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Directing responses to mine fires and explosions

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ABSTRACT: Decisions made during a response to a mine fire or an explosion greatly affect the final outcome. The safety of miners should be the primary concern with accounting for all of the miners the first issue for resolution. If miners have not safely evacuated from the mine, the last known location of the miners at of the event and anticipated travel routes are primary exploration areas. After the mine is evacuated, there are many very important decisions that must be made quickly and often under great stress. It is critical that the mine operator establish an orderly method to direct the mine emergency response. Designation of a Command Center, staffed with personnel charged with developing plans, is a common method of establishing control. Scheduling of key mine managers will be critical, since decisions must be made 24 hours a day, and people working for extended periods with little or no sleep do not always make clear or cognizant decisions. Internal communications, passing information on to subsequent shifts, and external communications with families and media must be accurate and timely. Assembling resources for responding to the mine emergency is critical for an effective response, and pre-planning can pave the way to a successful recovery. Sampling mine gasses and accurately determining the composition of gas mixtures is a common tool used to develop response plans in all fires and explosions. It is essential that preparations for emergency situations are made well in advance of a disaster. Effective communications are essential for mine management to successfully respond to a mine emergency. This paper discusses some considerations which need to be addressed in directing a response to a mine fire or explosion.

1 Introduction

While the chances of a mine fire or explosion occurring may be slim, there are a number of mine fires that occur every year. Prevention of fires is certainly preferred over fire fighting and mine recovery operations. The cost benefit of fire prevention can be measured in significant financial savings and in many cases by saving lives of miners.

The potential fire and explosion ignition sources vary by mine, but there are many common potential sources including mobile equipment, belt haulage, welding and cutting, methane ignitions, frictional ignitions, lightning strikes and electrical equipment malfunctions. Some mines are prone to spontaneous combustion of ores and coal, especially in abandoned areas and gobs.

Proper examination for and correction of hazardous conditions, maintaining accurate mine maps, proper maintenance and diligence in completing assigned duties in the mine can allow mine operators to avoid many fires. Maintaining fire detection and suppression systems, and training miners on fire fighting techniques can provide protection when fires do occur. It is during the fires that cannot be easily extinguished that intensive mine emergency responses take place.

Locating miners unable to evacuate the mine must be a focal point of the operation. While the last known work location is the likely place to begin a search, it is also important to consider other factors miners may take into account while escaping. These may include the available transportation, location of breathable air, refuge chamber locations, SCSR storage areas, travelways and conditions, and designated escapeways. MSHA may assist by providing seismic detection equipment which can aid in finding trapped and missing miners.

When all miners are able to be evacuated safely, the focus of the operation shifts away from mine rescue to minimizing risk of injuries to miners while extinguishing fires, re-establishing mine systems and preparing to resume production. Along with the reporting of the accident will come a need for investigation to identify the cause of the accident so that similar occurrences can be avoided.

Preparation for a major mine fire or explosion can mitigate the common delays and mistakes that can occur. While most mine managers will thankfully have little experience with major mine disasters, it is essential that preparations for emergency situations are made well in advance of a disaster. Anticipating the needs during a mine fire or explosion allow the responders to make logical decisions which will later pay dividends in saved time and effort.

Identifying resources and organizing responses must be integrated into a total mine emergency preparedness plan to effectively deal with the many aspects of a mine fire or explosion.

2 Establishing a Command Center

After mine management has notified enforcement agencies about the mine emergency, there will be a significant number of people arriving at the mine to provide assistance. Years of experience has taught responders that establishing a secure Command Center and limiting the access to it is essential for maintaining organization and avoiding chaos. MSHA will expect mine operators to develop logical plans for responding to mine fires and explosions and will approve plans to advance with fire fighting efforts, mine rescue personnel, and others so that the safety of the responders is assured to the extent possible.

The number of people in the Command Center should be limited to representatives from the mine, the state regulatory agency, MSHA, and the representative of the miners if applicable. The four-party system for manning the Command Center has proven most effective for providing timely response to company requests. The number of persons from each organization should be self-regulated to maintain both necessary representation and organization. A mine emergency operation Command Center can be thrown into chaos when too many people allowed access.

The Command Center should be adequately isolated from distractions and should be provided with adequate communications equipment and resources for conducting the mine rescue and recovery operations. Monitoring communications between the surface and underground operations from within the Command Center is critical for understanding future needs and developing subsequent plans. The likely path to success may take an unexpected turn when least expected. Unless the Command Center is fully apprised and aware of the findings and discoveries, significant time and resources may be wasted.

Figure 1. Mine Emergency Command Center

During some mine emergencies it has been found to be helpful to post at a central location the progress made over previous hours and days to allow others to be briefed without disturbing the Command Center. Maps with furthest points of advance, charts and graphs with current gas sampling data, and erasable 'white boards' with updatable information can be used to keep all persons on mine property up-to-date on important issues and events (Wesley, 2006). For example, the progress of borehole drilling (hole depths) can be easily maintained for any interested party to view. The same can be maintained for nearly any other activity. Some processes that have been tracked in past responses include inert gas injection locations and rates, mapped progression of rescue teams, status of seal construction, and longwall face recovery.

3 External Communications

External communication needs will depend much upon the type of accident the mine has experienced. The report of an explosion or fire with missing or trapped miners will attract a higher level of attention, including national media outlet coverage, than a smaller accident which will be reported mainly by local media focused on local concerns, such as the affect a stoppage in production may have on the community. Depending on how news-worthy the mine emergency may be, the mine operator may often be approached by the press for updates and briefings. It has been of utmost concern to provide families of miners with all available news prior to making public statements regarding mine rescue operations. This has been publicly restated and reinforced by State government officials at every mine emergency operation since the 2002 Quecreek mine inundation accident, where families have been assured of first notification. The media has been repeatedly reminded that no news will be released to the public prior to family notifications.

Assigning a spokesperson to deal with the press can be an effective way of providing information while not distracting those in the most responsible positions for directing the mine emergency response. In addition, when appropriate, assigning a family liaison can be instrumental in maintaining a positive relationship and to keep lines of communication open during the ordeal.

Among many lines of communication that may be established and maintained are those with local emergency management personnel, local and state law enforcement, local medical transportation and emergency medical technicians, suppliers, local hospitals, other nearby mining companies, and federal and state government officials.

4 Identifying Necessary Resources

The resources needed for any mine emergency will surely depend upon the type of emergency the operator is facing. Mine ventilation is a key element to any emergency response. The known ventilation patterns prior to the accident are helpful in developing a plan of action. Unfortunately, when an explosion is known to have damaged ventilation controls, it is impossible to fully establish new ventilation circuits. However, if a reliable ventilation system model exists, computer simulations can aid in developing possible ventilation scenarios. These models should be used with extreme caution due to the

varied unknowns.

Other engineering resources such as maps, water system design and supply, electrical system diagrams, surface facilities and resources must be available to address any developing concerns. Supplies for fire fighting activities such as water line, fire hoses, foam generating machines and foam, and other necessary equipment may be readily available at some mines, and may be maintained by some mine rescue units. However, the mine operator may want to assure the resources are readily available prior to the time they are needed. While all resources may not be in the supply yard, they must be immediately available. Materials for building seals should also be arranged in advance to assure sealing of mine openings can be readily accomplished if needed.

While many supplies are normally found in short order, other necessary resources may be a bit more difficult to arrange. Drilling companies, capable of drilling boreholes of various sizes in a wide range of terrains and conditions, should also be contacted immediately. The location of boreholes should be pre-planned and drilling should begin as soon as possible. In many instances, multiple boreholes may be required to be drilled simultaneously. The mine operator's emergency response plan should address the availability of all resources.

A related concern to drill rigs is the availability of surveyors to properly locate surface drill pads and accurately locate drill locations. Technology has advanced significantly over the past 20 years, but operators of surveying equipment must still provide the manpower for completing these important tasks.

Figure 2. Multiple drill rigs at underground coal mine fire.

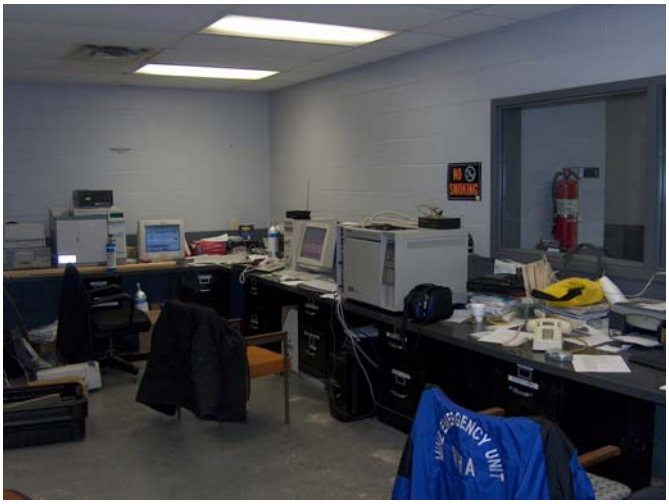
Inventories of ventilation control materials such as line curtain, stopping materials and sealing materials should be checked. These may be needed for re-establishing ventilation if disruptions are encountered, or for building temporary seals. Roof supports such as posts, cribbing and jacks may be needed to re-support bad top in areas of exploration. Simple hand tools such as hammers, sledgehammers and saws can quickly become short in supply.

Inert gas suppliers should be identified by the operator and contacted to determine availability. Nitrogen gas generators are also useful for providing lesser quantities of inert gas, possibly at a lower cost. In some circumstances, remote sealing of portions of the mine is a viable method to aid in isolating fire areas, and to reduce the volume of the mine which must be inerted to control a fire. The method has been used successfully in a number of mines under varying conditions, and may be a consideration.

5 Gas Sampling

As is discussed in nearly every written resource on mine fires and explosions, gas sampling is a tool whose

Figure 3. Gas chromatograph setup in mine offices



importance cannot be over-emphasized. Critical decisions will be most often based on the results of gas sampling.

For this reason, the proper installation of sampling lines must be a primary concern. Ideally, samples from boreholes should be collected through solid steel pipe, installed to the mine openings from the surface, with adequate perforations for sampling within the mine. Mitchell (1996) has provided a good design for this purpose. Reliable sampling will also be a key to reopening sealed mines.

Analysis of samples with a gas chromatograph has been the gold standard for many years. A tried and true method, it is an operation requiring skilled operators to assure sample reliability and accuracy of results. It is important that the chromatograph be placed in a secure area, with adequate power and space for setup and processing of samples. While MSHA maintains and dispatches a mobile chromatograph laboratory, under some conditions it is advantageous to set up in an office-style facility. Extreme weather and temperatures are significant factors for relocating the chromatograph to a substantial building.

Some companies maintain their own chromatograph, and others may contract services for gas sample analyses during mine fires and explosions. MSHA will consider the results of any chromatograph when making decisions regarding the approval of plans submitted for approval. But because analytical methods used by other

chromatograph operators do not provide the precision of the MSHA methods, and in some instances do not include analyses of the same gases, the results are most often considered a supplement to the MSHA analyses. This is especially significant for low-levels of hydrogen, carbon monoxide and other fire gasses.

Along with gas sampling and chromatograph analyses, the barometric pressure must also be monitored and forecasted. Pressure forecasts are available from a number of sources, but most readily from internet web pages. The effect of changes in barometric pressure is at some mines extreme. The rate of change, especially extreme falling barometer rates, can have a significant impact on mine fire fighting, rescue and recovery operations.

Gas sampling may include use of hand-held detectors prior to collection of samples for analysis via gas chromatograph. It is important to realize that all detectors have upper limits of detection, and that when making decisions based upon these gas readings that the limits are understood. This includes both limitations on the full range of detectability as well as possible interference of other gasses. For example, if a particular detector is indicating consistent carbon monoxide levels of 500 ppm, it may be an indication that the detector has a range up to 500 ppm, and that the levels may in fact be much higher than indicated. Again, knowing the capabilities and limitations of detectors prior to needing to respond to a fire or explosion is critical in making the right decisions.

6 Scheduling Personnel

In the initial response to an incident, there is a natural tendency for all employees to immediately respond, and for key mine management officials to remain on-site nonstop for many hours or even days. It is critical to the operation to set up a schedule when it is clear that the mine emergency operation may face extended periods of time. People working with little or no sleep do not always make clear or cognizant decisions. Adding the stress of missing or trapped miners to a fire or explosion situation can surely cause mental fatigue and eventually total exhaustion. At that point, a valuable human resource may be compromised, as well as the efficiency of the operation.

It is also important to provide adequate rest areas, foods and fluids. This is common practice when mine rescue teams are utilized. The same should be provided for command center and support personnel. Without adequate provisions, fatigue will be a more significant issue.

It is likely that many new faces will be on mine property. A list of personnel from the agencies may be helpful for mine management to track who is on the property at any given time. A method for communicating essential data should also be established between all of the parties to assure all are apprised of developing situations, discoveries, and changes in the mine requiring immediate responses.

7 Cameras and Robotics

Cameras have been used in mine emergency responses for a number of years. MSHA hopes to see an increased used of robotics in mine rescue in the future. Cased and uncased boreholes have allowed access with these devices to areas to verify the integrity of ventilation controls, observe ground conditions and smoke within open entries, and search for missing miners. The next developing technology will be the use of robots to explore remote underground areas. The first attempt to use a robot via borehole access was made at the Crandall Canyon mine accident in 2007.

Figure 4. Borehole camera

8 Summary and Conclusion

Preparing for a mine fire or explosion is essential for an effective response. Identifying resources and organizing responses must be integrated into a total mine emergency preparedness plan to effectively deal with the many aspects of a mine fire or explosion.

While no two emergency responses are exactly alike, they all have some similarities. Without adequate planning and proper execution, each has the capabilities to become a chaotic nightmare with unnecessary delays in time and wasted effort and expense.

9 References

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