

INCORPORATING DECISION-MAKING INTO QUARTERLY ESCAPE TRAINING

The more exposure miners receive to judgment and decision-making challenges through training, the better their chances for survival in real-life mine emergencies

BY MICHAEL J. BRNICH JR. AND ERICA E. HALL

The 19 fatalities in two explosions and a mine fire in underground coal mines in 2006 raised a number of issues about mine emergency preparedness and response. Reviews of federal investigation reports for these incidents indicated that investigators had concerns about miners' ability to don and use self-contained self-rescuers (SCSRs); miners' judgment and decision making abilities; miners' familiarity with escape procedures; and emergency communications (Murray et al. 2007; Light et al. 2007; Gates et al. 2007).

Following the three major mine incidents in 2006, the National Mining Association's (NMA) Mine Safety Technology and Training Commission (MSTTC) reviewed National Institute of Occupational Safety and Health's (NIOSH) prior research on mine emergency decision-making. In addition, the commission conducted a survey to seek the opinion of industry and Mine Safety and Health Administration (MSHA) safety professionals on issues related to "training for preparedness." Of the 79 participants in the survey, 76% felt there was a need to improve training on how to make decisions during mine emergencies, including those involving self-escape and aided rescue (Mine Safety Technology and Training Commission, 2006).

NIOSH has conducted research focusing on judgment and decision-making in mine emergencies. A study by Vaught et al. (2000) looked at judgment and decision-making in the context of escaping a mine fire. In 2010, researchers conducted interviews with personnel from six coal mining operations to understand how they approach judgment and decision-making when developing quarterly mine escape training (Brnich and Hall 2013).

Judgment and Decision-making in Emergencies

Judgment and decision making has been studied in a variety of areas including clinical settings (Harbison 2001; Lauri et al. 2001), emergency management (Kowalski-Trakofler et al. 2004), and offshore oil and gas emergencies (Flin et al. 1995). But limited literature exists on the process of miners' judgment and decision-making under stress. The only known study to look at these processes in mining was conducted by Vaught et al. (2000) in which researchers had the opportunity to interview miners who escaped mine fires that occurred in western Pennsylvania. During open-ended interviews, workers discussed their actions from the time they first became aware that there might be a problem in their mine until they reached safety. In analyzing the interview data, researchers discovered an array of decision variables, which can be related to various aspects of individual and group behavior during the escape process.

In 2012, the Division of Behavioral and Social Sciences and Education of the National Academies undertook a study that assessed self escape from underground coal mines. In their final report, the National Academies acknowledged the importance of

decision-making as a critical component of self escape in underground mine emergency situations. They also suggest that decision-making not be based solely on in-the-moment choices, but also be driven by the accumulation of knowledge and skills (NAS 2013).

Teaching Judgment and Decision-making Skills in Mining

The concept of teaching judgment and decision-making skills to miners is not new. In fact, the concept has been around for some 30 years. From 1984 to 1990, under a U.S. Bureau of Mine contract, 70 classroom simulation exercises were developed and field tested with mine workers around the United States (Cole et al. 2001). Focusing mainly on underground coal mining, these simulations were based on actual injury or disaster events as reported in formal investigation accounts by MSHA. The simulation exercises developed were designed to teach critical problem-solving and decision-making skills to help miners deal more effectively with emergency events when they happen.

The 70 exercises simulate important aspects of cognitive problem solving and decision-making, which are useful for preventing or limiting the effects of a mine emergency situation. The simulations developed covered two broad domains: 1) how miners respond to mine emergencies (e.g., first aid, self rescue and escape) and 2) how miners integrate safety concepts in the context of performing routine production work. Content areas covered by the simulations include 1) first-aid care; 2) technical areas including ground control, ventilation, fires and explosions, escape strategies, etc.; and 3) a mix of first aid and technical content.

After development of the initial classroom simulations, NIOSH authored additional training exercises designed to teach judgment and decision-making skills (USBM 1994; Cole et al. 1998; Brnich et al. 1999). NIOSH has also developed a suite of training products aimed at teaching miners about the deployment and use of refuge alternatives. These include two tabletop simulations covering decision-making during escape, including when to seek refuge (Vaught et al. 2009; Brnich et al. 2011). A third, computer-based simulation exercise allows trainees to choose from multiple courses of action when faced with escaping a mine fire (Kosmoski et al. 2011).

Judgment and Decision-making Process in a Mine Emergency

As discussed earlier, judgment and decision-making has been studied in a variety of settings. However, the NIOSH study by Vaught et al. (2000) was the first one to examine judgment and decision-making in a mine emergency — in this case, escaping a mine fire. Based on the testimony given by escapees, researchers discovered that miners underwent a complex decision-making process as they escaped. From their findings, investigators were

able to construct a model of the judgment and decision-making process (Figure 1). To understand this model, it is useful to analyze two key findings revealed by the research: how escaping miners perceive the problem in an emergency and how they act on the problem in an emergency.

Perceiving the Problem

In the Vaught et al. 2000 study, researchers learned that escaping miners go through a multistep process in judgment and decision-making. This process is ongoing and continues from when they first recognize there is a problem until they reach safety. First, miners are presented with an initial problem. In the case of the miners who were interviewed for the cited study, the problem was the underground mine fire. As the miners began to perceive what was going on, various background problems factored in, such as not knowing the fire's location, the smell of smoke, and so forth. The context or perspective of the event was also a factor. When the miners smelled smoke, they initially placed the fire events within the framework of a normally occurring event, such as bonds being welded at track rail joints or mechanics using cutting torches.

Acting on the Problem

In the case of the Vaught et al. 2000 study, miners eventually perceived that a problem existed and then entered a diagnosis or analysis phase. Miners experienced stress from a variety of sources, including information uncertainty, which affected their ability to analyze the situation.

After analyzing the situation, miners began to look at available options for responding to the circumstances. Once options were evaluated, miners made decisions on the best option to select and then executed their decision. Overall most miners made good decisions during their escape ordeals. But in some instances, miners made choices and executed decisions only to find that they made the wrong choice. They would then be required to re-evaluate the situation, perhaps through further diagnosis, and then look at other choices and make new decisions on courses of action they would follow.

In the cited study, NIOSH researchers identified several important points about judgment and decision-making in mine emergencies:

- First, miners tended not to identify the problem adequately. Often they tried to place the problem within the context of

normal activities, such as equating the smell of smoke to mechanics using cutting torches.

- Second, escapees' diagnoses were affected by the nature of the warning message they received. At one mine, the call came into the section reporting a fire. The continuous miner operator and helper on this section were simply told to shut down their machines — "...we're going home." These miners went through their normal end-of-shift routine before going to the mantrip.
- Third, miners' feelings about available options and choices were impacted most by their knowledge of the mine and the quality of information available. Generally researchers found that the more knowledge escapees had about the mine and the better the quality of information available to them, the more miners studied choices more carefully and made better decisions on actions to take.

Judgment and Decision-making Training: What Companies Are Doing

Prior research and published post-disaster reports have established the importance of and need for teaching judgment and decision-making to help escaping miners deal with emergency situations. To better understand what industry is doing, NIOSH researchers interviewed mine safety personnel representing six different underground coal mine operators in the United States about how they conduct mandated quarterly escape training. Personnel interviewed included individuals from four companies operating large underground mines in the southern U.S., Northern Appalachia, and the western U.S. The other individuals were from two companies operating small one- and two-unit underground mines in Northern Appalachia.

During the interviews, company personnel were asked to describe aspects of their quarterly escape training including if they teach judgment and decision-making. The various companies take a range of approaches to conducting quarterly escape training at their operations. In general, safety and/or training department personnel develop the quarterly scenarios. These scenarios and any additional information are then typically passed to the foremen who are often responsible for conducting the training.

The six companies follow the basic mandated content requirements for conducting quarterly escape training. It appears all six operators are incorporating some elements of judgment and decision-making into their training. But the nature and variety seems to vary widely among the six companies. However, several operators have shown creativity in their approach. For example, one company may pull a person out of an escape group, unbeknownst to the foreman. If the foreman did a head count, he would note the miner was missing. The foreman would then need to make the decision whether to look for the missing miner or evacuate with the rest of the crew.

At one operation, the foreman leading the training inserted "obstacles" along the route for the crew to encounter. This challenges the crew and requires them to decide what to do. At another mine, the safety personnel developed a flowchart for trainers to follow when conducting quarterly escape training. The flowchart provides guidance to trainers when conducting the training and helps in teaching decisionmaking skills during the evacuation exercise.

While the representatives from the six companies said they incorporate some level of judgment and decision-making into escape

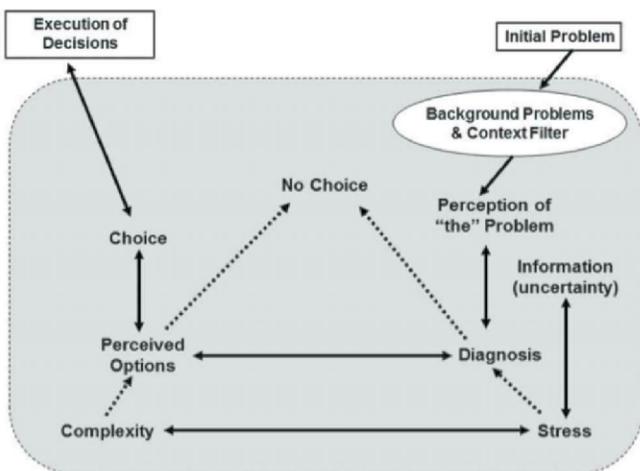


Figure 1: Model of judgment and decision-making (after Vaught et al. 2000).

training, all agreed there is a need for guidance in developing scenarios that include judgment and decision-making components.

Incorporating Judgment and Decision-making Into Escape Training

During quarterly escapeway training, miners must travel either the primary or alternate escapeway in its entirety, find and use directional lifelines and tethers, locate caches of SCSRs as well as refuge chambers, cross overcasts and/or undercasts, travel through manddoors, switch escapeways if needed, and negotiate unique escapeway conditions. Given these requirements, adding teaching points requiring miners to make decisions during their escape can be accomplished when a particular scenario is developed. Creatively incorporating judgment and decision-making components into mandated quarterly training will help add variety to the training and enhance the miners' learning experience.

Sample Scenario Based on a Mine Fire Event

Looking at an excerpt from a sample situation based on a mine fire will be illustrative. The selection comes from an example escape scenario developed by NIOSH (Brnich and Hall 2013). The decision points identified in the example scenario are based on real-life decisions that escaping miners had to make.

For this example, decision point excerpts were used from a scenario where there is a fire located at the section belt takeup, outby the working section. The crew is to travel the primary escapeway, which is also the section's main intake. While these sample decision points are not all inclusive, they present examples of the types of decisions escaping miners may face.

Initial information provided: The section foreman receives a call that there is a fire in the takeup rollers of the section belt at the head drive. Heavy smoke has been observed just inby the mouth of the section and is moving toward the section in the primary escapeway. The foreman is ordered to evacuate the section.

Initial action: Initially the foreman notifies miners of the problem and tells them to gather at the section assembly location. When everyone is gathered, the foreman makes a head count and has everyone together. The crew smells smoke but no smoke is visible. Referring to the judgment and decision-making model (Figure 1), trainees at this stage are made aware of the initial problem and are in the process of perceiving the problem and processing information.

Example decision point: Smelling smoke on the section and based on their diagnosis of the situation, the crew members must decide whether they should don their SCSRs. Even if the CO level is as low as 0 to 5 ppm, the crew members can elect to delay donning their SCSRs. As part of the training, the crew members should be allowed to talk about possible choices and decide what they should do.

Discussion: Although the CO level may be under 50 ppm, CO levels can rise to high levels in a very short period of time without warning. High levels of CO can be present, even in clear air. Trainees should consider the positive and negative aspects of donning their SCSRs at this time.

Real-life example: In November 1968, 21 coal miners escaped the Farmington No. 9 mine following a major explosion. Eight of the escapees were rescued from the Mahan's Run airshaft. All eight miners were wearing a filter self-rescuer when they arrived at the bottom of the air shaft. While waiting to be rescued, five of the eight miners removed their self-rescuers

because the air was clear of smoke. Even though more than 144,000 cfm of air was coming down the shaft, the five miners became unconscious because of high CO levels in the immediate vicinity. Luckily they were revived before being hoisted up the shaft to safety (NIOSH 2009).

Example decision point: As the crew continues their escape on foot in the primary escapeway, one miner injures his ankle when he steps on a piece of coal lying on the mine floor. The miner says it is hard to walk. The crew members must decide what they will do to help the injured miner. This decision point adds a background problem along with stress, and complexity to the escape situation. The crew must look at available options for managing the injured miner and then make a choice on how to proceed.

Discussion: Talk with the group about possible options for dealing with the injured miner. These might include slowing the group down so the injured miner can keep up, helping the injured miner walk, or taking him to the nearest outby refuge alternative. Ask miners in the escape group what they would do.

Another Real-life example: There have been instances where miners have been injured while escaping a mine emergency. In one case, crew members were escaping from their section after a fire was discovered on a piece of haulage equipment outby the section. The coal seam height was around 48 in. and the walkway between the belt and the rib was narrow. One miner in the group was having difficulty navigating along the beltline and breathing from his SCSR. Eventually the miner collapsed and could no longer continue escaping with the group. The crew had to make a critical decision — stay with the downed miner and try to help him escape, or split the group and allow the faster miners to escape and notify incoming emergency responders about the downed miner. The crew decided to split the group. When the first miners reached safety, they told incoming rescuers where the downed miner was located. Since the fire had been extinguished, intake air was redirected to the belt entry to bring fresh air down the belt to where the downed miner was located. He was successfully rescued (Vaught et al. 2000).

These example decision points presented are typical of those that escaping miners might encounter during a mine fire emergency. The decision points miners may encounter will depend on the type of emergency they face. The nature of the situation, the effects of the event on the mine's physical environment, and the overall complexity of the escape also influence the decisions that escaping miners must make.

Discussion and Conclusions

For decades, emergency escape training has included few if any opportunities for challenging miners' decision-making capabilities. Generally mine safety and health practitioners have focused on select components of mine emergency escape such as knowledge of escapeways and the use of emergency breathing apparatus. It has only been since 2006 that miners have been required to participate in more frequent escape drills, based on one of four possible general emergency scenarios.

Past research has shown that good judgment and decision-making is a critical element in mine emergency escape. While development and administration of training simulations for teaching miners judgment and decision-making skills is not new, the idea of teaching these skills in the context of mandated quarterly escape training is relatively new. As Cole et al. (2001) discussed, both mine safety trainers and miners themselves found substantial value in the use of classroom simulation exercises for

teaching judgment and decision-making. Given these findings, there are compelling reasons for incorporating judgment and decision-making components into quarterly escape training to further enhance trainees' base of knowledge to aid them in escaping an underground mine emergency.

This article has presented an overview of judgment and decision-making skills, including how the judgment and decision-making process takes place and how it can be incorporated into mine emergency escape situations. The example decision points provided offer a general framework for trainers to consider when developing new escape exercises. Readers are encouraged to read the NIOSH Report of Investigation 9692, which offers more information on judgment and decision making along with a complete sample escape situation that incorporates judgment and decision making (Brnich and Hall 2013). The more exposure miners receive to judgment and decision-making challenges through training scenarios, the better they will be at making solid decisions when escaping real-life mine emergencies, therefore improving their chances for survival.

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