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## IMPROVED RECOGNITION OF LIFELINE TACTILE SIGNALS BY MINERS

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Conducting regular assessments of each miner's knowledge and skills with respect to lifelines should be a key component of miner safety training. The better prepared miners are to escape from the mine quickly, the better their ultimate chances of survival. Recent NIOSH research reveals several ways miners can be helped to improve their recognition of lifeline tactile signals.

Lifelines with various tactile signals have been required by federal regulation 30 CFR Part 74.380 since 2009. There are now five types of tactile signals on lifelines: directional cones (which indicate the direction to go outby), a coil to indicate a refuge chamber, two sets of double cones to indicate a self-contained, self-rescuer (SCSR) cache, two directional cones in a row to indicate a branch line, and a ball to indicate a personnel door. These signals were instituted to provide an additional navigational tool to help miners escape in the event of an emergency.

Despite the implementation of this new safety feature, miners may not always remember what the signals mean, especially in an emergency situation. It is important miners are able to identify the signals reliably because it could save them a significant amount of time while trying to escape. In addition to telling them which direction is outby, the signals could save them time because, instead of following a branch line to find out where it leads, miners can feel the signal at the beginning of the branch line and immediately know what is available at the end. They can also immediately identify when a line is a branch line as opposed to the main lifeline which leads them directly out of the mine.

During underground mine emergencies, miners typically evacuate as part of a crew or small group. Therefore, it is important they know how to work effectively as a team to plan and carry out their evacuation. However, it is impossible to predict the circumstances under which a miner may need to navigate out of the mine. If miners are working alone or become separated from their crew, they must be able to escape on their own. Because of this, miners should not depend on their fellow crew members to

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get them out of the mine, but rather should know how to escape on their own. It is important that each and every miner be able to identify the lifeline signals independently of the rest of the crew.

#### Recent NIOSH Field Tests

A team of NIOSH researchers recently assessed a group of underground coal miners' ability to correctly identify the five lifeline tactile signals. A total of 345 miners working at a large western coal mine in August 2010 participated in both a written and a hands-on behavioral assessment. Researchers returned three months later to administer a follow-up test, that allowed them to measure any change in knowledge retention over time. During the first round of tests in August, miners completed both a behavioral and written assessment of their knowledge. During the second round of tests in November, miners completed a written assessment only. Some miners participated in both groups thus allowing researchers to determine if those miners had retained their knowledge over time.

During their regularly scheduled safety training classes (during the months prior to the NIOSH field tests), the mine's training staff had explained to all miners the purpose and placement of lifelines and the meaning of the five tactile signals. Mine trainers were provided with flash cards to help miners further review the meaning of the tactile shapes during the three months between the first and second tests.

Immediately following their annual underground smoke expectations training, miners were asked to walk a 100-foot length of lifeline in theatrical smoke and to identify each lifeline tactile signal they came across. All of the miners participated. The "test" lifeline was set up to ensure that each miner would have to identify all five signals. To be realistic, multiple instances of some signals were used (e.g., there had to be a branch line indicator for each of two branch lines—one for an SCSR cache and one for a refuge chamber). There were a total of eight signals on the line, including three directional cones, two branch line signals, one personnel door signal, one SCSR cache signal, and one refuge chamber signal. A researcher walked with each miner and recorded whether the miner identified each of the eight signals correctly or incorrectly. As the miners encountered each signal along the lifeline, they were asked what it indicated. For example, the miners might say "refuge chamber" when they felt the coil on the line, which would be correct. Table 1 presents the distribution of scores. Many (78%) of the miners had a perfect score (eight out of eight correct).

Three groups of miners were asked to complete a short written matching test. This exercise consisted of examining a map, such as the one shown in the figure on page 53, and matching each tactile signal shown on the map to its correct label (e.g., matching the ball with a personnel door). Group 1A consisted of the same 345 miners who also completed the behavioral test in August. Immediately following the completion of their behavioral test, each miner was asked to complete the matching exercise. Of these 345 miners, 89.3% had a perfect score (five out of five). The average score was 4.76. The distribution of scores on this matching test is shown in the second column of Table 2.

Following the initial test in August, the researchers returned approximately three months later to retest miners and determine if they could still identify the signals. For the retest, 191 miners were asked to complete the written map matching exercise. Each miner was given one map with all five signals on it (there were five versions so they may or may not have received the same configuration of the signals). Of these 191 miners, 147 had completed both the written and behavioral assessments in August, and the other 44 miners had not been tested previously.

Group 1B consisted of 147 individuals who completed the map matching exercise in both August and November. Of these miners, 87.1% had a perfect score (five out of five). The average score was 4.69. The distribution of scores on this matching test is shown in the third column of Table 2. Of the 147 individuals in Group 1B, 89.7% of them scored the same or better than they scored in August, and 10.3% scored lower. There appears to be relatively little change in the overall performance of individuals who were tested in both August and November. It appears the miners who were tested in August were able to maintain their level of performance over time.

Group 2 consisted of the 44 miners who completed the map matching test in November but who did not complete the test in August. The scores for this group were lower than the scores of both of the other two groups. Only 70.5% of miners in Group 2 received a perfect score (five out of five) compared to 89.3% of miners in Group 1A and 87.1% in Group 1B. The average score for Group 2 was 4.34. The distribution of scores on this matching test is shown in the fourth column of Table 2. The major difference between Group 2 versus Group 1A is that Group 2 only completed the written assessment, not the behavioral assessment of the signals. The results suggest that combining a behavioral assessment with a written assessment helped miners achieve higher scores.

#### Frequent Mistakes and Misconceptions

In the written matching test, out of the five signals, the branch line, refuge chamber and SCSR cache signals were the most frequently misidentified. The signals for branch line (two cones) and SCSR cache (double diamond) may be confused with each other because both signals are made up of a combination of

multiple cones. The signals for SCSR cache (double diamond) and refuge alternative (coil) may be confused with each other because they are the two signals that denote what might be at the end of a branch line.

Researchers also received some verbal feedback from the miners that revealed a few misconceptions. For example, some miners incorrectly called the branch line signals “change of direction” indicators and interpreted to NIOSH researchers the signal meant the lifeline was changing directions. Also, some miners knew the correct meaning of the signal, but felt it was necessary to follow every branch line while escaping on the lifeline.

#### Recommendations for Lifeline Tactile Signal Training

Based on the research results, several recommendations emerge for trainers involved in helping miners improve their recognition of lifeline tactile signals:

- Incorporate frequent lifeline tactile signal refresher training sessions using simple flashcards. Refresher sessions can be conducted during pre-shift safety and informational meetings above ground or below ground at the start of a shift or during a meal break. Refresher sessions can be conducted in large groups or one-on-one. Reviewing the lifeline tactile signals using the flashcards will take only a few minutes. Templates for making your own flashcards are available from NIOSH at <http://www.cdc.gov/niosh/mining/products/product195.htm>.
- Be sure to emphasize the differences between signals that are commonly confused. The signals for branch line (two cones) and SCSR cache (double diamond) are often confused because both signals involve a combination of multiple cones. Likewise, the signals for SCSR cache (double diamond) and refuge alternative (coil) are commonly confused because both signals also appear on branch lines. One miner stated he remembers the signal for SCSR cache by remembering that SCSR has four letters and the signal is made up of four cones. Trainers can ask miners to suggest other methods they use to remember what the signals mean.
- Correct miners’ misperceptions about branch lines. Some miners incorrectly called the branch line signals “change of direction” indicators and interpreted to NIOSH researchers that the signal meant the lifeline was changing directions. Inform miners the double cone signal does not indicate a change in direction of the main lifeline, but instead indicates a branch line leading to either an SCSR cache or a refuge alternative.
- Remind miners that branch lines do not lead out of the mine; instead they lead to an SCSR cache or refuge alternative. Miners should only follow a branch line during escape if they need to use or reach whatever the branch line leads to. Some miners knew the correct meaning of the signal, but incorrectly felt it was necessary to follow every branch line while escaping on the lifeline.
- Use stickers and posters as a useful memory jogger. Some coal companies are giving their miners reflective stickers that show the shapes of the five lifeline signals. This helps to reinforce what miners are taught during their new miner and annual refresher safety training sessions.
- Trainers should consider making up a short length of lifeline with the tactile signals attached, and use it during training sessions to provide miners with hands-on practice in identifying the meaning of the signals.
- The research findings suggest it is advisable to use both hands-on and written techniques for assessing the recognition of lifeline tactile signals. Combining the two approaches appears to be more effective than using only a written test. For various reasons (e.g., test taking anxiety or low literacy), some people have trouble performing well on written tests even though they may be capable of performing appropriately during an emergency. Alternatives to written exams can include oral question and answer sessions and hands-on demonstrations by the trainee. The best methods of conducting remedial instruction and of assessing competencies will vary depending upon characteristics of the individual miner, and upon the particular type of knowledge, skill, or ability being tested.

Regardless of the method used, it is important for each and every miner to possess knowledge of escape-related information, including the meaning of the lifeline tactile signals. Well-prepared miners will be able to escape more effectively and improve their chances of survival while reducing the need to send mine rescue teams into potentially dangerous situations.

Disclaimer

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

About the Authors

Dr. Catherine Kingsley Westerman, formerly with NIOSH, is an assistant professor in the School of Communication Studies at the University of Tennessee. Robert Peters is a manager in the Office of Mine Safety and Health Research at NIOSH. He can be reached at [rpeters@cdc.gov](mailto:rpeters@cdc.gov) or 412-386-6895.

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