Mine Emergency Response Development/ Mine Rescue Contest: A Combined Exercise

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Abstract
Mine emergency response development (MERD) training exercises were authorized in the Mine Rescue Teams regulation 30 CFR 49.60(b) as a way to satisfy the 2006 Mine Improvement and New Emergency Response Act of 2006 requirement for all coal mine rescue teams to participate in two local mine rescue contests (MRCs) per year. In April 2008, eight mine rescue teams participated in a combined MERD and MRC at the National Institute for Occupational Safety and Health, Office of Mine Safety and Health Research, Safety Research Coal Mine (SRCM) located in Pittsburgh, PA. In 2009, two combined MERDs/MRCs were conducted—one with six teams at the Mining Technology and Training Center (MTTC) in Ruff Creek, PA, and the other with five teams at the National Mine Health & Safety Academy Mine Simulation Lab (MSL) in Beckley, WV. These three MERDs were designed to fulfill the requirements necessary for consideration as MRCs. However, the exercises varied in the use of command structure and personnel.

MERDs and MRCs were developed for very different reasons, but both are important to learning and emergency response preparedness of mine rescue teams. The purpose of an MRC is to build teamwork, train, and demonstrate the level of skills required to respond to a mine emergency, with a winning team chosen based on performance. The purpose of a MERD is to improve crisis management skills for the individuals making critical decisions in the command center (CC). These two purposes can be in conflict unless accommodations are made to satisfy the training needs of both the teams and the CC personnel. This paper describes the three MERDs and explores whether these exercises can be successfully used to enhance mine rescue team capabilities while meeting the requirements for MRCs.

Introduction
Prior to passage of the Mine Improvement and New Emergency Response Act of 2006 (MINER Act), mine rescue teams were classified in two ways: as “competition teams” that spent a large percentage of their training time on contest rules and procedures, or as “go teams” that seldom, if ever, participated in mine rescue contests (MRCs) but responded to mine emergencies. Training time for the “go teams” was used to develop emergency response skills. Passage of the MINER Act required all teams to compete in at least two local MRCs each year [MINER Act 2006]. Some teams expressed concern that they would find themselves at a disadvantage when participating against teams that had a great deal of MRC experience. One way to fulfill the requirement, yet not requiring teams to participate in regular open competition, was to use a Mine Emergency Response Development (MERD) exercise as an MRC, as provided for in the February 8, 2008,

Mine Rescue Teams: Final Rule (30 CFR 49.60(b)), with the approval of the Mine Safety and Health Administration (MSHA) District Manager. MERDs are a natural extension of emergency responder training because these types of training exercises provide mine rescue team members experience with overall crisis management.

A goal of the NIOSH Office of Mine Safety and Health Research (OMSHR) is to minimize the risk to and enhance the effectiveness of emergency responders. One of the first MERD/MRC combined exercises was organized by NIOSH OMSHR and the Pennsylvania Department of Environmental Protection (PaDEP) Bureau of Deep Mine Safety in April 2008 for eight composite mine rescue teams. Composite teams are those whose members come from different companies and mines. The combined MERD/MRC was conducted over three days at the OMSHR Safety Research Coal Mine (SRCM). Each team participated on one of the three days. None of the participating teams had prior experience in an MSHA-sanctioned MRC. Personnel representing MSHA, PaDEP, labor, and the mine operators managed the command center (CC), just as they would in a real emergency. The exercise followed 2008 national coal MRC rules, which qualified the exercise as one of the two required MRCs. Each team worked a different area of the mine containing different problems to solve and, therefore, each team had different experiences requiring different amounts of time to solve.

The following year, after a NIOSH researcher witnessed a successful MERD/MRC scenario developed and tested in May 2008 at the Edgar Mine [Lovely 2010], Colorado Mine Safety & Training Program, two additional 2-day exercises were conducted using the Colorado format. One exercise was conducted by the Mining Technology and Training Center (MTTC) in Ruff Creek, PA, and the second by the WV Alliance at the National Mine Health & Safety Academy Mine Simulation Lab (MSL), near Beckley, WV. In these exercises, both the CC and the mine rescue field were staffed by team members. This allowed mine rescue team members to gain the experience of being the decision-makers and to have a better understanding as to why decision-making delays occur. In these exercises, each team solved the same problem, which removed the built-in time variation experienced at the SRCM exercise.

Background on MERDs and MRCs

MERDs and MRCs came into being for very different reasons. The purpose of a MERD is to improve crisis management skills for the individuals making the emergency decisions in the CC [Kravitz and Peluso 1986]. The purpose of an MRC is to build teamwork, train, and demonstrate a minimum level of the skills required to respond to a mine emergency, with a winner chosen from the participating teams. The two missions can be in conflict; however, there are ways to adapt a MERD as an MRC for mine rescue teams, as shown by the strategies used at the SRCM and those at MTTC and MSL. The following two subsections describe the differences between MERDs and MRCs.

Mine Emergency Response Drills

A MERD is a role-playing exercise intended to improve crisis management skills in the event of a mine emergency. Originally, it was the acronym for Managerial Emergency Response Development [Kravitz and Peluso 1986, Lauriski 2002]. MERDs usually reflect a simulated emergency situation or may be adapted from an actual mine emergency. The scope can range from a tabletop or paper exercise to a Level 1 or full-scale, mine-wide exercise where production is stopped, all mine personnel are involved, and all state, federal, and emergency management agencies participate. The objectives of a MERD usually include evaluating one or more of the following: mine site pre-planning and emergency preparedness; responsible person

(RP) training; CC management and operations; and communication. Good communications are especially critical between the CC, the fresh air base (FAB), and the mine rescue teams. The CC must also maintain good communication with involved agencies, such as emergency management services (police, fire, ambulance, search and rescue, Red Cross, etc.), hospitals, media, families, mine rescue services, and teams. Individuals in the CC (mine rescue personnel, representatives from regulatory agencies, mine or corporate management, and labor) are required to interact with one another, explore possible solutions, create a response plan, direct the mine rescue teams, and ensure that rescuers are not exposed to dangerous conditions.

Typically, CC participants and RPs are expected to use the emergency response plan (ERP) developed specifically for that mine as a guide for their initial organization and response. A well-developed MERD includes all the mine resources that would be available in a real emergency so that a true test of the response plan can be evaluated and improved, if necessary. Progressive organizations may use MERDs as a framework for continuous improvement of their emergency response capabilities. Often, organizations conduct their own simulation drills to prepare in-house responders, but rarely do all of the organizations involved in an actual response train together [Alexander et al. 2011, in press].

Mine Rescue Contests

MRCs are simulations in which teams follow official contest rules to address an underground mine emergency. The emergency can include water inundations of various depths, bad or fallen roof, fires, explosions, missing or injured miners, ventilation disruptions, or a combination of any of these components. An excerpt from the Holmes Safety Association Bulletin for November 1992 states:

"Mine rescue contests are designed to sharpen skills and test the knowledge of team members who would be called on to respond to a mine emergency. The contest requires team members to solve a hypothetical problem while being timed and observed by judges according to contest rules."

In an MRC, which is usually held on a practice field, gymnasium, or a similar non-mine setting, the team members are presented with a problem and, in conjunction with their FAB attendant/team briefing officer, the team alone decides how to explore the mine and what actions to undertake as they advance. The team is required to follow the MRC rules in making their decisions—e.g., how far they can advance, what protections must be employed for team safety, what ventilation changes might be needed, etc. There is no external input as the team works the problem. MRCs are scored in the following categories:

- The complete and correct solution of the underground problem.
- Time needed to complete the problem.
- A written test of 10 multiple choice questions taken verbatim from the MRC rules' 100 statements of fact.
- The accuracy of the maps drawn by the team mapman and briefing officer.

SRCM MERD/MRC Exercise-SRCM Format

The exercise was set up in the OMSHR SRCM located in Bruceton, PA. The SRCM is a drift mine, developed in the 5.5-ft-thick Pittsburgh coal seam, using the conventional (undercut, drill, and blast) room and pillar mining method. The average entry dimensions are 6.5 ft high by 14 ft wide. The mine is accessed through two portals; one is the main intake entry that includes the track and the second is a return entry. As can be seen in Figure 1, the inby portion of the mine consists of a series of entries and crosscuts, with

the farthest distance from the portals being approximately 1,500 ft. In order to run two or three mine rescue teams in succession on the same problem, the mine was divided into three zones—one for each team to explore.

Goals of the SRCM MERD/MRC

The objectives were:

1. Follow the 2008 national coal MR rules.
2. Maintain team safety at all times, explore and rescue any victims, and extinguish any fires.
3. Enhance realism by having teams work under the direction of a functional CC and emergency response representatives.

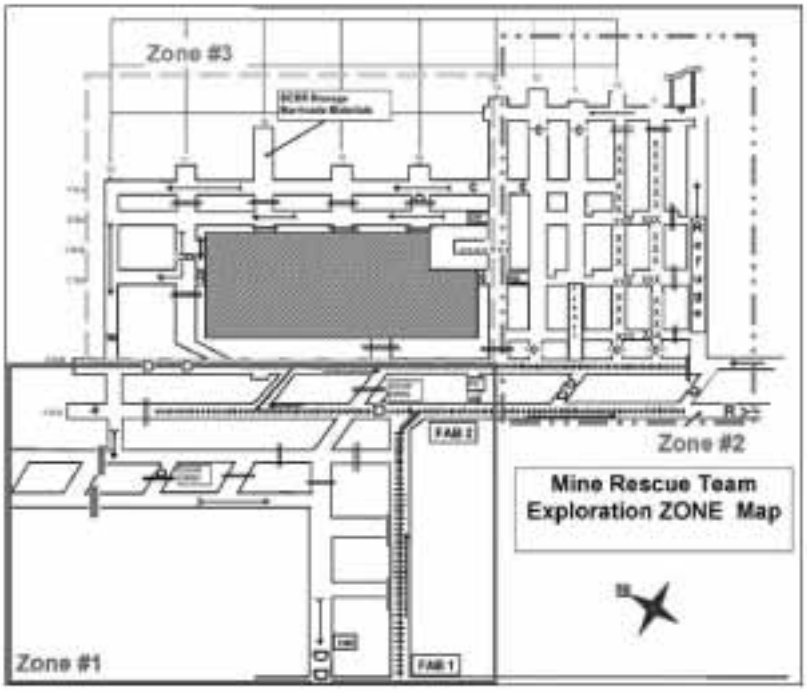

Figure 1 – SRCM map showing the three exploration zones and the two FABs.

The emergency scenario was as follows: the Stefko No. 3 Mine operates one working section with two production shifts and one maintenance shift per day. A fire was discovered approximately 1 hour before the day shift began, as workers arrived at the mine. There were three miners underground when the fire was reported to the responsible person on the surface (a trainer, for this exercise). The RP then contacted the responders, management, and the federal and state agencies. As the contacted personnel began to arrive, the CC was formed, MSHA and state inspectors were briefed on the situation, and the RP handed off responsibility and information to the now-in-control CC.

Command Center

The SRCM exercise was developed to utilize an operator/trainer as the RP to take charge and organize the initial response according to the mine's ERP. The CC (Figure 2) was staffed by mine operator liaisons from companies representing the mine rescue teams, PaDEP mine inspectors, a labor representative, and MSHA experts in mine emergencies. Half of the CC personnel admitted to having limited knowledge of MRC rules and had never closely watched a mine rescue team work a problem. The MSHA experts provided guidance, when necessary, to the CC personnel. Many of the lead participants had prior training in the Mine Emergency Command System (MECS) [Varley 2010] or with the procedures outlined in the MSHA publication IG 110 [2008]. However, the CC participants had never trained together.

Figure 2 –Command Center used as part of the SRCM MERD/MRC exercise.

Other participants in the exercise represented the following groups: MSHA mine rescue teams (judges), MSHA managers, gas detector vendors, the PA Special Medical Response Team (SMRT), Department of Energy, Allegheny County Emergency Management System, the City of Pittsburgh, and local fire departments. Between 55 and 67 participants were on-site on each of the three days. Coordination of these volunteers was one of the responsibilities of the CC. Approximately halfway through the exercise, the CC staff relinquished responsibility to a second shift to provide those individuals an opportunity to become more involved in the CC process. In an actual emergency, a CC representative could relinquish responsibility due to fatigue, deteriorating judgment, or for other reasons. This switchover of personnel demonstrates the need for an adequate number of available CC personnel. A sufficient number of adequately trained personnel are needed to provide at least three shifts of coverage per day [Alexander et al. 2011, in press].

Normally, the mine operator is responsible for drafting a specific response plan for the emergency situation based on the ERP of the mine and the experience of the participant. The plan must be submitted to MSHA for approval to proceed. In the interest of time for this exercise, MSHA provided a verbal approval.

The pace of making decisions appeared to be dependent on the amount of control that the lead participants exercised. Some operators made specific appointments of people for tasks, such as serving as liaisons with media, police, etc., while others allowed CC personnel to assume those various tasks. Initially, the participants were unsure of their roles until a working organization was established within the CC. If the CC participants had trained together on the mine ERP and the MECS system prior to the MERD, they most likely would have performed the CC tasks more efficiently.

One state team trainer acted as the exercise facilitator in the CC. This exercise facilitator kept the decision-making focused, provided a sense of urgency to the CC personnel, and corrected for various underground factors such as noises and lights that were not part of the exercise and real-life air ventilation movements which conflicted with movements indicated on the map.

When the CC personnel were reminded that national coal MRC rules must be followed, the participants expressed disappointment because some rules are in conflict with practical behaviors. For example, in a real-life situation, a team is almost certain to advance to a fallen miner immediately upon discovery, assuming there are no apparent hazards present. However, several MRC rules could prevent the teams from advancing to the fallen miner, such as the “2+3 rule” concerning systematic search, or the 20-minute rule which requires team members to do a team check at intervals of no greater than 20 minutes, or the 25-ft link line limit specifying that the distance between the mine rescue team captain and tail captain be no greater than 25 ft. (2010 National Mine Rescue, First Aid and Bench Contest Rules).

The Fresh Air Base

The briefing officer at the FAB maintained communication with the CC and the team. The officer kept track of team progress on a mine map and relayed information and questions between the CC and the team. In the case of a MERD, the personnel in the CC direct all activities of the team. The team has limited discretion to act unless a quick decision is made by the team to retreat because of an unsafe situation. The FAB was initially located outside the portal (figure 3) and was then moved into the mine.

Figure 3 – Fresh Air Base 1 before it was moved into the mine.

To prevent or correct any potential communication errors when information is relayed from the teams through the FAB to the CC, teams were immediately debriefed by the CC when they exited the mine and their maps were compared to ensure that the official CC map was accurate. In real emergencies that may involve long travel times out of the mine, this debriefing may be delayed by as much as 4 hours [Waggett 2008].

The Mine Rescue Teams

The first mine rescue teams arrived at the mine as the CC was being established. The teams unloaded their equipment, checked in with the CC, and prepared to go underground as if responding to a real emergency. The CC briefed the first team once the CC was confident that the team could safely enter the mine. The team then reported to the min-portal, where they were briefed by the mine manager (figure 4). FAB1 was set up near the portal at this time.

Figure 4 – Mine manager addressing mine rescue team members.

The CC then ordered the team into the mine to begin the exploration. The other two teams, acting as standby and back-up teams, were given instruction on gas detection and gas sampling techniques and reported (simulated) gas readings from the fan and mine borehole to the CC.

Teams were instructed to use national MRC rules to explore the mine, accurately map significant features, locate missing miners, and extinguish the fire. The maps and procedures were judged so that a winning team could be selected for the combined MERD/MRC exercise. Each team was accompanied by two MSHA mine rescue team members or state mine rescue team trainers who served as judges. The exercise was designed so

that the first team followed the contaminants, smoke (as shown in Figure 5), and carbon monoxide, as indicated by placards in the return air. Team 1 conducted systematic exploration of zone 1 and relocated the FAB from outside the mine to an area inside the mine (FAB2), where the team had confirmed that the atmosphere was clear. Team 1 briefed team 2 about the assumed fire location. Team 2 then proceeded to locate the fire and extinguish it. When the second team left the mine, the third team entered and continued the exploration until it found the missing miners and brought them to safety. Each team member used between 1 and 2 hours of oxygen during the exercise. At the end of each day, the judges met with all the team members to provide feedback on actions that were performed well and actions where improvements could be made.

Following MRC rules and simultaneously working under the direction of others was a new experience for the rescue teams. Some teams expressed frustration that the CC slowed their advance, even though, in a real emergency, teams would be required to work under the strict direction of a CC. In a non-MERD contest, the teams and their FAB attendant(s) make all their own decisions while attempting to complete the exercise as quickly as possible.

Figure 5 – Mine rescue team working in light smoke.

Discussion: Can the SRCM Format MERD be considered an MRC?

After the SRCM exercise was conducted and the teams debriefed, the comments received from the participants concluded that the MERD requirements, meant to simulate a real emergency response, were, in many ways, in conflict with MRC requirements. Because of these differences between MERDs and MRCs, this combined MERD/MRC exercise exhibited the following shortcomings:

- Time could not be used as a factor in determining a contest winner because three different contest zones were explored in the mine.
- The involvement of the CC in decision-making and approving all team movements prevented the team from controlling response times.
- The contest zones contained different degrees of difficulty, so direct comparison of team performance was not practical; e.g., only one team moved the FAB, fought a fire, or found missing miners.
- Some directives from the CC were in conflict with MRC rules.

There were also three important positive outcomes from this exercise:

1. For the first time, these eight teams were required to work under the direction of a CC, which enhanced the realism of the exercise.
2. Approximately 20 CC participants had the experience of directing teams in an actual coal mine rather than providing directions to a simulated team in the next room.
3. Eight FAB attendants gained experience in communicating with a team and CC simultaneously. This interaction more realistically simulated a real emergency.

During the initial stages of the exercise when only a few individuals were in the CC, there was some confusion, since none of them had practiced together using a standard protocol and they did not know their individual duty assignments. Once the CC was fully staffed, a leader was selected from the operator representatives. This person assigned duties and prepared a response plan in consultation with the labor, state, and federal representatives for approval by MSHA.

At times, the CC expressed frustration because of the apparent slow progress of the teams. Part of this perceived delay was due to some CC personnel having no experience with mine rescue teams. Experienced personnel who had served in various CC roles during actual emergencies were able to advise the new CC participants on the reasons for the "delays." Inexperienced CC personnel could gain experience by accompanying team members during mine exploration exercises. In this way, these CC personnel could observe how the teams address and solve problems [Conti 2000]. Another improvement for inexperienced CC participants would involve training in the proper preparation of approvable response plans.

The teams and CC both reported frustration during the combined MERD/MRC. From the perspective of the teams, the CC squandered too much time directing the teams and then often did not follow the typical contest rules for systematically exploring a mine. This resulted in back-tracking, essentially wasting the efforts and time of the team. The primary frustrations of the CC involved the time needed for the teams to get organized and their own uncertainty in tracking the activities and locations of the teams.

Post-exercise comments from CC personnel on the effectiveness of the MERD as a training tool were positive. However, six of the eight teams did not like the combination of a MERD and MRC because of what they considered differing interests between the team and the CC. The problem lies with making real-life decisions as opposed to being judged on how well the teams followed MRC rules.

Some conflict can be expected when conducting combined MERD/MRC exercises where one activity focuses on the teams and the other focuses on the decision makers (CC). When a MERD exercise includes a mine rescue team, both the teams and the CC personnel can benefit from the experience. However, judging teams under national MRC rules while participating in a MERD that uses different sections of a mine resulted in diminished performance in terms of team competitiveness and non-uniform judging conditions.

Since the teams could not act independently, they could not be fully evaluated on their decision-making capability or by how quickly and systematically they explored the mine. The teams reported that many times the CC took too long in providing them with directions. However, judges reported that all teams responded well to the CC needs and carried out their assignments quickly and safely.

Participant comments addressed the attitude of the teams regarding this simulated emergency. When arriving at the scene of an actual mine emergency, teams experience an almost instinctive sense of urgency unique to that incident. At a traditional MRC, urgency is created for the teams by knowing they must use and rely on their own judgment to address the issues required of the contest and because of the time component. Upon arrival at the SRCM site, the teams regarded the MERD/MRC exercise as an ordinary practice and did not establish that sense of urgency. In the future, it is important to build a sense of urgency into the exercise so that the practice is as realistic as possible. As noted by Mitchell [1990], in an emergency "Time is never your friend."

Comments from the numerous participants indicated that this was a good exercise and learning experience, but a number of changes needed to be made. Specific issues that need to be addressed include how to use time as a judging factor, equalizing the tasks that teams were required to do in exploring different zones of the mine, building a sense of urgency into the exercise, and resolving the conflicting purposes of a traditional MERD and an MRC.

MTTC and MSL MERD/MRC Exercises Colorado Format

The MERD/MRCs conducted in 2009 utilized a different approach from that used at the SRCM in 2008. In addition to using a MERD as an MRC, the exercises were designed to give the mine rescue teams experience in managing the CC and, thus, gain a better understanding of the issues which might limit the advance of a team. The exercises were held by the WV Alliance at the National Mine Health and Safety Academy MSL in Beckley, WV, and at MTTC at Ruff Creek, PA. The exercises were modeled after the MSHA-approved MERDs/MRCs developed and executed at the Edgar Mine in Idaho Springs, CO, in 2008 [Lovely 2010].

Coal and metal/nonmetal mine rescue teams regularly train at the Colorado Mine Safety and Training Program Edgar Mine facility [Bealko at al. 2010]. National MRC rules [MSHA 2009] were modified and approved by MSHA District 9 so that teams could be judged during a MERD while, at the same time, enhancing their rescue-related skills. The initial MERD exercise was held in May 2008 with three teams. In this 2008 MERD/MRC, one team managed the CC, the second team worked the underground problem, and the third team demonstrated additional mine rescue skills that were included in the MERD/MRC criteria being judged. Each team was judged on their activities and decision-making opportunities as they rotated through each position. The underground portion of the exercise was different for each team because they continued the exercise begun by the previous team. In this way, no team had an advantage when they rotated. These specific training facilities are discussed by Bealko et al. [2009] and Alexander et al. [2011].

The 2009 MERD exercise was set up as a traditional MRC with the added complication that the briefing officer was required to obtain permission from the CC before authorizing actions by the mine rescue team. These exercises differed from the Colorado format in that each team was faced with the same or similar simulated emergency.

Goals of the 2009 MTTC and WV Alliance MERD/MRCs

Three specific goals were set by organizers at MTTC and MSL:

1. Comply with the MINER Act of 2006 and the June 2009 MERD Guidelines, promulgated by MSHA, so that the MERD would qualify as an MRC.
2. Make the MERD as realistic as possible to show how the national MRC rules can be adapted to a real-life situation.
3. Allow the members to work as a team to address a simulated mine emergency, to serve in the capacity of CC officials, and to participate in a skills training opportunity [2009 MTTC].

The MERD/MRC and Skills Training

As with a traditional MRC, the teams had to respond to a simulated underground emergency. The differences were that, while one team was working the in-mine exercise, another team served in the CC, and the remaining teams participated in skills exercises. These skills exercises involved navigation and mapping in smoke, first aid, a written test (10 multiple choice questions taken verbatim from the contest rules “100 statements of fact”), fire-fighting/hose handling, and gas testing.

A significant benefit of having the teams serve in the CC was to provide them the opportunity for actual decision-making (Figure 6). This also enabled the team members to better understand the reasons for the CC delays in providing instructions for the next team action.

The exercises that were held in 2009 put less emphasis on training MERD participants, since the personnel staffing the CC (i.e. the team members) were not likely to be in that role during actual mine emergencies. The team members commented that the CC experience was invaluable in that it showed team members a broader perspective of the CC operations. The team members encountered some of the factors that must be considered prior to any decision for action on the team's part, the legal responsibilities that must be addressed, and the overall "big picture" that develops when information comes in from a variety of sources.

Discussion: Can the Colorado Format MERD be considered an MRC?

The format for MERD/MRC exercises used at MTTC and MSL appeared to have few shortcomings. With a diminished emphasis on training CC participants, the conflict between the needs of the CC and the teams is negligible. One judging factor that differs from a stand-alone MRC is that time should not be a determining factor in declaring a contest winner. Although the CC function is minimized, the teams are still affected by requirements from the CC and the time needed to receive and execute its directives. In these simulated underground exercises, the CC personnel felt that the teams were taking excessive time in solving the problem while the teams felt that the CC was taking excessive time in providing instruction to them.

These exercises were opportunities for mine rescue teams to train and be judged, as well as to gain an understanding of how teams and the CC interact. The exercises allowed the FAB attendants as well as the other five team members to experience control by the CC. Comments from participants indicated that, other than using time as a judging factor, the Colorado format provides a good method for combining a MERD and an MRC.

Figure 6 – Mine rescue team staffing the CC at MTTC.

Conclusions

OMSHR researchers evaluated two methods of conducting MERDs as MRCs. The SRCM format, while providing a learning experience for all participants, introduced significant issues that needed to be addressed. Using three separate exploration zones within the exercise prevented equal judging methods from being applied to each team. The conflicting objectives of a MERD (to train and prepare CC personnel for a real mine emergency) and an MRC (to train and evaluate mine rescue team skills and abilities) resulted in delays which, in turn, invoked frustration in many of the participants. However, participants did acknowledge that these delays were more realistic than the fast pace with which MRCs are conducted. Finally, the time necessary for completion was shown to be an invalid factor in determining a winner.

The Colorado format for the MERD/MRC exercises appears to be more successful in the fair selection of a winning team as required by MSHA. The reduced emphasis on training CC personnel and using team members to staff the CC made the exercises at MTTC and MSL less frustrating for participants while still contributing to mine rescue team training. As with the SRCM format, the time necessary for completion should not be used to determine a contest winner.

CC personnel with no experience at directing teams should accompany a team during mine exploration exercises to observe how the teams address and solve problems. In addition, CC personnel should be trained to work together on the mine ERP and approvable response plan, as well as be familiar with the MECS system prior to the MERD.

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Contents

Feature

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