THE ABCs OF KSAs

Assessing the self-escape knowledge, skills and abilities of coal miners

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What simple step can help to prevent a mine emergency from becoming a mine disaster? Preparation.

Mine emergencies can happen at any moment. Although all mines and mine emergencies are unique, being equipped with an easily adaptable set of knowledge, skills and abilities (KSAs) can help underground coal miners prevent a dangerous situation from becoming a tragedy.

The Mine Improvement and New Emergency Response Act of 2006 (MINER Act) strengthened existing safety and health training regulations and introduced new measures aimed at improving emergency preparedness and response in underground coal mines. Although the MINER Act also required non-specified assessment of the self-escape KSAs of miners, there is no standard protocol dictating how to teach or evaluate these competencies.

Now more than 10 years later, the National Institute for Occupational Safety and Health (NIOSH) expanded its research to answer these important questions:

- What are the critical self-escape competencies that all miners need in order to be prepared to respond to an emergency?
- In light of training regulations that are now a decade old, how confident are miners in their ability to self-escape in the event of an emergency?

One of 895 underground coal mineworkers who volunteered to participate in NIOSH's self-escape survey study.

Identifying Critical Self-escape KSAs

Prior NIOSH research, the National Research Council 2013 report, "Improving Self-Escape From Underground Coal Mines," and multiple industry reports have addressed the need for improved self-escape training and assessment that emphasizes task mastery over the completion of time-based training requirements. To address this need, under a NIOSH contract, the Group for Organizational Effectiveness (gOE) and Aptima Inc. partnered to conduct a formal task analysis to identify the tasks critical for successful self-escape. The primary goal of this work was to provide detailed descriptions of all tasks critical to successfully self-escape. The protocol was reviewed and approved by the NIOSH Institutional Review Board and found to be in compliance with the Paperwork Reduction Act by the Office of Management and Budget.

Assessing Gaps in Critical Self-escape KSAs in Miners

To identify gaps in the critical self-escape KSAs among mineworkers, NIOSH developed a survey using 28 of the critical self-escape tasks identified in the task analysis. Because standard self-escape competency and assessment protocols are yet to be developed and real-world performance is difficult to assess, mineworker confidence was used as a "proxy" to measure competence. Participating miners were asked, "On a scale of 0-100%, how confident are you that you could correctly demonstrate or explain the following (KSA) to a brand new miner?"

In late 2016, NIOSH researchers visited eight mines and collected surveys from 895 volunteer mineworkers. To the authors' knowledge, this is the first study to assess gaps in the critical self-escape KSAs from the perspective of the mineworkers themselves.

"MAKE SURE YOU HAVE A GOOD UP-TO-DATE MAP AND KNOW THE ESCAPEWAYS OUT OF THERE RIGHT OFF THE BAT. . . IF THE GUYS . . . THAT DIED IN THE FIRE KNEW THEIR ESCAPEWAYS . . . AND KNEW WHERE THEIR SELF-RESCUERS WERE, THEY WOULD HAVE MADE IT OUT."

— Jim Behling, from the 2017 documentary, "Remember Wilberg"

"Remember Wilberg" is a documentary film produced under a grant from NIOSH, written and directed by Elaine Cullen, and produced by the UTA Film School.

Key Results

Survey results suggest that, despite united efforts to improve health and safety training by researchers and industry alike, there are still many gaps in critical self-escape KSAs among mineworkers.

Figure 1 displays the 28 items included on the survey along with the percentage of hourly and salaried mineworkers who report they are not fully confident in each of the self-escape tasks. For example, as shown in Figure 1:

- 23% of the hourly workers surveyed reported less than full confidence in their ability to demonstrate or explain how to properly don a self-contained self-rescuer (SCSR).
- 40% reported being less than fully confident about where to report in the event of an emergency.
- Less than half reported full confidence in their ability to explain the chain of command for reporting an emergency, or how to read mine map symbols.

When reviewing these results, it is especially important to note the wording of the question itself. The question introduced no complicating conditions (stress, smoke, real emergency, etc.), so the re-

sponses reflected how confident each miner is in his or her ability to correctly perform or explain these tasks to a new miner under normal, non-threatening conditions. This, along with other issues related to collecting self-reported data (e.g., potential concerns about confidentiality of answers and overrating of self-confidence), suggest these results could actually be viewed as "best-case scenario" estimates of confidence. This could signify that results might, in fact, overestimate levels of self-escape competency among this sample of mineworkers.

Importantly, it might not be realistic to expect that every mineworker be 100% confident in each and every self-escape task included on the survey. However, these results provide a clear indication that miners lack confidence in their own self-escape capabilities in multiple areas, and that there is significant room for improvement.

After receiving results representing their miners, individual mine operators and safety managers were able to tailor their training to better address the gaps in KSA confidence. Although the overall study results may not be generalizable to the underground mining population at large, these results (See Figue 1) can help to give mine operators, safety managers and individual miners everywhere an idea of where gaps in self-escape KSAs might exist.

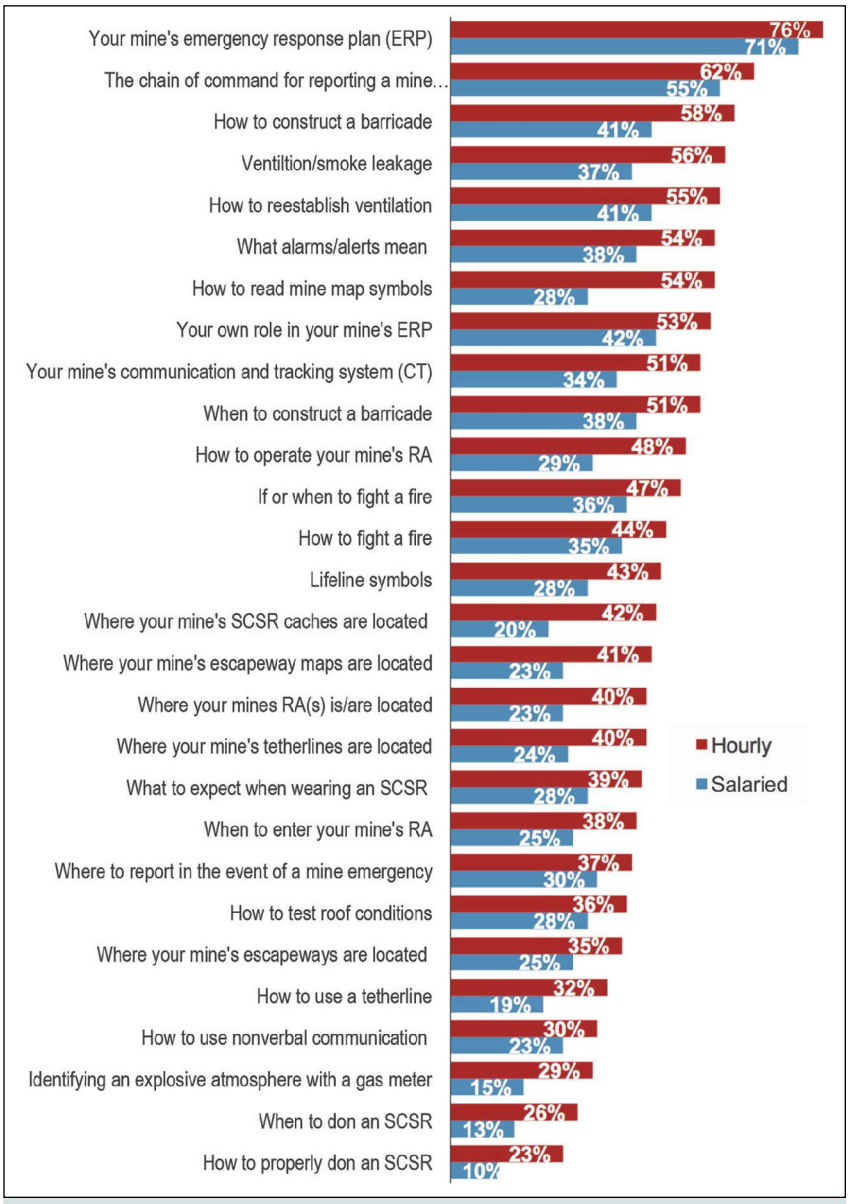

Figure 1—Percentage of mineworkers out of 895 surveyed who are not fully confident in their ability to correctly demonstrate or explain critical self-escape knowledge, skills and abilities.

Improving Critical Self-escape KSAs in Miners: What You Can Do Now

Despite the gaps in critical self-escape KSAs reported here, the good news is that every mine can immediately begin working on increasing worker proficiency in the "basic" knowledge critical to self-escape, including:

- Where the mine's SCSR caches are located.
- Where the mine's escapeway maps are located.
- Where to report in the event of a mine emergency.
- Where the mine's refuge alternatives are located.
- Where the mine's tether lines are located.
- The chain of command for reporting a mine emergency.
- The location of the mine's primary and secondary escapeways.

This critical knowledge can be easily and briefly covered every shift or periodically, as the working sections move, as part of the crew pre-shift meetings or via informal "quizzes" or "spot checks" during the workday. These brief exercises can also serve to increase proficiency in map reading and the correct identification of mine map symbols.

Gaps in KSAs that require procedural skill are being further studied by NIOSH in an effort to develop evidence-based training recommendations for mine operators and safety trainers for dissemination in 2019. In the interim, Table 1 outlines currently available resource materials for critical KSAs, including a number of available training aids.

As NIOSH continues to research self-escape preparedness, these results serve as a reminder of how important it is for mines to continuously review training materials assess the KSAs of their workforce. Defining and developing critical competencies will help to ensure mineworker readiness to avert potential tragedies.

For more information, contact mining@cdc.gov.

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of NIOSH. Mention of any company or product does not constitute endorsement by NIOSH.

Table 1—Resource materials available for training miners in critical knowledge, skills and abilities (listed from lowest to highest reported confidence).

Knowledge, Skills and Abilities	Resources and How to Cover/Review
Your mine's emergency response plan (ERP)	Your mine's emergency response plan.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
Chain of command for reporting a mine emergency	Your mine's emergency response plan; your mine's firefighting and evacuation plan.
	Escape and Evacuation: A Miners' Education and Training Toolbox. Penn State Miner Training Program. Available at: https://sites.psu.edu/minertraining/msha/escapeandevacuation/.
	Review during pre-shift crew or safety meetings; ask miners where they should report an incident.
How to construct a barricade	Virginia Department of Mines, Minerals, and Energy (DMME)—Barricading. Available at: www.dmme.virginia.gov/dm/AccidentsAndFatalities/SafetyBulletins/CarbonMonoxideHalt.pdf.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
Ventilation/smoke leakage	Your mine's ventilation plan.
	Escape From a Mine Fire. Video deals with the experiences of two miners in escaping an underground coal mine fire in 1988. Both discuss the importance of paying close attention to alarms and warnings. Available at: https://arlweb.msha.gov/Streaming/VintageClips.asp.
	Escape From Farmington No. 9: An Oral History—NIOSH Publication No. 2009-142D. Available at: https://www.cdc.gov/niosh/mining/works/coversheet1628.html.
	Advanced Mine Rescue Training—Coal Mines. Module 3—Mine Ventilation. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/MineRescue/Training/IG7.pdf.
	Train miners to recognize disaster change in ventilation, smoke, etc. Discuss key ventilation points during crew pre-shift or safety meetings; annual refresher training; during quarterly mine escape training.
How to reestablish ventilation	Your mine's ventilation plan.
	Discuss during crew pre-shift or safety meetings; new miner and annual refresher training.
How to read mine map symbols	Underground Coal Mine Map Reading Training—NIOSH Publication No. 2009-143c. Available at: www.cdc.gov/niosh/mining/works/coversheet1825.html.
	Cover during annual refresher training or other safety training sessions.
What alarms mean	Your mine's firefighting and evacuation plan.
	Escape From a Mine Fire. Video deals with the experiences of two miners in escaping an underground coal mine fire in 1988. Both discuss the importance of paying close attention to alarms and warnings. Available at: https://arlweb.msha.gov/Streaming/VintageClips.asp.
	Review during crew pre-shift or safety meetings. Emphasize importance of recognizing and responding to audio/visual alarms.
Your own role in your mine's emergency response plan (ERP)	Your mine's ERP.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
When to construct a barricade	Your mine's firefighting and evacuation plan.
	Virginia Department of Mines, Minerals, and Energy (DMME)—Barricading. Available at: www.dmme.virginia.gov/dm/AccidentsAndFatalities/SafetyBulletins/CarbonMonoxideHalt.pdf.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
Your mine's communication and tracking system (CT)	Your mine's ERP.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
How to operate your mine's refuge alternative (RA)	Your mine's RA deployment and operation instruction materials; manufacturer's training material.
	How to Operate a Refuge Chamber: A Quick Start Guide—NIOSH) Publication No. 2011-100. Available at: www.cdc.gov/niosh/mining/works/coversheet1695.html.
	Refuge Chamber Expectations Training—NIOSH Publication No. 2010-100. Available at: www.cdc.gov/niosh/mining/works/coversheet455.html.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training; use listed NIOSH RA operations training resources.
If or when to fight a fire	Fire Response Preparedness for Underground Mines—NIOSH) Publication No. 2006-105. Available at: www.cdc.gov/niosh/mining/works/coversheet749.html.
	Cover during regular firefighting drills, during annual refresher training.

How to fight a fire	Your mine's firefighting and evacuation plan.
	Fire Response Preparedness for Underground Mines - NIOSH Publication No. 2006-105. Available at: www.cdc.gov/niosh/mining/works/coversheet749.html.
	Firefighting—a collection of mine gas training materials in PowerPoint and other formats. Available at: http://miningquiz.com/powerpoints/firefighting.htm.
	Advanced Mine Rescue Training—Coal Mines. Module 5—Fires, Firefighting, and Explosions. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/MineRescue/Training/IG7.pdf.
	Train miners to fight fire based on their role(s) in mine's firefighting and evacuation plan; conduct hands-on firefighting training yearly with all miners.
Lifeline symbols	Lifeline Tactile Signal Flashcards. Available at: www.cdc.gov/niosh/mining/works/coversheet1826.html.
	Review during pre-shift crew or safety meetings; use lifeline section with all tactile symbols and quiz miners. You can also use the NIOSH flashcard resource to quiz miners.
Where your mine's SCSR caches are located	Your mine's escapeway maps; your mine's quarterly escape training.
	Review during crew pre-shift or safety meeting; ask miners the locations of caches; review locations using escapeway map.
Where your mine's escapeway maps are located	Your mine's escapeway maps; your mine's quarterly escape training.
	Review during pre-shift crew or safety meeting. Ask crews where maps are kept in their work area.
Where tether lines are located	Your mine's firefighting and evacuation plan.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training.
Where your mine's refuge alternative(s) (RA) is/are located	Your mine's escapeway maps; your mine's quarterly escape training.
	Review during crew pre-shift or safety meeting, ask miners the locations of RAs; review locations using escapeway map.

What to expect when wearing an SCSR	Expectations Training for Miners using Self-Contained Self-Rescuers in Escape from Underground Coal Mines—Journal Occupational Environ Hygiene, 2008 Oct; 5(10):671-677. Available at: www.cdc.gov/niosh/mining/works/coversheet985.html.
	I Can't Get Enough Air! Proper Self-Contained Self-Rescue Usage. DHHS (NIOSH) Publication No. 99-160. Available at: www.cdc.gov/niosh/mining/works/coversheet343.html.
	Self-Contained Self-Rescuers (SCSR's) Interactive Training Course—Inspection, Maintenance, and Use. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/interactivetraining.htm.
	Review/discuss during quarterly escape training; annual smoke training. If possible, allow miners to breathe from a live SCSR.
When to enter your mine's refuge alternative (RA)	When Do You Take Refuge? Decision-making During Mine Emergency Escape—NIOSH Publication No. 2011-177C. Available at: www.cdc.gov/niosh/mining/works/coversheet1556.html.
	Harry's Hard Choices: Mine Refuge Chamber Training—NIOSH Publication No. 2009-122. Available at: www.cdc.gov/niosh/mining/works/coversheet1838.html.
	Man Mountain's Refuge: Refuge Chamber Training Instructor's Guide and Trainee's Problem Book—NIOSH Publication No. 2011-195. Available at: www.cdc.gov/niosh/mining/works/coversheet1679.html.
	Seek Refuge: Your Third Line of Defense. Penn State Mining Training Program. Available at: https://arlweb.msha.gov/Streaming/SCSRClips.asp.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training; use listed NIOSH RA use decision-making training resources.
How to test roof conditions	Your mine's roof control plan.
	80-hour Underground Miner Pre-Employment Training Program Study Guide—Unit 12 Roof/Rib Control. West Virginia Office of Miners' Health, Safety, and Training. Available at: www.wvminesafety.org/PDFs/80%20HR.Underground%20Study%20Guide.pdf.
	Roof Control. MSHA Catalog of Training Products. Cat. No. 36. Available at: Mine Safety and Health Administration, email—MSHADistributionCenter@dol.gov.
	Discuss during crew pre-shift or safety meetings; new miner and annual refresher training.
Where to report in the event of a mine emergency	Your mine's firefighting and evacuation plan.
	Location varies by mine. Review in pre-shift crew or safety meetings; during quarterly escape training.
How to identify an explosive atmosphere with a gas meter	Mine Gases—a collection of mine gas training materials in PowerPoint and other formats. Available at: http://miningquiz.com/powerpoints/mine_gases.htm.
	Advanced Mine Rescue Training—Coal Mines. Module 2—Mine Gases. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/MineRescue/Training/IG7.pdf.
	Review gas monitor during crew pre-shift or safety meetings; annual refresher training; during quarterly mine escape training.
Location of your mine's primary and secondary escapeways	Your mine's escapeway maps.
	Review during pre-shift crew or safety meeting. Using escapeway map, ask crew members to show the route they would travel from their work area.
How to use a tether line	Your mine's quarterly escape training.
	Discuss during crew pre-shift or safety meetings; discuss during quarterly mine escape training; ask trainees to demonstrate using a tether line.
How to use nonverbal communication (hand/cap lamp symbols)	Nonverbal Communication for Mine Emergencies—NIOSH Publication No. 2012-104. Available at: www.cdc.gov/niosh/mining/works/coversheet461.html.
	Discuss during crew pre-shift or safety meetings; review during quarterly mine escape training; use listed NIOSH nonverbal communication training resource.
When to don an SCSR	Predetermined talking points that might include: first sign of smoke, rising CO levels, dropping O_2 levels.
	Self-Contained Self-Rescuers (SCSR's) Interactive Training Course—Inspection, Maintenance, and Use. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/interactivetraining.htm.
	Cover during quarterly escape training, pre-shift crew or safety meetings; annual refresher training.
How to properly don an SCSR	Your mine's quarterly escape training; annual smoke training; your mine's annual refresher training.
	Self-Contained Self-Rescuers (SCSR's) Interactive Training Course—Inspection, Maintenance, and Use. Mine Safety and Health Administration. Available at: https://arlweb.msha.gov/interactivetraining.htm.
	SCSR Transfer Process. Collection of links for streaming media for various SCSR models. Mine Safety and Health Administration. Available at https://arlweb.msha.gov/Streaming/SCSRClips.asp.
	Review steps during crew pre-shift or safety meetings; review and provide feedback during hands-on training; annual refresher training.