideally, it is expected that the trigger values used would be from derived data. In this example, the source of these facts could not be readily established other than through expert assessment, review and recommendations.