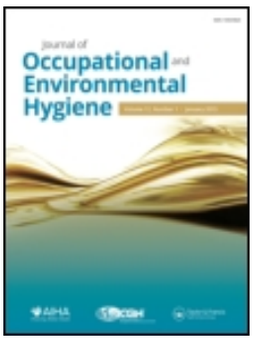

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Expectations Training for Miners Using Self-Contained Self-Rescuers in Escapes from Underground Coal Mines

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National Institute for Occupational Safety and Health researchers conducted a study to investigate the human response issues related to wearing a self-contained self-rescuer (SCSR). The goal was to develop training to educate miners on what they could expect from their units during an escape. Subjects included miners who had experience wearing SCSRs, manufacturers, and researchers. Results identified nine key areas of concern: (1) starting the unit, (2) unit heat, (3) induction of coughing, (4) unit taste, (5) difficulty in breathing while wearing the unit, (6) quality of the air supplied, (7) nose clips, (8) goggles, and (9) the behavior of the breathing bag. In addition, researchers reviewed the literature on human response under duress. This article describes the expectations training program, which comprises the findings of the SCSR study and what is known about the normal human response in an emergency. The authors present background on SCSRs and the SCSR switchover procedure mandated in the recent federal Mine Improvement and New Emergency Response Act of 2006, which provided the impetus for the expectations training.

Keywords disaster, escape, mining, self-contained self-rescuer, training

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The findings of this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

INTRODUCTION

Self-contained self-rescuers (SCSRs) provide the wearer with a 1-hr oxygen supply as mandated by U.S. government regulations. SCSRs were developed in the late 1970s and deployed in U.S. mines in the early 1980s for use by coal miners during emergencies, such as fires, explosions, or gas inundations in which the ambient atmosphere becomes toxic. As their name implies, SCSRs are meant to serve one purpose—to allow a miner to self-rescue by escaping the mine. They are not intended to be used for other purposes, such as fire fighting. As with other oxygen-supplying apparatuses such as the closed-circuit breathing units worn by mine rescue teams, SCSRs are fairly complex devices and thus require detailed analysis.

There are two types of SCSRs produced and sold. Both are closed-circuit breathing apparatuses; that is, the units do not exhaust CO_2 but remove it from the breathing circuit internally. One type of SCSR stores O_2 as a compressed gas and uses a chemical bed of lithium hydroxide (LiOH) to absorb CO_2 as the miner exhales. It is started by opening a valve on the oxygen cylinder that fills a breathing bag. The other type uses potassium superoxide (KO_2, a solid chemical that reacts with moisture in the breath) to generate O_2, with LiOH used to remove much of the CO_2 from the breathing circuit.

This study focused on the problematic use of SCSRs by miners who attempted to escape the Wolf Run Mining Company's Sago Mine in West Virginia following an explosion. The particular SCSR used by miners at the Sago Mine was a combination unit in terms of providing oxygen. The initial oxygen is provided by a small compressed oxygen cylinder that yields 7 to 8 liters of oxygen. When the oxygen cylinder is activated, the wearer receives an initial supply of oxygen that is sufficient until the potassium superoxide begins to generate oxygen. If the oxygen cylinder fails, the device can be "cold started" by the miner expelling several breaths to inflate the breathing bag. A SCSR's complexity requires some level of training by miners to ensure correct use. Figure 1 depicts miners wearing compressed oxygen SCSRs during a mock escape drill. Federal mining regulations require that every person entering an underground coal mine in the United States has to be furnished with an SCSR.[1]

In 1981, SCSR devices were introduced into U.S. mines. Although much time, effort, and money had gone into the development of these engineered devices, very little effort was spent in teaching people how to use them. More recently, self-rescuer training was included as one of several mandatory courses in Title 30 *Code of Federal Regulations* Parts 48 and 75.[1] Specifically, SCSR training was implemented into the broader, required course on self-rescue and respiratory devices, such as respirators. However, this course was one of 12 covered during a single 8-hr day. It called for instruction and demonstration in the use, care, and maintenance of self-rescue

FIGURE 1. Miners wearing compressed oxygen SCSRs during a simulated escape

and respiratory devices employed at the mine. Thus, training consisted of a short demonstration of the donning procedure once a year. Few miners ever had the opportunity to actually put on an apparatus and see what it felt like to use one. Further, miners had no notion of what to expect when wearing the SCSR in an escape situation.

BACKGROUND

In 2006, several major incidents occurred at underground coal mines in the United States, resulting in 19 worker fatalities. These included a fire at the Aracoma Coal Company, Inc., Alma No. 1 Mine in West Virginia, in which 2 miners died; an explosion at the Kentucky Darby Coal Company Darby No. 1 Mine, where 5 miners died; and the explosion at the Sago Mine in which 12 miners died. For illustrative purposes, the authors focus here on the Sago disaster because of the number of fatalities and the relevance of SCSRs to this case.

On Monday, January 2, 2006, at approximately 6:30 a.m., an explosion occurred at the Sago Mine, leading to the death of 12 miners. Thirteen miners were working in the vicinity of the explosion. Twelve were members of a coal production crew. Of this group, 11 of the 12 perished from carbon monoxide poisoning. The thirteenth miner was working alone about 1500 feet from the other 12; he was killed by the force of the explosion. The sole survivor of the production crew was able to give testimony in the ensuing investigations conducted by the Mine Safety and Health Administration (MSHA)[2] and the West Virginia Office of Miners' Health, Safety and Training (OMHST).[3] The survivor devoted many of his statements to the functioning of the crew's SCSRs, the type that uses potassium superoxide to generate oxygen. This article is based on the OMHST Report of Investigation, which is rich in detail and devotes an entire section to SCSR use. When appropriate, verbatim quotes are given to represent exact detail from this report. As might be expected, there are some inconsistencies in the testimony, so the authors present both sides of the issue when apparent contradictions occur.

Following the explosion, the crew started out of the mine on their track-mounted personnel carrier. They soon encountered debris on the track that made it impassable. The crew then entered their primary escapeway, a tunnel that could lead them out of the mine. They walked approximately 305 m (1000 ft) through a potentially deadly atmosphere before donning their SCSRs. "While it is unclear the location at which the self-rescuers were donned, [the survivor] stated that the attempt to walk out was aborted by the section foreman because three of the twelve rescuers were not functioning."[3] At another point in the report, however, there is a different interpretation of the attempt to walk out of the mine: "Finding their way blocked by smoke and debris, the crew was forced to return to [their workplace], gathering materials to build a barricade as they went." What is not at issue in either statement is the fact that three individuals were convinced that their SCSRs were not working.

Once back in their workplace, the crew began to erect a barricade of plastic sheeting that would provide some protection from the smoke and, they hoped, from carbon monoxide. The miners took off their SCSRs while they were building the barricade.[3] After the barricade was finished, all 12 men went behind it to wait for rescue teams to arrive. The survivor reported that there were not enough SCSRs to go around, since after a time, four miners were not able to make theirs work. Individuals shared with each other, trading off SCSRs between them. Besides removing and replacing mouthpieces while sharing the apparatuses, members of the crew also removed their mouthpieces to talk. The OMHST Report of Investigation concluded that "The cumulative exposure to carbon monoxide before, during, and after their SCSRs apparently stopped producing oxygen exposed the individuals to levels that were fatal."

It is extremely unlikely that 4 of the 12 devices would malfunction (three initially and the fourth later). All models of SCSRs on the market undergo extensive and rigid laboratory testing prior to being certified for use in underground mines. Title 42 *CFR* Part 84 charges NIOSH and MSHA with jointly reviewing and issuing certifications for respirators used for mine emergencies and mine rescue, including SCSRs. Title 42 *CFR* Part 84 also delineates minimum design criteria for apparatus, testing criteria for apparatus, and other provisions. Within NIOSH, the National Personal Protective Technology Laboratory (NPPTL) in Pittsburgh, Pa., is responsible for evaluating and certifying SCSRs for use in underground mines. NPPTL has extensive protocols in place for testing and certification of respiratory devices including SCSRs.

Twelve SCSRs were recovered from behind the barricade at Sago; after which, "MSHA took custody of the SCSRs and placed them in sealed plastic bags for transfer to NIOSH's National Personal Protective Technology Laboratory [NPPTL]

in Bruceton, PA."[3] Investigators at the NPPTL evaluated all 12 recovered units, concluding that "All had been deployed and examination of the chemicals inside the canisters indicated that they all had started producing oxygen." None of the SCSRs, however, had been used to anywhere near full capacity. In fact, the average amount of potassium superoxide spent was only 38.2%. The SCSRs of the three victims who the survivor stated wore malfunctioning units initially had produced as much O_2 as the others, and one showed evidence of moisture in the canister.

Because of the way SCSRs were handled during the building of the barricade, it is apparent that they were not used correctly, at least not in that instance. Lack of knowledge of how the devices work may have had something to do with their misuse, especially if the miners took the mouthpieces out or shared the devices as reported by the surviving miner. In turn, this may have led to CO poisoning, which would have affected the miners' reasoning and decision-making abilities, leading to further misuse of the SCSRs.

The OMHST report[3] detailed some of the complex characteristics of the chemical-oxygen unit that workers need to know but typically do not. First, cold starting the device may entail a considerable amount of time. It can take as long as 7 min for the apparatus to build up to 19.5% oxygen, which is reason enough, from a trapped miner's point of view, to think the unit is not working. Thus, when the survivor tried to cold start his buddy's SCSR at one point during the disaster, he might not have given it enough time. Second, breathing hard and rapidly moves more carbon dioxide and moisture through the canister. Trying to push or pull a greater volume of air through the chemical bed than it was designed to handle will generate breathing resistance. As noted earlier, miners might then remove their units to seek more breathing comfort, which is what happened when the crew members were building their barricade. Third, while the chemical reaction is progressing, it is generating heat, which keeps the KO_2 in a molten state. If the wearer removes the SCSR for a few minutes, as the victims did with theirs, the canister cools and the KO_2 solidifies. Once solid, the KO_2 forms a hard coating around the potassium superoxide, making it very difficult to restart the device. The result could be an SCSR with only a small portion of the potassium superoxide expended, as in the units recovered from behind the barricade.

In response to the mining incidents of 2006, on December 8 of that year, MSHA promulgated a new rule on emergency mine evacuation. The rule states: "MSHA is concerned that miners may not be able to recognize when an SCSR is functioning properly. This may have caused miners to remove their SCSRs prematurely, thinking that the device was not working when breathing became difficult. Also, miners need the skills and knowledge to initiate (cold start) an SCSR if it fails to start automatically after the starting sequence is initiated."[4]

At MSHA's request, NIOSH developed expectations training that will address the above concerns. The present study was conducted to determine problems and issues that miners and investigators have voiced based on past experience. Basic human responses under duress have been reviewed and included in the training. The expectations training focused on what miners could expect from their SCSR, as well as what to expect from themselves and others in an escape situation. For this article, the authors define expectations training as training that provides the trainees with sufficient physical, cognitive, psychological, and behavioral information (beyond the necessary technical information and hands-on experience) to allow them to understand any potential symptoms they might experience while performing a task or action.

Earlier Studies

Although there have been few studies regarding how to teach miners what to expect when using SCSRs, the notion that there ought to be expectations training for miners has been discussed for years. The fact that miners need to be educated about how the devices perform and what to expect from themselves when under duress is borne out in NIOSH interviews with 48 miners who escaped fires at three underground coal mine operations in western Pennsylvania in 1988 and 1990. As an example, from the miners' comments, a majority of them were unaware that (1) there is breathing resistance when SCSRs are used, and (2) this resistance increases the longer the apparatus is worn. Consequently, when they encountered breathing resistance, the miners thought their SCSRs were not working properly. As a result, more than half of them either took their mouthpieces out or breathed around them while remaining in a potentially deadly atmosphere.[5–7]

Accounts of incidents such as these have brought the reliability of SCSRs into question among members of the mining community. Concern over a crisis of confidence that was not based on empirical data led the Joint Government, Labor, and Industry Task Group on Person Wearable Self-Contained Self-Rescuers to suggest that expectations training could be employed to restore miners' confidence in the units. The task group devoted 12 pages to discussions of how to improve donning training and introduce expectations training. One observation particularly germane to this article came from an individual who noted that his company believes that one of the training objectives should be to educate the user regarding the kinds of stressors and performance expected from the SCSR.

Whether lack of confidence played a part in the 2006 tragedies, there have been numerous instances in which miners died, but subsequent laboratory tests established that their apparatus was not used up.[3,8] This presents a perplexing problem for investigators, one that has no easy answers. The Report of Investigation by MSHA into the Sago Mine disaster illustrates this point very well.

Previous studies outside the mining industry have concluded that individuals' behavior and decision making is influenced by prior experiences and training.[9] In addition, other investigators have recommended that training on SCSRs should include mention of common complaints aired about the units.[10]

A study evaluating test protocols for smoke divers working in the heat was conducted with nine male subjects (firefighters).[11] Firefighting activities involve strenuous physical work that is often performed in a hot and hostile environment with similarities to the exertion during escape under apparatus from a serious mine explosion and fire. It is known that the combination of physical activity, heavy clothing, and thermal stress results in increased physiological and psychological stress.[12] The study showed that strenuous smoke diving efforts at 130°C produce greater thermal stress and result in a perception of greater effort than at lower temperatures. The stress is greater during longer tests, and the authors conclude that this may have implications for individual decision-making ability and the ability of workers to behave rationally with regard to their own safety and awareness of their limitations.

Another study related the use of realistic previews to training outcomes.[13] The authors note that little attention has been given to how employee point of view relates to expectations, attitudes, or decisions in the selection of training programs. They examined two variables that could affect a worker's entry into a training program: (1) the type of prior information offered about the program, and (2) the amount of freedom the worker had to take the program. Of interest to the present study was the type of prior information offered to the potential trainees. Trainees who received a realistic training preview were more likely to benefit from training and show commitment to their decision to attend the training; in addition, they were more motivated to learn. The authors conclude that it is becoming increasingly clear that understanding a trainee's point of view is critical to attaining positive training outcomes and to the overall success of training interventions.

Another interesting study looked into the effects of optimistic vs. realistic previews of training programs on self-reported transfer of learning. Sixty-four participants were divided into two groups: one group received informative, optimistic previews of the training; the other group received a realistic (positive and negative) preview. Findings showed that the optimistic preview had more positive impact on expectations, motivation, learning, attitudes, and transfer of learning.[14] Thus, according to this study, previewing training in an optimistic, positive manner will result in higher motivation and increased transfer of learning from the classroom to the workplace. It is important to note that this study was limited in that the subject sample was small; nevertheless, it raises a point to consider in training.

METHOD

This study involved 11 male subjects: four miners (two of whom had worn SCSRs during an escape from an underground coal mine, and two others had extensive in-mine experience with the apparatus); CEO/presidents of three SCSR manufacturing companies; one general manager of safety and training from a major U.S. mining company; and three government researchers who had served as laboratory subjects in the testing of SCSRs. Subjects were informed that their participation was voluntary and anonymous.

Each subject was interviewed in person or in a scheduled phone interview by the principal investigator—a research psychologist. Interviews lasted from 15 min to an hour. Subjects were asked questions about the human aspect of wearing an SCSR. The interview began with asking the subject to describe his history of experience wearing an SCSR. After understanding the subject's background, open-ended questions were asked, such as: *What was it like wearing the SCSR? Which unit did you wear, or have you worn?* Subjects were prompted by the interviewer as appropriate: *Did it have a taste? Did it have a smell? What did it feel like on your chest . . . on your nose? What concerned you while wearing the unit? What should other miners know about how these units feel and perform?*

Responses were recorded by the assistant researcher as written notes that were later transcribed, compared with, and integrated with the research psychologist's notes and observations. From this data, a list of issues regarding the wearing of the SCSRs was determined by analyzing individual interview responses. The individual issues were then compared with the responses of all interviewees to determine key issues and note consensus. NIOSH researchers also reviewed targeted psychological literature to determine important issues to include in relation to the expectations of self and others during escape.[15,16]

Limitations of this study: This study may be viewed as limited due to the small number of subjects interviewed. The authors interviewed a variety of experienced subjects—miners, manufacturers, and researchers—to saturation, which refers to the point in a study when the researchers are hearing nothing new. The nine key areas of concern were confirmed many times by the subjects.

RESULTS

SCSRs

It was noted that there are some differences between chemical-oxygen units and compressed oxygen units with respect to user expectations, emphasizing the importance for the miner to be trained on the specific unit used at his/her mine. There were nine key concerns resulting from the data analysis related to wearing an SCSR:

1. *Starting the unit*. Miners must start all types of units by either pulling a cord or opening a valve. Chemical-oxygen SCSRs may be cold started by the wearer exhaling into the unit until the bag is full.
2. *Heat*. All units grow hot to the touch. SCSRs employ chemical beds that generate oxygen (using potassium superoxide) and/or scrub carbon dioxide (using lithium hydroxide) from exhaled air. The chemical reactions that take place during breathing generate heat. Thus, the miner may experience discomfort on his/her chest

from the heat generated. It was suggested that miners use their clothing, a glove, or even an empty rock dust bag as protection between chest and unit.

3. *Induction of cough*. Most units are packed with a dustlike substance (talc/cornstarch) to prevent the hoses from sticking together or to absorb saliva. The resultant coughing by the wearer may last a few minutes. Miners are advised not to remove the mouthpiece but to cough directly into the unit. Subjects stated doing that may produce a gag reflex.
4. *Taste*. Miners have reported a variety of different tastes—from no taste to rubbery, bitter, metallic, or salty taste. A cornstarch taste was noted most frequently.
5. *Resistance to breathing*. All SCSRs have some level of breathing resistance associated with them simply because of their design. The breathing hoses, due to their design and size, present initial resistance. Chemical-oxygen units can be the most difficult to breathe through. As mentioned earlier, chemical-oxygen SCSRs use chemical beds to generate oxygen and/or to scrub carbon dioxide from exhaled air. As these chemical beds are gradually expended, there is less space for air to move through them, which causes breathing resistance to increase with time. Under normal circumstances the unit will continue to work as resistance builds up. Some miners have described that breathing through the units feels like breathing through a straw.
6. *Quality of breathed air*. In chemical-oxygen units the air is generally hot and dry. It may take a while for the chemical reaction to start. The harder the miner breathes, the greater the chemical reaction induced. Some subjects reported that their throat and tongue became dry, making it difficult to swallow. Compressed oxygen units were found to be hot and very humid.
7. *Nose clips*. Subjects usually reported that the unit's nose clips were uncomfortable, taking some time for wearers to get used to breathing through the mouth. Mouth breathing also may cause saliva to accumulate around the mouth. Excessive saliva may cause miners to remove the mouthpiece briefly to expel the saliva. Salvia can also enter the breathing circuit on chemical-oxygen units and accelerate the oxygen production process.
8. *The goggles*. Goggles protect the eyes from smoke and toxic gases. Subjects reported that the goggles fog up or can fill with sweat, which is uncomfortable and makes it difficult to see.
9. *The bag*. Bags on different units do not behave the same. It is important for miners to know how the bag functions on the specific unit they are using.

Miners should understand that once the chemical-oxygen units are activated, the chemical reaction will produce more oxygen than the wearer needs. The excess oxygen will cause the breathing bag to fill up and overflow out the relief valve. For the SCSRs used by the Sago miners, the main chemical reaction begins 15 to 20 min after the unit is activated. Until the chemical reaction kicks in, the breathing bag will not be full. Miners must also understand that their oxygen demand may be higher than the amount produced by the SCSR. In this case, the miner is "outbreathing" the SCSR. An escaping miner must slow down his or her activity level to reduce their oxygen need. As long as the miner is able to inhale and exhale, the fullness of the bag is immaterial. Once all the oxygen is released by the chemical reaction, the breathing bag will get smaller and smaller until the miner can no longer take a breath.

With compressed oxygen units, the volume of the breathing bag does not matter as long as there is pressurized oxygen in the cylinder. If more oxygen is needed than the constant flow provides, and the bag is emptied in the middle of a breath, the demand valve will open and pull what is needed directly from the cylinder. When the pressure gauge reads zero, the cylinder is empty.

In all SCSRs, there may never be an outward sign such as bag inflation, relief valve operation, increased resistance, or high temperature to indicate the unit is working. If the miner can breathe while wearing the unit, then it is supplying oxygen and thus functioning.

Psychological Response

The review of literature on human response to emergencies provided the following advice to the miners as part of their expectations training.

> It is normal to experience an *emotional reaction* during an emergency escape. You are experiencing stress and likely what is sometimes referred to as the fight or flight response. This is the survival instinct that we are all born with; it prepares us to fight or run. This response prepares the body to help you in your escape. Psychologists call an incident like an emergency escape from a mine a "traumatic incident" and we know what some of the normal human reactions are to traumatic incidents.
>
> *Responses to a traumatic incident* include physical, mental, emotional, and behavioral changes. Remember that strong reactions and emotions are normal reactions in an extra-ordinary situation. Individuals are different and report any or all of the following symptoms: Rapid heartbeat, Dry mouth, Sweaty palms, Increased anxiety, Fear, Sweating profusely, Feeling confused, Feeling overwhelmed, Shallow breathing, Nausea, Disorientation.
>
> *These are ordinary human responses to an extraordinary situation.*
>
> *What you can do.* Be conscious of slowing your breathing down. Walk at a steady pace. Stay with your buddy or crew. Watch out for each other. Think forward – think about getting out of the mine. Focus on the escape. Do not remove the mouthpiece to talk. Do not remove your unit until you are in fresh air or ready to switch to a new unit. Think forward.
>
> *Walk at a steady pace. Stay calm. Regulate your breathing.*

At the beginning of this section, the authors noted nine characteristics of SCSR behavior based on data from the study. In addition, by discussing the psychological response, the authors provided some information as to what miners might expect from themselves and how to cope in an escape scenario. There have been few studies in the mining industry on how to prepare oneself for emergencies. Yet, it is logical to assume that what is known about physical and psychological responses to traumatic incidents can be incorporated into a coping strategy that can be applied for the purpose of escape. A well-formulated strategy may help the individual think beforehand what he or she is likely to face in an actual emergency.

The question is then what part does the above advice play in building a strategy useful in preparing an individual to face a situation he or she has probably never faced before? After all, the tips appear innocuous. The answer is that these tips make up a type of advance organizer, one which links existing knowledge to that which is unknown.[17] Whereas there are several types of advance organizers, those that provide *new* information to the individual (for example, the fact that SCSRs get hot with use) are called expository organizers.[18] Research has suggested that expository organizers work best when there is no prior knowledge involved, since the advance organizer itself becomes the individual's prior knowledge. Thus, the earlier discussion of psychological response, although brief, is critically important in developing an effective coping strategy.

DISCUSSION

The integration of expectations training into SCSR training is timely and important in light of the 19 mining fatalities in 2006 and the previous studies conducted by NIOSH. Researchers conducting interviews in 1988 reported that miners did not know how to don their SCSRs and were unaware of what to expect from them. For example, miners were not aware that the units got hot against the chest and that there would be increasing resistance to breathing over time. In 1993, a joint government, labor, and industry task group on SCSRs concluded that expectations training needed to be introduced into emergency training. Studies outside the mining industry have concluded that decision making can be affected positively in individuals exposed to infrequent, high-impact situations if they have had prior experience and training. The mining industry may wish to consider realistic, optimistic training that has been shown to promote commitment in training, better transfer of learning from classroom to work environment, and a more positive attitude and motivation to learn.

The list of expectations developed from this study was given to MSHA to meet its urgent need to use this information as part of the new mandated SCSR training for teaching miners to switch from one SCSR to another in the event they need more than one unit to escape. The need for a training regimen for switching from one SCSR to a second unit was mandated by the Mine Improvement and New Emergency Response Act of 2006 (MINER Act),[19] Because of the urgency to meet the mandates of the MINER Act, the authors were operating under severe time constraints. They relied, therefore, on their expertise as trainers who have extensive knowledge of SCSRs to develop a curriculum that they judged to be useful for its intended purpose. They then trained a small convenience sample of other experts who were in a position to evaluate the content of the curriculum, and who found it to be logical and well constructed. There was no time to conduct a training field test with a sample of miners. However, questions of its applicability are now moot because every underground coal miner in the United States is trained quarterly using the curriculum developed by the authors.

CONCLUSIONS

Over the years there have been repeated calls for SCSR expectations training because a significant number of miners who have had to use the devices in an emergency maintained that the units did not work. This article presents the results of a small study undertaken at the request of MSHA to address this issue.

The authors began by framing the problem historically, then focusing on the Sago disaster of 2006, which is illustrative of how SCSRs have typically been used and misused by miners in emergency situations. The fact that three individuals were convinced that their apparatuses were not working undoubtedly had some bearing on their decision to return to the workplace and barricade after initiating an escape attempt through a mine tunnel.

With these issues as background, the authors next reviewed the few relevant studies that address expectations training in general. Although scarce, the existing research does indicate that prior experience and training influence individuals' behavior during events that occur infrequently but have a high consequence—a description that fits mine disasters perfectly.

The study involved 11 subjects with disparate backgrounds, some of whom had worn the SCSR extensively. The aim was to develop, as fully as possible, a list of characteristic issues relevant to the apparatus when in use. The result was nine key concerns that were generally agreed on by the subjects. These, combined with an assessment of psychological responses, made up the core of a training document that was turned over to MSHA for its use.

The ultimate conclusion for the mining industry from the research reported thus far is that expectations training for SCSRs is long overdue. There is a pressing need for much attention to this issue from both researchers and the industry in general.

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