Trigger Action Response Plans (TARPs) in Underground Coal Mines - Tips, Tricks and Pitfalls.

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Abstract

This paper will present the author's experience in observing the implementation of TARPS. The presentation will focus on the issues to be considered when establishing TARPS. These include:

- Variations in parameters due to location within the pit eg tailgate vs maingate.
- How many levels should a TARP have?
- Data validation processes.
- The processes that should be in place to establish normality and the natural variation in normality.
- The need to carry out preparatory work at low levels of the TARP so that when an action is required it can be carried out quickly and effectively.
- Establishing criteria for evacuation of a mine - to surface or place of safety.
- Establishing re entry criteria.
- The review process for TARPS.
- The allocation of roles and responsibilities.
- The integration with mine monitoring systems.
- Consistency with legal requirements and other external guidelines such as mines rescue guidelines.

Introduction

An integral part of Principal Hazard Management Plans is the TARP that defines the minimum set of actions required by site personnel in response to the deviation in mine conditions from normality. Unfortunately there are many examples in the recent past where the TARP has been found to be inadequate to manage a risk or control a hazard. This paper will focus on the hazards relating to gas, explosion and fire.

In many cases the TARP could be summarised as:

Level 1 - Normal		
Level 2 - Abnormal	-	tell the Ventilation Officer
Level 3- Really Abnormal	-	tell the Ventilation Officer
Level 4 – Oops!	-	Evacuate.

Related to this is the challenge with everyone on the surface what are the criteria for re-entry? - Especially in the conditions that mandated the evacuation still exist.
The most common reasons for the above TARP are:

- Resource requirements and costs of the actions and activities at the lower levels of abnormality - for example why activate inertisation systems if they may not be required?
- Lack of appreciation of the level of risk - If personnel have not been exposed to fire or explosion they may not appreciate the potential the hazard poses
- Inappropriate triggers - increasing gas concentrations may not indicate increasing risk as there is no direct link to the hazard.
- Assumption that the progression through the levels will be slow enough to allow all controls to be activated in a measured manner.
- The trigger is not real - one of the most common responses by mine site personnel to approaching an evacuation TARP is to convene a meeting to reset the TARP to a higher value, predicated upon the assumption that there is nothing wrong.

This paper aims to define the processes that will assist site personnel in developing TARPS particularly relating to the mine environment.

Fundamental principles

There are eight fundamental principles that TARPs should conform to.

- They must be simple and robust. When an alarm goes on night shift or weekends, the site personnel cannot afford to wait for Albert Einstein to arrive on site and solve the General Relativity equations to determine what actions are required.
- The TARPs must be adequately resourced both in terms of personnel and equipment. What if Albert Einstein is not contactable, what is done then?
- The focus of TARPS should be on prevention and control through early detection. This means that the trigger needs to be validated, clarified and remediation initiated.
- Setting triggers requires detailed knowledge of what is normal.
- TARPs need to be regularly reviewed and revised as necessary and experience dictates. This review process should occur at a time when things are normal.
- There is no substitute for high quality mine environment monitoring systems. This comes at a financial and resource cost which pales into insignificance when compared to lost production costs for false alarms.
- TARPs should be set based on the best available advice - both on site and off site. There is considerable experience within the Australian underground coal community that can be tapped into.
- If a TARP mandates an action, then that action must be carried out. Any action must have a due date/time and be audited to ensure completion.

Normality

The first essential issue to settle for a TARP is what defines normality. Consider spontaneous combustion TARPs. Figure 1 below indicates the starting point for the definition of normality Triggers in terms of the range of locations. These may increase if experience dictates that recently sealed goaves behave differently to older goaves

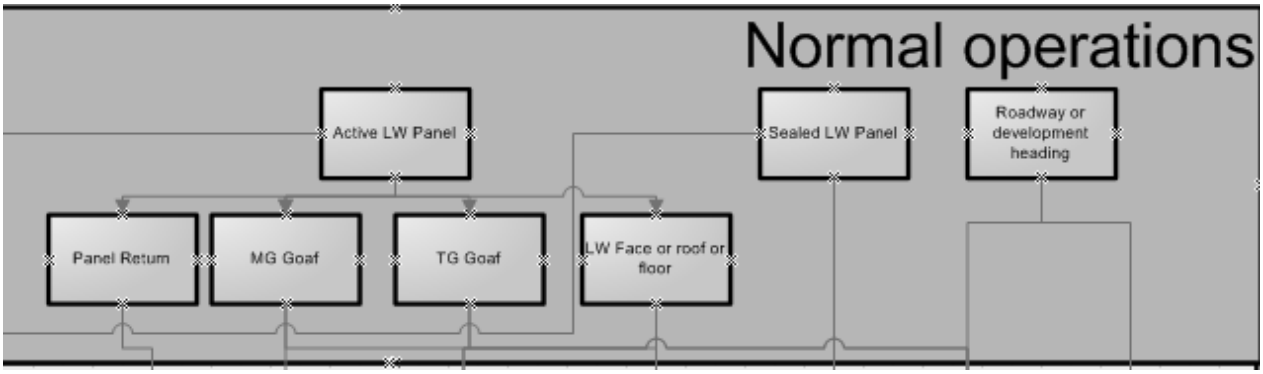

Figure 1. Geographic trigger variation.

Within the current longwall, each of the boxes would contain more sub- locations due to the variation, in environmental conditions with distance back from the face. Providing the geographical and temporal variations in the mine environment are characterised then it is relatively easy to define the limits of normality. Key indicators can then be determined based upon the data set. These may vary with location. For example oxygen deficiency is not a good indicator in a roadway but in a goaf may well identify leakage before spontaneous combustion becomes apparent. Concentration based indicators do not indicate intensity of a fire or heating. Increasing concentrations could mean increasing intensity, increasing extensivity or less dilution of the sample stream with other atmospheres.

Sampling from a number of locations requires the commitment of resources. People must be available to install and maintain all sampling lines. There must be adequate resources available: people, equipment and expertise; to collect and analyse the data promptly. Many mines rely on one person for this expertise or outside consultants to undertake this work. Clearly in an emergency this is not going to be adequate. Time is the enemy when people are trapped or a fire is developing.

In general there is no need for a large number of indicators. Very few are actually independent in any case. Figure 2 below indicates an analysis of the data obtained from goaf seals of a longwall mine. It demonstrates the correlation between hydrogen and carbon monoxide (CO) concentrations. It also shows the limited correlation with graham's ratio (CO to Oxygen deficiency).

For open roadways deficiency ratios will rarely be of value due to the small deviation of sample from fresh air. Detection systems are not designed, nor rated to detect deficiencies less than 0.5 % in oxygen. Even using CO make should be undertaken with care, and an understanding of the factors that could influence it. Figure 3. depicts return CO make plotted against retreat distance for a mine. The CO make

did not settle to a relatively constant value until the face had retreated beyond the square point. In addition due to the use of an open seal behind the face on the maingate to draw gas away from the face, the CO make underwent a saw-tooth behaviour as the distance between this seal and the face increased until the next cut-through was reached and it was sealed off.

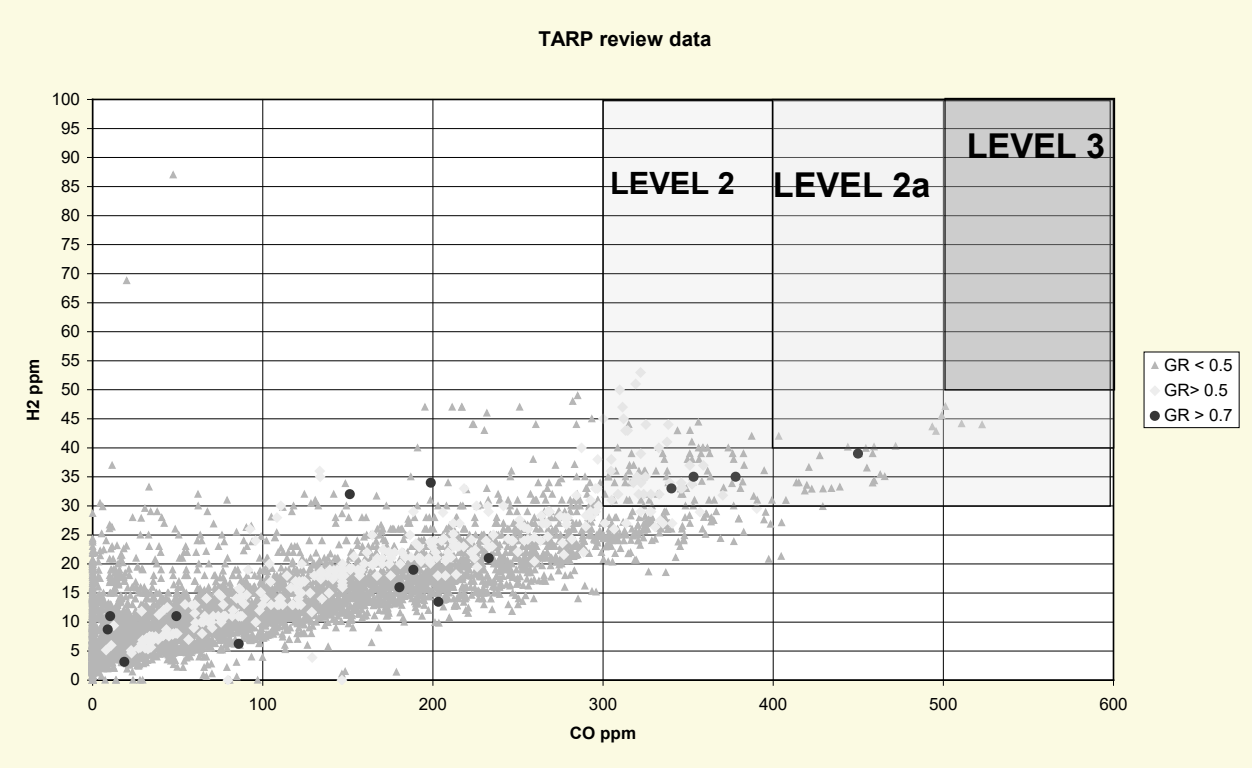

Figure 2. CO vs H2 concentrations in goaf samples.

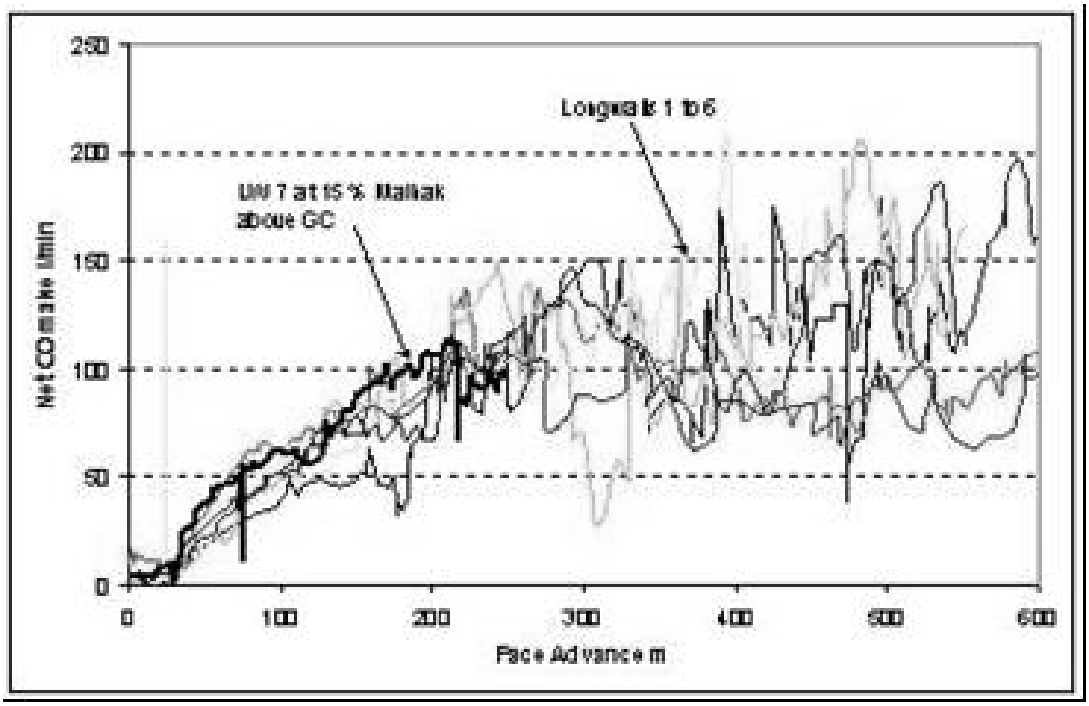

Figure 3. CO make vs face advance distance at mine X.

Abnormality

Once the limits of normality have been defined then it is easy to define abnormality. What is not so easy is to define increasing risk and when the higher levels of a TARP should be invoked. With spontaneous combustion in a longwall goaf, the triggers would be very different if there was no risk of explosion to those at a mine where there was the explosion risk due to a methane seam gas.

In general terms the number of abnormal TARP levels used should be defined by the ability to invoke controls prior to the situation becoming an unacceptable risk. However, in principle it is hard to argue beyond, an advisory level that indicates something is not normal, an alert level that indicates things are getting worse and controls are not working and finally an evacuate level.

At the first action level the priority should be to confirm the abnormality exists and initiate an assessment of the controls necessary to return the situation to normal. Typical actions at this stage would be additional sampling locations, increased sampling frequency, inspection of seals, and preparation for inertisation. A trigger that indicates air ingress into the goaf is a warning that spontaneous combustion could occur and preventive action needs to be undertaken to stop it and remove the oxygen. Site personnel should not wait to see if oxidation is detected.

If the second action level is reached this should trigger preparation for evacuation. Personnel should be prepared for a quick exit from the mine and the work environment should be set to a state where it is safe to leave equipment. For example: equipment will not get flooded if the power fails or is turned off and a close eye should be kept on the location of all personnel underground. Inertisation should be initiated at this stage and preparation for emergency sealing.

At the final level an orderly evacuation should be possible, leaving machinery in a safe condition. All actions that can be undertaken to facilitate a speedy re-entry to the mine should be carried out as the evacuation occurs. For example: emergency sealing of panel, and extra sample points. It is vital to ask the question what information is required to allow mine re-entry, how can this information be obtained, and set the processes in place to obtain this information, before evacuation occurs. Escalation of TARP level should not just be dependant upon increase in gas concentration it could also be time dependant. For example if the advisory level is maintained for more than a week the level automatically elevates to the alert level. There have been a number of cases of mines exceeding the normal limits and being in the advisory level of a TARP for many months. This should not occur, either the situation is not being controlled, in which case the TARP should be elevated to the next level; or the trigger point should be reviewed and reset as not being adequate. The resetting of triggers should only occur based upon sound and detailed analysis, and not because there is a danger that a trigger will be exceeded.

When setting triggers it is important to define which of the mine monitoring systems is to be used as the reference to decide the trigger has been reached. Portable handheld monitors are not designed to be precision gas monitors. Both tube bundle systems and gas chromatographs can be very accurate but they need to be

calibrated in the concentration ranges of interest. There have been many examples of a trigger being reached when a sample is analysed on the GC and not on the tube bundle system, due to inadequate calibration – dual range infrared analysers may require twelve calibration points to ensure linearity across both ranges. This takes time (and costs money) so there may be a tendency to not do the complete calibration. It is not going to generate confidence in mine management if the workforce hear that even though the trigger to evacuate has been reached on one system it is safe to be underground because the other system says it has not been reached.

An example of the importance of rate of change can be obtained from the explosion that occurred at Moura NO.2 Mine in August 7 1994. Figure 4 below shows the CO concentration in the hours immediately after sealing. The absolute concentration found just before the explosion was no higher than that found previously however the rate of rise of the CO was over 4 times that found previously In addition graham's ratio was over 0.8 which had not been found in previous sealing's, indicating advanced oxidation activity. Add in a flammable atmosphere and with hindsight there would be good grounds for evacuation.

Figure 4. CO concentration in 512 panel after sealing compared to previous sealing

The reverse can also be demonstrated where concentrations of CO have been monitored behind seals and over a period of many days it eventually reached a TARP trigger. There have been a number of instances where the CO has then remained constant at just above this trigger. The issue here is the setting of the trigger point and that it was not reviewed well before it was breached. Further, if it was an evacuation trigger, very little action has been taken at the lower trigger levels except that everyone watched it creep up.

This leads to the need to have a proper review process established for setting trigger points and for setting trigger points relevant to the mine and working section. In recent past mine evacuations have occurred because trigger points were taken from other mines without recognising the operational differences between the mines, trigger points from previous panels have not been updated to reflect changes in ventilation, seam thickness, retreat rate, face width etc. Underpinning this is an efficient and effective data collection, analysis and reporting system. This in turn must be supported by a sufficient pool of appropriately trained personnel. Finally the mine environmental monitoring system must be maintained and operated so that there is confidence in the accuracy of the data.

If there are triggers in TARPS then it is imperative that they be acted upon, otherwise the workforce will lose confidence in the ability of management to manage hazards and protect their safety.

It is not suggested that determining the conditions for re-entry after an evacuation will be easy, but every action that can reduce the time that people spend on the surface and increases the degree of reliability that the conditions underground are safe to enter, will save a mine much time and money as well prevent loss of life.

There is one last important point to consider with TARPS. Corrective actions do not have to wait until a trigger is exceeded. Vigilant personnel may notice abnormal gas concentration behaviour and initiate corrective actions earlier than required under the TARP. This is particularly true at the early stages where verification and validation of the data is the key. Another issue in initiating action is the ability to carry out the corrective actions. For example the VO may predict that a trigger may be reached on a weekend or night, that mandates major corrective activity such as initiating inertisation. Why wait till the weekend to initiate this when there may not be any resources available to carry out the work? Why not carry out all the preparatory work during the week so that when the trigger is breached all that is required is for the inertisation generation to be activated? Rates of change in concentration will give a good indication of the likelihood that a trigger will be reached.

Conclusion

In summary it comes down to the eight fundamental principles that TARPs should conform to.

- They must be simple and robust.
- The TARPs must be adequately resourced both in terms of personnel and equipment.
- The focus of TARPS should be on prevention and control through early detection.
- Setting triggers requires detailed knowledge of what is normal.
- TARPs need to be regularly reviewed and revised as necessary and experience dictates.
- There is no substitute for high quality mine environment monitoring systems.
- TARPs should be set based on the best available advice - both on site and off site.

- If a TARP mandates an action, then that action must be carried out, properly and promptly.

Good luck is no substitute for good management. Avoiding carrying out corrective actions because they cost money, delay production or cause adverse publicity, in the hope that the situation will not get any worse, is not a technique found in any good management text. Good management is about mindfulness and resilience. That means being prepared for adversity, expecting things to go wrong and being able to cope when they do.