INNOVATIVE STRATEGIES FOR MINE FIRE PREPAREDNESS

NIOSH - Pittsburgh Research Laboratory
Michael J. Brnich
Ronald S. Conti
Launa G. Mallett
Charles Vaught
William J. Wiehagen

Cyprus Twentymile Coal Company
R. Lincoln Derick

Presenter Bio

Charles Vaught, Ph.D.

Dr. Vaught was one of three directors of a multi-year U.S. Bureau of Mines project concerned with the development and field testing of short, valid simulations that teach and assess coal miners' grasp of critical health and safety skills. He has also served as the Principal Investigator on a series of projects intended to yield a general model of response activities in mine fires. This ongoing research is leading to the development of materials that can be used by mine safety trainers and others to prepare miners to cope effectively with such emergencies.

Dr. Vaught, a former underground coal miner, is an MSHA approved instructor who also holds the OSHA 501 trainer certification. He has a B.A. from Kentucky Wesleyan College, an M.A. from Western Kentucky University and a Ph.D. in the sociology of organizations from the University of Kentucky. His memberships include the American Sociological Association, the National Mine Rescue Association (Associate), the Southern Sociological Society and the United States Mine Rescue Association.

***INTRODUCTION

During the past 15 years the number of reportable mine fires has declined. A decline in the number of reportable fires is a gross indicator that allows experts to say something about the underground coal industry generally: There has been some improvement in overall mine fire preparedness. However, such an indicator is less reliable as a predictor of readiness at any particular operation. An indication of fire fighting preparedness would have to be assessed from evidence gathered at the mine site. In other words, there are two levels from which to view the problem. On a general level, there has been significant improvement in the industry's fire response capabilities over the past two decades. Specifically, however, little data has been gathered on a site-by-site basis to determine what improvements might be made on a local level. These improvements would move beyond regulatory compliance. It is expected that this manuscript, based on work conducted at an underground coal mine in the western United States, will help to focus attention on some central concerns involving this critical issue.

***BACKGROUND

Industry efforts to provide better fire protection has undoubtedly played a part in the trend toward fewer reportable fires. Each incident that occurs now, however, may be dealt with by a group of individuals with little prior experience in dealing with fire. It becomes critical to first understand their capabilities and then to enhance them where necessary.

The first aspect of an enhanced fire response capability involves hardware. Since timeliness is key to a successful first response, strict attention must be paid to the selection of appropriate sensors, depending upon where they are to be located underground. It is likely that more than one type could be utilized. Additionally, an operation should have a preventive maintenance schedule in place to insure that all detection and suppression devices work properly. Moreover, since early detection is of little value unless a quick response is mobilized, a mine ought to have an established warning and communication protocol that has been tested and refined as needed.

Because water is the most practical extinguishing agent once a fire has passed its incipient phase, a well prepared operation will have adequate quantities and pressure as well as the means to deliver it to a fire site. Such a system, realistically, would include such items as large diameter supply lines, portable fire hydrants and high pressure hoses with suitable nozzles. Rather than the minimum 50 gallons per minute, this system should be capable of delivering hundreds of gallons per minute for sustained periods of time. The implication here is that some thought must be given to water reserves.

Insofar as the task of detecting and extinguishing a fire may require the involvement of a complex system, current work at the Pittsburgh Research

Laboratory is aimed at developing and testing formal fire preparedness audits. The chief advantage of such a strategy, using a carefully defined and preset protocol, is that any strengths and weaknesses of a site could be highlighted in some systematic way. In addition, there would be less chance that problem areas might go undiscovered and hence uncorrected.

"The best facilities and equipment can never compensate for poor preparation" (Mitchell, 1990). There probably is no primary difference, during the incipient phase, between most fires that go unreported and one that results in a mine being sealed. It is simply that the latter either wasn't detected quickly enough or wasn't responded to properly. In order to achieve enhanced mine fire preparedness, mining companies will need to sharpen their strategy vis a vis available technology and equipment while investing increased time and effort in their human resources. If this is done, the number of reportable incidents will likely decline even further and there should be even less chance of another disaster or permanent mine sealing.

***STUDY SETTING AND COOPERATIVE WORK

The cooperating mine uses continuous and longwall mining to extract the Wadge seam, a high-volatile C bituminous coal. The operation is a slope mine that utilizes diesel jeeps and trucks as the major mode of transportation. It has a work force of 225 employees and mines 4,350,000 t per year. The mine experiences air slack, a process in which the coal disintegrates due to rapid changes in mine conditions (air movement and temperature changes). These rapid changes cause the surface moisture of the coal to evaporate more rapidly than the interior moisture replacement, causing the coal to fracture and disintegrate. As a result, the roof and ribs of the entire mine are wire meshed and bolted. In addition to having the floors of all belt drive areas cemented, the roof and ribs in the main drive area are also gunnited, and washed down frequently. The mine's haulage system consists of 11 km of 137 and 152 cm rubber belting. On longwall panels, the mine uses 3 entries and a bleeder system. CO sensors are used for fire monitoring. An automatic sprinkler system, with signal feeds back to a surface mine monitoring control room, is used for fire suppression at belt drives. The coal at this mine is susceptible to spontaneous combustion.

The researchers and company management agreed to cooperate and collaborate on a project to enhance underground mine fire preparedness. The goal of this effort was to develop and evaluate innovative strategies to teach and measure important components of fire response readiness. The components include fire prevention, detection, warning alarm systems, suppression systems, fire fighting procedures and equipment, evacuation and escape. These elements are traditionally assessed in terms of compliance with federal and/or state mandatory safety regulations or guidelines imposed by other authorities (company safety policies, insurance company standards, etc.). This research effort moved well beyond such existing practices. For any mine site, the absence of violations does not necessarily imply the absence of risk, nor reduced risk. Furthermore, compliance with fire prevention and response regulations does little to insure the best and most cost-effective use of available technology in preventing, detecting, responding to, or escaping underground mine fires.

This collaborative research sought to offer empirical insight to several important questions concerning fire preparedness. These questions are all aimed at either preventing fires from occurring, or preventing fires that do occur from causing disastrous consequences: (a) What does it mean to be "prepared" to respond to fire underground. How does one measure this response capability within the context of everyday work life? (b) What objective measures might be useful in an ongoing assessment of the technology in place to detect and respond to underground fires? This research effort involves a series of tasks that are being performed over a two and one-half year period. The outcomes of this work will offer greater perspective on the types of prudent business practices that can markedly and measurably enhance workers' readiness to respond effectively to incipient fires within underground coal mines. The goal is not to eliminate all fire risks. An essential element of this research is the concept of fire risk assessment, which combines aspects of hazard evaluation with frequency and severity analysis. Hazard evaluation involves identifying conditions, equipment and procedures which could cause a fire or contribute to a fire's growth and spread. Frequency and severity analysis entails estimating the likelihood of a fire occurring and the probable magnitude of resulting losses. Together, the activities produce cost-effective risk reduction strategies.

***Fire risk analysis and hazard evaluation**:* This task built upon field data collected by the Bureau of Mines at the cooperator's site over a two year period (1992-94). The result of this task was a set of fire scenarios forming the basis of a fire risk assessment. During a risk assessment, hazards are evaluated in terms of the likelihood that a problem may occur and the damage it would cause if such an event did occur. Adequate mine fire preparedness requires considering all of the possible fires that could occur. Some fires, however, are more likely than others at a given mine and some would result in greater damage than would others. These differences are identified by conducting a risk analysis. The outcome of the analysis can be used to target resources at the types of fires that are most likely and/or most destructive. Fires which are very likely to happen and would do considerable damage to people and property should be targeted for immediate remediation and/or plans should be made for effective response if remediation isn't possible. Potential fires that are less likely or that would have less severe consequences are identified for attention after the more serious situations have been addressed.

The people involved in this activity should be knowledgeable about the area of the mine that is being assessed. At the cooperating mine, fire brigade members are conducting a fire risk assessment of the entire property. Some examples of areas that have been selected for analysis include: a section, the main haulage areas, the underground shop area, and an outside fuel storage area. Large areas that were selected were subdivided into smaller parts and then later combined to yield overall results. One way the areas were chosen for inclusion was to ask the brigade members where they thought a fire would cause the most problems. They then conducted an analysis of each "problem" area they identified. Combining these results will provided information about the hazards in the larger area.

All of the possible fire hazards that existed in the area selected for study were identified. This was accomplished by determining all of the sources of ignition in the study area. The attached form called "Potential Fires" helped organize the ignition sources. Across the top of the form are labels for general types of fire, such as electrical and frictional. Under each general label, raters listed all of the specific sources of ignition of this type that could be found in the geographic area being analyzed. For example, under the label electrical items such as power centers and fan motors were listed. Under frictional someone identified sources like belt rollers or the belt on a motor. The items were made as specific as possible.

Potential Fires

Planned	SponCom	Machinery	Electrical	Frictional	Other

1. Mine Section or Area ______________________________

2. Date ____________________

While there might be many ways of assessing risk, recent literature suggests using the two concepts of probability of occurrence and severity of effects (DeVaul, 1992; Hau, 1993). For each fire hazard identified, a judgement needs to be made about the probability of a fire being caused by that ignition source and the severity of the consequences if such a fire did happen. The attached "Fire Hazard Risk

Matrix" was used to record a risk rating for each fire hazard in the terms high, medium, and low. To use the assessment several concepts must be understood: *Hazard* - any situation that has fire potential; *probability* - likelihood that the particular hazard will result in a fire at this location; *Severity* - an estimation of how serious the potential problem might be in terms of harm to people and/or damage to property.

It should be kept in mind that secondary incidents can occur as a result of the initial incident. For example, a small fire on the surface at an underground coal mine may cause electric power interruption to one mine fan in a multiple fan ventilation system. This may, in turn, cause major changes in ventilation underground and result in accumulations of methane in areas of the mine where it commonly is not found. An explosion hazard would now exist. Secondary incidents were also considered during the rating process.

Fire Hazard Risk Matrix

1. Hazard: ______________________________

2. Potential Location(s): ______________________________

		RISK ANALYSIS		
Probability	**HIGH**			
	MEDIUM			
	LOW			
		LOW	**MEDIUM**	**HIGH**
		Severity		

NOTES:

3. Mine Section or Area ______________________________

4. Date ____________________

In summary, to assess risk, the fire brigade raters: a) identified a source of ignition; b) determined whether the probability was high, medium, or low that the source wouldl actually cause a fire; and c) determined if the seriousness to life, property, and the environment of such a fire would be high, medium, or low. Using this model, those hazards deemed to have the greatest probability for occurring and the greatest severity to the operation were considered as high/high risk hazards. They would be the first priority for future training, mitigation, and/or response preparation efforts.

One way the raters organized their findings was to first take all of the completed "Fire Hazard Risk Matrix" forms and order them from high/high risk to low/low risk. They then put the ordered forms in a notebook. As a hazard was addressed, the corresponding form would be moved to the back of the notebook and the focus then turned to the hazard on the next page. Once they have worked through the entire book, they will have addressed all of the identified hazards.

Development and field test of a fire prevention checklist: The checklist encompasses conditions, procedures and equipment that have been frequently identified as having been the primary or contributing causes of underground coal mine fires. These include welding and cutting procedures and equipment, faulty electrical systems, spontaneous combustion, unsafe accumulations of combustibles, and improperly installed or inadequately maintained mechanical equipment (misaligned belts, faulty slippage and sequencing switches, stuck idlers, overheated compressors, diesel equipment, etc.). The table of contents is reproduced here, along with a sample of the questions asked about the first topic -- Water supply:

TABLE OF CONTENTS

Water supply 3
Hoses and nozzles 9
Foam fire fighting equipment 11
Fire extinguishers 14
Fire Cars/houses/safety trailers 18
Detection systems 21
Suppression systems 26
Combustible materials 28
Housekeeping 31
Evacuation plans 32
Responders to fire 32
Fire brigades 34
Mine rescue 35
Specialized equipment 36
Appendix A.- Example 1 of a cutting/welding permit 38
Appendix B.- Example 2 of a cutting/welding permit 39
Appendix C.- Example of a beltline inspection checklist 40

Water Supply

- *Is there a map of the water system? Yes ____ No ____.*

  Where is the location of the map?
  Who is the contact person?____
  When was the last time that the map was updated? ____

- *Availability of mine water supply: Unlimited supply ____ Reservoir ____*

  Other source ____
  Approximate gallons: _________.

- *Do you have water cars? Yes ____ No ____.*

  If yes, what is the total number of water cars _________.
  Approximate gallons: ____________.

- *Quality of underground water: Caustic ______ Acidic ______ PH level ______.*

  Hardness ______ mg/liter (200 is normal for drinking water)
  Total dissolved Solids (TDS) _______ mg/liter. (higher than sea water)

The fire prevention checklist also contains a number of tables, dealing with various hardware components. The tables are filled out by those performing the survey. A listing is provided below, along with the table dealing with conveyor belts:

TABLES

Main water lines 5
Branch water lines 6
Fire Nozzles 9
Fire hose 10
Throw distance - solid stream 11
Type of fire fighting foam generators on site 12
Foam concentrate 13
Fire extinguishers underground 15
Fire extinguishers surface 16
Fire sensors 22
Suppression systems 26
Water lances 26
Conveyor belt 29
Combustible materials stored or used underground 30

Belts

• If you utilize conveyor belting, please complete the following table on conveyor belt.

CONVEYOR BELT					
BELT CHARACTERISTICS					LOCATION
TYPE	WIDTH, INCHES	THICKNESS, INCHES	MSHA NUMBER	LENGTH, MILES	

The task of risk assessment is an on-going activity. Any time the work environment changes personnel at the cooperating site plans to ensure the risk assessment will be updated and the priorities re-evaluated.

***DISCUSSION

Using the development and testing of this site-specific information system as a base, researchers are generating a set of procedures and guidelines for teaching and measuring fire preparedness within the underground work force (the idea of "fire preparedness" includes components involving prevention, detection, suppression, evacuation and escape). These procedures and guidelines will include the following: (a) A set of mine emergency (fire preparedness) *training protocols* applicable for new hires. This instructional plan would include descriptions (a set of activities) and schedules for introducing new miners to fire prevention, detection, suppression and evacuation systems. The period for these performance based, activity oriented, training procedures is within the first two to three years of underground employment. (b) A set of mine emergency (fire preparedness) *testing protocols* applicable for experienced miners.

Peripheral to this effort, a set of practical questions and applied problems will also be developed. The purpose is to periodically check and refresh miners' knowledge and skills of site specific fire emergency protocols, fire suppression technologies, and fire warning systems. These situational questions and problems might be used by face bosses, safety representatives, mine management, or government inspectors for teaching and reinforcing fire prevention and suppression concepts/values within the work force. Any risk assessment will be most useful to mine personnel if they never consider it finished. Instead, it should always be thought of as a draft document that needs to be up-dated as things change.

***REFERENCES

1. DeVaul, R. E. (1992). "Emergency Response Plan Formulation and Implementation." Proceedings: Twenty-Third Annual Institute on Mining Health, Safety and Research, pp. 67-74.

2. Hau, M. L. (1993). "Coordinating Your Facility's Emergency Response." M. L. Hau & Assoc., Inc., Port Clinton, OH, 17 pp.

3. Mitchell, D. W. Mine Fires: Prevention, Detection, Fighting. Maclean Hunter, Chicago, IL, 1990, 198 pp.