NIOSH Mining Program Information Circular IC 9534

Self-escape Core Competency Profile:

Guidance for Improving Underground Coal Miners' Self-escape Competency

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Information Circular 9534

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Acronyms and Abbreviations

ABC	airway, breathing, and circulation
AED	automated external defibrillator
CCER	closed circuit escape respirator
CPR	cardiopulmonary resuscitation
DoD	Department of Defense
EGL	escape group leader
GAO	Government Accountability Office
gOE	Group for Organizational Effectiveness
IC	Information Circular
ISD/SAT	Instructional System Design/System Approach to Training
KSAs	knowledge, skills, and abilities
MINER Act	Mine Improvement and New Emergency Response Act of 2006
MSHA	Mine Safety and Health Administration
MSTTC	Mine Safety Technology and Training Commission
NAS	National Academy of Sciences
NIOSH	National Institute for Occupational Safety and Health
PPE	personal protective equipment
RA	refuge alternative
RP	responsible person
SA	situational awareness
SCBA	self-contained breathing apparatus
SCSR	self-contained self-rescuer

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Margaret E. Ryan, MPH;[1] Michael J. Brnich, Jr., CMSP;[2] Cassandra L. Hoebbel, PhD[3]

Introduction

About the Self-escape Core Competency Profiles

The National Institute for Occupational Safety and Health (NIOSH) developed this Information Circular (IC) for underground coal mine operators, managers, safety professionals, mineworkers, state and federal agencies, and anyone with an interest in improving self-escape preparedness. This document is intended to serve as a framework (or "competency profile") upon which self-escape training for underground rank-and-file coal miners can be based. NIOSH researchers define rank-and-file miners as hourly workers with no formal self-escape leadership training or expectation to serve in a leadership role during the initial stages of emergency response but who, nonetheless, must be able to self-escape in the event of a mine emergency.

The framework includes a set of nine core self-escape competency areas and related performance criteria. It is important to note that ALL underground coal miners, including those in self-escape leadership positions (e.g., the responsible person (RP) and the likely escape group leader (EGL)), must also be competent in these areas in addition to the competency areas specific to their leadership roles. These roles as they relate to endangered miners are covered in this document, but a detailed examination of all self-escape leadership roles and responsibilities is not. All aspects of mine emergency management remain a topic of great interest to NIOSH and self-escape leadership is the subject of ongoing research.

Mine safety personnel may use this document as a blueprint for planning and implementing competency-based training and assessment strategies at their mine sites. To help integrate this framework into current self-escape training practices, this document also includes guidance on how to introduce competency-based strategies into already required training activities (e.g., new miner training, annual refresher training, and quarterly escapeway training).

The self-escape competency profile for underground coal miners is based on the results of a four-year research project carried out by NIOSH in response to recommendations made by the National Academy of Sciences (NAS) to advance self-escape training [NRC 2013]. An in-depth

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description of the purpose and scope of this research, including stakeholder consensus building and validation exercises, is provided in this IC's companion publication, NIOSH Technical Report *Advancing Self-escape Training: A Needs Analysis Based on the National Academy of Sciences Report, "Improving Self-escape from Underground Coal Mines"* [NIOSH 2023].

Core Competency Areas and Training Topics

The main body of this IC presents a self-escape competency framework for rank-and-file miners. This includes nine core competency areas and related training topics, as follows:

1. Everyday preparedness
    a. Personal preparedness
    b. Accounting for personnel
    c. First aid
2. Situational awareness: mine layout
    a. Location of mine emergency features and resources
    b. Establishing and maintaining situational awareness
3. Emergency diagnosis and response
    a. Knowing signs of danger
    b. Decision-making
4. Wayfinding
    a. General principles
    b. Moving effectively as a group
    c. Location and use of emergency features and apparatus
5. Self-contained self-rescuers (SCSRs)[4]: locating, donning, and switching/swapping
    a. Locating
    b. Donning
    c. Switching/swapping
    d. General maintenance

[4] The SCSR approved under 42 C.F.R. Part 84, Subpart H, and closed circuit escape respirator (CCER) approved under 42 C.F.R. Part 84, Subpart O reflect two generations of the same respirator used in certain industrial and other work settings during emergencies to enable users to escape from atmospheres that can be immediately dangerous to life and health. The SCSR/CCER is used by miners to escape dangerous atmospheres in mines. Standards for the approval of CCERs were updated in a final rule published March 8, 2012, in which HHS codified a new Subpart O and removed only those technical requirements in 42 C.F.R. Part 84, Subpart H that were uniquely applicable to CCERs. All other applicable requirements of 42 C.F.R. Part 84 were unchanged. The purpose of these updated requirements is to enable NIOSH and MSHA to more effectively ensure the performance, reliability, and safety of CCERs used in underground coal mining.

The former Subpart H performance rating system classified SCSRs by the duration of breathing air. Because duration is quite variable across users based on their diverse individual factors such as age, weight, and fitness level, NIOSH 's Subpart O requirements evaluate CCERs based on the liters of oxygen provided rather than the more arbitrary assessment of duration used for the Subpart H SCSRs. NIOSH's regulatory change applies to the approval of these devices whereas MSHA's regulations apply to the deployment of these devices in mines. MSHA's regulations remain to be duration based.

Both SCSRs (approved under Subpart H) and CCERs (approved under Subpart O) are deployed in U.S. mines; however, the vast majority are SCSRs. For simplicity within this publication, NIOSH will use only the term "SCSR" throughout when referring to respirators that are appropriate to use for escape from atmospheres encountered in mining operation that are immediately dangers to life and health.

6. Self-contained self-rescuers (SCSRs): using and expectations
    a. What to expect when using an SCSR
    b. Communications
    c. Preparedness
7. Communication
    a. General principles
    b. Communicating within an escape group
    c. Communicating with the responsible person and surface personnel
    d. Communication technology
8. Refuge alternatives (RAs)
    a. When to enter
    b. Operation
    c. Managing resources
    d. Communicating
9. Firefighting
    a. Diagnosing
    b. When to fight a fire
    c. How to fight a fire

Each of these core competency areas is presented in the context of its related performance criteria; supplemental knowledge, skills, and abilities (KSAs); suggestions for training; and "KSAs in Action." These elements are defined below. Also, for use by trainers, individual competency assessment checklists for each of the nine competency areas detailed in this IC are provided in Appendix B. These checklists can be used by individual miners to self-assess or to indicate anonymously which areas they would like to see additional training or by safety trainers as a reference to assess whether miners are able to properly demonstrate or explain each of the KSAs.

Competency Areas

Through several stages and with substantial internal and external subject matter expert input along the way, researchers categorized critical self-escape KSAs identified through formal task analyses into nine core competency areas, listed above. These nine core competency areas are presented in the context of the four elements described below.

Performance Criteria (Core KSAs)

The core self-escape competency areas are made up of KSAs that task analysts [gOE/Aptima 2016a; 2017 a, c] and internal and external subject matter experts considered critical and necessary for all underground miners to possess [NIOSH 2023]. For each of the nine competency areas, there are a number of topic areas and related core (or "need to know") KSAs, which may serve as "performance criteria" or the learning objectives upon which to frame self-escape training and assessment activities. Successful explanation or demonstration of each KSA listed under each core competency suggests that miners have, for the time being, met the performance criteria or "mastered" that competency area. Examples of continuous formal and informal assessment activities that can be used to help monitor performance and prevent skill decay are described under each competency area's "Suggestions for Training."

Supplemental KSAs

The supplemental KSAs included in this document are those KSAs that subject matter experts considered "good" or "helpful" for rank-and-file miners to know. These supplemental KSAs may provide an opportunity for additional or enhanced self-escape training when combined with the core KSAs during self-escape training and preparedness activities.

Suggestions for Training

Unless otherwise noted, the authors adapted suggestions for training for each of the nine competency areas from previous NIOSH research, NIOSH-sponsored contractor reports [gOE/Aptima 2016 a,b; gOE/Aptima 2017 a,b,c], and external subject matter expert feedback. Researchers mapped specific training suggestions to the relevant competency areas so that trainers may refer to them when planning competency-based training and assessment activities.

KSAs in Action

The "KSAs in Action" sections include content from investigations and videos that document the mine emergencies that occurred at the Sago, Aracoma Alma No. 1, and Kentucky Darby Mines in 2006; Quecreek in 2002; Wilberg in 1984; and Farmington No. 9 in 1968. Researchers mapped specific KSAs listed in the competency profiles to quotations from cases representing actions taken or events that unfolded during past mine emergencies to provide real-world examples of why these KSAs are important and why miners must be proficient in them [Cullen 2017; MSHA 2007a; MSHA 2007b; MSHA 2007c; NIOSH 2009; Wooten 2006].

Miners' Self-escape Competency: Why It Matters

Successful self-escape can require miners to utilize a wide variety of KSAs, some of which are practiced throughout the year during required self-escape training and drills.

In three separate mine emergencies in 2006, over 80% of the miners who lost their lives survived the initial incident but perished while trying to-escape [Brnich and Kowalski-Trakofler 2010]. Investigative reports cited that deficiencies in miners' mastery of numerous critical self-escape KSAs contributed to these fatalities, and the reports linked these KSA deficiencies to inadequate self-escape training [GAO 2007; McAteer et al. 2006 a,b; MSTTC 2006; NIOSH 2015].

The Mine Improvement and New Emergency Response Act of 2006 (MINER Act) strengthened existing self-escape training regulations and introduced new technologies, resources, and practices aimed at improving emergency preparedness in underground coal mines. Although the MINER Act also required the assessment of miners' self-escape KSAs, it did not include explicit guidance on how to teach or evaluate these competencies [Hoebbel et al. 2018].

Moreover, the Mine Safety Technology and Training Commission [MSTTC] identified the lack of established assessment guidelines and practices as a key weakness in self-escape training system in the U.S. [MSTTC 2006], making it difficult for companies to readily identify gaps in critical self-escape KSAs before emergencies occur. NIOSH researchers have long emphasized the need for competency standards and procedures for measuring individual miners' self-escape preparedness [Peters et al. 2010], beginning with "a comprehensive listing of competencies for miners, foremen, managers, and responsible persons" [NIOSH 2010, p 43].

The NIOSH-sponsored investigation conducted by the NAS in 2013 resulted in similar recommendations for NIOSH and MSHA to follow to advance self-escape training by shifting away from an hours-based system and, instead, to adopt a train-to-mastery self-escape framework with competency standards [NRC 2013].

Establishing a Framework for Competency-based Self-escape Training

The industry's current hours-based system requires miners to attend a certain number of hours of annual refresher training, under the assumption that time in training will enable miners to build and maintain self-escape competence. Other activities, such as quarterly escapeway drills and SCSR expectations training, are more activity-based than hours-based, but guidance/requirements for competency assessment are limited.

Completion of time-based training alone may not lead to full competence, particularly for complex procedural tasks. Results from the NIOSH Self-escape Competency Survey indicated that current time-based training has not resulted in full self-escape confidence among the mining workforce on any of 28 broad self-escape KSAs included in the survey [Hoebbel et al. 2018]. A brief summary of these results can be found in Appendix A and a detailed description of this research effort is provided in NIOSH [2023]. These findings further highlight the need for more effective guidelines and materials that mine companies can voluntarily use to effectively train, assess, monitor, and improve miners' self-escape KSAs.

Mining regulations in other countries such as the United Kingdom [Health and Safety Executive 2014]; Australia [Queensland Government 2012], and South Africa [South African Government 1998] require that coal miners meet minimum levels of education, training, experience, and assessment outcomes to demonstrate competence required to fulfill roles in coal mining.

Competency-based education is also widely used in other fields, including the medical field and in emergency preparedness, to ensure that trainees can perform at a specific level of proficiency after they have completed training [Powell and Caraccio 2018; McGaghie et al. 1978].

According to Powell and Caraccio, there are four main requirements for a competency-based education system:

1. A standardized definition of competence
2. Frontline personnel willing to serve as competence assessors
3. Assessment, including evidence-based assessment tools and formative feedback
4. Performance monitoring and management over time

Using a Competency-based Framework for Continuous Self-escape Performance Management

To pave the way for effective self-escape training, NIOSH has developed an evidence-based set of self-escape competency areas with associated performance criteria along with training and assessment suggestions that the industry can use as an initial competency framework. Mine safety personnel can use these materials to introduce competency-based training, assessment, and continuous performance management strategies at their mine sites.

Figure 1 depicts an overview of how to carry out continuous performance improvement within the context of the Shewhart cycle (also known as "plan, do, check, act"). The Department of Defense (DoD) suggests that practitioners use the Shewhart Cycle as part of the Instructional System Design/System Approach to Training (ISD/SAT) [DoD 2001]. This same cycle is also recommended by the National Mining Association (NMA) in its CORESafety initiative for the management of safety and health in the mining industry [NMA, no date].

The cycle includes four basic steps: planning the approach, doing the activity, checking the results, and acting on the results.

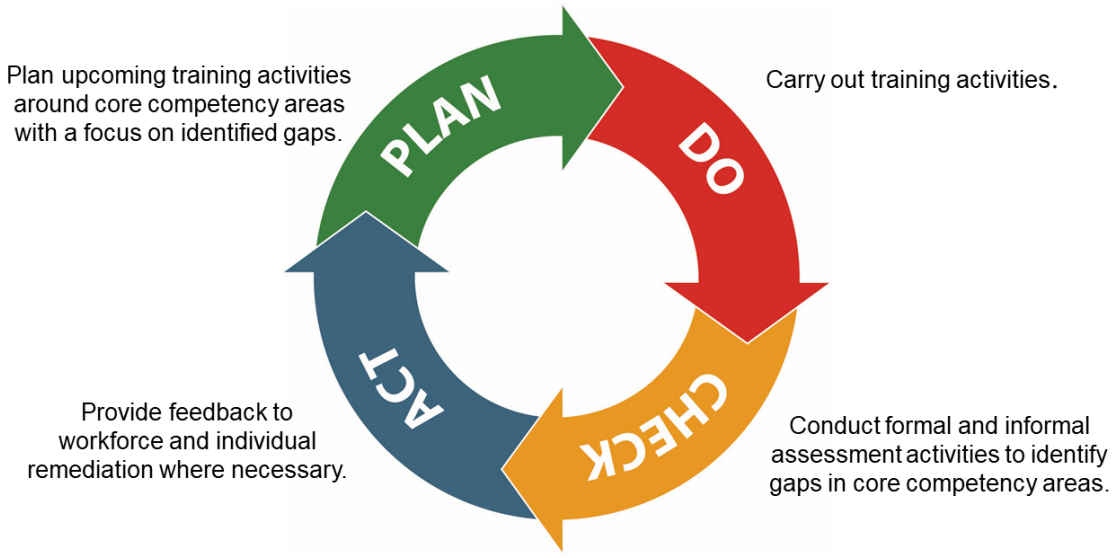

Figure 1. Illustration of the Shewhart cycle, which mine safety personnel can use as part of the ISD/SAT for continuous improvement [adapted from DoD 2001].

The cycle begins with the "plan." The plan will consist of all required training under CFR 30 48.8 (annual refresher training) and the MINER Act [2006] (quarterly escapeway drills and expectations training) with emphasis placed on any identified or suspected deficiencies in critical self-escape KSAs. Once the training topics have been identified, the training suggestions provided within this document can help to facilitate what trainers might "do" to facilitate learning. "Checking" can include debriefing and other formal and informal assessment activities. Given varying degrees of operator restraints (e.g., lack of time and other resources), rigorous assessment activities will not always be feasible. The checklists provided in Appendix B can be used either formally (check the box if the trainee can demonstrate or explain each KSA) and informally (distribute to trainees and ask them to check the KSAs they think they can properly demonstrate or explain or identify items they would like to see more of during upcoming trainings). Thus, mine safety personnel can "act" to specifically target the competency areas most in need of improvement so that training efforts are tailored to miners' specific, evolving needs, with the goal of continuous improvement.

Chapter 1
Everyday Preparedness

In addition to the core competencies discussed in the following chapters, it is essential that all miners remain current on all required trainings and take steps to increase personal preparedness to effectively respond to a mine emergency. Miners should be equipped with required personal protective equipment (PPE), functional devices such as multigas detectors and self-contained self-rescuers, and other necessities such as essential medications, reading glasses, food, and water. All miners should have a basic knowledge of who is working on their crew, including the designated responsible person (RP)[5] for their shift. All miners should also have basic first aid skills.

Photo by NIOSH

Figure 2: First aid kit situated at a mine's power center which serves as this mine's designated meeting place.

[5] § 75.1501 Emergency evacuations. For each shift that miners work underground, there shall be in attendance a responsible person designated by the mine operator to take charge during mine emergencies involving a fire, explosion, or gas or water inundation.

Core Competency Area

Table 1. Performance Criteria (Core KSAs) for Everyday Preparedness

Personal Preparedness	▪ Remains up-to-date on all required training ▪ Knows the relative risk propensity of the mine (e.g., which is most likely to occur: gas or water inundation, fire, or explosion) ▪ When appropriate, the miner carries the following: o Essential medications o Emergency medicine sticker and card with known conditions o Reading glasses o Wristwatch o Lunch and water ▪ Carries and knows how to use: o Multigas detector o Handheld radio o Required personal protective equipment (PPE) o Proximity sensor targets ▪ Has a serviceable[6] SCSR on one's person or within 25 feet of current location ▪ Conducts checks on all personal equipment to ensure it is in working order ▪ Has the ability to attach to a tagline/tetherline in the event one is needed (e.g., belt loop, pants loop) ▪ Knows one's own personal limitations and capabilities and has some familiarity with those of others on the crew/team ▪ Knows the chain of command for reporting a mine emergency (particularly for outby workers who may be working alone)[7]
Accounting for Personnel	▪ Knows the location of and ensures the safety of inexperienced miners, if assigned ▪ Knows the identity and approximate or likely location of the designated RP on each shift
First Aid	▪ Recognizes the need to seek medical assistance for oneself or others ▪ Knows where to locate first aid equipment and how to use it (e.g., backboard and straps, oxygen, automated external defibrillator (AED), bandages and dressings) ▪ Knows how to administer basic first aid for shock; check airway, breathing, and circulation (ABCs); and administer cardiopulmonary resuscitation (CPR)

[6] "Serviceable" is defined by the manufacturer and may be different for different SCSR models.
[7] This item was added to the competency framework based on external subject matter expert feedback which noted that outby workers, in particular, can benefit from this knowledge because it is not always straightforward to whom they should report; and oftentimes, the shift foreman and other "bosses" may not be in the workers' direct vicinity.

Supplemental KSAs for Rank-and-file Miners

- Knows procedures for immobilizing, transferring, and moving an injured miner
- Understands one's own role in emergency response and that of the section foreman, who will typically be responsible for leading the escape (i.e., the responsible person (RP) or escape group leader (EGL))
- Has in mind a general escape plan with the crew every shift
- Has general knowledge of personnel on crew and assigned locations, as well as others without assigned locations (e.g., construction crews, fire bosses, supply men)
- Knows the identity and location of new/inexperienced miners (e.g., "red hats," new hires)
- Knows which crewmembers, if any, have specialized emergency response training or experience (e.g., mine rescue, emergency medical, fire brigade)
- Knows one's own personal limitations and capabilities and has some familiarity with those of others on the crew/team
- If appropriate, carries the following:
    - Extra permissible light
    - Paper and pen

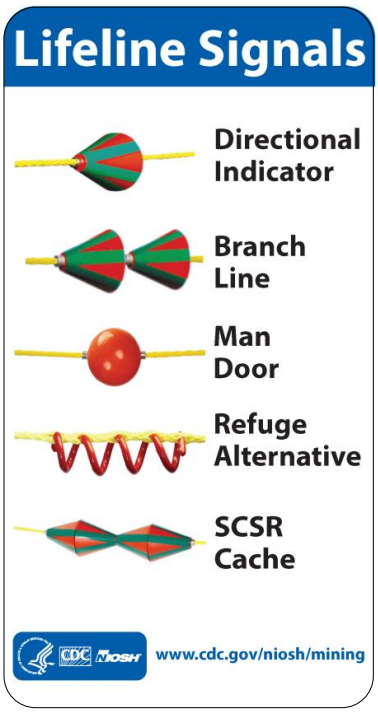

Figure 3. Reflective lifeline signals sticker[8]

[8] Reflective lifeline signals stickers are available upon request at mining@cdc.gov.

Suggestions for Training

First Aid

In addition to required first aid training, develop and incorporate practices into the training curriculum that require trainees to make decisions related to handling an injured miner (e.g., attempt to transport the injured miner out of the mine, to relative safety, or to await mine rescue).

Miners should be aware that sometimes, depending on the type of injury and severity of the injury, injured miners may need to be left behind during escape.

Conduct group discussions and hands-on activities of different scenarios where miners must decide what do to if a member of the escape group is injured.

- Discuss, demonstrate, and practice how to provide first aid to an injured miner.
- Discuss scenarios where the escape group might have to move critically injured miners to relative safety during escape.
- Practice moving an injured miner in a confined space with low visibility (e.g., lights off, dust or smoke simulation).
- Practice administering first aid only with the equipment available to miners underground (e.g., if an AED is not available underground, avoid practicing a scenario where an AED is used).
- Demonstrate moving, loading, and transporting an injured miner on a backboard on the mantrip while using escape equipment (SCSRs, goggles, etc.).
- Rotate leaders (e.g., crew, first aid) during quarterly escape drills.

Use regular, everyday events as training opportunities.

- Explain to miners on each crew what initial actions need to be taken in the event of an emergency (e.g., deenergize equipment, notify foreman, etc.).
- Allow non-maintenance workers to shut down the belt when it is scheduled to be stopped for normal maintenance.
- Periodically require miners to pull power and lockout/tagout mining equipment.
- Rotate the operation of mantrips among workers.

KSAs in Action

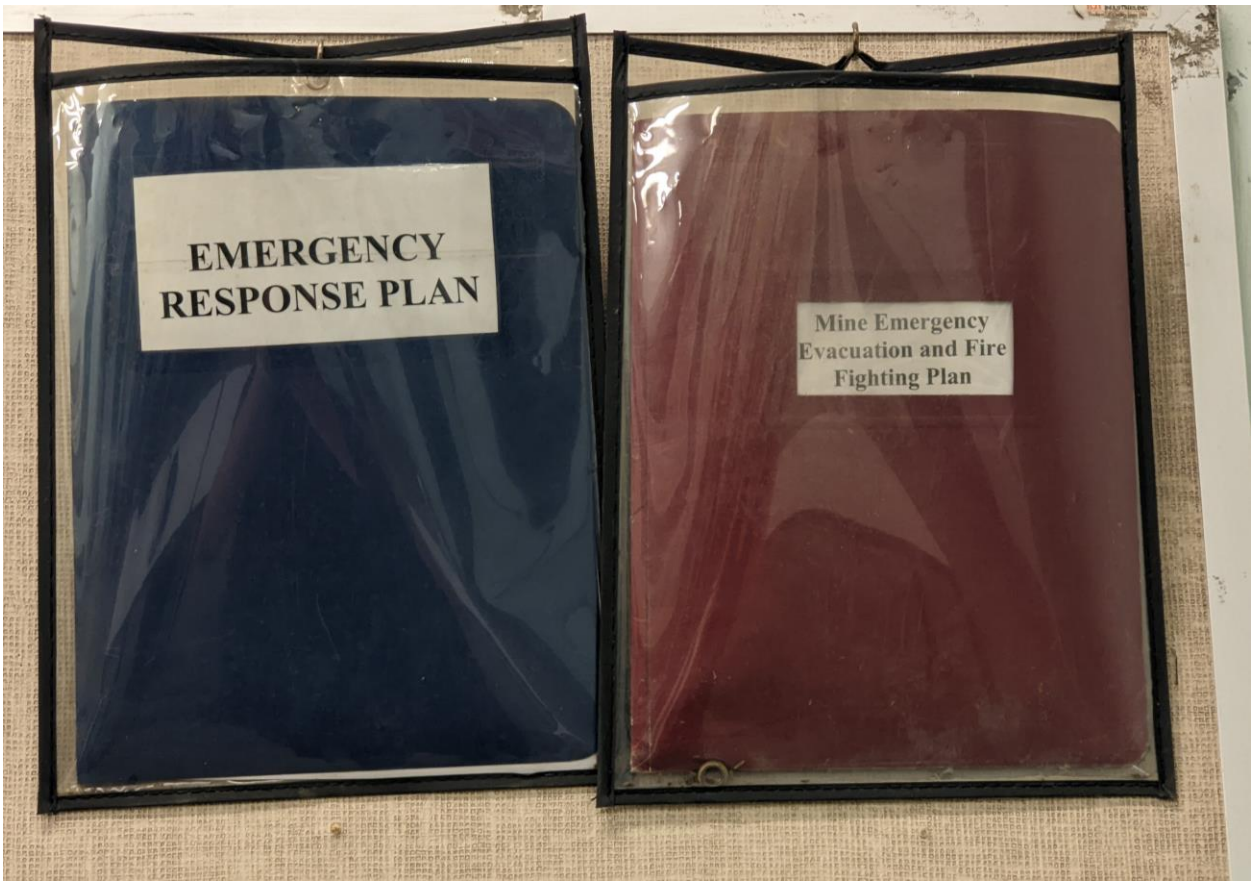

Photo by NIOSH

Figure 4. Accessible copies of the required Emergency Response Plan and Mine Emergency Evacuation and Firefighting Plan prominently displayed in the pre-shift area of an underground coal mine

Case:

Miners who formerly worked at the Wilberg Mine in Utah were interviewed about the 1984 fire that claimed 27 lives. One miner commented on the importance of everyday preparedness.

> *Your safety is in your hands. So keep yourself safe…take care of yourself. That's what you have to do. Nobody's gonna do it for you. You have to do it yourself.* [Cullen 2017]

Relevant KSAs:

- Knows the relative risk propensity of the mine (e.g., which is most likely to occur: gas or water inundation, fire, or explosion)
- Conducts checks on all personal equipment to ensure it is in working order
- Has the ability to attach to a tagline/tetherline in the event one is needed (e.g., belt loop, pants loop)

- Understands one's own role in emergency response and that of the section foreman, who will typically be responsible for leading the escape—i.e., the responsible person (RP) or escape group leader (EGL)
- Knows one's own personal limitations and capabilities and has some familiarity with those of others on the crew/team
- Knows the identity and approximate or likely location of the designated RP on each shift
- Has a serviceable SCSR on one's person or within 25 feet of current location
- Knows the chain of command for reporting a mine emergency (particularly for outby workers who may be working alone)
- When appropriate, the miner carries the following:
    - Essential medications
    - Emergency medicine sticker and card with known conditions
    - Reading glasses
    - Wristwatch
    - Lunch and water

Chapter 2
Situational Awareness: Mine Layout

Situational awareness (SA) can be defined as one's ability to combine information about the current environment/situation with prior knowledge to form a clear idea of what is going on and what might happen next [Dominguez 1994]. Put more simply, situational awareness means knowing what is going on around you. To establish and maintain situational awareness, it is important that miners be familiar with the general layout of the mine, including how entries and crosscuts are numbered, the locations of emergency response features and resources, and awareness of landmarks, signage, and the direction of airflow. Some miners may have the ability to construct a mental model of the mine layout while others may need to rely on physical maps and other sensory cues.

Figure 5. Escapeway map and roof control plan stored in PVC pipes at a mine's designated meeting place.

Photo by NIOSH

Core Competency Area

Table 2. Performance Criteria (Core KSAs) for Situational Awareness: Mine Layout

Location of Mine Emergency Features and Resources	▪ Recognizes one's personal position in the mine relative to the locations of all emergency features and resources, including the following: o Mine phones and other communication technology o Meeting places o SCSR caches o Lifelines and primary *and secondary* escapeways o Refuge alternatives o Barricading supplies o Tagline/tetherlines o Mine maps[9] o Firefighting equipment o First aid equipment and medical supplies
Establishing and Maintaining Situational Awareness	▪ Pays attention to landmarks, signage, and the direction and temperature of airflow on the ride into the section and at the work location ▪ Knows the general layout of the mine ▪ Knows the numbering of entries and crosscuts on section ▪ Knows what questions to ask to gather specific details about changing conditions within the mine ▪ Establishes and maintains awareness of one's own location within the mine relative to the event, if possible ▪ Recognizes one's personal position within the mine relative to the locations of all emergency features and resources including primary *and secondary* escapeways, exits, and fresh air ▪ Stays current on changes to mine installations (i.e., airshafts, slopes, and portals) ▪ Uses handheld multigas detectors to assess air quality as one moves throughout the mine ▪ Notes the locations of transportation and whether transportation to the working section is staying or leaving the work location ▪ Understands the basics of mine ventilation (location of air splits, airflow direction, point feeds, etc.) ▪ Knows what gases are present in the mine, how they interact, their potential effect on personnel, and event consequences ▪ Understands the basics of mine ventilation and expected airflow/ventilation in the mine ▪ Has a basic knowledge of the roof control plan and how it might change due to fires, explosions, etc. ▪ Knows the general locations of man doors (e.g., every 5th crosscut)

[9] Mines are increasingly using handheld electronic devices which may contain preloaded maps. If applicable, all underground miners should have familiarity with this technology.

Supplemental KSAs for Rank-and-file Miners

- Has general knowledge of relative mine elevation (e.g., the location of higher and lower elevations)
- Understands the general potential impact of different emergencies on mine structure, ventilation, equipment, power, and communications
- Is made aware of changes in airshafts/slopes/portals and walks at least once in the first week after change

Suggestions for Training

Miners' Understanding of the General Layout of the Mine

Help miners create a cognitive map of the layout of the mine and its features.

Cognitive maps are valuable for choosing and following an escape path that is most likely to lead to a successful escape. All miners should be able to read and interpret the mine map, but it is also important for them to build and make use of mental representations of the mine, known as a cognitive map [Anderson 1990]. Many people are able to create cognitive maps of their surroundings through experience and practice. These mental maps may be the only resource available to miners in an emergency.

- The following are important elements of a cognitive map:
    - The physical layout of the mine (e.g., SCSR caches, primary *and secondary* escapeways and lifelines, communication systems, and refuge alternatives)
    - Miners' current location within the mine
    - Miners' location relative to both the primary *and secondary* escapeways
- Encourage miners who are unable to create cognitive maps to always pay attention to their location within the mine and to carry or have easy access to a current mine map.
- Ensure miners know mine-specific primary *and secondary* escapeway marker colors and that these colors can vary by mine site.

Trainers and section leaders can help miners practice using a cognitive map as follows:

- Include the following in drill scenarios or quiz questions for the miners as they walk the escapeway during training:
    - Key features in the both the primary *and secondary* escapeways (e.g., lifeline, respective marker colors)
    - What to do if the escapeway is blocked at various points
    - How to handle challenges that may occur (e.g., what to do if SCSR caches have been moved without the available mine map reflecting the change)
- Immediately tell workers about new installations (e.g., entrances, shafts, slopes) rather than waiting until the next scheduled training.

- Have miners travel through the new installations within one week of the change.
- Predict and discuss what potential barriers or obstacles might exist on the way to the escapeway due to an explosion or other type of emergency.
- Present escape scenarios on up-to-date paper mine maps, showing locations of fire, inundation, explosion, or roof falls. Ask miners and teams of miners to draw the route they would take to escape in the presence of these obstacles.
- Review any cues that miners can use to determine which way to travel to get out of the mine in the presence of smoke or airborne dust in an emergency.
- Have the foreman review any recent changes or updates to the self-escape "picture" (e.g., if SCSR caches or refuge alternatives have been moved to new locations) with miners.
- During quarterly escapeway drills, note the estimated time it would take miners to walk the escapeways versus taking a mantrip.

Ask miners to consider situational awareness questions every time they go to a place to work.

Trainers and section leaders should encourage miners to ask themselves and each other the following questions daily:

- What am I/are we going to do in an emergency?
- Which direction will I/we head to escape (e.g., to find the escapeways, the mantrip, SCSR caches, etc.)?
- Where are the primary *and secondary* escapeways?
- Where is the closest escapeway?
- What is between the escapeways and me?
- Where are my coworkers?
- How do current or planned changes in the mine installations (e.g., to entrances, shafts, slopes) affect and/or change escapeway routes?
- Where can I find an up-to-date mine map?
- Do I have or know where to find what I would need to write a note (e.g., chalk, paper and pen)?

Integrate training opportunities into regular events at the job or worksite to maximize realism and promote skill transfer from the training environment to real life events.

- Without announcing ahead of time, ask miners to walk a portion of the escapeway path at the end of a shift.
- Use regular production moves to practice shutdown procedures.
- Provide the RP, EGL, or section foreman with "cue cards" of different escape scenarios to review with miners during initial shift meetings or when breaking for lunch.

Conduct surprise simulated emergency event drills that occur at varying times and have unexpected elements or obstacles.

- Conduct an underground escape drill at the end of a shift where miners need to escape the mine but the primary and/or secondary escapeways are blocked.
- Use SCSRs (e.g., expiring SCSRs that are available or training units) during surprise evacuation drills when feasible.
- Conduct an escape exercise where a section of the lifeline is down, or have miners navigate from the section to the beginning of the lifeline or from primary to secondary escapeway.
- Turn off lights, use theatrical smoke or obscured goggles to impair vision while navigating to the escapeway entrance.

Figure 6. Tagline/tetherline and escapeway map situated at an SCSR cache location.

KSAs in Action

Figure 7. Two miners navigating a smoke-filled simulated mine during an escape drill, looking at the mine map to locate key emergency resources while navigating towards the exit.

Cases:

In their investigative report of the 2006 Aracoma Mine fire, MSHA discussed events surrounding the evacuation of the crew from Section 2 after they encountered smoke in the escapeway.

> *It is not known why [the two miners that perished] did not escape via the alternate escapeway…[one] possibility is the two miners intended to remain in the NEM (Northeast Mains) intake air course. This was the route with which they were most familiar.* [MSHA 2007a, p. 13]

When reporting on the 2006 explosion at the Darby Mine in Kentucky, MSHA discussed findings from their assessment of the mine's escape drills and fire drills. The agency determined escape drills were not conducted properly in that the drills were not switched between the primary and alternate escapeways.

> *Given that the miners had to escape on foot due to the explosion, the lack of practice relating to the alternate escapeway, more likely than not, added to the delay in evacuation of the mine.* [MSHA 2007b, p. 26]

> *Had the miners been more familiar with the alternate escapeway, it is reasonably likely that the miners would have fared better in their escape attempt from the mine.* [MSHA 2007b, p. 26]

NIOSH researchers interviewed two miners who escaped from the 1968 explosion at Mountaineer Coal's Farmington No. 9 Mine. One of the miners said his crew regularly emphasized meeting at the air shaft if there was a mine emergency. He said after the explosion occurred, the dump operator never came to the air shaft.

> *…and every weekly safety meeting that we had we always said if anything happened go to the new air shaft. He [the dump operator] didn't do it. He went the wrong way.* [NIOSH 2009]

In their investigation of the 2002 Quecreek water inundation, MSHA noted multiple factors that contributed to the success of the rescue of nine trapped miners, which included the KSAs of the endangered miners.[10]

> *The miners who escaped the inrush of water made (similarly) good decisions. Their knowledge of escapeways and escape procedures aided their escape.* [MSHA 2003, p. 66]

> *[Utilityman/Miner Helper] stated they should move to No.1 entry. [Shift foreman] had considered going to No. 2 entry since it had a little more space but agreed since No. 1 entry was located at the highest elevation on the section.* [MSHA 2003, p. 16]

Miners who formerly worked at the Wilberg Mine in Utah were interviewed about the 1984 fire that claimed 27 lives. One miner commented on the importance of wearing goggles while using SCSRs.

> *My biggest thing is always be aware of your surroundings, everything that's going on around you. Keep your eye on the roof, keep your eye on the ribs; know who's there with you, who's not there with you and pay attention and remember your training.* [Cullen 2017]

One miner, escaping with his crew, was having trouble with his SCSR. He decided to take an escape route that was less contaminated with smoke.

> *I made the decision I couldn't go in this smoke…I did know where I was because…I'd worked in that area a lot…The other overcast that we just went over was over the intake…So*

[10] Although the 9 endangered miners were ultimately rescued from Quecreek mine, the miners utilized critical wayfinding, decision-making, teamwork, and communication KSAs to get themselves into a position to make rescue possible. Other miners underground and those on the surface are also credited with quick thinking, effective decision-making and strong communication KSAs to lead to a successful outcome.

I went back…I went into the door and it wasn't too bad…[I] got into the intake escapeway in 2 Northwest [and followed it out]. [NIOSH 2000, p. 80]

The crew this miner was with was escaping through heavy smoke in the left return escapeway. As the crew reached a particular overcast where heavy smoke was pouring out, this miner recognized where he was and decided to make his way to the intake escapeway where he found the air was much clearer. He never told the escape group he was going out another way.

Note: While this decision worked out for both the decision-maker and the group he separated from, it is often recommended that endangered miners stick together and always recommended that they communicate their ideas, plans, or decisions to others in the group, whenever possible.[11]

Relevant KSAs:

- Recognizes one's personal position in the mine relative to the locations of all emergency features and resources including primary *and secondary* escapeways, exits, and fresh air
- Has general knowledge of relative mine elevation (e.g., the location of higher and lower elevations)
- Moves to higher elevation points, if possible, during water inundation
- Establishes and maintains awareness of one's own location within the mine relative to the event, if possible
- Knows the general locations of man doors (e.g., every 5th crosscut)
- Is made aware of changes in airshafts/slopes/portals and walks at least once in the first week after change

[11] All miners from this crew successfully escaped. However, when the main grouped exited the escapeway and conducted a head count, they discovered the last miner in line in the escape group was missing. This resulted in three miners going back into the smoke-filled escapeway and traveling to the last set of overcasts to look for him. Unable to find the missing miner, the group returned and learned the miner was out of danger.

Photo by NIOSH

Figure 8. A rescue capsule similar to the one used to rescue nine miners at Quecreek in 2002 and a display commemorating the rescue at the MSHA Academy in Beckley, WV.

Chapter 3
Emergency Diagnosis and Response

Early diagnosis of potentially dangerous events in the mine can help in the prevention of or early response to a mine emergency. Thus, it is critical that all miners know and keep an eye out for signs of danger (e.g., smoke presence, loss of power, change in ventilation, elevated gas levels, alarms) and that they know what to do in the event that something does go wrong (e.g., travel to meeting location, alert others, decide to self-escape).

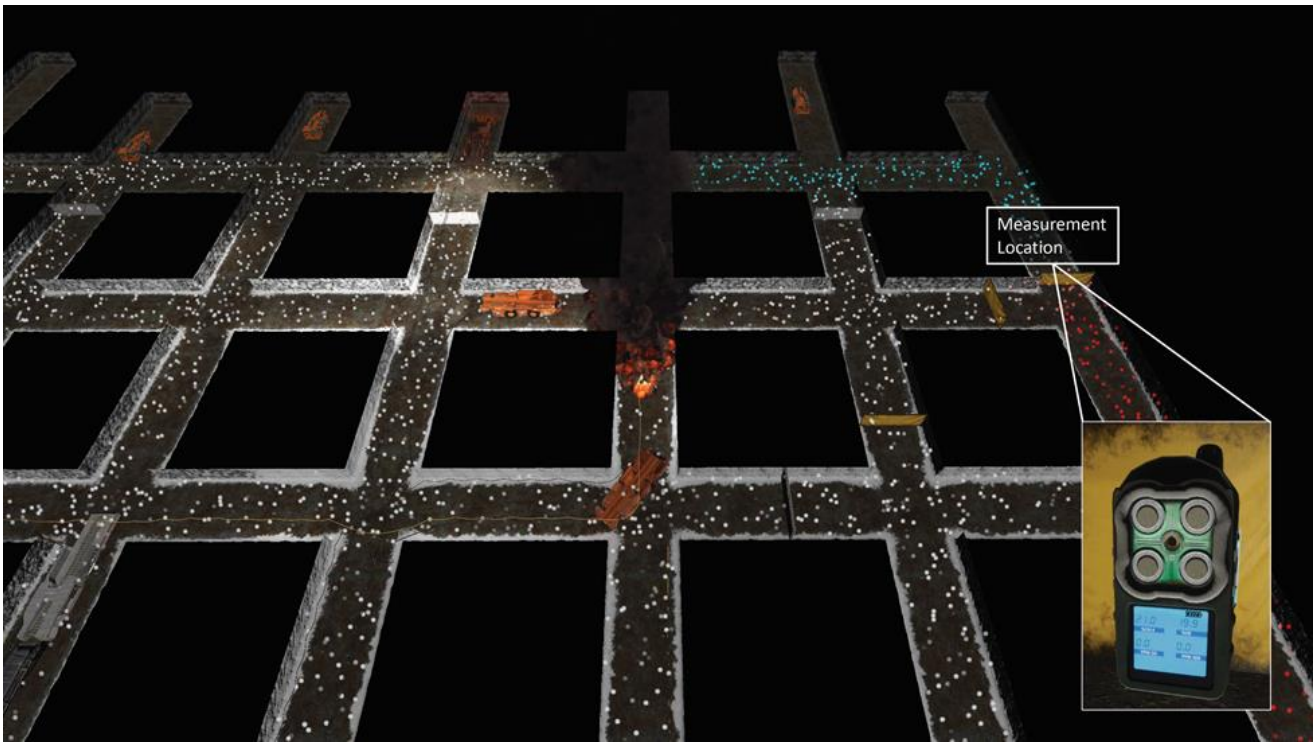

Figure 9. A screenshot from NIOSH's VR Mine[12] immersive simulation training software depicting a section of a mine with dynamic ventilation. Simulations such as these can be useful to train for emergency diagnosis and response decision-making.

[12] More detailed descriptions of VR Mine and its potential for emergency response training is available in the NIOSH Technical Report associated with this IC [NIOSH 2023], Bellanca [2019], and Orr [2019].

Core Competency Area

Table 3. Performance Criteria (Core KSAs) for Emergency Diagnosis and Response

Knowing Signs of Danger	▪ Knows the relative risk propensity of the mine (e.g., which is most likely to occur: gas or water inundation, fire, or explosion) ▪ Understands the significance of smoke presence (in airways, coming from fans, in return air shafts) ▪ Understands that even a small, localized methane explosion can damage or destroy ventilation control devices ▪ Knows critical gas levels (carbon monoxide (CO), oxygen (O_2), methane (CH_4), hydrogen sulfide (H_2S), etc., if applicable) and how to respond, if out of acceptable limits ▪ Recognizes the meaning and significance of audio and visual alarm sensor alerts ▪ Recognizes the occurrence of and potential significance of a power outage or other interruption to the operation of fans ▪ Communicates conditions to the surface and other miners underground as soon as possible ▪ Calls out to confirm whether or not fans are running ▪ Understands the impact of fire, gases, and smoke on air quality ▪ Understands that both asphyxiation and poisoning can occur due to poor air quality ▪ Knows to verify and never ignore alarms and alerts ▪ Knows water or gas inundation can affect ventilation
Decision-making	▪ Recognizes the need to self-escape from the current work location or to travel to a meeting location or other place of relative safety ▪ Receives, acknowledges, and acts upon RP, EGL, dispatcher, and other outside guidance, as appropriate ▪ Knows to always ride out of the mine instead of exiting by foot if possible ▪ Understands the roles of the EGL and RP and defers to them if appropriate ▪ Recognizes the need for oneself or someone else to assume a leadership role ▪ Has general understanding of whether an injured miner or miners should be left in an RA to await rescue ▪ Knows if and when to turn off equipment power ▪ Knows where and how to barricade if all other options have been exhausted and an RA is not available ▪ Participates in the escape group's decision-making

Supplemental KSAs for Rank-and-file Miners

- Knows how and when to communicate any critical information about any miners still underground (location, headcount, names, physical conditions, needs)
- Knows how and when to communicate critical information about the situation (severity, conditions of the mine, affected areas, air quality, smoke, visibility, conditions of equipment, and needs)
- Knows if, when, and how to test roof conditions
- Knows who carries an anemometer to measure velocity and direction of airflow (e.g., foreman or fire boss)

Suggestions for Training

Diagnosis and Early Response

Prepare miners to be proactive and engaged in emergency preparedness and response.

Kowalski-Trakofler et al. [2010] describe initial response as "what happens between the time an incident is determined to be an emergency…and the time the rescue or escape is well underway" [Kowalski-Trakofler 2010, p. 1]. The timely diagnosis and response to a mine emergency, especially at the early stages, is critical to the survival of miners in a situation that involves self-escape. This requires that miners know the signs of danger and proactively know what action to take.

- Empower miners to communicate perceived risk before and during self-escape.
- Encourage miners to adopt the "see something, say something" mindset. This requires supervisor support and buy-in, which must be demonstrated to encourage participation. Trainers and mine management can emphasize this during training, encouraging this mindset and behavior from the training group.
- Accept suggestions and questions from miners in good faith.
- In addition to those in self-escape leadership positions (e.g., RP, EGL, dispatcher/operator), cross-train all rank-and-file miners to assume some leadership responsibilities during self-escape.

Train miners on proper reactions to nuisance alarms.

- Discuss "nuisance alarms" that occur during normal operating conditions or activities (e.g., welding/cutting along belt) or because of faulty monitoring equipment.
- Teach miners to verify, rather than ignore, the validity of alarms that are suspected to be false.

Train miners to understand and recognize cues associated with potential emergency events and to quickly respond.

- Discuss subtle cues like change in direction of airflow, alarms and alerts, missing miners, and the presence of smoke and other odors.
- Help miners understand they may have more complete information than other miners, mine management, the EGL, and the RP and may need to make solo decisions.
- Emphasize the importance of communicating critical information to the surface and other miners as soon as possible.

Decision-making

Structure training so that decisions need to be made quickly and under some sense of pressure.

Providing more practice with decision-making in a variety of self-escape scenarios might make it easier for miners to make quicker, better decisions in an emergency. Miners might be better able to rely on what they have learned through practice to respond to real emergency events. This will allow miners to leverage their training to help them make decisions under a variety of situations. Practicing all KSAs can lead to better retention and lessen the cognitive workload required for effective decision-making.

- Generate potential self-escape options.
- Discuss the tradeoffs and limitations of making quick decisions.
- Use time pressures to help uncover how trainees will respond under stress.
- Include elements such as surprises and varied challenges (e.g., impassible escapeway, communication and other equipment problems, roof falls).
- Periodically, on the section or other work location, present scenarios where decisions must be made quickly and with limited information, then debrief with groups about decisions that were made.
- Periodically switch up groups during training to ensure that miners can become more comfortable working with those outside of their regular work group.

Practice decision-making in groups, with varying exercises/mediums.

- Use low-cost, high-impact methods for practicing decision-making skills, including group problem-solving exercises, classroom simulations, scenario-based training, and case studies.
- Gradually adjust task difficulty over time as miners indicate they are ready for more challenging exercises.
- Employ a variety of training media and modes (e.g., virtual reality, tabletop exercises, classroom simulations).

- Structure training so that miners must make quick decisions and change their escape plans in real time as they encounter new information/barriers.
- Expose trainees regularly to realistic escape scenarios that enable them to develop and internalize "if-then" cues that they can instantly recognize when needed.
- Emphasize shared leadership when possible, to encourage the practice of transferring and sharing self-escape leadership functions among the escape group.

Discuss how to handle a scenario where one or more miners are missing after the initial emergency event.

- Have miners face a decision where they must decide to risk additional lives looking for missing miners or leave the missing miners and begin escape.
- Consider a simulation (e.g., quarterly response drill, tabletop exercise, scenario discussion) that could present situations that systematically vary in the risk the event poses to the miners, the number of missing miners, and the effects of miner knowledge of the mine layout and missing miners.

Increasing Realism

Provide high-fidelity simulations for developing self-escape knowledge and skills at trainings and drills other than annual expectations training, such as the quarterly escapeway drill.

In addition to introducing time pressure, consider the following:

- Utilize available technologies to communicate with the dispatcher on the surface.
- Have miners utilize an up-to-date mine map to bypass a simulated roof fall or other obstacle.
- Restrict trainees' vision (e.g., use goggles or glasses that restrict a trainee's ability to see).
- Use computer-based software (e.g., Mine Emergency Escape Training [Orr 2016] and Learn with Harry: Harry's Hard Choices [University of Arizona, no date]), if possible, so that a group of miners can practice tasks that require teamwork (e.g., gathering at the meeting place, communicating, making decisions). The University of Arizona's Western Mining Safety and Health Training Resource Center offers computer-based software for mine emergency response training: https://miningsh.arizona.edu/resources/software.

KSAs in Action

Figure 10. Miners navigating a smoke-filled simulated mine after fighting a simulated fire. They donned their SCSRs upon evidence of smoke and encountered fire while exiting the mine.

Case:

During his interview about the 1984 Wilberg Mine fire, a miner describes the mine atmosphere in the area where he was working during the early stages of the fire.

> *I looked around and it looked a little bit smoky. And I thought, well, they're running those muckers out on the intake. Hauling cribs up you got exhaust…diesel exhaust and stuff coming off those muckers and it didn't look excessive to me. It looked like just exhaust off the muckers.* [Cullen 2017]

The following excerpts, drawn from miners' experiences in evacuating hazardous conditions at various underground mines, are examples of individuals not perceiving danger when abnormal events begin to unfold. This normalization of unsafe circumstances can prevent quick diagnosis and response, and place miners in danger.

The fire boss at Brownfield[13]…saw the event incorrectly when he initially encountered smoke: "I stood up and I smelled smoke. I just kind of thought it was, you know, maybe a bad roller, the belt was rubbing on the straps, or something like that because we've had that before." [NIOSH 2000, p. 73]

The haulage foreman at Cokedale[14] seemed, to those who overheard his trolley phone exchanges, complacent about the problem he was facing: "I even heard him talk to the people [outside]. He said, 'Look in my locker or by my locker and get another trolley switch.'" [NIOSH 2000, p. 73]

…one of the workers on 3 Left…thought his crew was leaving the face to fight a manageable fire: "They said 'We got a fire on the belt. Back the machine out and let's go.' Well, I just felt we'd run down and put it out. I didn't think there was any real major [problem]…" [NIOSH 2000, p. 75].

The following excerpts are examples of miners working together to evaluate their escape options and escape during underground mine events that required evacuation.

Regrouping in the face area, several workers decided to gather information before beginning the next attempt to find their way out. An individual remembered the section map, which had been hanging in their dinner hole: "I stopped and got the map, read the map…what we wanted to do was see where it brought us out…[we] saw where it brought us out…we knew the smoke was coming down there so we knew…the fire had to be fairly close." [NIOSH 2000, p. 149]

… [the miners] in 5 South crew began their evacuation down the belt entry: "We said we couldn't go down the intake [escapeway] because that's where the smoke was coming from…so everybody decided to go down the belt line." These workers, who stayed close together throughout their escape, continued along the belt line until they hit heavy smoke and then crossed into the return aircourse. They traveled down the return entry, checking through doors for clear air as they went. [NIOSH 2000, p. 93]

Relevant KSAs:

- Understands the significance of smoke presence (in airways, coming from fans, in return air shafts)
- Understands the impact of fire, gases, and smoke on air quality
- Recognizes the need to self-escape from the current work location or to travel to a meeting location or other place of relative safety
- Understands that both asphyxiation and poisoning can occur due to poor air quality

[13] Pseudonym used in place of the actual mine name to ensure anonymity at time of interviews.

[14] Pseudonym used in place of the actual mine name to ensure anonymity at time of interviews.

Chapter 4
Wayfinding

Challenges and obstacles in the mine environment during self-escape (e.g., smoke, fire, gas, blocked escapeways) can make it difficult for miners to safely find their way to the mine exit. Miners need keen situational awareness regarding mine emergency features and resources. In addition, it is critical that miners know to accept the presence of obstacles or setbacks during self-escape. Escaping miners should avoid splitting up if at all possible.

Photo by NIOSH

Figure 11. A red colored marker to indicate whether this is the primary or secondary escapeway (left) and reflective signage to indicate the locations of a man door and SCSR cache (right)

Core Competency Area

Table 4. Performance Criteria (Core KSAs) for Wayfinding

General Principles	▪ Trusts training and relies on procedures learned and resources available ▪ Understands escape speed in emergency conditions can be reduced below normal walking speed ▪ Knows how to use other tactile wayfinding techniques (rib line, power cables, waterlines, belt, a cane or stick, if available) if a lifeline is not available ▪ Returns doors to the position they were found in when traveling through man doors or regulators ▪ Crosses over or under belts only at designated crossings ▪ Knows how to use handheld multigas detectors to assess air quality as one's position changes ▪ Recognizes the need for oneself or someone else to assume a leadership role ▪ "Goes low" in smoke, after an explosion, or when encountering debris or difficult walking conditions
Moving Effectively as a Group	▪ Moves with and avoids splitting up the group, and gathers others as encountered ▪ Places one's hand on the shoulder or belt of the person directly ahead if a tagline/tetherline is not available ▪ Reminds others to use available taglines/tetherlines ▪ Allows the most experienced worker to lead the tethered group, with the slowest person in the middle ▪ Whenever possible, remains attached to the tagline/tetherline when in smoke or dust ▪ Participates in identifying all miners present underground (e.g., headcounts) ▪ Communicates progress and other critical information (severity, conditions of mine, affected areas, conditions of equipment, and needs) to the surface and to other miners underground
Mine Emergency Features and Resources	▪ Knows how to find and use the following: o Mine maps o SCSRs (take extra units) o Firefighting equipment o Refuge alternatives o Taglines/tetherlines (e.g., with everyone on same side, remain tethered when in smoke or dust whenever possible) o Lifelines (knows tactile symbols) o Primary *and secondary* escapeways including mine-specific designated escapeway marker colors o Escapeway maps

Supplemental KSAs for Rank-and-file Miners

- Moves to higher elevation points, if possible, during water inundation
- Knows if, when, and how to test roof conditions and where to set roof supports
- Recognizes signs of panic in oneself and others
- Knows who carries an anemometer to measure velocity and direction of airflow (e.g., section foreman, fire boss)
- Carries or uses cached writing instruments (e.g., pen and paper, chalkboard)
- Offers to take control of the group during escape if appropriate/necessary

Suggestions for Training

General Principles

Practice moving through the mine under realistic emergency conditions.

Miners must travel through the mine in emergency conditions with the potential presence of dangers and obstacles such as smoke, fire, water, and structural damage such as roof falls or blocked escapeways. Thus, miners must be prepared to move through the mine in various conditions under emergency scenarios.

- Have miners navigate the mine tactilely (e.g., no cap lamps or other lights). For example, miners could be required to find a power center only tactilely by following a machine cable, while moving along the escapeway using a lifeline, or while following a conveyor belt.
- Practice crawling or duck-walking to prepare for when visibility is possible only by "going low."
- Practice nonverbal and verbal communication while using an SCSR. Emphasize keeping the mouthpiece in place at all times, including while communicating.
- Use simulated reductions in abilities (e.g., obscured vision or by creating an "injury" by strapping a knee or ankle) to increase realism in trainings throughout the year, not just during annual expectations training.
- Note difficulties during training for debrief and improved training.

Practice managing panic [Benson et al. 1974; Everly and Lating 2017].

- Practice deep (diaphragmatic) breathing with trainees, as it has been shown to produce a "relaxation response" [Benson et al. 1974] and aid in the management of acute stress [Everly and Lating 2017].

Moving as a Group

Practice using the tagline/tetherline.

Keeping the group together in a mine emergency, under limited visibility and in dangerous conditions, can be a challenge. Miners must be prepared to use taglines and tetherlines in an emergency, to ensure that everybody can stay together and find their way out of the mine.

- Practice using a tagline/tetherline under various scenarios—for example, when boarding a vehicle to self-escape, when the group must reverse its course, or when the group follows the lifeline.
- Train the group to all link to tagline/tetherline from same side.
- Set the pace to the slowest or weakest member of the escape group.
- Practice team coordination while miners are connected via a tagline/tetherline. Focus on communication and group situational awareness about changes to the mine environment during different disaster scenarios.
- Eliminate potential barriers to cooperative work among the miners. Practice strategies for controlling unhelpful emotions and train miners to work together to resolve conflicts in escape scenarios.

Practice team coordination.

- Review and discuss potential challenging conflicts that might come up during the process of self-escape.
- Review situations where the presumed EGL (typically the section foreman) might need to relinquish control to another individual (e.g., is in panic, is injured, is not as capable as another member), and where individual miners might need to assume a leadership role.
- Rotate non-supervisors into the role of the EGL during self-escape exercises. This will help miners understand the role of the EGL and how to support that role when needed. It will also help prepare them to carry out the EGL role if required.
- Provide opportunities for miners to discuss how they will work together in an emergency. Miners should establish and confirm their respective escape roles and responsibilities, as well as the actions they should take as a coordinated and cohesive group.
- Acknowledge the reality that conflicts may arise, and escape groups may split up due to differences of opinion on how to proceed.
- Discuss with miners how team dynamics may change in response to a stressful situation.
    - Help miners recognize that with uncertainty, some group members may hesitate or resist the leader (if, for example, the leader says to use the refuge alternative).
    - Expose miners to the unique challenges of team dynamics during escape training and allow them to work through them. Debrief afterwards.

Maintaining Situational Awareness

Provide mine map training and quizzes.

Miners' ability to maintain situational awareness in normal and emergency conditions can help prevent both everyday injuries and prepare them for self-escape. It is important that miners understand the mine's physical layout, the location of key self-escape resources, the exits and fresh air, and their own location within the mine. They must also maintain awareness of these things as their work location changes with work conditions and tasks.

- Present escape scenarios on up-to-date paper mine maps or handheld electronic devices, if available, showing locations of fire, inundation, explosion, or roof falls.
- Instruct miners to draw their escape route from a variety of potential emergency scenarios.

Train miners to understand the role and importance of situational awareness during escape. Discuss how to overcome barriers to situational awareness (e.g., panic, confusion).

Ensure that drills use designated escapeways (both primary *and secondary*).

- Provide training for various escapeways by introducing obstacles in the primary escapeway (e.g., with MSHA approval, conducting a scenario where a rockfall requires re-routing).
- Always debrief after scenario-based trainings (e.g., "What went well?"; "Could you have done something differently?").

KSAs in Action

Figure 12. A group of miners using SCSR expectations training devices entering a simulated mine filled with smoke for a drill. The miners are walking single file and have their right hands on the shoulder of the person in front of them to help them stay together in smoke.

Cases:

Several miners attempted to escape in a battery mantrip from their work area in the Darby Mine following the explosion.

> *After their personnel carrier became stuck on top of a damaged overcast, the crew attempted to escape out the No. 5 Entry following the high-voltage line…* [MSHA 2007c, p. 25]

The Section 2 crew at the Aracoma Mine left their mantrip and started escape on foot towards the alternate escapeway, staying together and close to the rib.

> *En route to the [exit]…the miners held on to one another as they navigated the entry toward [the exit]. The men used the coal rib to guide themselves outby…* [MSHA 2007a, p. 12]

One of the survivors of the Farmington No. 9 explosion was a shuttle car operator. After the first explosion, it was impossible to see because of dust and smoke. In his interview he described how his crew navigated back to the power center.

> *…my buggy cable was anchored at the dinner hole at the power center and that's where our self-rescuers were and…you couldn't see where to walk…So, we followed my buggy cable hand over hand back to the dinner hole…* [NIOSH 2009]

Miners who formerly worked at the Wilberg Mine in Utah were interviewed about the 1984 fire that claimed 27 lives. One miner commented on the importance of having situational awareness while wayfinding.

> *Make sure you have a good up-to-date map and know the escapeways out of there right off the bat…I'm a firm believer if the guys that died…in the fire…knew their escapeways and knew where their self-rescuers were, they would have made it out.* [Cullen 2017]

In their investigation of the 2002 Quecreek water inundation, MSHA noted multiple factors that contributed to the success of the rescue of nine trapped miners, including the escape group working together as a team.

> *…the 1-Left section crew's decisions to stay together, work as a team, and go to the highest ground were crucial for their survival.* [MSHA 2003, p.66]

The following excerpts are examples of mine crews using their understanding of the mine layout and key features to guide their escape.

> *A few moments later, several members of the group got lost by following reflective markers they thought led to an escapeway, but in fact marked a bleeder entry examination route which led to another part of the mine. The fire boss had to reassemble the group and told them: "Keep the stoppings to your left…if you don't see one, go over till you do find one, and then always have the stoppings to the left of you…I told them, ignore the reflectors, because you are going to get lost."* [NIOSH 2000, p. 173]

> *Although the group encountered moderate to heavy smoke in the return, the foreman knew that the return airway would lead them directly past the fire area. The foreman, therefore, decided to continue traveling in the return, since he could follow a row of posts in this entry to guide himself. "I mean the return is double-timbered. I just stayed between the props and went."* [NIOSH 2000, p. 123]

> *The crew from [another section] also traveled through the…left return and used the props to guide themselves: "…we knew that the return went straight down because we'd walked it before. So we just stayed in the 6-foot walkway between the posts…"* [NIOSH 2000, p. 123]

Relevant KSAs:

- Knows how to use other tactile wayfinding techniques (rib line, power cables, waterlines, belt, a cane or stick, if available) if a lifeline is not available
- Moves with and avoids splitting up the group, and gathers others as encountered
- Places one's hand on the shoulder or belt of the person directly ahead if a tagline/tetherline is not available
- Reminds others to use available taglines/tetherlines
- Allows the most experienced worker to lead the tethered group, with the slowest person in the middle
- Knows how to find and use mine maps, firefighting equipment, SCSRs, refuge alternatives, taglines/tetherlines, lifelines, escapeways, and escapeway maps

Chapter 5
Self-contained Self-rescuers (SCSRs): Locating, Donning, and Switching/Swapping

In a mine emergency, miners must be prepared to protect themselves if noxious gases (e.g., carbon monoxide) or low oxygen levels are present in the mine atmosphere. In case of a fire, they must protect themselves if there is the potential for life-threatening exposure to smoke. To prevent exposure to toxic, dangerous elements and to better ensure survival, miners must be prepared to successfully locate, don, and switch/swap between SCSRs during a mine emergency.

Photo by NIOSH

Figure 13. SCSR cache and tetherline storage.

Core Competency Area

Table 5. Performance Criteria (Core KSAs) for SCSRs: Locating, Donning, and Switching/Swapping

Locating	▪ Has a serviceable SCSR on one's person or within 25 feet of current location ▪ Knows the locations of SCSR caches ▪ Understands that SCSR caches are relocated during a section equipment or power move ▪ Moves outby toward next accessible cache to switch/swap SCSRs
Donning	▪ Knows to don an SCSR: o Upon evidence of a fire or explosion, first sign of smoke or heavy dust o When a multigas detector alarms and indicates that one or more gases is/are not within acceptable limits o When instructed to do so ▪ Knows it is possible that carbon monoxide will precede smoke or other evidence of fire ▪ Understands how to perform steps for opening, preparing, and donning all SCSRs in use at the mine: o Isolates the lungs first and adjusts straps to secure the unit close to the body second o Uses the manual start-up procedure if necessary and the correct procedure applicable to the model (e.g., chemical oxygen units) o If necessary, further adjusts neck straps so there is no tension or kinking in the breathing tube ▪ Knows to wear the goggles with SCSR unit to protect against absorption of carbon monoxide through the tear ducts ▪ Knows how and when to help others don an SCSR ▪ Understands that sealed, mine-ready SCSRs will be more difficult to open than those used during training ▪ Knows that a short-term SCSR will last about 10 minutes and knows to move to the nearest 1-hour unit after donning ▪ Knows that depletion rates may vary across devices and users ▪ Knows to keep the lungs isolated by never removing the nose clips or mouthpiece, even if it is uncomfortable or difficult to communicate
Switching/ Swapping	▪ Knows when to switch/swap between SCSRs based on time, levels of exertion, and oxygen gauge (if available) ▪ Knows breathing resistance is greater toward the end of the SCSR's rated duration ▪ Masters the sequence of steps for switching/swapping between SCSRs ▪ Knows how and when to help others switch/swap between SCSRs

General Maintenance	▪ Inspects one's own belt-wearable SCSR before each shift, checking the case, seals, clips, oxygen gauge (if available), and moisture indicator ▪ Does not use an SCSR for anything unsuited to its design (e.g., as a blunt force tool, as a seat) ▪ Knows when an SCSR should be removed from service

Suggestions for Training

Donning

Train SCSR use to the point it becomes automatic because of repetition and practice.

Miners must know how to don their SCSRs regardless of the conditions in the mine (e.g. in heavy smoke, with limited visibility, under stress). Donning the SCSR is often one of the first steps in evacuating from a mine emergency, ensuring that miners have a safe and adequate air supply when making their way out of a dangerous mine environment.

- Train miners often enough that the physical task of donning the SCSR correctly feels automatic, leaving them with the mental capacity to focus on other decisions and actions.
- Stress the importance of donning and wearing the goggles when using the SCSRs to prevent absorption of carbon monoxide through the tear ducts.
- Ensure that trainees understand procedural knowledge first (e.g., the steps required for donning an SCSR). Second, practice motor skills (e.g., hands-on practice donning the SCSR), and then third, focus on decision-making skills (e.g., whether to wait to don or switch/swap an SCSR).
- Whenever possible, use the mine's expiring SCSR units or procure expiring units from closed mines to increase realism in device use and expectations.

Practice donning SCSRs under stressful conditions that mimic the conditions of a mine emergency [MSHA 2007a, pg. 26].

- Practice in an environment with limited visibility (e.g., darkness, smoke).
- Practice in the presence of distractions (e.g., noise, radio communications, confusion).
- Practice under time pressure (e.g., safety personnel timing how long it takes each miner to complete the donning procedure).
- Practice using real SCSR units that have expired and need to be sent back for refurbishment.

Switching/Swapping

Improve team coordination through team training on switching/swapping SCSRs during an emergency.

Miners must know how to monitor their SCSR use and when to switch to a new unit. Additionally, the whole escape group must also be able to coordinate this process, planning and coordinating SCSR switching/swapping so that all miners' needs are met (e.g., the whole group switch/swaps together when the first member must switch/swap).

- Practice team coordination during training, even though miners may be with a different "team" during an emergency.
- Train miners to switch/swap SCSRs together each time they reach a cache. Although units of the same model have the same oxygen capacity, each miner will use up the unit's oxygen at different rates depending on their body's oxygen requirements.

KSAs in Action

Photo by NIOSH

Figure 14. A group of miners donning live M20 SCSR units during a quarterly training.

Cases:

In their investigation report of the Sago Mine explosion, West Virginia investigators discuss one escape group's use of SCSRs.

> *Some of the first-left crew donned their self-contained self-rescuers…However, others waited, thinking that they would find fresh air in the intake…when we [got to the intake] and saw that there was no fresh air there…we put our self-rescuers on…* [Wooten 2006, 3.2.2]

In their final investigation report of the Aracoma Mine fire, MSHA described the mine's SCSR training regimen.

> *Training included donning a training unit in a small, dark room…to simulate donning under stressful conditions and poor visibility, such as in a smoke-filled environment…The described training exceeded the SCSR annual refresher training requirements. Miners evacuating… indicated the training was invaluable to escaping the mine.* [MSHA 2007a, p. 26]

Miners who formerly worked at the Wilberg Mine in Utah were interviewed about the 1984 fire that claimed 27 lives. One miner commented on the importance of frequent hands-on SCSR training.

> *Now all of a sudden everybody had to put their hands on, and these are good things, you know had to put their hands on their rescuers…when you are in a situation like that, if you are in smoke, if you are disoriented, if you are scared, it's got to be automatic…* [Cullen 2017]

Relevant KSAs:

- Knows to don an SCSR:
  - Upon evidence of a fire or explosion, first sign of smoke or heavy dust
  - When a multigas detector alarms and indicates that one or more gases is/are not within acceptable limits
  - When instructed to do so
- Knows it is possible that carbon monoxide will precede smoke or other evidence of fire
- Knows to wear the goggles with SCSR unit to protect against absorption of carbon monoxide through the tear ducts
- Knows the locations of SCSR caches
- Moves outby toward the next accessible cache to switch/swap SCSRs
- Knows when to switch/swap between SCSRs based on time, levels of exertion, and oxygen gauge (if available)

Chapter 6
Self-contained self-rescuers (SCSRs): Use and Expectations

Miners must know what to expect when using an SCSR so they can feel confident that their device is working properly during self-escape. Nonverbal communication skills are critical so that miners do not put themselves in danger by taking the mouthpiece out to communicate verbally.

Photo by NIOSH

Figure 15. SCSR cache.

Core Competency Area

Table 6. Performance Criteria (Core KSAs) for SCSR Use and Expectations

What to Expect When Using an SCSR	▪ Knows that breathing resistance will occur and that it may feel as if the unit is not working properly even though it is ▪ Knows that the unit can become warm or hot to the touch and breathing resistance will increase the longer the SCSR is worn ▪ Understands that rate of escape should be reduced to below normal walking speed as breathing resistance increases ▪ Understands that resistance becomes greatest toward the end of the SCSR's rated duration ▪ Knows to slow down to avoid depleting the oxygen supply before a switch/swap is possible
Communications	▪ Knows that verbal communication will be difficult or impossible while using SCSRs ▪ Knows nonverbal communication techniques (e.g., cap lamp signals, blinking lights, writing, tapping codes, hand signals) ▪ Does not remove SCSR mouthpiece to communicate unless in fresh air (e.g., from RA)
Preparedness	▪ Picks up and carries an extra SCSR if possible ▪ Has a serviceable SCSR on one's person or within 25feet of current location ▪ Knows whether mantrip or other transportation is leaving the work area—if leaving, takes a 1-hour SCSR as transportation will not be immediately available ▪ Knows the duration of one's personal SCSR and where the nearest cache of one-hour/high-capacity units is located ▪ Knows the rated duration of all SCSRs in use at the mine ▪ After donning an SCSR, tracks how much time has passed since donning the unit if possible ▪ Reduces one's speed or activity rate as SCSR breathing resistance increases ▪ Raises the SCSR unit overhead if traveling through deep water ▪ Knows to wear the goggles from SCSR unit to protect against absorption of carbon monoxide through the tear ducts

Supplemental KSAs for Rank-and-file Miners

Knows to avoid fighting a fire while using an SCSR (a self-contained breathing apparatus (SCBA) with a full facepiece should be used instead, if the miner is trained and a unit available)

Suggestions for Training

What to Expect When Using an SCSR

Know and discuss the key issues that might influence a miner to remove their breathing apparatus [Kowalski-Trakofler and Vaught 2012].

To build trust in SCSRs and prevent confusion about whether the unit is working, trainers should help miners know what to expect when using the different types of SCSRs at their mine. Experience using SCSRs (or training units) while performing a variety of escape activities can help build knowledge and trust in the equipment. It can make miners more confident using these units during a real mine emergency.

Ensure that miners understand to not, under any circumstances, remove the SCSR mouthpiece unless they are certain they are in fresh air!

Key issues that might influence a miner to want to remove a breathing apparatus include:

- Heat generated by the SCSR
- Coughing
- Odd taste when the mouthpiece is inserted
- Difficulty breathing while using the unit
- Difficulty communicating
- Quality of the air supplied
- Nose clips slipping off or goggles fogging
- Behavior of the breathing bag (it may be working even if it isn't inflating)
- Too much weight on neck from hose pulling (adjust or readjust unit straps)

Provide training that gives a sense of the experience of using an actual SCSR for long periods.

- Advise miners that the speed with which one walks, physical conditioning, speed and depth of breathing, etc., will affect the rate of oxygen depletion.
- Have trainees walk around the mine property to replicate the actual time/distance it will take to walk out of the mine while using the live SCSR units, if possible. Use expectation trainers if live units are not available.
- Incorporate smoke, limited visibility, or crawling and ducking, which take longer and may use more oxygen than walking.

Use live SCSRs during training when possible.

- Use live SCSRs (e.g., operational SCSRs that have reached the end of their service life) whenever feasible.
- Encourage miners to share lessons learned from their experience using the live device.

- Explain to miners that if they are moving or breathing too fast, they may "over-walk" or "out-breathe" the SCSR—i.e., their oxygen requirement is greater than the unit can provide, and they must slow down.

Communications

Address the challenges to communicating verbally while using SCSRs and offer communication strategy alternatives.

Using an SCSR severely limits or prevents verbal communication during a mine emergency. To prepare miners to communicate during an emergency without taking off their SCSR mouthpieces—potentially exposing themselves to dangerous elements—miners must be fluent in some nonverbal communication strategies.

Options for communicating nonverbally while using an SCSR include the following gestures:

- Cap lamp signals
- Universal or mine-established tapping or beeping codes (1 = "Yes"; 2 = "No") to answer questions from the surface or elsewhere in the mine
- Paper and pencil, chalk, if available
- Hand signals, if trained [NIOSH 2011]

KSAs in Action

Photo by NIOSH

Figure 16. Miners preparing for an escape drill in a smoke-filled simulated mine while using SCSRs.

Cases:

In reviewing SCSR usage following the Darby Mine explosion, MSHA's final investigative report indicated miners did not appear to follow the correct procedure for using the devices.

> *The analysis of the SCSRs worn by [three miners who died of carbon monoxide poisoning] showed that the SCSRs had sufficient breathable oxygen capacity left to allow the miners to escape the mine. These factors indicate that proper SCSR usage procedures [including not taking the mouthpiece out to talk] were not followed.* [MSHA 2007c, pp. 36–37]

After reaching a fresh air intake shaft at the Farmington No. 9 mine to await rescue, a miner describes his intention to remove his self-rescuer in what appeared to be clear air. He further stresses the importance of leaving one's self-rescuer on until in a confirmed clear atmosphere.

> *And I started to take my self-rescuer out of my mouth when I looked over and Bud shook his head no and pointed to his rescuer. So, I left my rescuer in my mouth and within 30 minutes the 5 guys that had taken their rescuers out of their mouths were on the pavement, they were down…because of the carbon monoxide content in their blood.* [NIOSH 2009]

> *So, when they tell you to put a rescuer on don't take it off until you get outside, they're not kidding. Just because the atmosphere is clear and looks good doesn't mean it's clear. There could be some, there could be some, deadly atmosphere, parts of that atmosphere, that you can't see, so you keep that self-rescuer on till you get outside, okay.* [NIOSH 2009]

Miners who formerly worked at the Wilberg Mine in Utah were interviewed about the 1984 fire that claimed 27 lives. One miner commented on the importance of wearing goggles while using SCSRs.

> *But there were people who were wearing their rescuers but not their goggles…if you don't wear your goggles, you get carbon monoxide in those ducts in your eyes…carbon monoxide poisoning is accumulative* [sic] *it's not something that comes and goes…it builds up in your system…you have no oxygen carrying capacity. You're done.* [Cullen 2017].

The following excerpts are examples of common mistakes miners made when using SCSRs during underground mine evacuation, which could have dangerous or even fatal consequences depending on mine conditions.

> *Regarding use of their emergency breathing apparatus, expert opinion was that the crew members made some decision errors that could have killed them had carbon monoxide levels been high…[some] waited too long to don their apparatus. Secondly, almost half of the workers "cheated" by taking the mouthpiece out to breathe in areas where smoke was not so dense.* [NIOSH 2000, p. 98]

> *A bratticeman described his experience [using his SCSR]: "And it seemed like the harder you used, you know, it seemed like you wasn't getting the right amount of air out of them. But then [the boss] said, just slow the pace down."* [NIOSH 2000, p. 174]

> *Twenty-nine of the miners who escaped these fires (63%) reported having difficulty breathing with their SCSRs, largely because they were unfamiliar with how an SCSR worked. As a result, 27 of the 29 said they either took the mouthpiece out to catch a breath or "breathed around" the mouthpiece in smoke.* [NIOSH 2000, p. 120]

Relevant KSAs:

- Knows that verbal communication will be difficult or impossible while using SCSRs
- Knows nonverbal communication techniques (e.g., cap lamp signals, blinking lights, writing, tapping codes, hand signals)
- Does not remove SCSR mouthpiece to communicate unless in fresh air (e.g., from RA)
- Uses goggles with SCSR to protect against the absorption of carbon monoxide through the tear ducts

Chapter 7
Communication

Clear, concise communication is critical in a mine emergency. To share information and cooperate with miners and personnel inside and outside of the mine during escape, miners must know what information to communicate, how to communicate it, and who to communicate it to. This will help to expedite the coordination of emergency response activities and resources. Remember that the SCSR mouthpiece must not be removed to communicate. If it is safe to do so, communication can be attempted from a refuge alternative or by using nonverbal communication techniques.

Photos by NIOSH

Figure 17. Surface mine phone (left) and underground wireless tracking and communication systems (right).

Core Competency Area

Table 7. Performance Criteria (Core KSAs) for Communication

General Principles	▪ Speaks loudly and clearly ▪ Knows what information to gather and prioritize ▪ Knows how to concisely communicate critical information to others within the mine and on the surface ▪ Does not remove SCSR mouthpiece to communicate unless in fresh air (e.g., from RA) ▪ Communicates with SCSR mouthpiece in place ("grunt lingo") in the absence of fresh air ▪ When possible, leaves handwritten notes or use other communications to relay one's plans ▪ Picks up the mine phone when passed during escape (if it is safe to stop at and use during the emergency)
Communicating Within an Escape Group	▪ Knows how and when to communicate about plans and next steps with the EGL and others in the group ▪ Determines how and when to use nonverbal communications (e.g., cap lamp signals, blinking lights, writing, tapping codes, hand signals) with others in the mine ▪ Speaks clearly and confidently to reassure those who may be panicking or upset ▪ Provides updates on one's own physical condition and that of others in the group to the EGL
Communicating with the EGL and Surface Personnel	Reporting information: ▪ Communicates critical information about the miners still underground (e.g., location, headcount, names, physical condition, needs) ▪ Communicates progress and other critical information (severity, conditions of mine, affected areas, conditions of equipment, and needs) to the surface and to other miners underground ▪ Provides updates on the environmental conditions of the mine to the RP and surface personnel ▪ Provides updates on the situation, plan, next steps, and needs to the RP and surface personnel ▪ Provides updates on one's own physical condition and that of others in the mine to the RP and surface personnel Receiving information: ▪ Receives, acknowledges, and acts upon RP, EGL, dispatcher, and other outside guidance, as appropriate ▪ Repeats information received to confirm reception and understanding ▪ Confirms that information given is received and understood ▪ Knows what questions to ask to gather specific details about changing conditions within the mine

Communication Technology	▪ Understands how to operate all mine phones, radios, texting devices, and backup systems used at the mine ▪ Uses nonverbal communications with others when necessary

Supplemental KSAs for Rank-and-file Miners

- Understands the potential effects of an emergency on communications equipment
- Carries or uses cached writing instruments (e.g., pen and paper, chalkboard)
- Responds to questions with universal or mine-established taps or beeps (e.g., 1 = "Yes"; 2 = "No")

Suggestions for Training

Consider the value of training standardized communication techniques like structured communication, radio discipline, and nonverbal communication [NIOSH 1999, 2011a,b].

Communicating Within Escape Group

In a mine emergency, miners must work together during the process of self-escape. Effective communication skills can help the miners within the escape group coordinate their efforts.

Ensure all miners know the basic cap lamp communication signals.

Cap lamp signals may vary between mine sites and companies. Some examples include:

- Nodding in a circular motion = "It is safe to move forward"; "Come to me"
- Nodding up and down = "Move away" (or "Yes" when asked a question)
- Nodding from left to right = "Stop" (or "No" when asked a question)

Train miners to work together as a team in an emergency.

- Provide team-based practice under a variety of escape scenarios to encourage miners to work together as a unit during their escape efforts.
- Arrange for team-based practice to take place with and without the RP and EGL to encourage proper deference to leadership and leadership from rank-and-file miners when necessary (e.g., when the RP or EGL are injured or unavailable).

Communicating to Leadership/Surface Personnel

Teach miners to use structured communication [NIOSH 1999]—establishing the "who," "where," and "what" essentials—when reporting a safety hazard or emergency event to others [Kowalski-Trakofler and Vaught 2012].

- Ensure that miners identify themselves first (who), then indicate exactly where the incident is located (where), then clarify exactly what has happened (what).

Conduct scenarios in which communication lines between the miners underground and surface personnel are severed.

- Practice other ways trapped miners could communicate with the outside if seismic system is deployed (e.g., striking the mine roof with crib block).
- Practice escape without access to surface personnel, such as the dispatcher, RP, or other key leaders.
- Practice while keeping the mouthpiece in (nonverbal techniques or "grunt lingo").

Communications Technology

Allow opportunities for trainees to practice coordinating tasks and procedures, including using communications equipment to coordinate escape efforts.

In an emergency, miners will need to use communication technology to communicate with one another and mine management or outside personnel. This is crucial for the coordination of the escape process.

- Practice using all communication technology available at the mine to communicate to other personnel in the mine and on the surface.

KSAs in Action

Photo by NIOSH

Figure 18. A mine phone affixed to the inside of a refuge alternative door.

Case:

A mine examiner, walking the belt at the Aracoma Mine, immediately called the communications person to notify crews to evacuate.

> *[The belt walker] recognized smoke was traveling toward [the section]. He called outside and instructed [the dispatcher] to call [the section] and initiate an evacuation…receiving no response, [the dispatcher] then used the AMS computer to remotely stop the [belt]…Minutes after the belt was stopped, [the section production crew foreman] called [the dispatcher] to find out why the belt had stopped. [The dispatcher] informed [the section production crew foreman] of the fire and the need to evacuate.* [MSHA 2007a, pp. 8–9]

In their investigation of the 2002 Quecreek water inundation, MSHA concluded that multiple factors contributed to the success of the rescue of nine trapped miners, including the quick thinking and persistence of miners in the affected area to notify others underground.

> *[Shift foreman's] decision and [the shuttle car operator's] persistence to immediately notify the miners in 2-Left section was lifesaving because of the rapid inflow of water. Without that timely warning [the miners in 2-left] would not have been able to escape.* [MSHA 2003, p. 66]

The following excerpts are examples of communication breakdowns during underground mine evacuations that resulted in varying accounts of what the conditions were and some miners not receiving notice to evacuate unsafe conditions.

> *There were many independent conversations about the conditions that existed…with different information being shared. Some people were told a roof fall had occurred, [miner 1] was injured, and [miners 2, 3, and 4] were with him. Some were told there had been an explosion. Some were told a scoop battery was on fire while others may have been told there was a chance of a second explosion. [A foreman] knew miners had been injured and believed there was a fire in 4 Section.* [MSHA 2001, p. 15]

> *Although [the CO room supervisor] told [the mine manager] that miners were evacuating the mine, investigators found no indication that any miner was notified to evacuate at this time.* [MSHA 2001, p. 12]

> *…they said it was just a small [fire], burning on the belt. Well, if that's all there was to it, we could have took* [sic] *a fire extinguisher, run down there in the mantrip [and put it out].* [NIOSH 2000, p. 75]

> *The Barrier Section Crew exited the mine at the North portal at approximately 3:35 p.m. [Miner A and Miner B] were removing track at the East Mains area inby the South portal. They were not informed that an explosion had occurred and exited the mine about 4:10 p.m.* [MSHA 2010, p. 20]

Relevant KSAs:

- Knows what information to gather and prioritize
- Knows how to concisely communicate critical information to others within the mine and on the surface

- Understands how to operate all mine phones, radios, texting devices, and backup systems used at the mine
- Communicates progress and other critical information (severity, conditions of mine, affected areas, conditions of equipment, and needs) to the surface and to other miners underground
- Receives, acknowledges, and acts upon RP, EGL, dispatcher, and other outside guidance, as appropriate
- Repeats information received to confirm reception and understanding
- Confirms that the information given is received and understood
- Knows what questions to ask to gather specific details about changing conditions within the mine

Chapter 8
Refuge Alternatives

Refuge alternatives (RAs) provide a safe shelter if miners are unable to escape from the mine in an emergency and are often presented as the "last resort" for endangered miners. They are also suitable as a shelter for miners who are unable to escape due to injury, fatigue, or other limiting factors. They are a key self-escape resource and miners must know when and how to use them.

Photo by NIOSH

Figure 19. Reflective signage indicating the location of an RA in an underground coal mine.

Core Competency Area

Table 8. Performance Criteria (Core KSAs) for Refuge Alternatives

When to Enter	▪ Recognizes when all options for escape are exhausted and it is necessary to take refuge in an RA as the last resort ▪ Knows where and how to barricade if all other options are exhausted and an RA is not available ▪ Knows that, if miners are injured or unable to self-escape, the RA is an option while they wait for rescue
Operation	▪ Knows how to deploy and configure an RA following the manufacturer's instructions ▪ Knows where instructions are located ▪ Understands the steps for entering an RA ▪ Knows how to check the air quality both inside and outside the RA
Managing Resources	▪ Conserves available resources (air, food, water, light) ▪ Takes extra SCSRs into the RA
Communicating	▪ Utilizes available technology to maintain communication with the RP and dispatcher when possible

Suggestions for Training

How to Operate

Train miners on how to deploy the refuge alternative(s).

Miners may not be able to practice operating the RA and might need to deploy it for the first time during a mine emergency. Thus, they should be equipped with the guidance and instruction necessary to deploy the RA correctly when the time comes.

- Immediately train all new hires on the locations and deployment procedures of the mine's RAs.
- Regularly review deployment instructions for clarity and legibility and store in an accessible and known location near the RA.
- Discuss the fact that, although having to deploy an RA is unlikely, miners will be trying to deploy it under time pressure, reduced visibility, or other stressors.
- Communicate with mine management to ensure the RAs are positioned correctly with enough room to fully deploy (varies by manufacturer).

When to Enter

Encourage the use of refuge alternatives when necessary.

The RA offers a potential location for miners to await rescue if all exits out of the mine are blocked. It can also be useful as a location to leave miners whose condition might prevent their ability to escape. The RA should be described as a valuable resource in a mine emergency that should be used when needed for refuge.

- Talk with miners about the reasons why they might be reluctant to accept the refuge alternative as an option in the event of a mine emergency.
- Identify potential mechanisms for overcoming that obstacle.
- Ensure that miners are confident in their ability to deploy and use an RA, thereby minimizing one potential barrier to take refuge as the last resort.

KSAs in Action

Photo by NIOSH

Figure 20. A training demonstration of the deployment of an inflatable RA with the adequate space for requirements.

Cases:

In the West Virginia Office of Miners' Health and Safety Training's investigation report of the Sago Mine explosion, investigators discuss one crew's attempt to build a barricade when they believed escape was dangerous.

> *According to [the only surviving miner], the [crew] then returned to the face and built a barricade of curtain material to protect themselves from the dust and smoke.* [Wooten 2006, 3.2.4]
>
> *The eleven miners who perished in the [escape group] were…exposed to a hazardous atmosphere in the barricade after their SCSRs were no longer able to produce oxygen…* [Wooten 2006, 5.6.2]

Relevant KSAs:

- Recognizes when all options for escape are exhausted and it is necessary to take refuge in an RA as the last resort
- Knows where and how to barricade if all other options are exhausted and an RA is not available
- Knows how to deploy and configure an RA following the manufacturer's instructions
- Understands the steps for entering an RA
- Knows how to check the air quality both inside and outside the RA
- Takes extra SCSRs into the RA

Chapter 9
Firefighting

Fires can double in size every 5–10 minutes in an underground coal mine. Therefore, the ability to quickly diagnose that a fire is present, where it might be, and its potential cause is critical to miners' safety. Early detection and extinguishing of fires could be instrumental in preventing a dangerous event from becoming a deadly one. All miners should be trained in basic firefighting in the event they are in a position where they must fight a fire or assist in firefighting efforts.

Photo by NIOSH

Figure 21. Basic firefighting equipment stored in an underground coal mine.

Core Competency Area

Table 9. Performance Criteria (Core KSAs) for Firefighting

Diagnosis	▪ Knows how to visually inspect a fire to judge its severity (e.g., based on size and spread, heat, location) ▪ Recognizes that underground coal mine fires can double in size every 5–10 minutes ▪ Knows when, where, and how to shut off power ▪ Understands the basics of mine ventilation and expected airflow/ventilation in the mine ▪ Knows how to concisely communicate critical information about the fire to others underground and on the surface
When to Fight a Fire	▪ Knows to seek advice from the EGL, RP, or other personnel if unsure whether to stay or fight the fire ▪ Can determine when to abandon firefighting efforts and begin to or resume escape
How to Fight a Fire[15]	▪ Knows how to use a fire extinguisher ▪ Knows the location of firefighting equipment at all times ▪ Knows when, where, and how to shut off power ▪ Transfers from an SCSR to an SCBA with a full facepiece, if available and properly trained, before fighting a fire ▪ Knows how to activate fire suppression systems on mobile equipment ▪ Understands how to set up and use fire hoses (“right to fight”) ▪ Knows to confirm an available water source and flush lines before assembling fire hoses ▪ Uses a fog spray pattern to push smoke and heat away ▪ Keeps hoses between oneself and the rib to reduce tripping hazards ▪ Tests roof conditions and sets supports, if necessary, when fighting a fire ▪ Determines where to move based on one’s current location relative to the progression of the fire ▪ Keeps the mine exit/fresh air to one’s back when fighting a fire, whenever possible ▪ Monitors the working condition of firefighting equipment and ensures all hoses, fittings, and nozzles are the same size and thread

[15] It was noted by subject matter experts that most of these KSAs are critical for rank-and-file miners in the event they find themselves in a situation they ***must*** fight a fire.

Supplemental KSAs for Rank-and-file Miners

- Is familiar with which crewmembers, if any, have specialized emergency response training or experience (e.g., mine rescue, emergency medical, fire brigade)
- Knows the firefighting plan
- Knows own role in the firefighting plan
- Does not attempt to fight a fire while using an SCSR
- Understands the significance of smoke presence (in airways, from fans, in return air shafts)
- Understands the impact of fire, gases, and smoke on air quality
- Considers where other workers might be in relation to the fire
- Periodically tests air quality and velocity to note changes
- Reports progress to the RP
- Shares responsibility with mine management to regularly test water supply and pressure throughout the mine (i.e., 50 gallons per minute and 50 pounds per square inch)

Suggestions for Training

Diagnosis

Train miners on these aspects of fire scenarios and firefighting.

- Emphasize the importance of determining and communicating critical information to others in the mine and on the surface, such as:
    - What might be burning (coal, lubricants, conveyor belt, mobile equipment)
    - The location of the fire
    - The location of yourself and other miners in relation to the fire
    - The size and spread speed of the fire
    - The velocity and direction of airflow
- Discuss mine-specific coal volatility as it relates to the speed in which the fire may spread.
- Discuss the potential collapse of the mine roof in the vicinity of a fire.

Train miners to ask themselves the following key questions if or when they are investigating a fire.

- Where is the rest of my crew? Other miners?
- Is anyone around me trained in intermediate or advanced firefighting (e.g., fire brigade, mine rescue team members)?

- Where, if anywhere, can I remain in fresh air and avoid being exposed to smoke?
- If I'm going to escape, can I safely pass by the fire, or do I need to go a different way?

Train miners to understand the unique characteristics of the mine's coal seam and how it might be affected during a fire.

When to fight a fire

"Time is a critical factor in any fire situation, and a few seconds saved can mean the difference between a fire's extinction or a disaster" [NIOSH 2005, p. 11]. If qualified firefighters are not underground for the initial response to a small fire, advise miners to follow these steps:

- If alone, attempt to extinguish the fire and then report the fire to other miners and the surface.
- If two or more miners are together, one would report the fire to other miners and the surface, and the other(s) would attempt to extinguish the fire.
- If the fire is spreading quickly and already too big to fight, report the fire to other miners underground and the surface, and begin escape.

How to fight a fire

Familiarize the workforce with the mine-specific firefighting plan and use a combination of classroom and hands-on training in firefighting basics.

- Regularly provide all miners with hands-on training with all firefighting equipment available at the mine (e.g., fire hoses, fire extinguishers, firefighting foam).
- For hands-on training using fire hoses, train in groups of at least three miners.
- Encourage miners to share in the responsibility of monitoring the condition of the firefighting equipment and that all nozzles, fittings, and hoses are the same size and thread.
- Use real or simulated fires to practice firefighting techniques with groups of miners.
- Discuss the potential collapse of the mine roof in the vicinity of a fire.
- Discuss mine-specific coal volatility as it relates to the speed with which the fire may spread.
- Discuss how high ventilation velocities across the fire zone may affect the fire (e.g., expands it faster downwind than low velocity).
- Have classroom-based discussions or simulations that include critical decisions that must be made and how to effectively communicate about the fire to the RP, the surface, and other miners underground.
- Use on-the-job opportunities to train miners on how to respond to fires caused by job-specific hazards.

KSAs in Action

Photos by NIOSH

Figure 22. A group of underground coal miners engaged in hands-on firefighting training.

Cases:

Although there was fire hose and a fire hose connection available at the Aracoma Mine, miners were unable to properly use them. Also, power to the mine's water pumps had been cut off.

> *[The miner] was unable to [connect the firehouse to the firehouse outlet] because the threads of the firehose coupling and the threads of the firehose outlet were not compatible. When he opened the firehose outlet valve, in an attempt to direct at least some water onto the fire, he found there was no water in the line.* [MSHA 2007a, p. 8]
>
> *[Miners] carried firehose down the…belt entry and connected [it] to a fire outlet. However, water was not available because the supply line water pumps had been de-energized.* [MSHA 2007a, p. 15].

Relevant KSAs:

- Knows the location of firefighting equipment at all times
- Understands how to set up and use fire hoses ("right to fight")
- Knows to confirm an available water source and flush lines before assembling fire hoses
- Shares responsibility with mine management to regularly test water supply and pressure throughout the mine (i.e., 50 gallons per minute and 50 pounds per square inch)
- Monitors the working condition of firefighting equipment and ensures all hoses, fittings, and nozzles are the same size and thread

Chapter 10
Overall Suggestions for Training and Assessment

In addition to the nine core competency areas discussed above, some overall suggestions for training and assessment follow.

General Tips

- Train miners on the difference between information that can be accessed (e.g., the mine map) versus information that needs to be known (e.g., the location of the mine map).
- Deliver content using a broad range of methods (e.g., lecture, videos, hands-on practice, role plays, and computer-based modules) that include key decision points and feedback.
- Relate the training content to mine-specific characteristics whenever possible.
- Use formal and informal assessment of knowledge (e.g., the locations of mine emergency features and resources), which is itself a teaching method, especially when feedback is provided.
- Encourage miners to speak up and ask questions during training by explicitly telling them they have the right to do so and that it is their responsibility.

Planning Training

Tailor training and assessment curriculum around miners' needs when possible [Ryan et al. 2018].

If miners are struggling with a certain skill, such as map reading, incorporate it into training activities. For examples of how this is done, refer to Appendix C or the article, "Using Performance Management Strategies to Improve Mine Emergency Training and Preparedness" [Ryan et al. 2018].

Maximize the benefit of required quarterly escapeway drills by:

- Rotating leaders (EGL, RP, first aid) so miners can gain an understanding of the roles and responsibilities of others
- Using live SCSRs or expectations trainers whenever feasible
- Turning off lights or using obscured goggles to impair vision while navigating the escapeways
- Asking miners to identify tactile lifeline symbols and to point out locations of SCSR caches, RAs, etc.
- Affording all miners the opportunity to shut the power down
- Introducing time pressure to simulate the urgency of mine emergency escape
- Keeping track of and noting the time it takes to walk the escapeway vs. taking a mantrip

Boosting Trainee Motivation

Ensure that the training includes ample challenge, but structure it so that trainees leave the training with a sense of accomplishment.

- Expose trainees to challenges that they can work through successfully and provide positive feedback for meeting those challenges.
- Determine whether miners can properly demonstrate or explain critical KSAs before moving on to the next training topic, if time allows during formal or informal training and assessment activities.

Communicate the organization's commitment to and support for ensuring the safety of miners. Also, empower trainees to speak up and ask questions during training by explicitly telling them they have the right to do so and that it is their responsibility.

- Recognize that the trainee's belief in the level of organizational support for self-escape training will influence their motivation.
- Understand that all miners may not be willing or able to demonstrate proficiency in all critical KSAs but that the "rising tide" of workforce preparedness will raise the overall level of emergency response preparedness for the mine.

Improving Teamwork

Build trust between miners and the mine operator, safety professionals, and other leaders throughout the training.

- Encourage and reward miners for being proactive about safety on the worksite by asking for suggestions and taking those suggestions seriously. If feasible, workers might also be motivated by material rewards such as a picnic lunch after annual training is completed or by designing and purchasing tee-shirts with worker-inspired safety slogans.
- Teach trainees to ask questions or seek additional information; similar to "see something, say something." Stress miners' responsibility to speak up, point out perceived risks, and ask clarifying questions.
- Encourage miners to mention any concerns during training or regular work hours ("see something, say something"), then debrief the whole group at the training or in safety meetings.
- Conduct training and exercise activities with those in leadership positions to improve miners' teamwork and coordination abilities and to help them better understand their own role and the roles of others (e.g., the RP, section foremen) during self-escape.

Cross-train miners on various roles and jobs to help them understand and support those in other roles and in case they must step up to perform a different role during an emergency.

- Afford non-maintenance workers the experience of shutting down the belt when it is stopped for normal maintenance.

- Rotate operation of mantrips among all personnel on a shift to ensure all individuals can operate the mantrip if necessary.
- Engage trainees in role-play activities to teach skills such as assertiveness, cross-checking, and conflict management. Integrate role-play activities into quarterly escapeway drills or other trainings.
- Afford all miners the opportunity to shut down the power during section moves or quarterly escapeway drills.

Train miners other than those in supervisory positions to be able to assume some leadership responsibilities during self-escape.

- Train miners to be able to perform some of the duties of the RP and EGL during training and drills (e.g., surface personnel gather critical information and make appropriate notifications and underground personnel account for personnel and report information to the surface).
- Structure training scenarios where the designated leader is absent or incapacitated and miners must assume or share leadership responsibilities with others in the escape group.

Encourage peer training.

Mine safety personnel can use peer training techniques to teach new competencies, enhance current skills, correct performance deficiencies, or serve as a motivational tool for employees who are performing well (e.g., the coaches and mentors). These techniques may help reduce the time needed to learn skills or correct deficiencies because of the continuous and targeted feedback provided by coaches and mentors to the trainee.

Peer Coaching

Peer coaching is a training technique that involves using a combination of instruction and one-on-one guidance to improve trainees' performance in a particular area. The trainee is typically someone who has been working at the company for a while and is a known expert on specific tasks or procedure. Coaches must be skilled in how to perform the tasks and how to train others to perform them.

Peer Mentoring

Peer mentoring is a form of training in which a senior employee (or more knowledgeable employee) helps to guide a less experienced employee over a period of time. This type of training can result in an ongoing relationship or friendship between workers. The mentor often provides the junior employee with guidance and a clear understanding of the organization.

Incorporating Assessment and Feedback

Use assessment tools and strategies.

- Use simple assessment tools, such as quizzes or "spot checks" throughout the day, to evaluate individual self-escape KSAs covered in the training class. Spot checks could include periodically asking an individual to demonstrate a hands-on task or explain where

the primary *and secondary* escapeways are. These assessments can be carried out quickly and may provide insight into the overall performance of the workforce and areas in need of improvement that future trainings can address, and they can help identify individuals in need of immediate or personalized remediation.

- Develop strategies to evaluate training at the team level (e.g., during quarterly escapeway drills).
- Consider ways to assess performance via observation. For example, observers can examine teamwork by asking themselves these questions:
    - Did individual team members or the group share a mutual understanding of the task?
    - Did team members coordinate effectively?
    - Did team members recognize mistakes made by others? Did they work together to correct them?

Debrief trainees on performance.

- Perform a group debrief with trainees to discuss what was and was not done correctly and to give an opportunity for further questions or discussions. When facilitated by a seasoned leader, these discussions help to build mutual understanding of "lessons learned" and establish "best practices" for future reference.
- Remember to conduct spot checks and to provide feedback on the performance of solitary workers who may be alone at the time of an emergency.

Figure 23. A safety trainer debriefing trainees after an emergency drill.

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Appendix A: Demonstration of NIOSH Self-escape Competency Survey Results

Safety personnel from a coal company translated the NIOSH Self-escape Competency Survey results that were included in the *Coal Age* article "The ABCs of KSAs: Assessing the Self-escape Knowledge, Skills and Abilities of Coal Miners" [Hoebbel et al. 2018] into a simplified format to present at annual refresher training.

Safety personnel wanted to share the results with their workforce to let them know that if they lacked confidence in a certain area, they were not alone. Thus, they created simple slides to share the results of the NIOSH survey, which identified many gaps in miners' self-escape KSAs, and they presented these slides before training activities began. This prompted miners to speak up or ask questions whenever they were having difficulty understanding or performing a task during the training event. A detailed overview of this industry collaboration is provided in the *Coal Age* article "Using Performance Management Strategies to Improve Mine Emergency Training and Preparedness" [Ryan et al. 2018].

The next two pages demonstrate the simplified format that the mine company used to present the survey results.

Over 50%

of rank-and-file miners were less than fully confident that they could correctly demonstrate or explain:

- The mine's emergency response plan (ERP)
- The chain of command for reporting a mine emergency
- How to construct a proper barricade
- How to reestablish ventilation
- Ventilation/smoke leakage
- What alarms/alerts mean
- How to read mine map symbols
- When to construct a barricade
- The mine's communication and tracking (CT) system
- Your own role in the mine's emergency response plan (ERP)

Between 41% and 50%

of rank-and-file miners were less than fully confident that they could correctly demonstrate or explain:

- If or when to fight a fire
- How to fight a fire
- How to enter the mine's refuge alternative
- What lifeline symbols mean
- Where the refuge alternative(s) is/are located
- What to expect when wearing an SCSR
- The location of the mine's escapeways
- The location of the mine's SCSR caches
- Where the mine's tetherlines are located

Between 31% and 40%

of rank-and-file miners were less than fully confident that they could correctly demonstrate or explain:

- When to enter the mine's refuge alternative (RA)
- Where to report in the event of a mine emergency
- How to test roof conditions
- Where the mine's escapeway maps are located
- How to use a tetherline

Between 20% and 30%

of rank-and-file miners were less than fully confident that they could correctly demonstrate or explain:

- How to identify an explosive atmosphere with a gas meter
- When to don an SCSR
- How to properly don an SCSR
- How to use nonverbal communication

Appendix A References

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Appendix B: Personal Competency Assessment Forms

This appendix includes personal competency assessment forms for each of the nine competency areas detailed in this Information Circular. Miners can check the boxes next to specific KSA to identify where they might need or want additional training. Miners can also make suggestions on how training could be better from their perspective. This could lead to more KSA acquisition and retention.

These forms will help mine safety personnel identify training priorities and develop training activities targeted toward specific workforce needs.

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Everyday Preparedness

Personal Preparedness	☐ Remains up to date on all required training
	☐ Knows the relative risk propensity of the mine (e.g., which is most likely to occur: gas or water inundation, fire, or explosion)
	☐ When appropriate, the miner carries the following:
	  ☐ Essential medications
	  ☐ Emergency medicine sticker and card with known conditions
	  ☐ Reading glasses
	  ☐ Wristwatch
	  ☐ Lunch and water
	☐ Carries and knows how to use:
	  ☐ Multigas detector
	  ☐ Handheld radio
	  ☐ Required personal protective equipment (PPE)
	  ☐ Proximity sensor targets
	☐ Has a serviceable SCSR on one's person or within 25feet of current location
	☐ Conducts checks on all personal equipment to ensure it is in working order
	☐ Has the ability to attach to a tagline/tetherline in the event one is needed (e.g., belt loop, pants loop)
	☐ Knows one's own personal limitations and capabilities and has some familiarity with those of others on the crew/team
	☐ Knows the chain of command for reporting a mine emergency (particularly for outby workers who may be working alone)

Accounting for Personnel	☐ Knows the location of and ensures the safety of inexperienced miners, if assigned ☐ Knows the identity and approximate or likely location of the designated RP on each shift
First Aid	☐ Recognizes the need to seek medical assistance for oneself or others ☐ Knows where to locate first aid equipment and how to use it (e.g., backboard and straps, oxygen, automated external defibrillator (AED), bandages and dressings) ☐ Knows how to administer basic first aid for shock; check airway, breathing, and circulation (ABCs); and administer cardiopulmonary resuscitation (CPR)

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Situational Awareness: Mine Layout

Location of Mine Emergency Features and Resources	☐ Recognizes one's personal position in the mine relative to the locations of all emergency features and resources, including the following: ☐ Mine phones and other communication technology ☐ Meeting places ☐ SCSR caches ☐ Lifelines and primary *and secondary* escapeways ☐ Refuge alternatives ☐ Barricading supplies ☐ Tagline/tetherlines ☐ Mine maps ☐ Firefighting equipment ☐ First aid equipment and medical supplies
Establishing and Maintaining Situational Awareness	☐ Pays attention to landmarks, signage, and the direction and temperature of airflow on the ride into the section and at the work location ☐ Knows the general layout of the mine ☐ Knows the numbering of entries and crosscuts on section ☐ Knows what questions to ask to gather specific details about changing conditions within the mine ☐ Establishes and maintains awareness of one's own location within the mine relative to the event, if possible ☐ Recognizes one's personal position within the mine relative to the locations of all emergency features and resources including primary *and secondary* escapeways, exits, and fresh air ☐ Stays current on changes to mine installations (i.e., airshafts, slopes, and portals) ☐ Uses handheld multigas detectors to assess air quality as one moves throughout the mine ☐ Notes the locations of transportation and whether transportation to the working section is staying or leaving the work location ☐ Understands the basics of mine ventilation (location of air splits, airflow direction, point feeds, etc.) ☐ Knows what gases are present in the mine, how they interact, their potential effect on personnel, and event consequences ☐ Understands the basics of mine ventilation and expected airflow/ventilation in the mine ☐ Has a basic knowledge of the roof control plan and how it might change due to fires, explosions, etc. ☐ Knows the general locations of man doors (e.g., every 5th crosscut)

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Emergency Diagnosis and Response

Knowing Signs of Danger	☐ Knows the relative risk propensity of the mine (e.g., which is most likely to occur: gas or water inundation, fire, or explosion) ☐ Understands the significance of smoke presence (in airways, coming from fans, in return air shafts) ☐ Understands that even a small, localized methane explosion can damage or destroy ventilation control devices ☐ Knows critical gas levels (carbon monoxide (CO), oxygen (O_2), methane (CH_4), hydrogen sulfide (H_2S), etc., if applicable) and how to respond, if out of acceptable limits ☐ Recognizes the meaning and significance of audio and visual alarm sensor alerts ☐ Recognizes the occurrence of and potential significance of a power outage or other interruption to the operation of fans ☐ Communicates conditions to the surface and other miners underground as soon as possible ☐ Calls out to confirm whether or not fans are running ☐ Understands the impact of fire, gases, and smoke on air quality ☐ Understands that both asphyxiation and poisoning can occur due to poor air quality ☐ Knows to verify and never ignore alarms and alerts ☐ Knows water or gas inundation can affect ventilation
Decision-making	☐ Recognizes the need to self-escape from the current work location or to travel to a meeting location or other place of relative safety ☐ Receives, acknowledges, and acts upon RP, EGL, dispatcher, and other outside guidance, as appropriate ☐ Knows to always ride out of the mine instead of exiting by foot if possible ☐ Understands the roles of the EGL and RP and defers to them if appropriate ☐ Recognizes the need for oneself or someone else to assume a leadership role ☐ Has general understanding of whether an injured miner or miners should be left in an RA to await rescue ☐ Knows if and when to turn off equipment power ☐ Knows where and how to barricade if all other options have been exhausted and an RA is not available ☐ Participates in the escape group's decision-making

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Wayfinding

General Principles	☐ Trusts training and relies on procedures learned and resources available ☐ Understands escape speed in emergency conditions can be reduced below normal walking speed ☐ Knows how to use other tactile wayfinding techniques (rib line, power cables, waterlines, belt, a cane or stick, if available) if a lifeline is not available ☐ Returns doors to the position they were found in when traveling through man doors or regulators ☐ Crosses over or under belts only at designated crossings ☐ Knows how to use handheld multigas detectors to assess air quality as one's position changes ☐ Recognizes the need for oneself or someone else to assume a leadership role ☐ "Goes low" in smoke, after an explosion, or when encountering debris or difficult walking conditions
Moving Effectively as a Group	☐ Moves with and avoids splitting up the group, and gathers others as encountered ☐ Places one's hand on the shoulder or belt of the person directly ahead if a tagline/tetherline is not available ☐ Reminds others to use available taglines/tetherlines ☐ Allows the most experienced worker to lead the tethered group, with the slowest person in the middle ☐ Whenever possible, remains attached to the tagline/tetherline when in smoke or dust ☐ Participates in identifying all miners present underground (e.g., headcounts) ☐ Communicates progress and other critical information (severity, conditions of mine, affected areas, conditions of equipment, and needs) to the surface and to other miners underground
Mine Emergency Features and Resources	☐ Knows how to find and use the following: ☐ Mine maps ☐ SCSRs (take extra units) ☐ Firefighting equipment ☐ Refuge alternatives ☐ Taglines/tetherlines (e.g., with everyone on same side, remain tethered when in smoke or dust whenever possible) ☐ Lifelines (knows tactile symbols) ☐ Primary and secondary escapeways including mine-specific designated escapeway marker colors ☐ Escapeway maps

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—SCSRs: Locating, Donning, and Switching/Swapping

Locating	☐ Has a serviceable SCSR on one's person or within 25 feet of current location ☐ Knows the locations of SCSR caches ☐ Understands that SCSR caches are relocated during a section equipment or power move ☐ Moves outby toward next accessible cache to switch/swap SCSRs

Donning	☐ Knows to don an SCSR:
	  ☐ Upon evidence of a fire or explosion, first sign of smoke or heavy dust
	  ☐ When a multigas detector alarms and indicates that one or more gases is/are not within acceptable limits
	  ☐ When instructed to do so
	☐ Knows it is possible that carbon monoxide will precede smoke or other evidence of fire
	☐ Understands how to perform steps for opening, preparing, and donning all SCSRs in use at the mine:
	  ☐ Isolates the lungs first and adjusts straps to secure the unit close to the body second
	  ☐ Uses the manual start-up procedure if necessary and the correct procedure applicable to the model (e.g., chemical oxygen units)
	  ☐ If necessary, further adjusts neck straps so there is no tension or kinking in the breathing tube
	☐ Knows to wear the goggles with SCSR unit to protect against absorption of carbon monoxide through the tear ducts
	☐ Knows how and when to help others don an SCSR
	☐ Understands that sealed, mine-ready SCSRs will be more difficult to open than those used during training
	☐ Knows that a short-term SCSR will last about 10 minutes and knows to move to the nearest 1-hour unit after donning
	☐ Knows that depletion rates may vary across devices and users
	☐ Knows to keep the lungs isolated by never removing the nose clips or mouthpiece, even if it is uncomfortable or difficult to communicate

Switching/ swapping	☐ Knows when to switch/swap between SCSRs based on time, levels of exertion, and oxygen gauge (if available) ☐ Knows breathing resistance is greater toward the end of the SCSR's rated duration ☐ Masters the sequence of steps for switching/swapping between SCSRs ☐ Knows how and when to help others switch/swap between SCSRs
General Maintenance	☐ Inspects one's own belt-wearable SCSR before each shift, checking the case, seals, clips, oxygen gauge (if available), and moisture indicator ☐ Does not use an SCSR for anything unsuited to its design (e.g., as a blunt force tool, as a seat) ☐ Knows when an SCSR should be removed from service

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—SCSRs: Use and Expectations

What to Expect When Using an SCSR	☐ Knows that breathing resistance will occur and that it may feel as if the unit is not working properly even though it is ☐ Knows that the unit can become warm or hot to the touch and breathing resistance will increase the longer the SCSR is worn ☐ Understands that rate of escape should be reduced to below normal walking speed as breathing resistance increases ☐ Understands that resistance becomes greatest toward the end of the SCSR's rated duration ☐ Knows to slow down to avoid depleting the oxygen supply before a switch/swap is possible
Communications	☐ Knows that verbal communication will be difficult or impossible while using SCSRs ☐ Knows nonverbal communication techniques (e.g., cap lamp signals, blinking lights, writing, tapping codes, hand signals) ☐ Does not remove SCSR mouthpiece to communicate unless in fresh air (e.g., from RA)
Preparedness	☐ Picks up and carries an extra SCSR if possible ☐ Has a serviceable SCSR on one's person or within 25 feet of current location ☐ Knows whether mantrip or other transportation is leaving the work area—if leaving, takes a 1-hour SCSR as transportation will not be immediately available ☐ Knows the duration of one's personal SCSR and where the nearest cache of one-hour/high-capacity units is located ☐ Knows the rated duration of all SCSRs in use at the mine ☐ After donning an SCSR, tracks how much time has passed since donning the unit if possible ☐ Reduces one's speed or activity rate as SCSR breathing resistance increases ☐ Raises the SCSR unit overhead if traveling through deep water ☐ Knows to wear the goggles from SCSR unit to protect against absorption of carbon monoxide through the tear ducts

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Communication

General Principles	☐ Speaks loudly and clearly ☐ Knows what information to gather and prioritize ☐ Knows how to concisely communicate critical information to others within the mine and on the surface ☐ Does not remove SCSR mouthpiece to communicate unless in fresh air (e.g., from RA) ☐ Communicates with SCSR mouthpiece in place ("grunt lingo") in the absence of fresh air ☐ When possible, leaves handwritten notes or use other communications to relay one's plans ☐ Picks up the mine phone when passed during escape (if it is safe to stop at and use during the emergency)
Communicating Within an Escape Group	☐ Knows how and when to communicate about plans and next steps with the EGL and others in the group ☐ Determines how and when to use nonverbal communications (e.g., cap lamp signals, blinking lights, writing, tapping codes, hand signals) with others in the mine ☐ Speaks clearly and confidently to reassure those who may be panicking or upset ☐ Provides updates on one's own physical condition and that of others in the group to the EGL
Communicating with the EGL and Surface Personnel	Reporting information: ☐ Communicates critical information about the miners still underground (e.g., location, headcount, names, physical condition, needs) ☐ Communicates progress and other critical information (severity, conditions of mine, affected areas, conditions of equipment, and needs) to the surface and to other miners underground ☐ Provides updates on the environmental conditions of the mine to the RP and surface personnel ☐ Provides updates on the situation, plan, next steps, and needs to the RP and surface personnel ☐ Provides updates on one's own physical condition and that of others in the mine to the RP and surface personnel Receiving information: ☐ Receives, acknowledges, and acts upon RP, EGL, dispatcher, and other outside guidance, as appropriate ☐ Repeats information received to confirm reception and understanding ☐ Confirms that information given is received and understood ☐ Knows what questions to ask to gather specific details about changing conditions within the mine
Communication Technology	☐ Understands how to operate all mine phones, radios, texting devices, and backup systems used at the mine ☐ Uses nonverbal communications with others when necessary

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Refuge Alternatives

When to Enter	☐ Recognizes when all options for escape are exhausted and it is necessary to take refuge in an RA as the last resort ☐ Knows where and how to barricade if all other options are exhausted and an RA is not available ☐ Knows that, if miners are injured or unable to self-escape, the RA is an option while they wait for rescue
Operation	☐ Knows how to deploy and configure an RA following the manufacturer's instructions ☐ Knows where instructions are located ☐ Understands the steps for entering an RA ☐ Knows how to check the air quality both inside and outside the RA
Managing Resources	☐ Conserves available resources (air, food, water, light) ☐ Takes extra SCSRs into the RA
Communicating	☐ Utilizes available technology to maintain communication with the RP and dispatcher when possible

Training Comments/Suggestions:

Instructions:

1. Check the box next to the KSAs you would like to improve during future training events.
2. Please include training comments or suggestions related to your selections.

Competency Area—Firefighting

Diagnosis	☐ Knows how to visually inspect a fire to judge its severity (e.g., based on size and spread, heat, location) ☐ Recognizes that underground coal mine fires can double in size every 5–10 minutes ☐ Knows when, where, and how to shut off power ☐ Understands the basics of mine ventilation and expected airflow/ventilation in the mine ☐ Knows how to concisely communicate critical information about the fire to others underground and on the surface
When to Fight a Fire	☐ Knows to seek advice from the EGL, RP, or other personnel if unsure whether to stay or fight the fire ☐ Can determine when to abandon firefighting efforts and begin to or resume escape
How to Fight a Fire	☐ Knows how to use a fire extinguisher ☐ Knows the location of firefighting equipment at all times ☐ Knows when, where, and how to shut off power ☐ Transfers from an SCSR to an SCBA with a full facepiece, if available and properly trained, before fighting a fire ☐ Knows how to activate fire suppression systems on mobile equipment ☐ Understands how to set up and use fire hoses (“right to fight”) ☐ Knows to confirm an available water source and flush lines before assembling fire hoses ☐ Uses a fog spray pattern to push smoke and heat away ☐ Keeps hoses between oneself and the rib to reduce tripping hazards ☐ Tests roof conditions and sets supports, if necessary, when fighting a fire ☐ Determines where to move based on one’s current location relative to the progression of the fire ☐ Keeps the mine exit/fresh air to one’s back when fighting a fire, whenever possible ☐ Monitors the working condition of firefighting equipment and ensures all hoses, fittings, and nozzles are the same size and thread

Training Comments/Suggestions:

Appendix C: Using Competency-based Training Strategies to Improve Self-escape KSAs: A Case Study

One of the mine companies that participated in the NIOSH Self-escape Competency Survey [Hoebbel et al. 2018] incorporated NIOSH's research findings into its self-escape training practices over the course of one calendar year. Focusing on mine-specific gaps in KSAs, this company developed competency-based strategies for training, assessing, and improving the workforces' self-escape KSAs. They integrated these strategies into multiple training activities, including annual refresher training (1st Quarter), annual smoke expectations training (2nd Quarter), and a quarterly response drill (3rd Quarter). This appendix provides an overview of these efforts, which are detailed in the *Coal Age* article, "Using Performance Management Strategies to Improve Mine Emergency Training and Preparedness" [Ryan et al. 2018].

Table C1 presents the company's self-escape improvement efforts over the course of 2018.

Table C1. Using competency-based strategies during 2018 self-escape training and preparedness events

--	1st Quarter: Annual Refresher	2nd Quarter: Annual Expectations	3rd Quarter: Quarterly Escapeway Drill	4th Quarter: End-of-year Assessment
Action	Mine safety personnel used the KSAs listed on the Self-escape Competency Survey to develop a competency assessment form.	Mine safety personnel developed, implemented, and assessed a hands-on mapping exercise during the smoke drill. Trainees had the option to use a live M20 SCSR unit during the drill and attended 1.5 hours of hands-on firefighting training after the drill.	Mine safety personnel developed and carried out a firefighting scenario during the 3rd quarter escapeway drill.	Mine safety personnel re-administered the 1st quarter assessment form during a 4th quarter safety meeting.
Outcome	Identified KSA gaps in mine map and lifeline symbol knowledge, SCSR donning and expectations, and firefighting. Decided to focus on these areas during FY18 training events.	Miners performed well on the mapping exercises, and many took the opportunity to use the live SCSR. Miners appreciated the firefighting training and reported wanting more hands-on firefighting experience.	Mine safety personnel observed that miners had difficulty unrolling the hoses with the correct end lined up with the water source. They decided to go over this in future firefighting training and potentially develop and implement more helpful cues for the miners.	The workforce had about a 10% improvement, on average, between 1st quarter and 4th quarter results. Miners reported feeling more accountable and learning more from training during 2018 compared with other years.

Table C2 lists some of the self-escape KSAs from the NIOSH survey and matches them with the related assessment questions that Company A developed for an Annual Refresher quiz. These quiz items were created to assess miners' competency in these specific self-escape areas. Miners had to put their names on the top of the quiz and, after going over the forms, the mine safety trainer individually counseled those who did not meet the company's performance standard the next day.

Table C2. How trainers translated self-escape competency survey KSAs into quiz items

Self-escape Competency Survey KSA		Annual Refresher Quiz Item
How to don an SCSR	→	Which rescuer has a removable nose clip: EBA 6.5 or M20?
How to don an SCSR	→	Write out the key steps for donning an M20 SCSR unit
How to don an SCSR	→	Write out the key steps for donning an EBA 6.5 SCSR unit
How to don an SCSR	→	Write out they key steps for transferring from an M20 to EBA 6.5 SCSR unit
How to fight a fire	→	How long will a 20-lb dry chemical fire extinguisher last once you activate it?
How to fight a fire	→	Name at least 6 locations where we store fire extinguishers underground
How to fight a fire	→	How many gallons of water do our diesel fire cars hold?
How to identify an explosive atmosphere using a multigas detector	→	What is the explosive range of methane?
How to read mine map symbols	→	Name at least 4 safety/emergency response items listed on an escapeway map
Lifeline symbols	→	While traveling on the lifeline, what symbol indicates a branch line?
Lifeline symbols	→	What symbol on the lifeline indicates a door?
Lifeline symbols	→	What symbol on the lifeline indicates an SCSR cache?
Lifeline symbols	→	What symbol on the lifeline indicates a refuge chamber?
How to read mine map symbols	→	What symbol on an escapeway map indicates an overcast?
How to read mine map symbols	→	What symbol on an escapeway map indicates a regulator?
What to expect when using an SCSR	→	What SCSR makes a constant sound during use: EBA 6.5 or M20?
Where escapeway maps are located	→	Name two locations where we keep escapeway maps underground
Where SCSR caches are located	→	Name the specific locations where they keep SCSRs on section at your mine
Where taglines/tetherlines are located	→	Name two locations that we keep taglines/tetherlines underground

1st Quarter: Annual Refresher Training

Figure C1 was included in the Annual Refresher training quiz to assess miners' competency in lifeline and mine map symbol identification. Trainees had to match the items from the legend on the left side of the document to the appropriate mine map or lifeline symbol listed to the right. Mine safety personnel discovered that many of the trainees struggled in these competency areas and, as a result, tried to address and improve these competency gaps during the next self-escape training event.

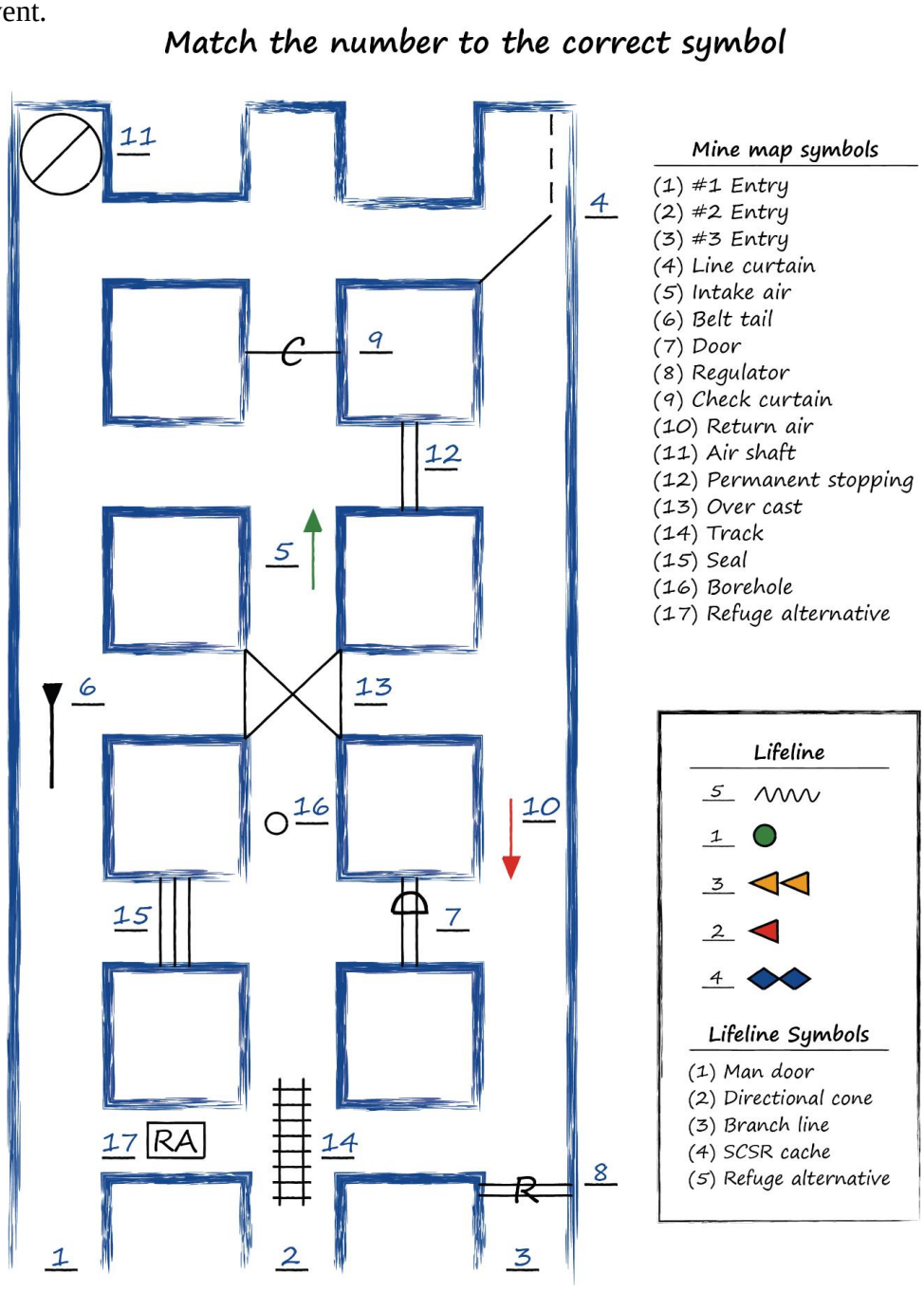


Figure C1. Annual refresher map and lifeline symbol competency assessment quiz. The figure shows the quiz correctly filled out.

2nd Quarter: Annual Expectations

During Annual Expectations training, each "escape group" was given a blank map of the simulated mine (as depicted in Figure C2). The escape groups, usually made up of 3-4 trainees, went through the simulated mine environment before the smoke drill began and mapped out the location of key emergency features (SCSR cache, fire extinguisher), the escapeways and mine features (e.g., man door signs, vent tubes). The groups then used this map to navigate the simulated mine in smoke, including locating and navigating to the SCSR cache and in attempting to escape.

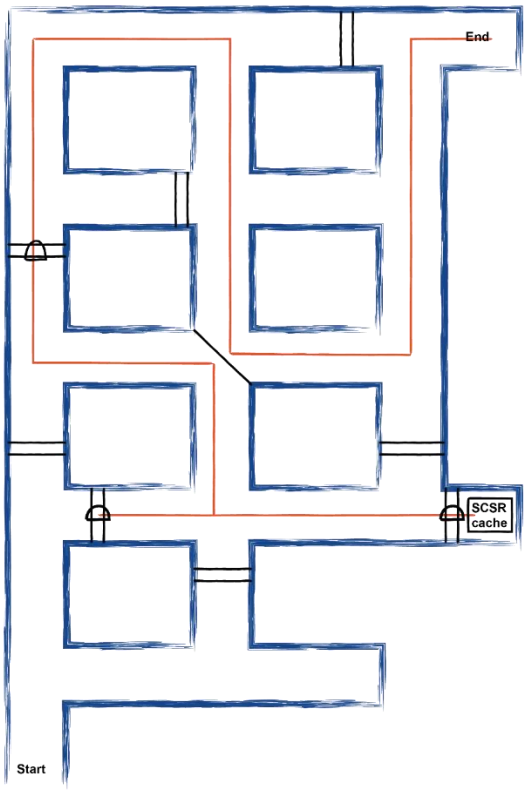


Figure C2. Annual expectations smoke drill mapping exercise. The figure shows a blank map for the miners to fill out as part of a self-escape exercise.

A safety trainer first explained the mapping exercise with trainees. Next, each group familiarized themselves with the simulated mine where the smoke drill was to take place before the drill began and mapped out the simulated mine layout (crosscuts, entries, where man doors or curtains were located, etc.), the primary *and secondary* escapeways, and where escape resources were located using the template they were given.

Miners then had to refer to the map they created when escaping the simulated mine in smoke during the drill. The safety trainer debriefed each of the groups after they went through the drill, assessing their maps for accuracy and answering any questions.

Miners were given the option to use (expired) live M20 SCSR units during the escapeway drill in order to gain hands-on experience using the real equipment as opposed to a training unit.

3rd Quarter: Quarterly Escapeway Drill

Mine safety personnel developed and implemented a firefighting scenario into the 3rd quarter quarterly escapeway drill, as described below.

Safety personnel went underground during the afternoon shift and told the outby shuttle car operator that he had to initiate a response to a scenario where the shuttle car caught fire outby.

The operator alerted others within and outside the mine via telephone, and the whole afternoon shift crew assembled and then collected and put together the firefighting equipment and advanced upon the "fire." The shift foreman helped coordinate the firefighting response efforts.

Mine safety personnel observed the miners' performance and debriefed with the whole shift crew afterwards about their performance. They asked miners for their feedback and thoughts on the firefighting plan and the drill.

4th Quarter: End-of-year Assessment

Mine safety personnel administered the same quiz that they had given miners in the beginning of the year during Annual Refresher Training again in the 4th quarter. Comparing results from the 1st and 4th quarter, trainers reported that individuals' scores improved by ~10% on average.

Trainees also had positive feedback about how much they learned over the course of the year. Some quotes from trainees are as follows:

- "I understand and learned a lot more from this year than last year."
- "[Training] keeps getting better . . . I never looked at things in such detail!"
- "Informative, showed areas I was not as competent as I may have thought."

Trainees also reported that they liked that they had to take quizzes about what they were learning in training, noting that it made them pay more attention.

- "I like the test that he gives out and that he collects it with your name on it. Accountability."
- "The quizzes keep you from daydreaming."
- "The accountability with the test is a good idea."

Appendix C References

Hoebbel C, Brnich MJ, Ryan ME [2018]. The ABCs of KSAs: Assessing the self-escape knowledge, skills and abilities of coal miners. Coal Age, *123*(1):30–34.

Ryan ME, Diamond J, Brnich MJ, Hoebbel C [2018]. Using performance management strategies to improve mine emergency training and preparedness. Coal Age *123*(9):37–39.

Appendix D: Training Resources

The resources below are organized by competency area to assist with developing and implementing competency-based training and assessment strategies.

Emergency Diagnosis and Response

Emergency Response Planning for Small Mines: Who Needs It?

A paper that discusses emergency response planning with a special emphasis on small mine sites.
https://www.cdc.gov/niosh/mining/works/coversheet43.html

Escape and Evacuation: A Miners' Education and Training Toolbox

A collection of 20 "toolbox talks" that include video components, a user's guide, and emergency scenarios that cover evacuation decisions and steps for self-escape. Penn State Miner Training Program 2008.
https://sites.psu.edu/minertraining/msha/escapeandevacuation/

Escape From Farmington No. 9: An Oral History

A video-based training module that can be used to educate both inexperienced and veteran miners on important issues related to self-escape procedures.
https://www.cdc.gov/niosh/mining/works/coversheet1628.html

Wayfinding

Behavioral and Organizational Dimensions of Underground Mine Fires

A report that can aid trainers in creating behavior-based training for improving miners' wayfinding skills. See Chapter 7: Smoke as an escape and behavioral environment and Chapter 8: Wayfinding and escape behavior.
https://www.cdc.gov/niosh/mining/works/coversheet45.html

Underground Coal Mine Map Reading Training

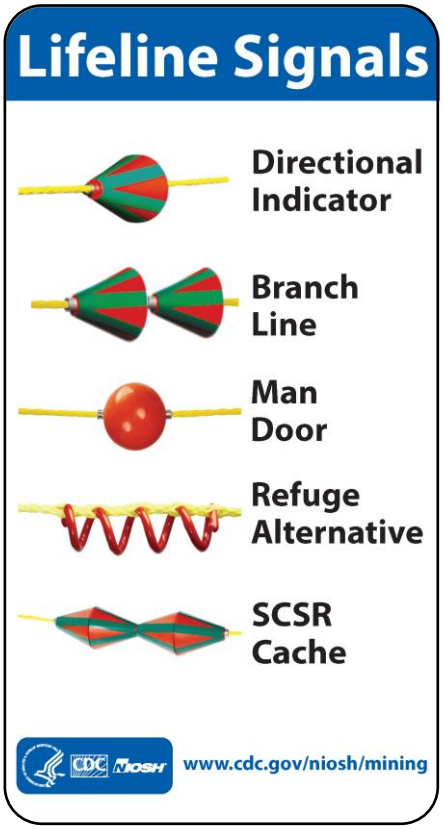
A training that includes three components for teaching and testing mine map reading skills.
https://www.cdc.gov/niosh/mining/works/coversheet1825.html

Lifeline Tactile Signal Flashcards

A collection of flashcards for practicing the lifeline tactile signals with the miners.
https://www.cdc.gov/niosh/mining/works/coversheet1826.html

Lifeline Signals Sticker

A NIOSH-developed sticker that miners can use (e.g., put on their hard hats) to aid in the interpretation of the meaning of lifeline signals. Contact mining@cdc.gov to request free copies.



SCSRs

CSE Corporation SCSR Training Products

An online SCSR training resource center, including training videos on SCSR donning and changeover.
https://www.csecorporation.com/Resources?search=1&topic=5&type=1

Expectations Training for Miners using Self-contained Self-rescuers in Escape from Underground Coal Mines

A journal article that describes the research behind a NIOSH-developed SCSR expectations training program.
https://www.cdc.gov/niosh/mining/works/coversheet985.html

I Can't Get Enough Air! Proper Self-contained Self-rescuer Usage

An instructor's guide for implementing a training program about proper SCSR usage.
https://www.cdc.gov/niosh/mining/works/coversheet343.html

Ocenco M20 to Ocenco EBA 6.5
A video from archived MSHA DVD regarding the safe transfer process of switching from one SCSR to another.
https://archive.org/details/gov.msha.dvd013.9

MSHA - Streaming Media Files - Drager SCBA Escape System: Care, Use, and Operation - Including SCSR Transfer
A review of basic information regarding the care, use, and operation of the Drager SCBA.
https://arlweb.msha.gov/Streaming/DraegerComp.asp

Communication

Advanced Tutorial on Wireless Communication and Electronic Tracking: CT System Survivability, Reliability, and Availability
A training tutorial that overviews wireless communication and electronic tracking in mines.
https://www.cdc.gov/niosh/mining/content/emergencymanagementandresponse/commtracking/advcommtrackingtutorial4.html

Nonverbal Communication for Mine Emergencies
A training program that teaches miners a series of nonverbal hand signals to use in the event of an emergency if they are unable to communicate verbally.
https://www.cdc.gov/niosh/mining/works/coversheet461.html

Radio 101: Operating Two-way Radios Every Day and in Emergencies
A program to train miners in the use of two-way radio communication in the mines.
https://www.cdc.gov/niosh/mining/works/coversheet522.html

The Emergency Communication Triangle
A 15-minute safety talk, including graphics, that focuses on the content of emergency warning messages. This talk presents a procedure for senders and receivers of emergency warnings.
https://www.cdc.gov/niosh/mining/works/coversheet838.html

Training to Improve Emergency Communication Skills
A paper that introduces a method for teaching workers to communicate necessary information when giving or receiving emergency warning messages.
https://www.cdc.gov/niosh/mining/works/coversheet1801.html

Refuge Alternatives

Emergency Escape and Refuge Alternatives
A training tool that can be used to teach miners about emergency escape and using refuge alternatives, including PowerPoint slides and an instructor’s guide.
https://www.cdc.gov/niosh/mining/works/coversheet366.html

Guidelines for Instructional Materials on Refuge Chamber Setup, Use, and Maintenance
Guidance for developing manuals and educational materials on refuge chambers for miners.
https://www.cdc.gov/niosh/mining/works/coversheet498.html

Harry's Hard Choices: Mine Refuge Chamber Training
A paper-and-pencil simulation that covers topics related to self-escape, including information gathering, knowing one's escapeways, and using SCSRs, multigas detectors, and refuge alternatives.
https://www.cdc.gov/niosh/mining/works/coversheet1838.html

Learn with Harry: Harry's Hard Choices
A serious game based on *Harry's Hard Choices: Mine Refuge Chamber Training* from the University of Arizona's Western Mining Safety and Health Training Resource Center.
https://miningsh.arizona.edu/learn-harry

How to Operate a Refuge Chamber: A Quick Start Guide
A training tool for teaching miners how to operate refuge chambers in a group-based training, including a PowerPoint presentation and instructor's guide.
https://www.cdc.gov/niosh/mining/works/coversheet1695.html

Man Mountain's Refuge: Mine Refuge Chamber Training
A training designed for teaching mine employees on how and when to use a mine refuge chamber, including an instructor's guide and trainee problem book.
https://www.cdc.gov/niosh/mining/works/coversheet1679.html

Refuge Chamber Expectations Training
A training to inform miners of what to expect psychologically and physically if they must use a refuge chamber in a mine emergency.
https://www.cdc.gov/niosh/mining/works/coversheet455.html

Underground Mine Refuge Alternatives: A Look at Food, Water, and Sanitation Requirements
An article that reviews the MSHA regulations for food, water, and waste disposal/sanitation in refuge alternatives.
https://www.cdc.gov/niosh/mining/works/coversheet1964.html

When Do You Take Refuge? Decisionmaking During Mine Emergency Escape
A training that exposes trainees to escape scenarios where they may need to enter the refuge alternative rather than continue attempting to self-escape.
https://www.cdc.gov/niosh/mining/works/coversheet1556.html

Appendix E: Post-exit Competency Items Based on Formal Task Analysis

Although the subject matter experts that contributed to this guidance document did not deem these post-exit items "critical to self-escape," they all stressed the importance of miners knowing to engage in self-care, to seek support for oneself and others, and to debrief about the incident after escape from an emergency. This appendix includes items from the original draft competency framework and others that were compiled by focus groups and external subject matter expert review.

Post-exit

To effectively engage in emergency response management, it is critical to, upon reaching safety outside of the mine, remain calm, gather together, and contribute to critical incident debrief. It is critical for mine management to arrange a critical incident stress debrief and important for miners to follow up with physical and mental health professionals, as necessary. Psychological first aid is a topic that should be included in miner safety and health training (e.g., toolbox talks, written materials and resources, annual refresher training).

Competency Area—Post-exit

Performance Criteria (KSAs)

Debriefing	☐ Communicates critical information about the miners still underground (location, headcount, names, physical condition, needs) ☐ Communicates critical information about the situation (route traveled, severity, conditions of mine, affected areas, conditions of equipment, and needs) ☐ Describes difficulties, barriers, deficiencies in information or other resources
Engaging in Self-care	☐ Participates in a group critical incident stress debrief ☐ Doesn't hesitate to follow up with mental health professionals, if needed ☐ Knows that not everyone reacts to stress the same way ☐ Maintains a healthy diet and gets adequate sleep and exercise ☐ Shares experiences with trusted coworkers, family, and friends ☐ Recognize signs of traumatic stress in self and others ☐ Knows when to seek additional help and support for self and others

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Promoting productive workplaces through safety and health research

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DOI: https://doi.org/10.26616/NIOSHPUB2023133