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National Institute for Occupational Safety and Health

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ACRONYMS AND ABBREVIATIONS

BRASH	Behavioral Research Aspects of Safety and Health
CFR	Code of Federal Regulations
ETS	Emergency Temporary Standard
MSHA	Mine Safety and Health Administration
MSTTC	Mine Safety Technology and Training Commission
NIOSH	National Institute for Occupational Safety and Health
NMA	National Mining Association
OMSHR	Office of Mine Safety and Health Research
SCSR	Self-contained self-rescuer
USBM	U.S. Bureau of Mines

Incorporating Judgment and Decisionmaking into Quarterly Mine Escape Training Based on a Mine Fire Scenario

Michael J. Brnich, Jr., C.M.S.P.[1] and Erica E. Hall, M.S.[2]

Abstract

The major coal mine disasters of 2006 raised a number of issues about mine emergency preparedness and response. These included concerns about miners' judgment and decisionmaking skills under the stress of a mine escape and miners' familiarity with escape procedures. In response, researchers from the National Institute for Occupational Safety and Health (NIOSH) sought to learn how mines are incorporating judgment and decisionmaking skills into mine escape training. They took an in-depth look at previous research on judgment and decisionmaking in self-rescue and escape training. They also conducted interviews with safety and training personnel from six underground coal operations to understand how mine operators are conducting mandatory quarterly escape training. This report discusses findings from these interviews, presents an analysis of previous research on judgment and decisionmaking in self-rescue and escape, and offers guidance to trainers on how to build judgment and decisionmaking into quarterly training drills.

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Introduction

In 2006, three major incidents occurred at underground coal mines in the United States resulting in worker fatalities. These included the explosion at the Wolf Run Mining Company's Sago Mine in West Virginia, in which 12 veteran miners perished; the 2006 mine fire at the Aracoma Coal Company's Alma No. 1 Mine, also in West Virginia, in which 2 miners died; and the 2006 explosion at the Kentucky Darby Coal Company's Darby No. 1 Mine where 5 miners died.

Reviews of federal and state investigation reports for these incidents concluded that investigators had concerns about: (1) miners' ability to don and use self-contained self-rescuers (SCSRs); (2) miners' judgment and decisionmaking skills; (3) miners' familiarity with escape procedures; and (4) emergency communications in the mine [MSHA 2007b,c]. As a general rule, such problems would not be expected with veteran work crews [MSHA 2007a].

Emergency Mine Evacuation Final Rule

After the catastrophic events of 2006, principally the explosion at the Wolf Run Mining Company's Sago Mine and the fire at the Aracoma Coal Company's Alma No. 1 Mine, the Mine Safety and Health Administration (MSHA), the federal regulatory agency for mining, issued new regulations on mine evacuation. The regulations stipulated a number of new requirements for mine escape and self-rescue that translated into a more integrated approach to self-escape training.

The new regulation calls for underground coal mine operators to develop evacuation training scenarios and to provide documented escape training to miners on a quarterly basis. These scenarios are developed based on common types of underground mine emergencies including fires, explosions, and water and gas inundations. The regulation stipulates miners must travel both the primary and secondary escapeways, alternating between them during each training quarter. Quarters are based on a calendar year (January–March, April–June, July–September, and October–December). The rules on quarterly escape training, however, do not specifically require miners to be given training in judgment and decisionmaking.

Judgment and Decisionmaking in Mine Emergencies

When an underground mine fire occurs, the event is investigated by both the state mining agency and MSHA. These investigations focus on the elements of the incidents in an attempt to identify actions taken, root causes of the incident, and to make recommendations to prevent such incidents from happening in the future. Prior to 1988, no one had studied mine fires or other mine emergency events from the perspective of human behavior in response to the emergency and escape from the mine.

In a previous study, Vaught et al. [NIOSH 2000] had the opportunity to interview 48 miners who each escaped from one of three different mine fires that occurred in western Pennsylvania. Interviewers first asked each miner to describe their actions and thoughts from the time they first became aware that there might be a problem in their mine until they reached safety.

Upon completion of their narratives, miners were asked a set of questions focused upon better understanding of key decisions and actions. With the permission of the miner, the interviews were recorded and transcribed. The 48 transcribed interviews resulted in more than 2,000 pages of data. The accounts were then assessed using a computerized cross-indexing scheme. Researchers next placed reported actions within generalized categories of response. Research team members discovered an array of decision variables, which were related to various aspects of individual and group behavior during the escape process. Each major aspect of the events has been incorporated into a model of the behavior of workers escaping from underground mine fires.

Judgment and Decisionmaking

Cole et al. [NIOSH 2001] noted real-world decisionmaking is often guided by internalized stories of past events which direct goals, judgment, and actions. As they point out, narratives or stories of events have been used for many years in miner training and other settings to teach important concepts.

However, there is limited literature on the process of miners' judgment and decisionmaking under stress. The study conducted by Vaught et al. [NIOSH 2000] was the first one to examine the judgment and decisionmaking process within the context of a mine emergency—which is, in this case, escaping a mine fire. Based on the testimony given in their interviews, researchers discovered miners underwent a complex decisionmaking process as they escaped. From their findings, Vaught et al. [NIOSH 2000] were able to construct a model of the judgment and decisionmaking process (Figure 1).

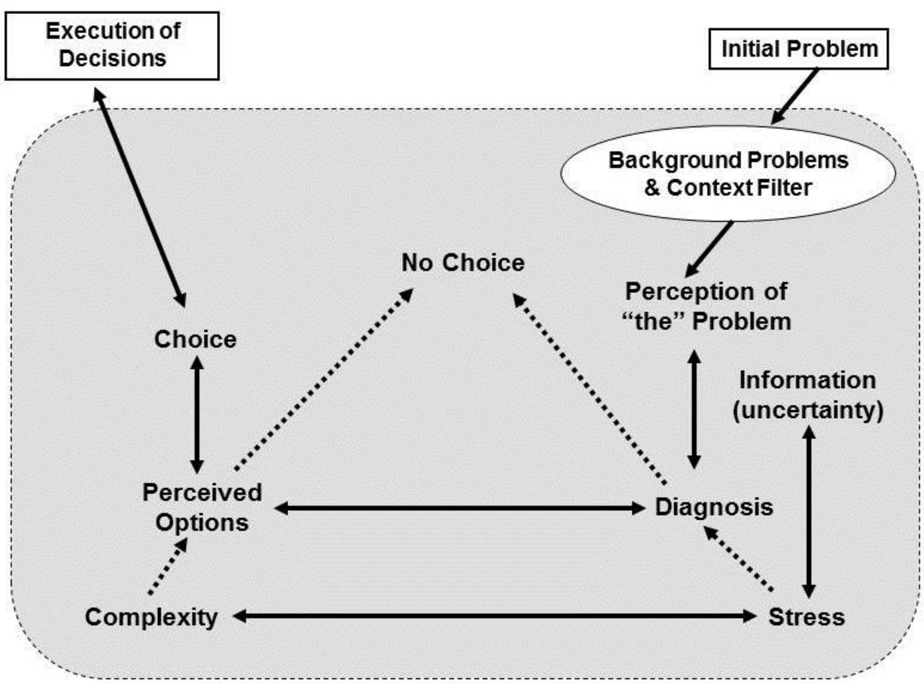

Figure 1. Model of judgment and decisionmaking [NIOSH 2000].

Vaught et al. [NIOSH 2000] found that escaping miners go through a multi-step process in judgment and decisionmaking. This process is ongoing and continues from when they first perceive there is a problem until they reach safety.

Perceiving the Problem

First, miners are presented with an initial problem. In the case of the 48 miners who were interviewed by Vaught et al. [NIOSH 2000], the stated problem was the underground mine fire. As the miners began to perceive what was going on, various background problems were factored in, such as the knowledge of the fire location, the smell of smoke, and so forth. The context 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, the conveyor belt rubbing somewhere, or mechanics using cutting torches. Similar perceptions were reported by McAteer et al. [2006] following the 2006 Aracoma mine fire [p. 20 of McAteer's report].

Acting on the Problem

The escaping miners interviewed by Vaught et al. [NIOSH 2000] eventually perceived a problem existed and then entered a diagnosis or analysis phase. Miners dealt with 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 then made decisions on the best option to select and then executed their decision. In numerous 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. As mentioned earlier, this judgment and decisionmaking process was ongoing throughout the entire escape scenario.

Based on findings from their analysis, Vaught et al. [NIOSH 2000] identified several important points about judgment and decisionmaking:

- First, miners tended not to perceive the problem adequately. Often they tried to place the problem within the context of normal activities. For example, when one miner heard there was a fire outby at the section belt drive, he first assumed it was probably some smoldering coal underneath the belt and that his crew was going to head down to the drive and put out the smoldering fire using fire extinguishers and rock dust.
- Second, the diagnosis made by escapees was 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 without knowing why and assumed "we're going home." These miners went through their normal end-of-shift routine, taking about 10 minutes of valuable time that could have been devoted to escape.

- Third, miners perceived the available options for responding to the situation, and their subsequent choices of which options to use were impacted mostly by their knowledge of the mine and the quality of information available. During one mine fire, the section foreman on one crew had only been working at the mine for about one week and was unfamiliar with the mine layout. The continuous miner helper was a former fireboss at the mine and knew the mine layout very well. The foreman and crew turned to him to lead them out to safety. Based on the miners' testimony, researchers determined the quality of decisions made and actions taken by escaping miners varied greatly.

From the testimony provided by the 48 miners, Vaught et al. [NIOSH 2000] found all miners escaped in groups. The typical group size was 8 to 10 workers; however, one group was comprised of only 3 workers. In some groups, most if not all members participated in the judgment and decisionmaking process. In others, decisions were made by only one or two persons. As a general rule, miners in the escape groups tended to go along with the decisions made, even though individuals sometimes felt there might be better options.

Similar responses were noted in independent reports of more recent events. Following the Sago Mine explosion, a report by the United Mine Workers of America described evacuations of two crews in the mine. The 1 Left crew, traveling into the mine when the explosion occurred, exited with little difficulty. Following the explosion, the crew gathered at the mantrip and started walking outby in the track entry. Because of thick dust and smoke, the crew decided to cross over several entries to get into the intake escapeway. The crew continued traveling outby without incident until they returned to the track entry where they were met by another mantrip and taken outside. This crew exited the mine with few problems [UMWA 2006].

The 2 Left crew appeared to separate from one another but then got back together at the mantrip. Attempting to escape in the mantrip, the crew encountered debris on the track. At this point they elected to go toward the section's intake escapeway. Because of smoke and believing several self-contained self-rescuers (SCSRs) were not working properly, the crew returned to the section and barricaded in the face of the No. 3 entry on their section [UMWA 2006].

McAteer et al. [2006] discusses the escape of the Section 2 crew during the Alma No. 1 Mine fire. After receiving word of the fire, the crew began their escape in the section mantrip. After traveling about 2,200 feet, the crew encountered light then heavy smoke. At this point the crew abandoned the mantrip, donned their SCSRs, and proceeded to the smoke-free secondary escapeway. While proceeding to the escapeway, two miners became separated from the rest of the crew and perished. Although riding out on the mantrip is easier and faster, the McAteer report questions why the crew decided not to walk out the secondary escapeway, especially knowing where the fire was located.

Research on worker behavior in mine fires led to the development of training aids, including three tabletop simulation exercises designed to teach judgment and decisionmaking skills. One exercise, developed by Cole et al. [1998], focuses on decisions that must be made when an escaping miner goes down and cannot continue with the group. The second exercise was developed by the U.S. Bureau of Mines (USBM) and centers on decisionmaking related to traveling on the mantrip as far as possible before deciding when to abandon transportation and continue to escape on foot [USBM 1994]. The third exercise, developed by Brnich et al. [NIOSH 1999], discusses how to properly use one's SCSR and how to decide when it's time to switch to another apparatus during a prolonged escape.

Vaught et al. [NIOSH 2009b] and Brnich et al. [NIOSH 2011a] also developed a suite of training products aimed at teaching miners about deployment and the use of refuge alternatives in underground coal mines. These include two tabletop simulation exercises covering decisionmaking during escape, including when to consider seeking refuge in a refuge alternative. A third NIOSH module, developed by Kosmoski et al. [NIOSH 2011b], is a computer-based simulation exercise that allows trainees to choose from among multiple courses of action when faced with escaping a mine fire (such as entering a refuge chamber or escaping alone). The simulation is a branching exercise that offers three possible sets of choices for trainees, depending on their initial courses of action.

Decisionmaking in Quarterly Escape Training

For decades, mine safety and health training has been bound by rules governing the content miners must be taught. Often this content is presented by an instructor discussing or demonstrating concepts. As such, there has been little opportunity for trainees to learn by experience and less time to emphasize judgment and decisionmaking skills within the context of the training session. Kowalski and Vaught [NIOSH 2002] point out that learning by experience is important to adult learners because adults learn best by having experiences and reflecting on them. As they suggest, adults learn best in situations where the learning is active, experienced-based, real-life-centered (i.e., based on real events), problem- and task-centered, and solution-driven. With the mandated quarterly escape training, miners now have the opportunity to learn by experience, and trainers have the chance to couple this experience-based learning with lessons in judgment and decisionmaking.

Following the three major mine incidents in 2006, the National Mining Association (NMA) Mine Safety Technology and Training Commission (MSTTC) reviewed NIOSH's prior research on mine emergency decisionmaking [MSTTC 2006]. As part of its efforts, the Commission conducted a survey to seek the opinion of industry and MSHA safety professionals on issues related to "training for preparedness." Of the 79 participants in the survey, 76% (60 participants) felt that there is a need to improve training in how to make decisions during mine emergencies, including during mine escape.

Prior research as well as published post-disaster reports have established the importance of and need for teaching judgment and decisionmaking skills to help escaping miners deal with mine emergency situations. For this report, the authors had the opportunity to interview mine safety personnel, representing six different underground coal mine operators in the United States about how they conduct the mandated quarterly escape training. Personnel interviewed included individuals from four companies operating large underground mines in the southern United States, northern Appalachia, and the western United States, and two individuals from companies operating small one- and two-unit underground mines in northern Appalachia.

During the interviews the companies' safety training personnel were asked to describe a variety of aspects of their quarterly escape training, including if they teach judgment and decisionmaking. The various companies take a variety of approaches to conducting quarterly escape training at their operations. In general, company safety and training department personnel develop the quarterly scenarios. These scenarios and any additional training information and materials are typically given to the section foreman who is often responsible for conducting the training.

To make efficient use of training time, several operators combine their quarterly escape training with other mandated requirements such as the 90-day inspection of SCSRs, inspection of the miners' tracking tags, and the required 90-day SCSR donning and switchover training. One company also incorporates a brief classroom session on self-escape before miners go underground for their escapeway drill. At another operation, 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.

Federal law in 30 CFR[*] 75.1502(c)(3) [2011] addresses mine emergency evacuation and firefighting programs of instruction. Specifically, this law mandates that evacuation training scenarios must include options for discussion and decisions. The 30 CFR 75.1504(b)(3) [2011] law stipulates how mine evacuation training and drills are to be conducted. Realistic escapeway drills must be initiated and conducted with a different, approved scenario during each training quarter. For each quarterly escape training session, miners must:

(1) Travel the primary or alternate escapeway in its entirety.

(2) Locate and use directional lifelines, tethers, SCSR caches, and refuge alternatives.

(3) Traverse overcasts, undercasts, and mandoors.

(4) Switch escapeways as applicable.

(5) Negotiate unique escapeway conditions.

In most cases mining companies closely follow the basic content requirements as mandated by MSHA, but in other instances companies have shown exceptional creativity in their approach. It appears all six operators are incorporating some elements of judgment and decisionmaking into their training, but the nature and variety of their training approaches seem to vary widely among the six companies. For example, one company may pull a person out of an escape group, without the knowledge of the section foreman. If the foreman did a head count, he would note the miner was missing. The foreman would need to make the decision whether to look for the missing miner or evacuate with the rest of the crew when told the fire could not be fought. At another operation the foreman leading the training will often insert "obstacles" along the route for the crew to encounter. This challenges the crew and requires them to decide what to do in unexpected situations. Although the representatives from the six mining companies said they incorporate some level of judgment and decisionmaking into escape training, all agreed there is a need for guidance in developing scenarios that include judgment and decisionmaking components.

[*] Code of Federal Regulations. See CFR in references.

Guidance for Trainers

As discussed previously, adults prefer learning experiences which are, among other characteristics, active, experienced-based, real-life-centered, task- and problem-centered, and solution-driven. Creatively incorporating judgment and decisionmaking components into mandated quarterly training will aid in adding variety to the training and enhance the trainees' learning experience.

Gathering Information

A wide variety of information and materials exist to assist trainers when developing decisionmaking components for quarterly escape training. Resources available to trainers include mine emergency incident reports from MSHA and state mining agencies, available documented narrative publications from NIOSH on mine emergencies, and mine emergency decisionmaking simulations developed by NIOSH's Office of Mine Safety and Health Research (OMSHR).

Decisionmaking Simulations

Since the mid-1980s, a variety of mine safety decisionmaking classroom simulation exercises have been developed by both the University of Kentucky's Behavioral Research Aspects of Safety and Health (BRASH) Working Group under contract with NIOSH OMSHR (formerly the U.S. Bureau of Mines) and also directly by OMSHR researchers. These problem-solving exercises are based on actual emergency events reported in formal investigations by MSHA and on firsthand information provided by miners who were directly involved in the events. Built on an unfolding narrative, they are designed to teach critical problem-solving and decisionmaking skills to help miners effectively deal with emergency situations.

These judgment and decisionmaking exercises translate federal and state safety laws, findings from accident data analysis, and expert knowledge into practical information that miners can apply every day in the workplace. As Cole [1993] suggests, the exercises: (1) draw on the extensive knowledge and expertise of a mature workforce; (2) capitalize on adult learners' desire for real-world learning; (3) present skills and information to be learned within authentic problem situations; and (4) focus on judgment and decisionmaking.

The exercises cover a variety of safety and health issues including first aid and medical emergencies, accident investigation, roof-fall entrapment, mine refuge chamber use, and mine escape. Although these simulations are designed for administration to groups in a classroom setting, they provide valuable, real-world content for instructors to use for incorporating decisionmaking into escape training.

Incorporating Judgment and Decisionmaking into Escape Training

During quarterly escapeway training, miners, according to Federal law [30 CFR 75 (2011)], 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 undercasts, travel through mandoors, switch escapeways if needed, and negotiate unique escapeway conditions during quarterly escapeway training. Given these requirements, teaching points requiring miners to make decisions during their escape can be added when specific scenarios are developed.

Using available resources, the authors offer a sample scenario based on the need to escape a mine fire. The decision points identified are based on real-life decisions that escaping miners had to make as found in various narrative sources, simulation exercises, and investigation reports.

Sample Scenario Based on a Mine Fire Event

This example uses a scenario in which there is a fire located at the section belt takeup, outby the working section, and the crew is scheduled to travel the primary escapeway, which is also the section's main intake. 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.

Examples of Decision Points in a Mine Fire Scenario

- 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 keeps everyone together. The crew smells smoke but no smoke is visible.
- **First Decision Point.** With the smell of smoke on the section, the crew must decide whether they should don their SCSRs. If the carbon monoxide (CO) level is 0 to 50 ppm (parts per million) as determined by the trainer, the crew can elect to delay donning their SCSRs. Allow the crew to talk about possible choices and to 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. 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, early morning 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. Even though more than 144,000 cfm (cubic feet per minute) 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 2009a].

- **Second Decision Point.** The crew must decide how to proceed to evacuate. Should they start out on the mantrip or travel on foot in the primary escapeway, or should the crew proceed to the alternate escapeway? The crew should discuss pros and cons of all options before deciding what to do. Obviously, the trainer directs them to follow the primary escapeway.
    - *Discussion*. Riding out of the section on the mantrip is by far the best option and would most likely be the choice in an actual emergency. Yet, for the exercise, miners need to travel the escapeway on foot so they become accustomed to following the lifeline and tethering together as a group. Following the alternate escapeway is a practical option, but should only be done if the primary escapeway becomes impassable.
- **Third Decision Point.** The crew proceeds to the primary escapeway and locates the lifeline. While the air here is still clear, the crew must decide if they are going to tether themselves together. Have the crew discuss positive and negative aspects of tethering together.
    - *Discussion*. By tethering together, the crew can ensure that they stay together as a group while escaping. Keeping everyone together is critical to avoid confusion and reduce the likelihood that escaping miners will become separated. Although tethering keeps the group together, it can slow groups down and prevent them from traversing the escapeways as quickly as they might otherwise.
    - *Real-life example*. During one mine fire, a crew was escaping by following the alternate escapeway. When the group reached an overcast, the last miner in the line decided to break away from the escape group but did not tell anyone. His intent was to travel on his own along another route with which he was familiar. After the crew reached safety, several miners in the original escape group realized their coworker was missing when they did a head count. As a result, three of them donned fresh SCSRs and went back into the alternate escapeway in very heavy smoke looking for their missing coworker. It was later determined that the coworker took another escape route and reached safety [NIOSH 2000].
- After tethering themselves together, the crew begins traversing the primary escapeway while holding onto the lifeline.
- **Fourth Decision Point.** At about five minutes into the escape, the foreman's multigas detector alarm sounds. The crew must decide if they should don their SCSRs at this time (Figure 2). The trainer should ask the crew why they should or should not don their apparatus at this time.
    - *Discussion*. When CO is detected, miners need to don their SCSRs immediately. As previously mentioned, CO can be present in clear air and the level can rise quickly. This is why it is important that someone in an escape group have a multigas detector with them at all times.

Figure 2. Miners preparing to escape by donning their self-contained self-rescuers (SCSRs).

- **Fifth Decision Point.** After donning their SCSRs, the crew continues to escape. They encounter light smoke at first, then hit heavier smoke, reducing visibility to 20 feet. The crew must decide if they wish to continue their escape in the primary escapeway or check the alternate escapeway for smoke and move into it if the air is clear or the smoke lighter.
  - *Discussion*. This is a good time to talk about the pros and cons of switching escapeways. This scenario requires miners to follow the primary escapeway the entire distance. In an actual situation, it would be reasonable to find the nearest mandoor leading to the alternate escapeway and checking it for smoke. If the smoke was lighter, it makes sense for escaping miners to switch escapeways. However, as long as they have a lifeline to follow, they can continue out, using the primary escapeway.
- **Sixth Decision Point.** After traveling half of the way out of the mine, escaping miners encounter an obstacle, a bad roof just outby an intersection. A large slab of roof has fallen and brought down the lifeline, but the escapeway is still passable. The crew must decide what to do—should they attempt to continue in the primary escapeway or go to the alternate escapeway to get around the bad roof?

  NOTE: The bad roof area can be either simulated with yellow caution tape or a placard; or the trainer can simply tell the crew what they have encountered.
  - *Discussion*. This is a critical decision point for an escape group. Although a slab of roof has fallen, it may be impossible to assess overall roof safety in moderate or heavy smoke. Even if miners would decide to continue out the primary escapeway and skirt the side of the roof fall, the lifeline may have been taken down by the roof fall. This means miners would have to step off the lifeline in

smoke and may experience difficulty navigating back to the lifeline once they have passed the bad roof area. Briefly talk with the crew about the pros and cons of how to manage the situation.

NOTE: Because the escapeway used for the quarterly training must be walked in its entirety, the trainer will need to bring the crew back to walk the portion of the escapeway that was bypassed if the group decides to move to the alternate escapeway.

  - *Real-life example*. In one mine fire, a crew was escaping in moderate to heavy smoke following their section's primary escapeway. After traveling about eight crosscuts, the group came upon a roof fall in the escapeway. The section foreman, who was in the lead, immediately turned the group around and took them back several crosscuts to a mandoor that led from the primary escapeway to the return. The group crossed into the return and traveled about five crosscuts outby before reaching another door leading from the return back to the primary escapeway. The crew got back into the primary escapeway, having gone around the roof fall, and continued until they reached clear air outby the fire [NIOSH 2000].

- **Seventh Decision Point.** The crew decides to go into the alternate escapeway to pass around the bad roof. In the process, one miner injures his ankle when he steps on a piece of coal lying on the mine floor. The miner says he is having trouble walking. The crew must decide what they will do to help the injured miner.
  - *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 the miner to the nearest outby refuge alternative. In this case, it would be best to help the injured miner walk while keeping the crew together. Ask miners in the escape group what they would do.
  - *Real-life example*. There have been instances where miners have been injured while escaping a mine emergency. In one case, a crew was escaping from their section by following the beltline. The coal seam height was around 48 inches 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. At one point the miner went down 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 outby, they told incoming rescuers where the downed miner was located. Because 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 [NIOSH 2000].

- **Eighth Decision Point.** The escaping crew has been wearing their SCSRs for nearly forty minutes and they have reached a cache of units. The group must decide if they are going to stop and switch SCSRs, pick up a second SCSR and continue on, or look for another escape route where the air is clear. Allow the crew to talk about their options and discuss their choice with them.
    - *Discussion*. While miners may still be breathing fairly well from their SCSRs, the best option is to switch apparatus at this time. This will ensure that all miners have a fresh apparatus, and it allows escapees to work together and help one another while switching SCSRs. Taking a unit and continuing on will only require the group to stop multiple times while different miners switch out SCSRs.
- The crew switches apparatus at the cache and continues on outby to safety.
- The eight decision points presented in this example are typical of the circumstances escaping miners might encounter as they egress the mine during a mine fire emergency. In any given emergency, there may be more decision points or fewer depending on the nature of the emergency, the effects of the event on the mine's physical environment, and the overall complexity of the escape as a result of these factors. Regardless of the type of mine emergency scenario a trainer develops for a quarterly escape training session, the example presented here can serve as a model for developing other scenarios which include judgment and decisionmaking components.

Discussion and Conclusions

For decades, emergency escape training has been conducted with minimal content and contained few if any opportunities for challenging miners' decisionmaking 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 by federal mandate to participate in more frequent escape drills, based on one of four possible general emergency situations that present imminent danger to mines. These include fires, explosions, gas inundations, and water inundations.

Past research has shown that good judgment and decisionmaking are critical elements in mine emergency escape. Although development and administration of training simulations for teaching miners judgment and decisionmaking skills is not new, the idea of teaching these skills in the context of mandated quarterly escape training is relatively new. Research by Cole et al. [NIOSH 2001] revealed that both mine safety trainers and miners themselves found extreme value in the use of classroom simulation exercises for teaching judgment and decisionmaking. Given these findings, there are compelling reasons for incorporating judgment and decisionmaking components into quarterly escape training to further enhance trainees' base of knowledge to aid them in escaping an underground mine emergency.

This publication has presented an overview of judgment and decisionmaking skills, including how the judgment and decisionmaking process works and how it can be incorporated into mine emergency escape situations. The sample scenario offers a general framework for trainers to consider when developing new escape exercises. The more exposure miners receive to judgment and decisionmaking challenges through training scenarios, the better they will be at making solid decisions when escaping real-life mine emergencies, and therefore improving their chances for survival.

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