Unified Mine Rescue Training (Advanced)
Underground Coal and Metal/Nonmetal Mines

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Introduction

As history has taught the mining industry, with such mine disasters as Monongah, Winter Quarters, Sago, and Upper Big Branch, Mine Rescue cannot rest on past successes. It must continue to learn from mistakes and continue to strive to become better and more efficient.

Mine rescue efforts are highly organized operations that are constantly analyzing the ever changing situations and environments as well as engaging in an orchestrated execution of tasks carried out by highly trained and skilled individuals who work as a team.

Appropriate reaction to events (such as fires, explosions, inundations, and other hazards) require a total response plan that encompasses all the steps from hazard recognition and containment to rescuing survivors and restoring mining operations, so it requires quality training.

Mine rescue team members **must** be trained according to the requirements under **30 CFR Part 49 - Mine Rescue Teams.**

- Subpart A—MINE RESCUE TEAMS FOR UNDERGROUND METAL AND NONMETAL MINES

- Subpart B—MINE RESCUE TEAMS FOR UNDERGROUND COAL MINES

These training requirements are built on a set of systematic training principles that include both initial and advanced mine rescue team training prescribed by MSHA's Office of Educational Policy and Development (EPD).

Prior to serving on a mine rescue team, team members are required to complete the 20-hour initial training in the use, care, and maintenance of the type of breathing apparatus (SCBA) which will be used by their team.

MSHA Instructional Guide **(IG 5)** provides team trainers information on how to conduct the initial training as well as the basic principles and responsibilities of serving on a mine rescue team.

It includes training objectives, activities, such as donning a SCBA and team positions which is aimed at giving team members a solid foundation for the advanced mine rescue team training as emphasized in **IG 5**:

> "As a team member, you will be responsible for rescuing miners and recovering a mine, often under very hazardous conditions. The lives of trapped miners, those of your fellow team members, and even your own life will depend on how well you perform your job. The training program you're beginning is a demanding pursuit that involves careful study and strenuous physical activity. It requires a personal commitment to work hard, practice, and become the best team member you can be."

Role as an Instructor

The instructor is assuming an important responsibility – that of building and maintaining a capable mine rescue team. What the team members learn during these training sessions could very well help save their lives and the lives of their fellow miners. Remind the team throughout training that this program has been developed with their health and safety in mind.

These training materials are complete and self-contained. Study the module before teaching the class in order to be familiar with the material and take time to review applicable regulations. Be flexible and take time to tailor the material to the team's needs. Where a training exercise encompasses other mine rescue requirements in Part 49, such as the requirement to wear an apparatus while in smoke, credit the team members under each requirement.

Remember, the key to effective instruction is to be familiar and comfortable with the content and to make it as realistic and as much hands-on as possible.

Purpose of this Guide

This instructional guide is designed to help underground mine rescue teams build the critical skills necessary to perform mine emergency rescue and recovery work.

Underground mine rescue team members must be trained according to the requirements under 30 CFR 49.

- Subpart A - MINE RESCUE TEAMS FOR UNDERGROUND METAL AND NONMETAL MINES
- Subpart B - MINE RESCUE TEAMS FOR UNDERGROUND COAL MINES

This guide is divided into self-contained units of study called "modules." Each module covers a separate topic. The modules include instructional text which includes some suggestions and visuals to assist with training; throughout the text smaller visuals are included for quick reference, but the larger visuals and text-only visuals are in the Appendix.

Coal Mine Rescue Teams and Trainers should use this guide in conjunction with the IG 7a Advanced Skills Training guide.

Overview

The modules include:

1. Surface Organization
2. Mine Gases
3. Mine Ventilation
4. Exploration
5. Fires, Firefighting, and Explosions
6. Rescue of Survivors and Recovery of Bodies
7. Mine Recovery

They are organized as follows:

1. Training Objectives
2. Course Materials
3. Notes
4. Instructional Text
5. Training Activities
6. General Review Questions
7. Glossary
8. Visuals are in the Appendix (a separate book) for your convenience.

NOTE: Take time to thoroughly review objectives and materials in each section *before* conducting training activities. Remember to **always** comply with the manufacturer's recommendations for the use, care, and maintenance of the type of SCBA or other equipment used by the team.

Advanced Mine Rescue Team Training

Surface Organization

Module 1

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Course Objectives

A. The mine rescue team will be able to recognize and apply the key components and resources necessary to effectively organize a mine rescue and recovery operation.

B. Team members will be able to:

   a. Review their mine's approved Emergency Response Plan (ERP). NOTE: ERP terminology only applies to coal.

   b. Use the mine's emergency notification plan.

   c. Explain the importance of establishing a chain-of-command and identify the team's place in this chain.

   d. Recognize the organization of the various facilities and arrangements normally recommended for carrying out rescue and recovery operations.

   e. Explain the various personnel and duties normally involved in surface organization.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers; answers are provided in green text. Allowing an open discussion about the reasoning behind their answers will help comprehension and retention.

A. Required:

   a. Visuals and Handouts. Larger visuals and text-only visuals are provided in the Appendix; use these visuals while discussing the corresponding content.

   b. Pencil and paper for each team member

B. Suggested:

   a. Mine's Emergency Notification Plan

   b. Laptop computer

   c. PowerPoint program

   d. Chalkboard and/or flip chart

Course Outline

A. Emergency Notification Plan

B. Surface Arrangements
   a. Command Center
   b. Security
   c. Team Staging and Briefing Area
   d. Bench Area for Apparatus
   e. Food and Sleeping Quarters
   f. Laboratory
   g. Medical Facilities
   h. Information Center
   i. Liaison Function
      i. Family Waiting Area
      ii. Press Room

C. Chain-of-Command

D. Key Personnel and Responsibilities
   a. Mine Superintendent and/or Responsible Persons
   b. Mine Foreman
   c. Chief Electrician
   d. Chief Mechanic or Mechanical Foreman
   e. Mine Manager (Outside)
   f. Safety Director
   g. Chief Engineer
   h. Supply/Warehouse Personnel

Emergency Notification Plan

Federal regulations require each underground mine post their mine's emergency notification plan outlining the procedures to follow when notifying the mine rescue teams that there is an emergency which requires their services:

- Metal and Nonmetal Teams: 30 CFR 49.9
- Coal Mine Rescue Teams: 30 CFR Part 49.19

The mine's notification plan should include all persons and services that will be needed at the mine site during an emergency, such as police officers, supply clerks, telephone operators, medical personnel, ambulances, and other emergency vehicles. **NOTE:** Show the team a copy of their mine's emergency notification plan, or refer to Visual 1 for a sample plan.

SAMPLE MINE EMERGENCY NOTIFICATION PLAN				
Contact	**Name**	**Address**	**Telephone (Home)**	**Telephone (Office)**
1. Mine Rescue Team Trainer				
2. Mine Rescue Team Members				
3. Mine Superintendent and Responsible Persons				
4. Mine Foreman				
5. Safety Director				
6. General Mine Manager				
7. General Mine Superintendent				
8. District Inspector (State and Federal)				
9. Chief, State Department of Mines				
10. District MSHA Office				
11. Miners' Representative				
12. Law Enforcement Agencies				
13. Medical personnel, ambulances, and other emergency vehicles				
14. Hospital to be alerted				

Visual 1 - Sample Emergency Notification Plan (Blank)

Surface Arrangements

Surface arrangements cover a wide range of activities requiring the coordinated efforts of many people, including such tasks as:

- Establishing a Command Center
- Briefing all mine rescue teams on vital information, conditions, and up-to-date plans; and

- Obtaining and distributing necessary supplies and equipment necessary for the operation.

Maintaining readiness for a mine emergency operation requires preparation, training, and planning; all of these must be part of the mine's Emergency Response Plan (ERP).

Command Center

The Command Center is the hub of rescue and recovery operations and is typically comprised of mine management personnel, federal and state officials, and miners' representatives. The Command Center receives a tremendous amount of information and will require secure communications equipment connected to underground phones, other surface phones, and should allow direct communications capabilities with mine rescue teams underground.

All decisions concerning the mine rescue teams such as assignments, scheduling, tracking, rotations, and methods of exploration and/or firefighting are made by the Command Center. The decision process is sometimes time consuming, but it is important to understand the impact a single decision will have on the entire operation. A hasty or wrong decision could mean disaster and the loss of life.

Security

Having good security at the mine is important to keep the roads open, ensure that curious bystanders are not injured, and that bystanders do not hinder the mine rescue effort. All roads and paths leading to the mine should be secured and guarded by assigned company personnel or police officers. Incoming traffic should be regulated by authorized personnel to keep out unnecessary vehicles so that the roads can remain open for needed personnel, supplies, and emergency vehicles. Command Center access should always be securely maintained.

Team Staging and Briefing Area

When the teams arrive at the mine site, they will be checked in and assigned to a team area. The mine rescue team coordinators will develop a "rotation schedule" for the deployment of all teams. The schedule should be designed so there is a clear working order and standby teams always available. Time should be allotted for teams to rest and clean, test, and prepare their apparatus and other equipment.

SAMPLE SIX-TEAM ROTATION SCHEDULE (24-Hour Period)												
Team No. and Captain	**Two-Hour Time Periods**											
1	Work	R	R	Standby	Standby	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB
2	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB	Work	R	R	Standby	Standby
3	Standby	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB	Work	R	R	Standby
4	Standby	Standby	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB	Work	R	R
5	R	Standby	Standby	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB	Work	R
6	R	R	Standby	Standby	Backup at FAB	Work	R	R	Standby	Standby	Backup at FAB	Work

NOTE: This schedule is a sample of how six teams could be rotated during a 24-hour period. If a larger number of teams are available, the schedule of rotation would, of course, be different.

R = Reserve FAB = Fresh Air Base

Visual 2 – Sample Rotation Schedule

Bench Area for Apparatus

An area that has work benches should be set aside as an apparatus room where the apparatus can be cleaned, tested, and prepared by bench persons or team members. The area should be free of clutter, have water supply for cleaning equipment, and safe access to the correct type of electrical outlets that provide power for compressors, dryers, and bench-testing equipment. Arrangements for facilities, mine emergency services, and personnel must be planned out, in advance as part of the mine's Emergency Response Plan (ERP).

Laboratory

If it will be necessary to test samples of the mine air during the rescue and recovery operation, a laboratory with suitable air analysis equipment should be set up at the mine for testing such air. If this is not possible, the air samples will be sent to an off-site laboratory for analysis.

Medical Facilities

The mine will need to arrange for medical services and facilities. This could range from standby ambulances and a first-aid room to a temporary hospital, depending on the nature of the emergency. These arrangements should consider identifying and designating a safe location for a helicopter landing pad.

Information Center

An information center is directed by the Command Center and will be established on the surface to release information to families and the public. The center must be secured, staffed, and controlled by authorized personnel.

Liaison Function

Section 7(3) of the MINER Act of 2006 requires that in such accidents, that the Mine Safety and Health Administration shall serve as the primary communicator with the operator, miners' families, the press and the public. The liaison function serves to maintain a point-of-contact between the Command Center personnel and other concerned parties such as:

- Family Members
- Mining Company Representatives
- Legal Representatives
- Local Officials
- Property Owners
- News Media

Family Waiting Area

A separate and secure area (preferably off-site from incident ground) will usually be set aside to brief families and friends of any affected miners.

Press Room

An area should be set up for press and media representatives to gather and receive the news releases issued from the information center. This area should be completely separate from the family members and preferably offsite.

Chain-of-Command

A great number of people will be doing many different jobs during a rescue and recovery operation. Therefore, it is important that a clear chain-of-command is established, so the operation can be well-coordinated and carried out efficiently.

Located at the top of the chain-of-command is the mine superintendent and/or the operator’s designated Responsible Persons who will delegate duties for all mine rescue personnel, according to the mine’s Emergency Response Plan (ERP). ***Regulations for the designation of “Responsible Persons” apply only to coal.***

Teamwork, coordination, and good communications are crucial during a mine emergency operation, so all personnel involved in the operation, especially mine rescue team members, must know exactly the duties and responsibilities expected of them, to whom they report, and who reports to them. Local, state, and federal (MSHA) officials will respond and work directly with the company mine officials and mine rescue team personnel. Local and federal officials normally do not take charge of a mine rescue operation unless it is deemed absolutely necessary. Their role is usually to provide assistance and guidance during the mine emergency, approve modifications to the rescue and recovery plan, and ensure that all rescue and recovery work is carried out safely and according to state and federal laws.

The mine rescue team is a crucial link in the chain-of-command. The team is under the direct supervision of the team captain who works and communicates directly with all the designated official(s) responsible for coordinating the operation.

Responsible Persons designated and certified by the coal mine operator are required to take charge in the event of a mine emergency. Responsible Persons will need to perform and delegate a variety of duties during the initial phases of rescue/recovery efforts (see 30 CFR Section 75.1501 for training requirements for Responsible Persons). ***Again, regulations for the designation of "Responsible Persons" apply only to coal.***

Mine rescue teams must receive accurate, concise, and reliable briefing information from the Command Center to perform their duties in a safe, timely, and efficient manner. The teams need up-to-date mine maps for exploration duties, so it is extremely important to develop a standardized method of reporting gas readings and other critical information for communicating with Command Center and the Fresh Air Base (FAB).

Briefing and Debriefing Sessions

Command Center personnel are in charge of conducting the briefing/debriefing sessions, and it is recommended that they determine who will be included. It is suggested that the team captain, the map man, and the team's trainer be included.

Accurate communication is essential at the team briefing and debriefing sessions because valuable information is gained and shared. Input from the working teams is crucial as it will be used to make decisions on how to proceed.

The Command Center makes the final decisions regarding all aspects involved in the operation. The exchange of information and ideas between the Command Center and the mine rescue teams carrying out the assignments is extremely important to the successful completion of the assignment, so a thorough briefing session before teams enter the mine or are dispatched to their assigned area is essential. The safety of the team and other persons is dependent upon the team receiving accurate and up-to-date information on the mine's conditions which should be accurately communicated to the oncoming team(s).

The team(s) should ask questions about anything they are unsure about, and they should express to the Command Center all concerns they have with their assignment. Below are items that are usually covered in a team briefing:

- Mission of the exploring team
    - Missing miners (if any) and their possible location
- Conditions in the affected areas, such as:
    - Current air readings and methane liberation
    - Adverse roof conditions
    - Water accumulation
- Environmental conditions:
    - Ambient air temperatures and/or humidity
    - Barometric pressure
    - Electrical storms, etc.
- Condition of the mine fan(s)
- Mine height
- Mine rescue work that has already been completed and covered in the debriefing of the previous team
- Review of the Approved Rescue/Recovery Plan

Key Personnel and Responsibilities

The following list suggests a sample of personnel and their various duties to be carried out during a mine emergency. Thoroughly review and understand the regulations in Part 49 of the 30 CFR, the mine's Emergency Response Plan (ERP), policies, and procedures in place at the mine(s) covered by the team. ERP applies to coal mines ONLY.

Mine Superintendent and/or Responsible Persons

The mine superintendent and/ or other Responsible Person(s) designated and trained by the company will have a wide variety of crucial responsibilities during mine emergency and rescue operations. The term "Responsible Persons" is used for coal mines only.

These designated persons will be part of the group at the Command Center. Working in cooperation with state and federal officials, they will oversee and manage numerous aspects of rescue and recovery operations which include:

- Brief and coordinate mine rescue teams and other mine rescue personnel.
- Maintain up-to-date mine maps.
- Obtain and monitor gas readings and other conditions.
- Monitor underground communications continuously.
- Communicate directly with the FAB personnel and mine rescue teams underground.
- Notify and brief family members of trapped or missing miners and other personnel (this should be done in person).
- Brief news media (if and when necessary).

Mine Foreman

Duties of the mine foreman may include the following:

- Organize underground operations for each shift in cooperation with the person in charge, federal inspectors, state inspectors (if applicable), and miners' representatives.
- Provide suitable transportation for people and supplies, as needed.
- Notify all persons on the notification plan and inform them of the emergency.
- Attend the telephone at the Command Center.
- Assign people for errand duty.

Chief Electrician

Duties of the chief electrician may include the following:

- Pull and immediately lock electric switches when authorized by the person in charge.
- Maintain on-site communication infrastructure, both voice and data.
- Provide on-site power connections needed for mine rescue equipment.
- Arrange for any needed assistants.

Chief Mechanic

Duties of the chief mechanic may be:

- Check explosion doors (for exhausting fan) or weak wall (for blowing fan) for damage. Ensure explosion doors are closed or weak wall is repaired.
- Check fan and, if necessary, arrange for an electrician or machinist to make repairs to the fan.
- Monitor the fan operation and the atmosphere in and around the fan house if the fan is exhausting. With an exhausting fan, proper precautions should be taken to avoid asphyxiation or an explosion in the fan house.

Mine Manager (Outside)

Duties of an outside mine manager may include:

- Arrange for guards and state and/or local police to:
  - Rope off and guard all mine openings.
  - Guard all roads and paths leading to the mine.
- Designate a check person to monitor people entering and leaving the mine. The check person should:
  - Attend to assigned station within the roped-off area.
  - Allow no one to go underground except persons authorized by the officials in charge.
  - Examine each person (entering the mine) for matches and smoking materials, making no exceptions.
  - Check off each person by name and number and record the time as they go in and come out of the mine.
- Set up an area where food and drinks are available for the rescue teams and other personnel.
- Set up medical facilities and make arrangements for sleeping quarters.

Safety Director

Duties of the safety director may include:

- Assemble mine rescue teams and first-aid crews.
- Provide facilities and equipment for testing, cleaning, and recharging the breathing apparatus.
- Assign personnel to issue, record, and return mine rescue equipment.
- Consult with the mine manager or superintendent regarding plans for rescue and recovery operations.

Chief Engineer

The chief engineer may perform the following duties:

- Provide up-to-date maps (both hard copy and electronic) showing regular airflow and locations of ventilation controls, doors, pumps, substations, machinery, and the electrical system (with control switch locations).
- Alert adjoining mines if they are connected underground with the affected mine.
- Obtain maps of adjoining mines.
- Make arrangements to furnish drilling rig equipment, if needed.
- Direct surveyors to establish control points on the surface should drilling be necessary.

Supply/Warehouse Personnel

A supply person may be responsible for the following duties:

- Have ready for immediate use: nails, brattice cloth, hatchets, axes, saws, picks, boards, telephones, wires, any needed gas testing equipment, sledge hammers, slate bars, shovels, suitable roof supports, lifting jacks, stretchers, batteries, first- aid supplies as needed, and apparatus parts and supplies.
- Obtain and distribute equipment, supplies, and non-sparking tools needed.
- Prepare an inventory of existing equipment and supplies.
- Contact other mines and suppliers to obtain other needed supplies and equipment.
- Provide coveralls, safety shoes, gloves, hardhats, flashlights, safety glasses, and lamp belts.
- Keep a record of all equipment issued and returned.

Glossary

Backup Team – The rescue team stationed at the Fresh Air Base as a “backup” for the working team beyond the FAB.

Bench Area – An area where apparatus is cleaned, tested, and prepared for use.

Chain-of-Command – Order of authority and division of responsibilities among personnel.

Command Center – Headquarters for the rescue and recovery operation.

Fresh Air Base (FAB) – Base of operations from which the rescue and recovery teams can advance into irrespirable atmospheres.

Emergency Notification Plan – This is a plan for notifying necessary personnel when there is an emergency at the mine along with all necessary contact information.

Rotation Schedule – Schedule that establishes a clear order of team usage during a rescue and recovery operation.

Standby Team – Team scheduled to be on the surface in ready reserve when rescue teams are working underground.

Triage – System of assigning priorities of medical treatment to injured persons.

Advanced
Mine Rescue Team Training

Mine Gases

Module 2

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Course Objectives

A. As a team, they will be able to conduct tests for dangerous gases and interpret their findings.

B. Team members will be able to:

   a. Use these concepts: Specific gravity, explosive range, toxicity, asphyxiate, and solubility.

   b. Explain the physical properties and characteristics of each gas they may encounter following a fire, explosion, inundation, or other disaster.

   c. Analyze the mine for locations where such gases might be found and explain how to detect them.

   d. Explain the composition, physical properties, and characteristics of smoke, rock strata gases, and the damps.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers; answers are in green text and in italics.

A. Required Materials:

   a. Larger visuals and the **text-only visuals** are provided in the Appendix; use these visuals while discussing the corresponding content.

   b. Pencil and paper for each team member.

   c. List of gases the team may encounter at mines to which they may respond.

B. Suggested Materials:

   a. Gas testing devices used by MSHA MEO

   b. Chalkboard and/or flip charts

   c. PowerPoint program

Course Outline

A. Introduction
  a. Gas Detection
  b. Gas Detector Requirements
  c. Portable Gas Detectors
  d. Air Sampling and Chemical Analysis

B. Basic Gas Principles
  a. Description
  b. Diffusion of Gases
    i. Atmospheric Pressure and Its Effects on the Diffusion Rate
    ii. Temperature and its Effects on Rate of Diffusion
    iii. Specific Gravity or Relative Weight
  c. Explosive Range and Flammability
  d. Solubility
  e. Color/Odor/Taste
  f. Health Hazards
    i. Toxic Gases
    ii. Asphyxiating Gases
  g. Review Questions and Answers

C. Mine Gases and Their Detection
  a. Normal Air
  b. Oxygen
  c. Carbon Dioxide
  d. Methane
  e. Carbon Monoxide
  f. Nitrogen
  g. Oxides of Nitrogen
    i. Nitric Oxide
    ii. Nitrogen Dioxide
  h. Hydrogen

i. Hydrogen Sulfide
j. Sulfur Dioxide
k. Heavy Hydrocarbons
    i. Changing Conditions
    ii. Guidelines for Rapid Exploration
    iii. Ethane
    iv. Propane
    v. Butane
l. Acetylene
m. Radon

D. Smoke, Rock-Strata Gases, and the Damps
    a. Smoke
    b. Rock-Strata Gases
    c. Damps
    d. Review Questions and Answers

Introduction

Under normal conditions, many gases are present, but the mine's ventilation system brings in fresh air to remove the harmful gases and supply oxygen. During a disaster, the situation may be quite different. Fires or explosions may release dangerous gases, and the ventilation system could be disrupted resulting in an oxygen-deficient atmosphere and/or a toxic or explosive gases buildup.

Gas Detection

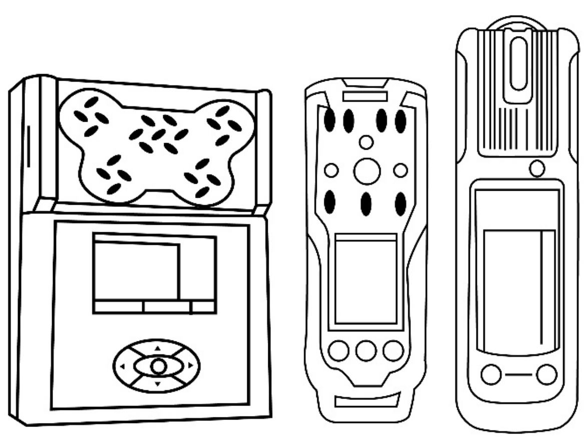
Gas detection is an important part of any rescue or recovery operation. The team will make frequent tests for gases as it advances beyond the FAB. For safety reasons, know what harmful gases are present, how much oxygen is in the atmosphere, and whether or not gas levels are within the explosive range. In addition to providing existing conditions, knowing what gases are present and in what concentrations provides clues as to what happened. Test results give information about existing conditions. For example, if carbon monoxide (CO readings) is present, there is probably a fire. The amount of carbon monoxide gives indication of the extent of that fire.

Gas Detector Requirements

Regulations [49.6(a)(6) and 49.16(a)(6)] require mine rescue stations to have "four gas detectors appropriate for each type of gas that may be encountered at the mines served. Gas detectors must measure concentrations of methane from 0.0 percent to 100 percent of volume, oxygen from 0.0 percent to at least 20 percent of volume, and carbon monoxide from 0.0 parts per million to at least 9,999 parts per million."

Portable Gas Detectors *(Visual 1)*

The type of gas detection equipment most often used by mine rescue teams is the portable gas detector. Portable gas detectors include such devices as electronic instruments that provide direct readings of gas concentrations and pumps used in conjunction with various stain tubes.

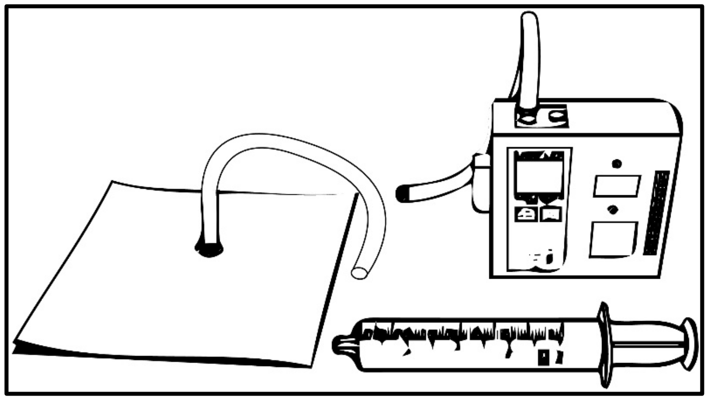


Visual 1 - Gas Detectors

Multi-gas detectors are direct reading instruments that monitor several gases at once, typically methane, oxygen, and carbon monoxide. The detectors the team uses should be equipped with sensors to detect other gases they could encounter at mines they will assist. These devices are used to test the mine atmosphere repeatedly while advancing beyond the FAB.

Air Sampling and Chemical Analysis *(Visual 2)*

Another way to test for gases is to collect air samples in special syringes, sample bags, evacuated bottles (bottles from which air has been removed), or gas/liquid displacement containers. A sample pump is needed to fill sample bags. These samples are then sent to a laboratory for analysis. Analysis is sometimes performed at the mine site with portable equipment.



Visual 2 - SKC Sample Bag and Sampler Pump

Chemical analysis is a more time-consuming process than testing with a portable device, but its advantage is accuracy. It gives exactly what gases the sample contains and precisely what amounts.

A complete chemical analysis can reveal the presence of gases that portable detectors are not designed to detect. Air samples aren't taken as often as portable detector readings, but they're still an important part of rescue and recovery operations. Air samples may be required in ventilation shafts and return airways. This method is often used to get information about existing conditions prior to sending teams underground. Air samples taken behind sealed areas are analyzed to determine when it is safe to begin recovery work. Air samples collected by the team members should include the name of the person collecting the sample, the location it was collected, date of collection, time of collection, the hand-held readings measured (at the same time) in location the sample was drawn.

Basic Gas Principles

In order to test for gases and to understand what the test readings mean, it is helpful to know a little about the characteristics and properties of the gases. After learning general information, the particular gases the team may encounter during rescue and recovery work need to be specifically studied.

Description

A solid has a definite shape and volume. A liquid has a definite volume, but changes shape according to the shape of its container. However, a gas is a substance with neither a definite shape nor volume. It expands or contracts to fill the area in which it is contained.

Diffusion of Gases *(Visual 3)*

The volume of a gas changes in response to any change in atmospheric pressure or temperature. For example:

- An increase in pressure causes a gas to contract.
- A decrease in pressure causes a gas to expand.
- An increase in temperature causes a gas to expand.
- A decrease in temperature causes a gas to contract.

The rate of diffusion is also affected by the ventilating air currents. This rate is greatly increased by higher velocities of air currents or by turbulence in the air.

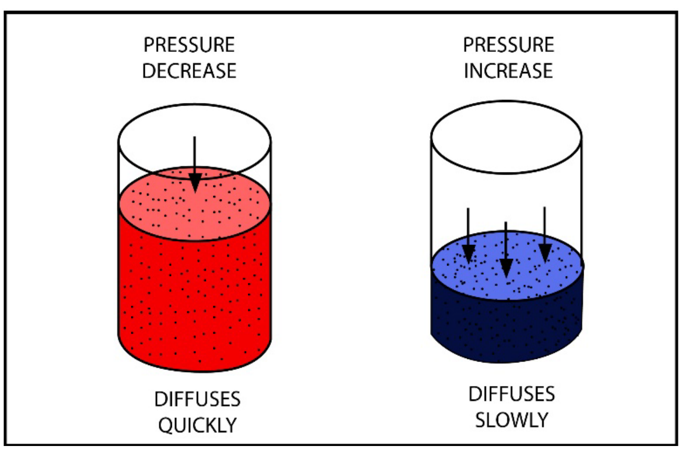
Knowing the effects of air current, temperature, and pressure on a gas will help determine its rate of diffusion. The rate of diffusion is how quickly the gas will mix or blend with one or more other gases and how quickly it can be dispersed.

Atmospheric Pressure and Its Effects on the Diffusion Rate *(Visual 4)*

Pressure exerted on a gas is usually atmospheric pressure. Atmospheric pressure is measured on a barometer. A rise in the barometric reading indicates an increase in pressure. A drop in barometric reading indicates a decrease in pressure. The atmospheric pressure varies within a mine just as it does on the surface.

Atmospheric pressure affects the diffusion rate. If the barometer rises, the pressure increases, and the gas contracts. A gas that is squeezed into a smaller area like this is more concentrated, so it disperses more slowly. It's much easier for concentrations of explosive gases to build up when the barometric pressure is high.

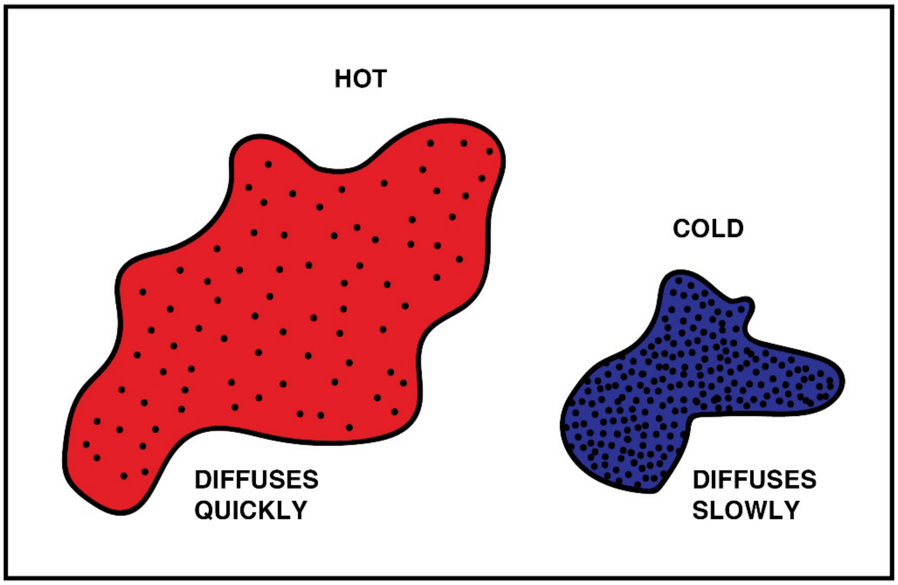
When the barometric pressure falls, the pressure on the gas is reduced and the gas responds by expanding. Once the gas expands, it is less concentrated allowing it to disperse more quickly.



Visual 4 – Effects of Pressure on Gas

Temperature and Its Effects on Rate of Diffusion *(Visual 5)*

High temperatures cause gases to expand, so they disperse quicker. Therefore, heat from a mine fire will cause gases to expand and disperse more easily. Whereas, the lower temperatures have the opposite effect; gases respond to cold by contracting causing them to disperse more slowly.

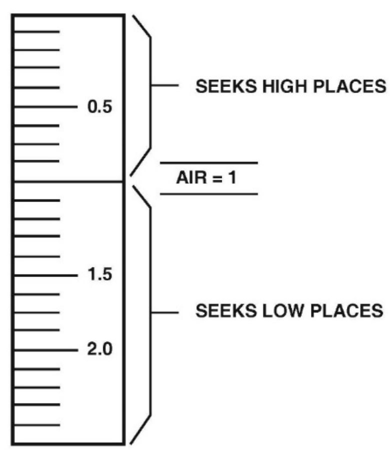


Visual 5 – Temperature Effects on Gas

Specific Gravity or Relative Weight *(Visual 6)*

Specific gravity (relative weight) is the weight of a gas compared to an equal volume of normal air under the same temperature and pressure. The specific gravity of normal air is 1.0. The weight of air acts as a reference point from which we measure the relative weight of other gases. A gas that is heavier than air has a specific gravity higher than 1.0. A gas that is lighter than air will have a specific gravity less than 1.0.

If the specific gravity of a gas is known, where to test for it is known. Gases issuing into still air without mixing tend to stratify according to their specific gravity. Light gases or mixtures stratify against the roof, and heavy gases or mixtures tend to stratify along the floor. For example, methane has a specific gravity of 0.5545 which is lighter than normal air, so it will rise and collect in greater concentrations near the top or roof of a mine, so test for it near the top (within 12 inches from the top). Sulfur dioxide has a specific gravity of 2.2638 which is much heavier than normal air, so it will collect in low areas of a mine, so test for sulfur dioxide in low areas of the mine.



Visual 6 - Specific Gravity

In still air, the ordinary process of diffusion is a very slow process. However, under usual mine conditions the ventilating air currents and convection currents produced by temperature differences cause a rapid mechanical mixing of gases with air. Once the gases are mixed, they will not separate or stratify again. It's much easier to remove a concentration of a light gas like methane by ventilation than it is for heavier gases like sulfur dioxide.

To summarize:

- Gases disperse quicker when the
  - Temperature increases,
  - Barometric reading and pressure decreases, and/or
  - Its specific gravity is less than normal air (1.0)
- Gases disperse slower when the
  - Temperature decreases,
  - Barometric reading and pressure increases, and/or
  - Its specific gravity is greater than normal air (1.0).

Explosive Range and Flammability

A gas that will burn is said to be "flammable." Any flammable gas can explode under certain conditions. For it to explode, there must be enough gas and oxygen in the air and an in ignition source.

The range of concentrations within which a gas will explode is known as its "explosive range." Figures representing the higher and lower limits of the explosive range are expressed in percentages. The amount of oxygen that must be present for an explosion to occur is also expressed as a percentage. When the necessary oxygen concentration approaches that found in normal air, the level is expressed simply as "normal air." For example, the explosive range of methane is 5 to 15 percent in the presence of at least 12.1 percent oxygen.

Solubility

Solubility is the ability of a gas to be dissolved in water. Some gases found in mines are soluble and can be released from water. Sulfur dioxide and hydrogen sulfide are water-soluble gases that may be released from water.

Solubility is an important factor to consider. When a mine is sealed off for any length of time, water can collect in it. This water may have occurred naturally, or it may have been introduced during firefighting. Stirring up the water by walking through or pumping it out causes the water to release large amounts of soluble gases which would not otherwise be found in the mine atmosphere.

Color/Odor/Taste

Color, odor, and taste are physical properties that can help identify a gas, especially during barefaced exploration; these may be the first clues that a particular gas is present. For example, hydrogen sulfide has a “rotten egg” odor. Some gases may taste bitter or acidic; others sweet. The odor of blasting powder fumes together with a reddish-brown color indicates there are oxides of nitrogen present. However, never rely only on the senses to positively identify a gas. Only detectors and chemical analysis can do that. Many hazardous gases, such as carbon monoxide, have no odor, color, or taste.

Health Hazards

Toxic Gases *(Visual 7)*

Some gases found in mines are toxic (poisonous). This can refer either to what happens when breathing the gas or when it contacts exposed skin. The degree to which a toxic gas will affect a person depends on three factors:

- How concentrated the gas is,
- How toxic the gas is, and
- How long you are exposed to the gas.

Each toxic gas has a Threshold Limit Value (TLV). TLVs denote average concentrations of gases to which workers are permitted to be exposed over an 8-hour daily period. The TLV of a gas is expressed in “parts per million” (PPM).

For example, the TLV for carbon monoxide (CO) is 50 PPM (or 0.005 percent) which is relatively low. This means that the most CO a person can be exposed to over an 8-hour daily period without harmful effects is 1/200 of one percent; that isn’t much. The TLV for carbon dioxide (CO_2) is 5,000 PPM (0.500 percent) which is higher. It can be tolerated in concentrations up to ½ of 1 percent CO_2 over an 8-hour daily period without harmful effects.

Some toxic gases are harmful to inhale, but the self-contained breathing apparatus (SCBA) will protect from such gases as long as the face-to-facepiece seal is tight. The SCBA won’t protect from toxic gases that harm the skin. If wearing a SCBA in petroleum-based fumes for prolonged or successive periods, the fumes can permeate its rubber parts so that the apparatus no longer provides adequate protection. In these cases, the team may be forced to leave the area.

Asphyxiating Gases

“Asphyxiate” means to suffocate or choke. Asphyxiating gases suffocate by displacing oxygen in the air; thus, producing an oxygen-deficient atmosphere. Since the self-contained breathing apparatus supplies oxygen, it will protect against asphyxiating gases.

Review Questions and Answers

1. How do temperature and pressure affect a gas, and how do these factors affect mine rescue?

    - *These factors affect the diffusion rate of gases in the mine.*
    - *Temperature increases cause expansion.*
    - *Temperature decreases cause contraction.*
    - *Pressure increases cause contraction.*
    - *Pressure decreases cause expansion.*
    - *Mine rescue work could be delayed or halted until a gas is dispersed.*

2. What is specific gravity?

    - *The specific gravity (or relative weight) of a gas is its weight in relation to an equal amount of normal air under the same temperature and pressure.*

3. What can be determined if the specific gravity of a gas is known?

    - *Specific gravity determines where the gas will stratify in still air in the mine (whether it will rise or fall). It determines how easily a gas can be diffused or flushed out of the mine by ventilation.*

4. What is the explosive range of a gas and why is it important for rescue team members to know the explosive range of gases they encounter?

    - *The explosive range of a gas is the concentrations within which a flammable gas can explode when there is a specific amount of oxygen present.*
    - *Knowing the explosive ranges of gases that may be encountered and the amount of oxygen necessary for an explosion, you will immediately know when you encounter a potentially explosive atmosphere.*

5. What is a toxic gas?

    - *A gas that is capable of causing damage to living tissues, impairment of the central nervous system, severe illness or, in extreme cases, death when it is ingested, inhaled, or absorbed by the skin or eyes.*

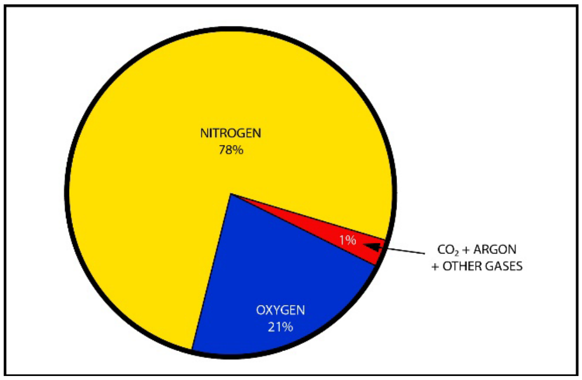
6. How can you protect yourself from toxic gases?
    - *Wearing a self-contained breathing apparatus (SCBA) will protect from many of them. However, it does not provide protection against gases that attack the skin or enter the body through the skin. Neither will it provide protection if wearing it for prolonged or successive periods in petroleum-based fumes because such fumes may permeate the rubber.*
7. How does an asphyxiating gas produce an oxygen-deficient atmosphere?
    - *It displaces oxygen.*
8. How do you protect yourself in an oxygen-deficient atmosphere?
    - *Wear an SCBA, which supplies oxygen.*
9. Why is it important to know the solubility of certain gases in water?
    - *Gases dissolved in water can be liberated in large quantities when mine rescue teams disturb the water by walking through it, or by beginning pumping operations.*
10. Why should you know the characteristic color, odor, and taste of gases you may encounter?
    - *The characteristic color and, if the team is barefaced, odor or taste of a gas may be the first clue a rescue team has that the gas is present in the mine atmosphere.*

Mine Gases and Their Detection

Normal Air

The air we normally breathe is a mixture of gases. Clean, dry air at sea level is made up of 78 percent nitrogen and 21 percent oxygen. The remaining one percent is made up of argon, carbon dioxide, and small traces of other gases like neon, helium, krypton, xenon, hydrogen, methane, nitrous oxide, and ozone.

Air is colorless, tasteless, and odorless. During day-to-day mining operations normal air can become contaminated. The carbon dioxide and water vapors exhaled during respiration are contaminants. Also, forces exerted on the roof, rib, floor, and face during mining may allow trapped gas pockets to escape into the mine air. Blasting produces pollutants such as carbon monoxide, hydrogen sulfide, and oxides of nitrogen.



Visual 8 - Normal Air Composition

Even internal combustion engines and battery-charging stations can be sources of contamination because they can produce hazardous fumes. Normally, these contaminants are carried away by the ventilation system, but during a disaster the ventilation system could be partially or totally disrupted.

Fires and explosions can disrupt ventilation by damaging ventilation controls. Falls and rock bursts can disrupt it by obstructing the flow of air. In addition, the disaster itself may provide additional sources of contamination. Fires and explosions often produce dangerous gases, and inundations may release water-soluble gases.

The gases present in a mine following a disaster varies according to the type of mine and disaster. The type of equipment used (electrical, compressed air, or diesel) will also affect which gases are present. However, rescue teams must know how to test for oxygen deficiency and carbon monoxide for all mines. In addition they may need to know how to test for hydrogen sulfide, oxides of nitrogen, and so on. The team needs to know how to test for all the gases that may be present in the mines in which they will be servicing.

NOTE: Refer to manufacturer's instructions and recommendations for the use and maintenance of specific testing devices. Discuss gas-testing equipment and devices <u>after</u> discussing the gases they may encounter; supply them with information on all gases they may encounter.

Oxygen (O_2)

1. Specific Gravity: 1.1054

2. Explosive Range and Flammability: Oxygen is not an explosive gas, but it does support combustion.

3. Health Hazards: Oxygen found in normal air is not toxic. It is essential for life; you are accustomed to breathing air containing about 21 percent oxygen. It is harmful to breathe air that is low in oxygen, and breathing extremely oxygen-deficient air can kill you. When the oxygen content drops to about 17 percent, you'll begin to breathe faster and deeper because the body is trying to compensate for the lack of oxygen. A 15 percent concentration will cause dizziness and headaches. If the oxygen content drops as low as 9 percent, you may lose consciousness. A 6 percent concentration or less is almost always fatal. There are five main causes of oxygen deficiency in the mine:
   - Ventilation failing to bring enough oxygen to the work area.
   - Displacement of the air's oxygen by other gases.
   - A fire or explosion that consumes oxygen.
   - The absorption of oxygen by coal, particularly at freshly cut faces.
   - Consumption of oxygen by workers.

4. Solubility: Moderately soluble in water.

5. Color/Odor/Taste: Colorless, odorless, and tasteless.

6. Cause or Origin: Oxygen is the second largest component of normal air. About 21 percent of normal air is oxygen.

7. Where Found: Everywhere.

8. Detection Methods: Modern electronic oxygen indicators are used to detect oxygen-deficient atmospheres. Hold the portable detector below waist level when testing for oxygen deficiency. Chemical analysis will also detect oxygen deficiency.

9. When to Test: During exploration, test as often as necessary.

10. Meaning of Findings: If the fan is operating, an oxygen-deficient atmosphere could indicate that an explosion has taken place or there is fire. Oxygen deficiency may also indicate that the mine's ventilation system has been disrupted. Very low oxygen levels reduce the possibility of methane explosions.

Carbon Dioxide (CO_2)

1. Specific Gravity: 1.5291

2. Explosive Range and Flammability: Carbon dioxide will neither burn nor explode.

3. Health Hazards: Normal air contains about 0.04 percent carbon dioxide. When present in high concentrations (2 percent or higher), carbon dioxide causes you to breathe deeper and faster. Breathing air containing 5 percent carbon dioxide increases respiration 300 percent, causing difficult breathing. Breathing air containing 10 percent carbon dioxide causes violent panting and can lead to death.

4. Solubility: Carbon dioxide is soluble in water.

5. Color/Odor/Taste: Carbon dioxide is colorless and odorless. High concentrations may produce an acid taste.

6. Cause or Origin: Carbon dioxide is a normal component of air and is a product of complete combustion (burning). Oxidation and the decay of timbers also produce carbon dioxide. Carbon dioxide is also a by-product of the respiration (breathing) process. Fires, explosions, and blasting operations produce CO_2. In some mines, it is liberated from the rock strata.

7. Where Found: Because it's relatively heavy, CO_2 will be found in greater concentrations along the floor and in low places in the mine. It also often shows up in abandoned workings, during fires, and after an explosion or detonation of explosives.

8. Detection Methods: Use a carbon dioxide detector, a multi-gas detector, or chemical analysis to test for carbon dioxide. Because CO_2 tends to collect near the mine floor, hold the portable detector low.

9. When to Test: Test for CO_2 after a fire or explosion; test for it when entering an inactive area of the mine or reopening a sealed area.

10. Meaning of Findings: Elevated CO_2 readings may indicate that a fire or explosion has taken place somewhere in the mine. High readings may also indicate an oxygen-deficient atmosphere.

Methane (CH_4)

1. Specific Gravity: 0.5545

2. Explosive Range and Flammability: Methane is flammable. Its explosive range is 5 to 15 percent when there is at least 12.1 percent oxygen. Methane is most explosive in the 9.5 to 10 percent range. Methane's explosive range is not an absolute measure of safety. There are several other important factors to take into consideration. For example, the presence of other combustible gases with wider explosive ranges or lower ignition points than methane may result in a more highly explosive mixture.

   Coal dust also lowers the methane's explosive limits. A mixture containing coal dust and as little as 1½ to 2 percent methane may be explosive. Because moisture tends to keep dust levels down, dust will be more of a problem underground in the winter months when the mine air is less humid.

   Cold dry air from outside a mine will be warmed as it goes through the mine. Warm air will hold more water vapor than cool air; therefore, it picks up moisture from inside the mine. This will cause a dry condition in the mine even though the humidity is higher underground than on the surface.

3. Health Hazards: Methane is not toxic. In high concentrations, however, it can cause asphyxiation by lowering the oxygen content of normal air. The most dangerous aspect of methane is the fact that it is explosive.

4. Solubility: Slightly soluble in water.

5. Color/Odor/Taste: Colorless, odorless, and tasteless.

6. Cause or Origin: Methane is the most common flammable gas found in coal mines. It is a normal component of coal (originating from the decomposition of vegetable matter during its formation). It can be liberated in large quantities from feeders, blowers, or clay veins in coal mines. It's also often liberated from virgin (uncut) coal and released at freshly broken coal faces.

7. Where found: Methane is relatively light, so it collects in high places such as near the roof of the mine. It is also found at freshly cut faces, in poorly ventilated areas, and in abandoned or unused sections of the mine.

   There is usually more methane in deep workings than at the outcrop. Deeper mines usually contain more methane than shallow ones, and shaft mines contain more methane than drift mines.

   Expect to find more methane in coal beds that are adjoined by tight, compact strata than in coal beds adjoined by loose or porous strata. Methane is also a problem in areas of faulting of the coal seam.

Generally, more methane is found in regions where the strata is uniform and unbroken rather than where the strata is folded or broken. Mines below the water table tend to have more than those above the water table. It is usually easy to disperse and remove from the mine by means of ventilation since it has a low specific gravity.

8. Detection Methods: To test for methane, use a methane detector or chemical analysis. Remember that methane is a light gas, so hold the portable detector high. Do not rely on the low range reading from a methane detector in low oxygen, it won't read correctly as it needs oxygen to function.

9. Where to Test: During team exploration, test as often as necessary to determine the methane content of the surrounding atmosphere. Test for methane when normal ventilation is disrupted and when entering abandoned workings.

10. Meaning of Findings: If methane is present, it is important to monitor it carefully because it is potentially explosive if there is enough oxygen present. If it exists in potentially explosive concentrations or in a combination with other gases or coal dust, its explosive range is extended, and the team may be required to leave the mine.

Carbon Monoxide (CO)

1. Specific Gravity: 0.9672

2. Explosive Range and Flammability. Carbon monoxide is explosive and flammable. Its explosive range in normal air is 12.5 to 74.2 percent.

3. Health Hazards. Carbon monoxide is highly toxic even in very low concentrations. Exposure to as little as 0.15 to 0.20 percent CO is extremely dangerous. It combines easily with the red blood cells (hemoglobin) - the cells that normally carry oxygen to the body's tissues. Once the cells have taken up CO, they no longer have the capacity to carry oxygen. It doesn't take much to interfere with the blood's oxygen-carrying capacity because the gas combines with hemoglobin 200 to 300 times more readily than oxygen.

   The first symptom of carbon monoxide poisoning is a slight tightening across the forehead and possibly a headache. The poisoning is cumulative over time, so as exposure continues, it continues to build up. If exposed to a high CO concentration, you may experience very few symptoms before losing consciousness. As little as 500 PPM (0.05 percent) can kill you in three hours.

4. Solubility: Carbon monoxide is slightly soluble in water.

5. Color/Odor/Taste: Colorless, odorless, tasteless.

6. Cause or Origin: It is a product of the incomplete combustion of carbon material. It is produced by mine fires and explosions of gas. Carbon monoxide is produced by the burning or detonation of explosives, and it is emitted from the exhaust of internal combustion engines; that's why automobile exhausts are deadly.

7. Where Found: Carbon monoxide is found during mine fires and after explosions or detonations of explosives. It can also usually be detected near internal combustion engines.

8. Detection Methods: Carbon monoxide can be detected by means of carbon monoxide detectors, multi-gas detectors, or by chemical analysis. Since CO is slightly lighter than air, hold the portable detector at chest level.

9. When to Test. During any team exploration, test as often as necessary to determine the atmosphere's CO content, especially if fire is suspected.

10. Meaning of Findings. The presence of CO for a continued period of time definitely indicates there is a fire somewhere in the mine.

Nitrogen (N_2)

1. Specific Gravity: 0.9674
2. Explosive Range and Flammability: Nitrogen is not an explosive gas and it will not burn.
3. Health Hazards: Nitrogen is nontoxic. However, in above-normal concentrations, it acts as an asphyxiant because it lowers the oxygen content of the air.
4. Solubility: Nitrogen is about half as soluble as oxygen is in water.
5. Color/Odor/Taste: Colorless, odorless, tasteless
6. Cause or Origin: Normal air contains approximately 78 percent nitrogen, making nitrogen the largest component of normal air. Underground, nitrogen levels may increase as coal faces adsorb oxygen. Gas blowers and feeders may give off nitrogen, and it is also released from coal during mining. Another source of nitrogen in underground mines is the detonation of explosives. Nitrogen may be injected into a mine to control fires or prevent explosions.
7. Where Found: Expect to find elevated nitrogen readings at the face areas because they adsorb oxygen. Increased nitrogen levels are often present after explosives have been detonated.
8. Detection Method: Chemical analysis.
9. When to Test: Test for nitrogen when you suspect that the atmosphere is oxygen-deficient, and in abandoned or inactive workings where ventilation is inadequate. Test for it in mines where nitrogen is known to issue from rock strata.
10. Meaning of Findings: An elevated nitrogen content indicates an oxygen-deficient atmosphere.

Oxides of Nitrogen:
Nitric Oxide (NO), Nitrogen Dioxide (NO_2 or N_2O_4)

1. Specific Gravity: NO_2 – 1.5894

2. Explosive Range and Flammability: NO_2 will neither burn nor explode.

3. Health Hazards: Oxides of nitrogen are highly toxic. Breathing even small amounts irritates the throat. When mixed with the moisture in the lungs, they form acids that corrode respiratory passages and cause them to swell. Often, the symptoms don't show up until several hours after exposure.

   Exposure to 0.01 to 0.015 percent can be dangerous for even short exposures, and 0.02 and 0.07 can be fatal for short exposures. If exposure has been severe, the victim may die by literally drowning in the water that has entered the lungs due to the body's attempt to counteract the corrosive effects of the acids formed by the oxides of nitrogen.

4. Solubility: Very slight solubility in water.

5. Color/Odor/Taste: Oxides of nitrogen are colorless at low concentrations and become reddish-brown at higher concentrations. They smell and taste like blasting powder fumes.

6. Cause or Origin: They are produced by burning and by the detonation and burning of explosives. The exhaust of diesel engines emits them. In the presence of electrical arcs or sparks, nitrogen in the air combines with oxygen (oxidizes) to form oxides of nitrogen.

7. Where Found: Because they're heavier than air, oxides of nitrogen tend to collect in low places in the mine. They can be found when electrical malfunctions produce arcs or sparks, and after blasting operations.

8. Detection Methods: To test for nitrogen dioxide or nitric oxide, use a multi-gas detector, stain tubes, or chemical analysis. Hold portable detectors low because these are relatively heavy gases. Their reddish-brown color may be another indication that there is nitrogen dioxide present.

9. When to Test: Test for oxides of nitrogen following a fire or explosion and after the detonation of explosives. Since diesel exhaust is a source of these gases, test in areas where diesel equipment is used.

10. Meaning of Findings: High NO_2 readings could indicate there has been a fire or that explosives are burning. Malfunctioning electrical equipment producing arcs or sparks could also be the source. If diesel equipment is causing the elevated NO_2 readings, it indicates ventilation is inadequate.

Hydrogen (H_2)

1. Specific Gravity: 0.0695

2. Explosive Range and Flammability: Hydrogen is a highly explosive gas. Air containing 4 to 74.2 percent hydrogen will explode even when there is as little as 5 percent oxygen present. Very violent explosions are possible when air contains more than 7 to 8 percent hydrogen. The presence of small quantities of hydrogen greatly increases the explosive range of other gases.

3. Health Hazards: At high concentrations, hydrogen can replace oxygen in the air and act as an asphyxiant. The most hazardous aspect of hydrogen, however, is the fact that it is highly explosive.

4. Solubility: Not soluble in water.

5. Color/Odor/Taste: Colorless, odorless, and tasteless.

6. Cause or Origin: Hydrogen is produced by the incomplete combustion of carbon materials during fires and explosions. It may also be liberated when water or steam comes in contact with hot carbon materials during firefighting. Battery charging also produces hydrogen.

7. Where Found: Hydrogen tends to collect in high places because it is relatively light. It is found in the vicinity of battery charging stations, where explosives have been detonated, and after explosions. Hydrogen may be detected during firefighting when water or foam extinguishing methods are used. It is found in areas that have been sealed in order to extinguish a fire.

8. Detection Methods: Hydrogen can be detected with a multi-gas detector, stain tubes, or by means of chemical analysis. Hold portable detectors high.

9. When to Test: Test for hydrogen after any fire or explosion and near battery charging stations in the mine. Also test for it when water, water mists, or foam is used to fight fires.

10. Meaning of Findings: The presence of hydrogen could indicate that a fire or explosion has taken place. Firefighting with water or foam could also be producing the hydrogen. Elevated readings could also indicate that there is inadequate ventilation around battery charging stations.

Hydrogen Sulfide (H_2S)

1. Specific Gravity: 1.1906

2. Explosive Range and Flammability: Hydrogen sulfide is flammable and explosive in concentrations between 4.3 and 45.5 percent in normal air. It is most explosive at 14.2 percent.

3. Health Hazards. It is one of the most poisonous gases known. In low concentrations (.005 to .010 percent), H_2S causes inflammation of the eyes and respiratory tract. Slightly higher concentrations (.02 to .07 percent) can lead to bronchitis or pneumonia. Higher concentrations (.07 to .10 percent) can cause rapid unconsciousness, cessation of respiration, and death. Rapid death can occur at levels above 0.10 percent.

4. Solubility: Soluble in water.

5. Color/Odor/Taste: Hydrogen sulfide is colorless, has the odor of rotten eggs, and a slight sweetish taste.

6. Cause or Origin: Hydrogen sulfide is produced when sulfur compounds decompose. It is found in certain oil and gas fields and in some gypsum mines. It may be liberated from methane feeders. It is often liberated when acid mine water corrodes metallic sulfides. It can also be released from mine water which contains the gas in solution. Heating sulfides in the presence of moisture may produce the gas. Blasting in sulfide ores can also liberate hydrogen sulfide.

7. Where Found: Hydrogen sulfide is found in low places of the mine because it is a relatively heavy gas. It's often found in pools of water. In some mines, it may be found near oil or gas wells. Hydrogen sulfide may be detected during mine fires. Since it is a water-soluble gas, it is often liberated from the water in sealed areas as the recovery crews walk through the water or begin pumping operations.

8. Detection Methods: Detect using a hydrogen sulfide detector, multi-gas detector, stain tubes, or a chemical analysis. It is relatively heavy, so hold the detector low. It has a distinctive "rotten egg" odor. Continued exposure to the gas dulls the sense of smell, so smell is not always a reliable detection method. Eye irritation is another indication that hydrogen sulfide is present.

9. When to Test: Test for hydrogen sulfide in poorly ventilated areas of the mine, during unsealing operations, and following mine fires.

10. Meaning of Findings: A buildup of hydrogen sulfide could indicate that ventilation is inadequate. Oil or gas wells may seep and produce it. The presence of hydrogen sulfide might also indicate that excess water is accumulating in sealed or inaccessible areas of the mine.

Sulfur Dioxide (SO_2)

1. Specific Gravity: 2.2638; the high specific gravity makes it hard to disperse by ventilation.

2. Explosive Range and Flammability: Will not burn or explode.

3. Health Hazards: Sulfur dioxide is a very toxic, irritating gas that is dangerous even in small concentrations; as little as 0.04 to 0.05 percent is dangerous to life. Even very tiny amounts of sulfur dioxide (.001 percent or less) will irritate the eyes and respiratory tract. Larger concentrations can cause severe lung damage and may cause respiratory paralysis and the complete inability to breathe.

4. Solubility: Highly soluble in water. (Sulfur dioxide is one of the most soluble gases found in mines.)

5. Color/Odor/Taste: Sulfur dioxide is colorless, but it has a bitter, acid taste and a strong sulfurous odor.

6. Cause or Origin: Sulfur dioxide may be produced by blasting in sulfide ores and by fires containing iron pyrite (commonly known as "fool's gold"). Sulfur dioxide may be released during the burning of some diesel fuels and by sulfide ore dust explosions.

7. Where Found: Because it is relatively heavy, sulfur dioxide tends to collect in low places in the mine and near sumps. Expect to find it after some fires or explosions.

8. Detection Methods: Test for sulfur dioxide by means of a multi-gas detector, stain tubes, or by chemical analysis. Hold the detectors low when testing for it since it is heavier than normal air. The distinctive odor and taste as well as the irritation of the eyes and respiratory tract are all good indicators of its presence.

9. When to Test: Test for sulfur dioxide when stagnant water is disturbed since it's highly soluble in water. Test after fires or explosions and when sealed areas of the mine are opened after mine fires.

10. Meaning of Findings: High SO_2 readings could indicate a mine fire or a sulfide ore dust explosion.

Heavy Hydrocarbons:
Ethane (C_2H_6), Propane (C_3H_8), Butane (C_4H_{10})

1. Specific Gravity:
    - Ethane - 1.0493
    - Propane - 1.5625
    - Butane - 2.0100

2. Explosive Range and Flammability:
    - Ethane – between 3 and 12.5 percent in normal air.
    - Propane – between 2.12 and 9.35 percent in normal air.
    - Butane – between 1.86 and 8.41 in normal air.

3. Health Hazards: These gases are not toxic. At high concentrations they can displace enough oxygen to cause death by asphyxiation, but they are rarely found in such high concentrations in mines.

4. Solubility: All three are slightly soluble in water.

5. Color/Odor/Taste: All three are colorless and tasteless. Ethane is odorless. In certain concentrations, propane and butane may produce a characteristic "gassy" odor.

6. Cause or Origin: After mine fires, small concentrations of these gases are often detected along with methane in mines that have methane. Sometimes they leak from gas or oil wells.

7. Where Found: The heavy hydrocarbons are often found in mines adjacent to oil or gas wells. These gases collect in low areas since they're heavy.

8. Detection Methods: Detect ethane, propane, and butane with a portable detector or by chemical analysis. These gases are combustible, so they will register on low range methane detectors; however, the readings will not be accurate. These gases are relatively heavy, thus hold the portable detector low when you test for them.

9. When to Test: Test for these gases following fires or explosions when methane is present. Test for the heavy hydrocarbons if oil or gas casings are accidentally entered during mining operations.

10. Meaning of Findings: In significant concentrations, the heavy hydrocarbons can extend methane's explosive range if the mine has methane. Elevated readings could indicate the possibility that a methane explosion occurred or that there is seepage from an adjacent gas or oil well.

Acetylene (C_2H_2)

1. Specific Gravity: 0.9107

2. Explosive Range and Flammability: Acetylene is combustible but it will not support combustion. Its explosive range in normal air is 2.5 to 80 percent.

3. Health Hazards: Acetylene is slightly toxic. In high concentrations, it can cause asphyxiation by depleting the oxygen in the atmosphere.

4. Solubility: Slightly soluble in water.

5. Color/Odor/Taste: Acetylene is colorless and tasteless. It has a slight garlic odor.

6. Cause or Origin: Acetylene is formed when methane is burned or heated in air having low oxygen content.

7. Where Found: Acetylene is found after methane explosions in air having low oxygen content.

8. Detection Methods: Test for acetylene with stain tubes or by chemical analysis. It can be recognize by its characteristic garlic odor. Since acetylene's specific gravity is near that of normal air, hold portable detectors at chest level.

9. When to Test: Test for acetylene after a methane explosion in air that is oxygen deficient.

10. Meaning of Findings: The presence of acetylene could indicate that an explosion has taken place in an area with low oxygen content, such as in a sealed area.

NOTE: For some mines, acetylene will not be a potential problem. Therefore, teach this material only if necessary.

Radon (Rn)

1. Specific Gravity: 7.526

2. Explosive Range and Flammability: Nonexplosive and nonflammable.

3. Health Hazards: Radon is not toxic. However, radon and radon daughters are radioactive and emit radiation. Continued exposure to high levels of these gases has been linked to lung cancer. Mines are required to keep exposure to radiation below 4 WLM (Working Level Months) per year. The exposure for any one month is limited to one WLM. The working level is a measure of the potential alpha particle energy of radon daughters in the mine atmosphere.

4. Solubility: Radon is highly soluble in water.

5. Color/Odor/Taste: Colorless, odorless, and tasteless.

6. Cause or Origin: Radon is a gaseous decay product of the uranium series that is found in all uranium mines. It can be liberated, but to a lesser extent, from almost any rock or soil. As radon is liberated into a mine atmosphere, it continues to decay and forms airborne particles the size of atoms called radon daughters.

   Radon daughters are particularly dangerous because they adhere to respirable dust and can be inhaled with the dust. Once inhaled, they become deposited in the lungs where they continue to decay, giving off radiation and damaging lung tissue. Radiation can also be absorbed by the skin. If the radiation hazard in an area is very high, breathing protection and protective clothing may be required.

7. Where Found: Radon is mostly found in uranium mines. Stagnant air carries heaviest concentrations. Pools of water will carry it. Radiation levels can jump extremely fast when ventilation is disrupted.

8. Detection Methods: Survey meters are used to sample particulate matter in the air on a scheduled basis. Dosimeters can be used to monitor an individual's exposure and can be worn by the miners.

9. When to Test: Regular tests are required in uranium mines. Tests should be made when ventilation is disrupted and when opening a sealed area.

10. Meaning of Findings: Excessive readings would indicate a disruption of ventilation.

Smoke, Rock-Strata Gases, and the Damps

Smoke

Smoke is a result of combustion. It consists of tiny particles of solid and liquid matter suspended in the air. The particles in smoke are usually soot or carbon, and tar-like substances such as hydrocarbons.

Although smoke may irritate the lungs while inhaling it, it is not normally considered to be an asphyxiant. However, smoke usually contains carbon monoxide and other toxic or asphyxiating gases produced by fires. This is why it is so dangerous to inhale smoke. If there is a sufficient amount of hydrocarbons in the smoke, the hydrocarbons can make the smoke explosive.

Besides the dangers involved in inhaling smoke and its potential for explosion, smoke also limits visibility. This single factor adds an extra element of difficulty to rescue and recovery operations.

Burning belts and cable insulation smoke contains toxic substances produced by the decomposition of Neoprene. These are very toxic when inhaled. For more information on these gases, refer to Module 5 – Fires, Firefighting, and Explosions.

Rock-Strata Gases

Rock-strata gases occur in some metal mining districts in the United States, particularly in Colorado and Nevada. Commonly called rock gas because it is released from the rock strata under the influence of atmospheric pressures. It is assumed to be largely nitrogen and carbon dioxide which causes an oxygen-deficient atmosphere, so breathing protection should be worn.

Damps

The word “damp” comes from the German word “dampf,” which means “vapors or gases.” Damps are the names early miners gave to mixtures of gases. Many of these terms are still used today. These names often describe what causes the mixtures or how they affect miners. The damps commonly found in mines are:

Whitedamp is a mixture of carbon monoxide and air which results from mine fires. It gets the name “whitedamp” due to it being found in high concentrations of black powder smoke, which is white. The carbon monoxide in this mixture makes it toxic.

Stinkdamp is a mixture of hydrogen sulfide and air. Stinkdamp gets its name due to the characteristic “rotten egg” odor of hydrogen sulfide. It is highly toxic and in certain concentrations it can be explosive.

Afterdamp is a mixture of carbon monoxide, carbon dioxide, methane, oxygen, nitrogen, and hydrogen. It is called “afterdamp” because it’s usually found after a mine fire or explosion. Afterdamp is toxic to breathe and may be oxygen-deficient. Carbon monoxide is the most poisonous of the gases in afterdamp.

Blackdamp caused miners' lights to go out. It is actually a mixture of carbon dioxide, nitrogen, and air. Blackdamp is produced by methane fires and explosions, so it could contain carbon monoxide. This mixture is oxygen-deficient making breathing difficult.

Firedamp. This is a mixture of methane and air that will burn or explode when ignited. The "fire" in firedamp comes from the fact that the mixture is flammable.

NOTE: Discuss the explosive ranges of the gases that are a problem at the mines the team will be serving.

Review Questions and Answers

1. What are the five main causes of oxygen deficiency in the mine?
    - *Insufficient or improper ventilation which fails to bring enough oxygen to the work area,*
    - *Displacement of the air's oxygen by other gases,*
    - *A fire or explosion that consumes oxygen,*
    - *The absorption of oxygen by coal, particularly at freshly cut faces,*
    - *Consumption of oxygen by workers.*

2. What are the explosive gases that may occur in the mine or mines you may be called to service?
    - *Carbon monoxide 12.5 to 74.2%*
    - *Hydrogen 4.0 to 74.2% even with as little as 5% oxygen present*
    - *Hydrogen sulfide 4.3 to 45.5%*
    - *Methane 5 to 15% in at least 12.1% oxygen*
    - *Ethane 3.0 to 12.5%*
    - *Propane 2.12 to 9.35%*
    - *Butane 1.86 to 8.41%*
    - *Acetylene 2.5 to 80%*

3. Name the gases that can be detected by color, odor, or taste, and explain these identifying features.

    - *Carbon Dioxide - acid taste in high concentrations.*
    - *Nitrogen Dioxide - reddish brown in higher concentrations, odor and taste of blasting powder fumes.*
    - *Hydrogen Sulfide - rotten egg odor (however, continued exposure deadens the sense of smell), slight sweetish taste.*
    - *Sulfur Dioxide - sulfur odor, acid taste.*
    - *Propane and Butane - "gassy" odor in certain concentrations.*
    - *Acetylene - slight garlic odor.*

4. Which gases are toxic if inhaled?

    - *Carbon Monoxide, Oxides of Nitrogen, Hydrogen Sulfide, and Sulfur Dioxide.*

5. What are the five major damps? Explain what each mixture contains and why it's dangerous.

    - *Whitedamp - carbon monoxide and air. Toxic.*
    - *Stinkdamp - hydrogen sulfide and air. Toxic, and may be explosive.*
    - *Afterdamp - carbon monoxide, carbon dioxide, methane, oxygen, nitrogen, and hydrogen. Toxic, explosive, and can be oxygen-deficient.*
    - *Blackdamp - carbon dioxide, nitrogen, and air. Oxygen-deficient. Can cause suffocation.*
    - *Firedamp - methane (5 to 15%) and air. Can explode.*

General Review

Mine Gases

Choose the correct answer to each of the following questions.

1. Normal air contains approximately what percent oxygen?
    a. 15%
    b. 21%
    c. 31%
    d. 79%

2. The explosive range of a methane/air mixture (5-15%) will change if:
    a. Certain other combustible gases are present.
    b. Coal dust is suspended in the atmosphere.
    c. There is less than 12.1% oxygen in the atmosphere.
    d. All of the above.

3. Carbon monoxide is:
    a. A gas found in all mining operations.
    b. A normal constituent of air.
    c. Detected during a mine fire or explosion.
    d. A product of the breathing process.

4. An elevated concentration of carbon dioxide in mine air can be harmful because:
    a. It is highly explosive.
    b. It increases the breathing rate.
    c. It is highly toxic in small concentrations.
    d. All of the above.

5. An elevated concentration of nitrogen in mine air can be harmful because:
    a. It can lower the oxygen content of the air.
    b. It is highly explosive.
    c. It is highly toxic.
    d. All of the above.

6. Oxides of nitrogen can occur in a mine atmosphere:
    a. When certain explosives are used.
    b. When diesel-powered equipment is being used.
    c. When electric equipment produces arcs or sparks.
    d. All of the above.

7. Accumulations of hydrogen in the atmosphere are dangerous because it:
    a. Is highly toxic.
    b. Is highly soluble in water.
    c. Is highly explosive.
    d. Gives off a suffocating odor.

8. Characteristics of hydrogen sulfide include:
    a. Explosive.
    b. Highly toxic.
    c. Can be liberated from pools of stagnant water.
    d. All of the above.

9. Which of the following is not true of sulfur dioxide?
    a. It is explosive.
    b. It is highly toxic.
    c. It is highly soluble in water.
    d. It can occur during mine fires.

10. The most likely source of ethane, propane, or butane in a mine is:
    a. Use of diesel equipment.
    b. Battery charging stations.
    c. Leakage from adjacent gas or oil wells.
    d. All of the above.

11. Acetylene would normally be found in a mine atmosphere where:
    a. Diesel equipment is used.
    b. Methane has burned or exploded in air with a lowered oxygen content.
    c. Leakage has occurred from adjacent oil or gas wells.
    d. Battery charging stations are located.

12. Match each damp with its components:

_____	1.	Firedamp	A.	Carbon Monoxide and Air
_____	2.	Blackdamp	B.	Hydrogen Sulfide and Air
_____	3.	Afterdamp	C.	Carbon Dioxide, Nitrogen and Air
_____	4.	Whitedamp	D.	Methane and Air
_____	5.	Stinkdamp	E.	Carbon Monoxide, Carbon Dioxide, Methane, Oxygen, Nitrogen, and Hydrogen

13. Mine rescue teams are required by Federal law to have available:
    a. One detecting device for every gas listed as dangerous by the U.S. Bureau of Mines.
    b. One detecting device for each gas normally encountered in the mine(s) the team serves.
    c. Four detecting devices for each gas normally encountered in the mine(s) the team serves.
    d. One detecting device for each team member.

14. Atmospheric pressure and temperature are important factors because they:
    a. Affect the rate of diffusion of a gas by ventilation.
    b. Can cause false readings on gas detection instruments.
    c. Lower oxygen content in the mine.
    d. All of the above.

15. Two gases that are highly soluble in water are:
    a. Methane and Acetylene.
    b. Hydrogen Sulfide and Hydrogen.
    c. Nitrogen and Sulfur Dioxide.
    d. Hydrogen Sulfide and Sulfur Dioxide.

16. A gas that is normally found near the roof or in high places in the mine is said to have a low:
    a. Level of Toxicity.
    b. Level of Explosivity.
    c. Specific Gravity.
    d. Level of Solubility.
17. The amount of coal dust suspended in the mine atmosphere is most important because:
    a. It can alter the explosive range of methane.
    b. It can affect the specific gravity of oxygen.
    c. Hydrogen is liberated from the coal dust.
    d. Coal dust lowers the oxygen content in the mine atmosphere.
18. A nontoxic gas can still be dangerous because it can:
    a. Displace Oxygen.
    b. Burn.
    c. Explode.
    d. All of the above.
19. The type of coal mine where the greatest amount of methane would be likely to be found would be a:
    a. Drift mine with tight and compact adjoining strata.
    b. Drift mine with loose or broken adjoining strata.
    c. Shaft mine with tight and compact adjoining strata.
    d. Shaft mine with loose or broken adjoining strata.
20. Gases that are neither toxic nor explosive:
    a. Are not found in mine atmospheres.
    b. Are not dangerous.
    c. Can be dangerous because they can displace oxygen.
    d. Cannot be detected with today’s detection instruments.

General Review
Answer Key

1. B
2. D
3. C
4. B
5. A
6. D
7. C
8. D
9. A
10. C
11. B
12.

    D 1.

    C 2.

    E 3.

    A 4.

    B 5.

13. C
14. A
15. D
16. C
17. A
18. D
19. C
20. C

Glossary

Adsorption – Physical adhesion of molecules to the surfaces of solids without chemical reaction.

Asphyxiate – To suffocate or choke.

Atmospheric Pressure – Force exerted by air. Atmospheric pressure is measured on a barometer.

Blower – A gas feeder under high pressure which causes the gas to issue at considerable velocity.

Casing – Piping used to support sides of a borehole and to prevent entry of loose rock, gas, or liquid.

Combustible – Capable of burning; flammable.

Contaminant – Something which fouls or impurities.

Corrode – To eat away gradually.

Damps – Descriptive names given by miners to identify mixtures of gases.

Diffuse – To scatter, spread out, or blend.

Disperse – To scatter or get rid of; to dispel.

Explosive Range – The range of concentrations within which a gas will explode if ignited (expressed in percentages).

Feeder – Small cracks through which methane or other gas escapes from coal.

Flammable – Burnable.

Ignite – To set on fire.

Inundation – The state of being flooded.

Methane Outburst – Sudden emission of methane from coal seam or surrounding rock.

Mine Atmosphere – The air in an underground mine.

Oxidize – To cause to combine with oxygen.

Poison – Substance which destroys life or health.

PPM – Parts per million.

Smoke – Tiny particles of solid and liquid matter suspended in air.

Solubility – Ability to dissolve in water.

Specific Gravity – The weight of a gas compared to an equal volume of air under the same temperature and pressure.

Sulfur – A nonmetallic element which exists either free or in combination with other elements. It often occurs as pyritic sulfur, commonly known as “fool’s gold.”

TLV – Threshold Limit Value is used to denote the average concentrations of gases to which workers can (under Federal regulations) be exposed over an 8-hour daily period.

Toxic – Poisonous.

Vacuum Bottle – Container used to collect gas samples for chemical analysis.

Advanced Mine Rescue Team Training

Ventilation

Module 3

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Course Objectives

A. The mine rescue team will be able to analyze how air is coursed through a mine and identify ventilation controls, take air measurements, and build or alter ventilation controls.

B. The team members will:

   a. Explain the purpose and methods of mine ventilation.

   b. Interpret a section of a ventilation map, identify ventilation controls, and explain how they affect the movement of air.

   c. Explain the purpose and importance of following the proper chain-of-command when altering ventilation.

   d. Use air measurement devices.

   e. Construct ventilation controls.

NOTE: Before conducting training on this topic, thoroughly review all relevant sections of the 30 CFR:

Part 57 – Metal/Nonmetal

- Subpart C - Fire Prevention and Control
- Subpart D - Air Quality, Radiation, Physical Agents, and Diesel Particulate Matter and
- Subpart G - Ventilation

Part 75 – Coal

- Subpart D - Ventilation

Use the ventilation plans and site-specific mine maps for mines serviced by the team when presenting this material.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers.

A. Required:

   a. Larger visuals and the text-only visuals are provided in the Appendix; use these visuals while discussing the corresponding content.

   b. Pencil and paper for each team member

   c. Site-specific mine maps showing ventilation

   d. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams

B. Suggested:

   a. Anemometer

   b. Smoke tube (and stopwatch)

   c. Chalkboard or flip chart

   d. Laptop with a PowerPoint program

Course Outline

A. Introduction
B. Understanding Ventilation
    a. Airflow
    b. Natural Ventilation
    c. Mine Fans
C. Ventilation Maps
    a. Map Symbols
        i. Intake and Return Airway Symbols
        ii. Other Mapping Symbols
D. Ventilation Controls
    a. Types of Stoppings/bulkheads
        i. Permanent
        ii. Temporary
    b. Check Curtains or Run-Through Checks
    c. Line Brattice
    d. Auxiliary Fans and Tubing
    e. Overcasts and Undercasts
    f. Mine Doors
    g. Regulators
    h. Box Checks and Belt Regulators
    i. Review Questions and Answers
E. Assessing Ventilation
    a. Reporting Condition of Existing Ventilation
    b. Measuring Airflow
        i. Anemometer
        ii. Smoke Tube
    c. Review Questions and Answers

F. Building Ventilation Controls
    a. Constructing Temporary Stoppings/Bulkheads
    b. Constructing Permanent Stoppings/Bulkheads
    c. Air Locks
    d. Line Brattice

Introduction

Mine rescue team members need to be familiar with mine ventilation, in particular the ventilation of the mine in which the team will be working. Know the basics about ventilation methods and ventilation controls; more importantly know how to build the ventilation controls.

After a fire, explosion, or flood in a mine, rescue teams are usually needed to assess and re-establish ventilation.

During exploration of the mine, the team will be checking the condition of the ventilation system. Some controls may have been destroyed or altered. Your initial responsibility will be to report these conditions to the Command Center. Under no circumstances do you ever alter ventilation without having Command Center orders to do so.

Thanks to the team's reports, the Command Center will have a good overview of the ventilation system and the degree to which it has been damaged. The Command Center can then give directions on how to re-establish the ventilation.

Due to the Command Center making decisions based on what the team sees, it is extremely important that you assess and report the ventilation accurately. Additionally, the Command Center will be depending on the team to correctly build ventilation controls.

Understanding Ventilation

For this section, refer to the following federal regulations:

- 30 CFR Part 75 Section 75.333 – Ventilation controls
- 30 CFR Part 75 Section 75.350 – Belt air course ventilation
- 30 CFR Part 57
    - Subpart C - Fire Prevention and Control
    - Subpart D - Air Quality, Radiation, Physical Agents, and Diesel Particulate Matter and
    - Subpart G - Ventilation
- Any Petitions of Modifications that affect Mine Ventilation.

Airflow

The purpose of mine ventilation is to provide a sufficient volume of air to disperse and remove harmful gases, dust, smoke, and fumes, and to provide adequate oxygen. When ventilated, air from the surface enters at the main intake (or intakes) and is directed or "coursed" through the mine by a system of ventilation controls. These controls force the air to move in certain directions and at certain velocities to ensure air reaches all sections of the mine. The return air from the working sections is then channeled to the main return and eventually exits the mine. **NOTE:** Display a ventilation or section map and **trace the intake and return air**.

To obtain the 'flow' of air through the mine, there must be a difference in air pressure between the intake and return airways. The basic principle underlying mine ventilation is that air always moves from high pressure regions to low pressure regions, so the return air must be at a lower pressure than the intake to get it to flow from the intake to the return. This is achieved either by mechanical or in some smaller MNM mines, by natural means.

Natural Ventilation

In natural ventilation, air flows due to the difference between the pressure inside and outside the mine. This natural pressure can only be supplied by an energy source; the only natural energy source that can create and sustain an adequate airflow is thermal energy. This is due to temperature differences. The thermal energy is added to the air as it passes through working places and mine openings.

In general, warm air displaces cold air due to the differences in elevation and in temperature of the mine workings. The greater these temperature differences, the larger the natural ventilation pressure created and the larger the resulting airflow. Natural ventilation is rarely used in large mines because the pressure differential is usually not great enough to create a sufficient and steady airflow.

Mine Fans

Mine fans are used to create this pressure differential by changing the air pressure at specified points in the mine. The greater the pressure difference the fan creates, the faster the flow of air. This method of using a fan to create the pressure differential is known as mechanical ventilation.

The mine fan(s) can create this pressure differential either by blowing air into or exhausting air out of the mine. Blowing fans are used mostly in mines that have little overburden. These mines may have surface cracks, so a blowing fan is used to ensure any air that leaks through a crack will leak away and not into the mine.

In most cases, one main fan is used to ventilate the entire mine or a particular section of the mine; however, in larger mines several main fans may be used. These fans may be exhausting, blowing, or a combination of the two. Teams need to be familiar with the ventilation plan for each mine they service.

To help ensure the team's safety while working underground, the main fan(s) should be monitored or guarded by an authorized individual to both ensure that no alterations in its operation are made without orders from the Command Center and to ensure that it operates continuously. If the fan stops while underground and hazardous conditions ensue, the team will be withdrawn.

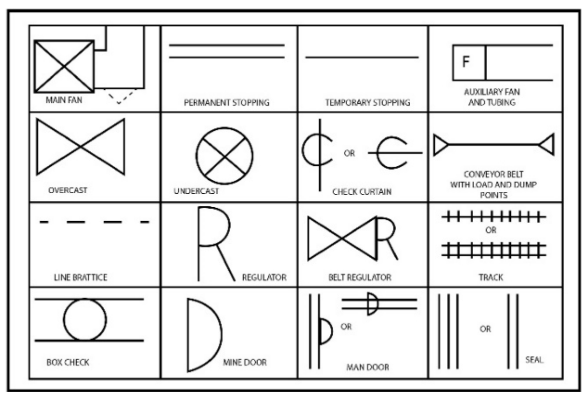
Ventilation Maps

Mine rescue team members need to be able to read and comprehend a mine map that shows ventilation. This basic knowledge is needed for all team members not just the map person. The team's map person is responsible for marking information on the map as the team explores and assesses ventilation. Some small and remote MNM operations have contracted coal teams to cover their mine rescue requirements, so the team's help could be requested at a different type of mine than your own. The team needs to be familiar with mine maps for all mines to which they may respond.

During the team's briefing and before going underground, the team will be given an up-to-date ventilation map of the area to be explored. Study it and get familiar with where you are going and what you should expect to see. It will show what other teams have already found and completed.

Map Symbols

Map symbols can differ from one mine to the next, so be familiar with the specific map symbols used at mines your team services. It's a good idea for the map person to affix a legend of each map symbol to the bottom of the map or mapboard as well as the scale to which the map is drawn. **NOTE:** Refer to actual ventilation maps from mines the team covers and incorporate those specific symbols into training.



Visual 1 – Sample Mine Map Symbols

Intake and Return Airway Symbols

If the ventilation system is badly damaged or is out completely, the distinction between intake and return air may not be valid, but the ventilation map indicates the normal path or currently known direction of the intake and return airflow. Sometimes color-coded lines or arrows are used to distinguish between the intake and return airways (for example, blue or green arrows for intake and red arrows for return air); however, this can be a problem if maps are photocopied.

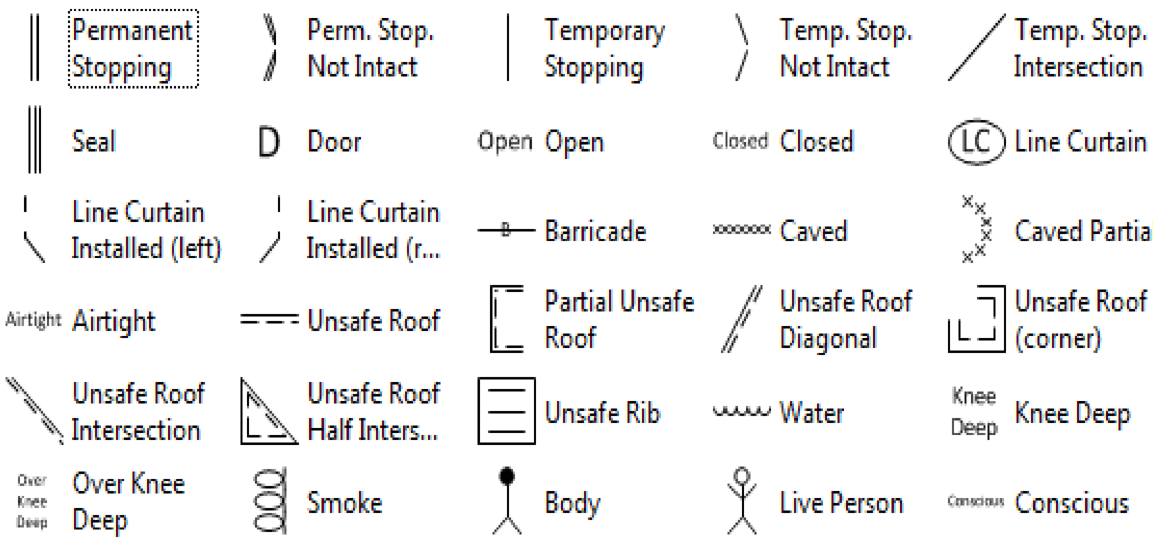
The following symbols are used to show type and direction of airflow:

Intake Airflow Direction:

Return Airflow Direction

Low-Velocity Airflow:

Here are more commonly-used map symbols:



Other Mapping Symbols

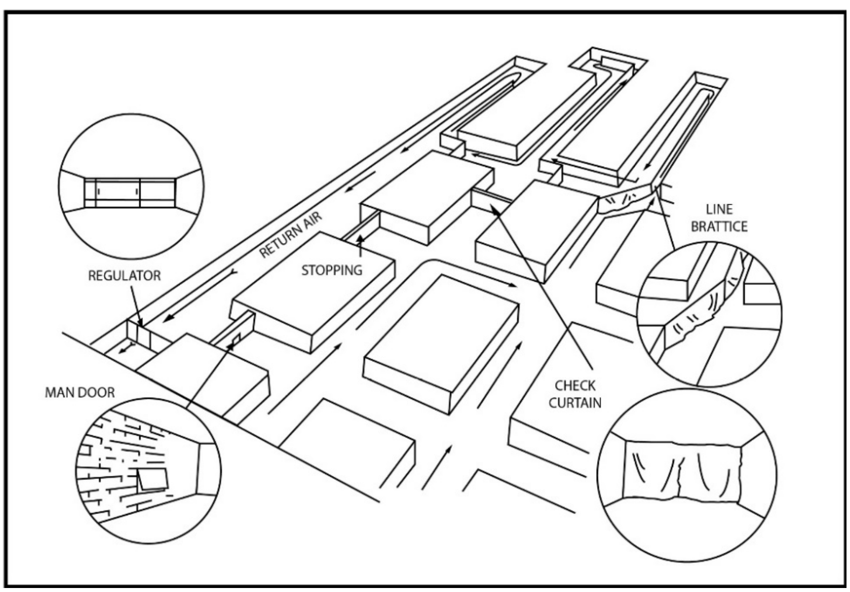
Some other commonly-used mine map symbols are shown below:

	Direction of Intake Airflow
	Direction of Return Airflow
	Direction of Low-Velocity Airflow
	Main Fan
F	**Auxiliary Fan and Tubing**
or	**Temporary Stopping**
	Permanent Stopping
	Line Brattice

	Overcast (if used)
	Undercast (if used)
R	**Regulator**
R	**Belt Regulator**
	Box Check
	Belt Conveyor with Belthead and Tailpiece
D	**Mine Door**
or	**Track**
or	**Man Door**
or	**Check Curtain or Run-through Curtain (if used)**

Ventilation Controls

Ventilation controls are used underground to properly distribute the air to all sections of the mine. Ventilation controls do this by controlling both the direction of the airflow and the amount of air that travels. Visual 2 shows how ventilation controls direct air to the working faces.



Visual 2 - Ventilation Controls

It is important to “control” and “course” the air underground, so it reaches all areas of working places without short-circuiting. Short-circuiting occurs when intake air goes directly into the return rather than moving up to the working faces.

Ventilation controls are used to split the air from the main intake and direct it to the various sections because each working section is required to be ventilated with its own separate supply of fresh air (air split).

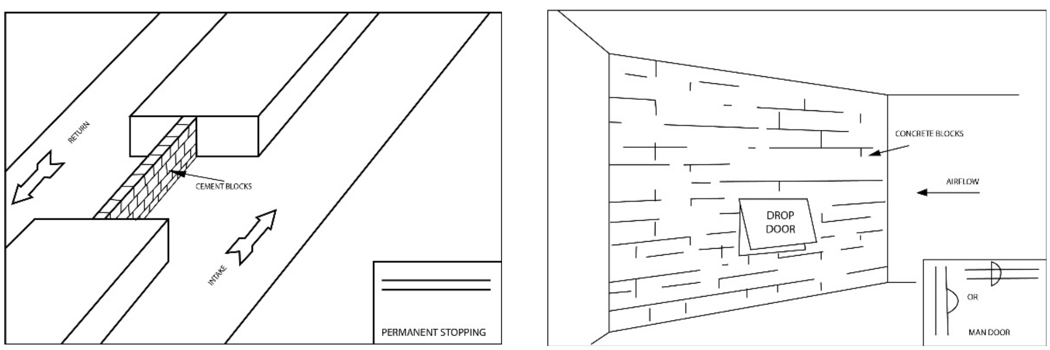
The following ventilation controls work collectively to control the intake air movement to the working sections and out the returns.

A. **Stoppings/Bulkheads**

Stoppings/bulkheads are used to keep intake air in one entry separate from return air in the next entry so that the intake air doesn’t short- circuit into the return before it reaches the working faces.

B. **Permanent Stoppings/Bulkheads** *(Visuals 3 and 4)*

Permanent stoppings/bulkheads are built of incombustible materials such as concrete blocks or metal panels. They are sealed tightly against the roof, floor, and ribs to prevent air leaks; porous stoppings made of concrete blocks are plastered on the high-pressure side to reduce air leakage.



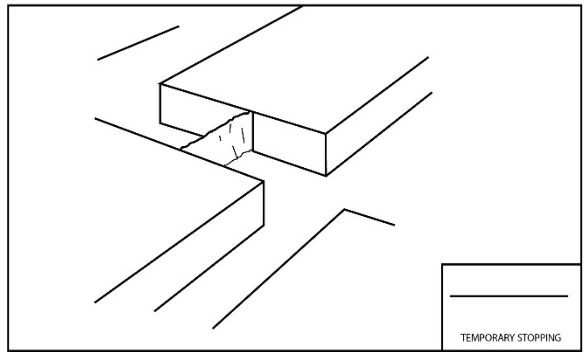
Visuals 3 and 4 - Permanent Stoppings

Permanent stoppings/bulkheads with a man door (or drop door as seen in Visual 4) allow miners to pass through the crosscut to another entry. Man doors are not meant to be ventilation controls, but if propped open, it can affect airflow and may cause intake air to short-circuit into the return.

C. **Temporary Stoppings/Bulkheads** *(Visual 5)*

Temporary stoppings/bulkheads are used in active workings to temporarily advance and direct the airflow until a permanent stopping can be built. They are usually built of canvas, brattice cloth, or plastic; some are built with a frame of wood. In mine rescue work, they are used to advance ventilation as the exploration or mine recovery work progresses.

There are specially designed ones available for use in mine rescue work which are fast and easy to install. One is an inflatable, rubberized type called a "parachute" stopping. It is a self-sealing stopping; urethane foam is usually used for sealing the edges to increase its effectiveness by making more airtight.

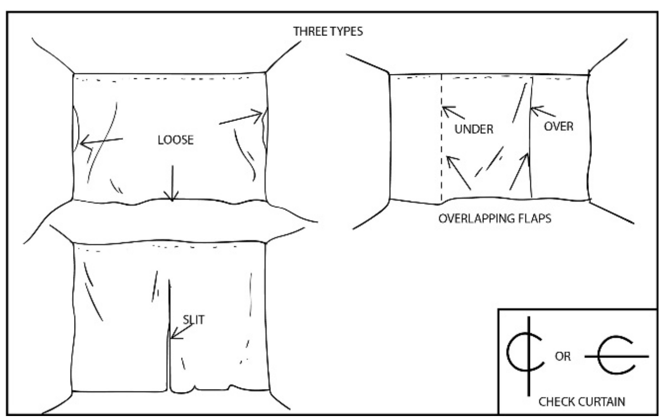


Visual 5 – Temporary Stopping

D. **Check Curtains or Run-Through Checks** *(Visual 6)*

A check curtain (run-through check) is a brattice cloth, canvas, or transparent plastic curtain that is hung across a passageway and opens to allow miners and equipment to pass through. Check curtains are used to deflect the intake air current into a working area. They are fastened at the top only and can be either one piece or have a slit in them or overlapping flaps. Check curtains are designed to close automatically after you have passed through so that they continue to direct air to the working place.

If they get pulled down or do not fully close, they can cause the air to short-circuit causing it to never reach the working face. If the team finds a fallen check curtain, leave it as is and report the condition to the Command Center. They will decide if and what changes are needed in the ventilation.

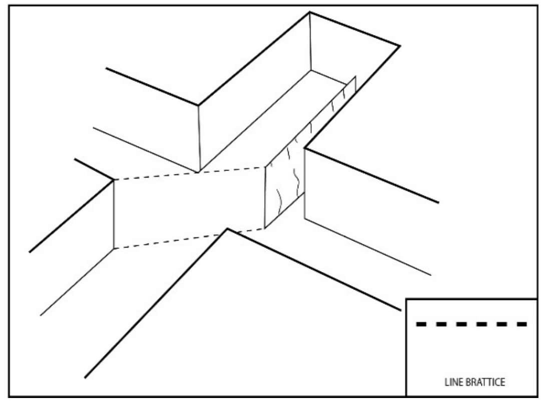


Visual 6 – Check Curtains

E. **Line Brattice** *(Visual 7)*

Line brattice (line curtain) is brattice cloth or plastic hung to channel intake air from the last open crosscut to the working face. It is extended as the mining progresses to keep the air flowing to the face. Line brattice is hung from the roof to the floor, extending from the end of a check curtain to within ten feet of the working face. It can be hung on a rough lumber frame, on timber posts, or from special fasteners, and secured to the roof with spads.

Line brattice is useful for teams when they need to ventilate an area or need to split an air current as they are advancing ventilation. The map symbol is depicted by a dashed line.



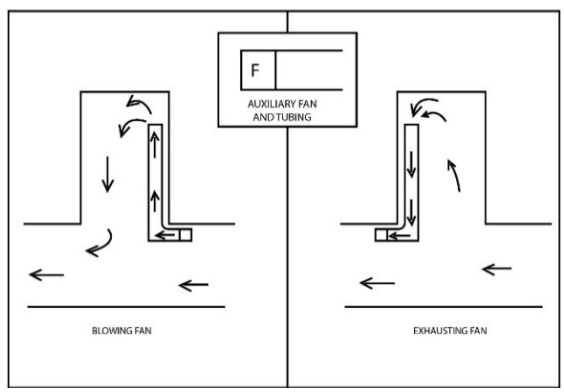
Visual 7 – Line Brattice

F. **Auxiliary Fans and Tubing** *(Visual 8)*

In mines where continuous mining machines cut large quantities of coal and produce large amounts of dust, auxiliary ventilation systems are often used to better control and direct airflow to or from the face. These systems consist of an auxiliary fan and tubing.

The auxiliary fan can be used to either exhaust or blow the air. The tubing, which is usually suspended from timbers or roof bolts (if approved), carries the air to or from the working face. This tubing can be either rigid (for exhausting systems) or collapsible (for blowing systems).

An auxiliary system allows the continuous miner to operate without being obstructed by line brattice. The tubing is easily moved closer to the working face making it convenient to extend ventilation to the face as the mining advances. Visual 8 shows how auxiliary fans and tubing affect ventilation at the face.

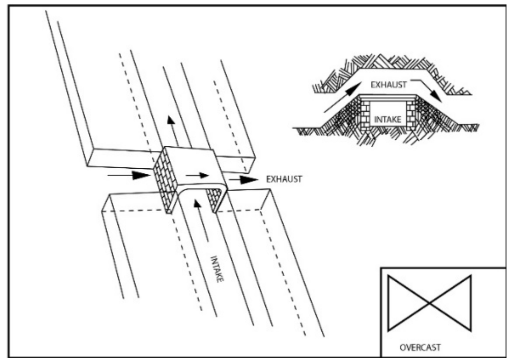


Visual 8 – Auxiliary Fan and Tubing

G. Overcasts and Undercasts *(Visual 9)*

Overcasts and undercasts are used to permit the two air currents to cross without the intake air short-circuiting into the return because they frequently cross paths at intersections within the mine.

Overcasts are like enclosed bridges built above the normal roof level of the mine. Undercasts are like tunnels built below the normal floor of the mine. Sometimes they are made of pipes going from one stopping to another, across an intake airway, allowing the return air to pass over or under the intake air; they isolate the airflow so as to prevent the air from short-circuiting.



Visual 9 – Overcast

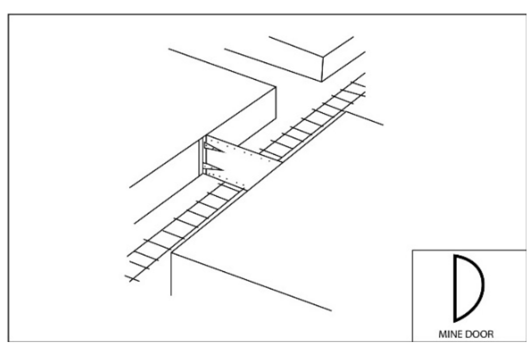
Undercasts are seldom used because they are apt to fill with water or debris which would severely slow down the flow of air through them; therefore, overcasts are used more often. They are usually built with concrete block walls sealed against the ribs and floor along with some type of airtight roof made of pre-stressed concrete, railroad ties, or steel beams. This type of overcast is frequently used to allow air to cross over a conveyor belt without mixing with the split of air that ventilates the belt.

H. **Mine Doors** *(Visual 10)*

In areas of heavy traffic, such as haulageways, mine doors are used as ventilation controls. The doors are usually hung in pairs, forming an air lock that prevents a change in ventilation when one door is opened.

The doors serve to direct the airflow from the main haulage entry and into another entry. At the same time they can be opened to allow equipment and people to pass through without disturbing the ventilation. The doors should always be opened and closed one at a time to maintain the air lock. Mine doors can also be used to isolate air splits.

Mine doors are hung so the ventilating air pressure will push them closed if they are accidentally left open. However, the **doors should always be closed after passing through them.** Some doors must be closed manually; others will close automatically. If the **airflow is reversed**, the ventilating air pressure will no longer keep the mine doors closed.

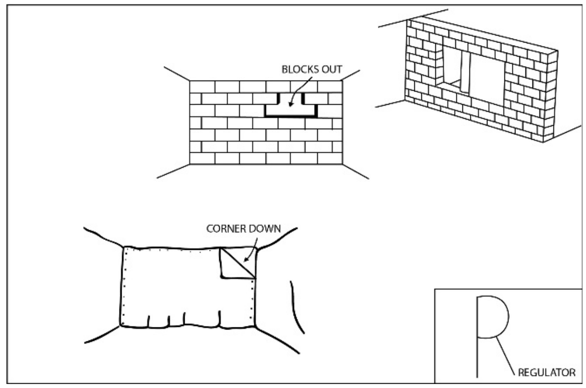


Visual 10 - Door

I. **Regulators** *(Visual 11)*

Regulators are used to control and adjust the quantity of airflow in the mine in order to ensure proper distribution. They are used in mine ventilation to regulate airflow to meeting the individual needs of each air split. There are many different kinds of regulators that can be used:

1. Section regulators used in returns are often sliding doors or windows built into permanent stoppings that are near the mouth of a section.
2. Teams should mark a visible reference point to return the sliding door back to the original set-point of the regulator.

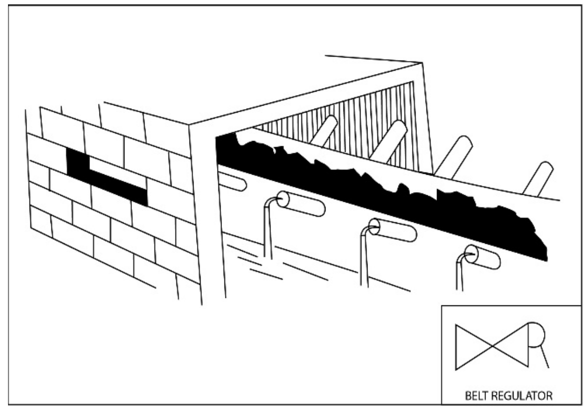


Visual 11 – Types of Regulators

3. Opening or closing it adjusts the airflow to a section. If one of these regulator doors is opened to allow miners to pass through, it must always be closed to the position in which it was found.
4. Another type of regulator can be made by knocking blocks out of a permanent stopping. The airflow can be adjusted by removing blocks or replacing blocks.
5. Taking down one corner of a check curtain can make another type of regulator. The opening at the corner lowers the air's resistance and allows more to flow. The airflow can be adjusted by lowering the corner to make a larger opening, or tacking it up to make a smaller opening.
6. Another type of regulator can be made by hanging a check curtain so that it does not reach the floor of the mine. This again would lower the air's resistance and allow more air to flow. This type of regulator can also be adjusted to change the airflow.
7. A pipe overcast can also serve as a regulator.

J. **Box Checks and Belt Regulators** *(Visual 12)*

Conveyor belts are usually in or near intake air passages. This presents a problem since a fire on the belt would cause smoke and carbon monoxide to mix with intake air. Conveyor belts must be isolated from both intake and return air. This is done with box checks which are temporary or permanent stoppings/bulkheads built at each end of the belt to limit the intake air flowing over the belt. They are built with openings in them to allow the belt to pass through. They let a little airflow through into the isolated belt entry so that the belt will be ventilated with its own split of air. After the belt has been ventilated, the air is then drawn out through a belt regulator into the return.



Visual 12 – Belt Regulator

The belt regulator regulates the quantity of air that flows along the belt. This can be done by removing blocks from a permanent stopping when the belt is beside the return. This opening allows the beltway air to go directly into the return. The size of the opening can be adjusted to regulate the flow of air along the belt. If the belt is beside the intake, the belt's return air must cross the intake airway through an overcast.

Review Questions and Answers

1. Define and discuss the purpose or function of the following items:

    a. Stoppings/Bulkheads

    Stoppings/Bulkheads are used to direct air through the mine. They keep intake in one entry separate from return in the next entry so that the intake air doesn't short-circuit into the return before it reaches the working faces.

    b. Line Brattice

    Line brattice is used to channel intake air from the last open crosscut to the working face.

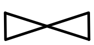
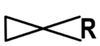
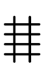
    c. Regulators

    Regulators are devices which, by their adjustment, can regulate airflow to meet the individual needs of each air split.

    d. Auxiliary Fans and Tubing

    Auxiliary fans and tubing are used to provide sufficient airflow to face areas during mining operations.

2. What does each ventilation map symbol listed below indicate?
   (**Note**: Use the symbols used at the mines the team will service).

Symbols:		***Correct Answers*:**
⊠		*Main Fan*
		*Auxiliary Fan and Tubing*
or		*Temporary Stopping*
		*Permanent Stopping*
		Line Brattice
		*Overcast*
⊗		*Undercast*
R		*Regulator*
		*Belt Regulator*
		*Box Check*
		*Belt Conveyor with Belthead and Tailpiece*
D		*Mine Door*
 or 		*Track*
 or 		*Man Door*
₵ or 		*Check Curtain or Run-through Curtain*

Assessing Ventilation

During a mine emergency, it is important to determine as quickly as possible the condition of the ventilation system. This includes knowing the condition of the ventilation controls and knowing the direction and velocity of the underground airflow.

Reporting Condition of Existing Ventilation

The officials at the Command Center need to receive accurate information regarding the ventilation controls and air lines so that they can make the appropriate decision as to what changes to make in the ventilation. Therefore, as the team advances during exploration, all the ventilation controls should be checked, especially those in the affected part of the mine. When the team comes to a regulator or door, the map person should note its position, and it should be reported to the Command Center.

Communicate the type and extent of damage. For example, if a stopping/bulkhead or other type of structure has been blown out by explosive forces, note the direction in which it appears to have blown. Even if they are not destroyed, indications of blocks having been moved should be reported. The most helpful indicator of the origin of an explosion is **the direction** in which blocks have moved in or out of stoppings/bulkheads across entries near intersections. However, the movement of stoppings/bulkheads blocks <u>in crosscuts</u> seldom indicate the actual origin of an explosion.

The Command Center considers several factors before it orders a change in ventilation. Most importantly, it has to consider how the alterations will affect ventilation into an unexplored area. The rule-of-thumb when altering ventilation is not to change the ventilation into an unexplored area because the wrong alterations could cause changes in the air at the FAB, push deadly gases or smoke into areas where survivors are located, force explosive gases back over fire areas or hot spots and cause an explosion, or redirect and feed air to a fire.

Mine rescue teams should <u>NEVER</u> alter ventilation without direct orders from the Command Center.

Measuring Airflow *(Visuals 13, 14, 15, and 16)*

There are times when a team will be asked to determine the direction and velocity of airflow in a certain section of the mine. Knowing the velocity is important because it can be used to calculate the quantity of airflow which in turn enables the team to check if the ventilation system is functioning as a whole and if it is functioning as it should in a given area. All findings are reported to the Command Center, so they can calculate and compare them to the normal readings obtained previously at the mine.

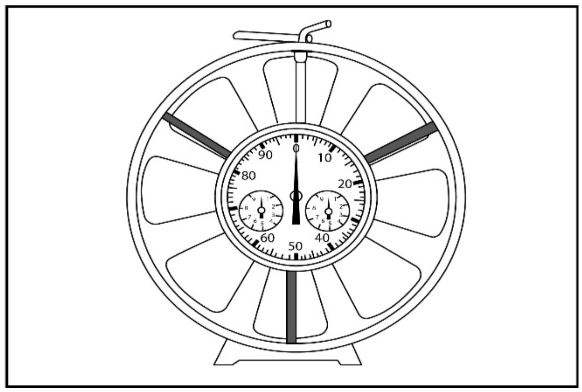
The two instruments commonly used to measure air movement are the anemometer and the smoke tube. The smoke tube is used mainly to determine what direction very slow-moving air is moving, and at what velocity. The anemometer is used to measure medium- and high-velocity air movement.

High velocities are sometimes encountered in the ducts or tubing where using an anemometer is difficult. For such measurements the most practical instruments are a Pitot Tube or Magnehelic, which can be inserted through a small hole in the duct or tubing. The Pitot tube has a U-tube water gauge or some other differential pressure gauge for determining the velocity pressure inside the duct or tubing.

Anemometer *(Visuals 13 and 14)*

An anemometer is a small sort of windmill with a mechanical counter for recording the number of revolutions caused by the moving air current. It is used to measure air velocities of over 120 feet per minute. There are two types of anemometers:

1. A regular anemometer is used to measure medium velocities from 120 to 2,000 feet per minute; and
2. A high-velocity anemometer is used for measuring velocities from 2,000 to 10,000 feet per minute.

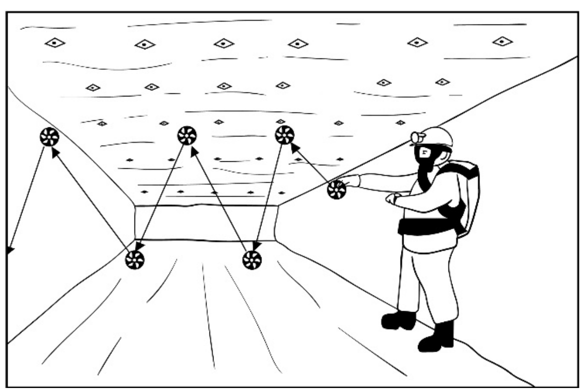


Visual 13 – Anemometer

The anemometer measures the **linear feet of travel** and requires timing (usually one minute) to determine **velocity** in feet per minute. Then, the **area** of the airway (where the reading is taken) is computed in square feet. The **area** is then multiplied by the **velocity** to obtain the quantity of the air current in cubic feet per minute.

A commonly-used method of measuring the velocity is to traverse the airway, so an accurate measurement is taken of the average velocity in the airway. This procedure is as follows:

- Stand with your back to one rib and hold the anemometer in a vertical position out in front of you at full arm's length. Position the anemometer so that the air current will enter the back of it (that is, the side without the dials). Keep your free arm close to your body.

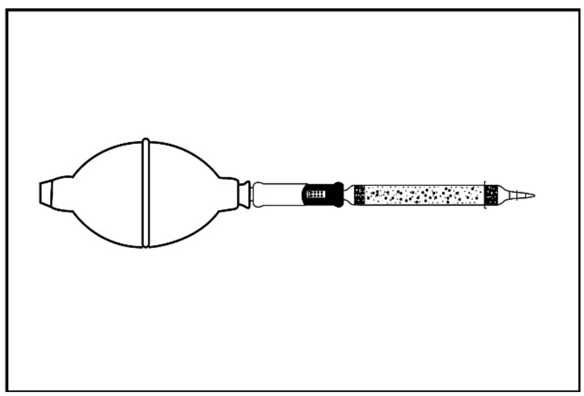

Visual 14 – Traverse Method

- Turn the anemometer on and walk slowly to the opposite rib, pacing yourself to get a one minute reading. Be sure to keep the anemometer out in front of you (to decrease resistance as much as possible). The anemometer should be raised and lowered as you walk to the opposite rib so that the average velocity of the air is measured.
- At the end of one minute, turn off the anemometer and read the dials. This reading will have to be corrected by using the manufacturer's table of corrections for the various velocity readings.
- Determine the cross-sectional area of the entry by multiplying the width times the height.
- Report the velocity and area measurements to the Command Center; they will calculate the airflow quantity in cubic feet per minute by multiplying the area (ft^2) by the corrected velocity (ft/min). If the anemometer reading is taken for **less than a minute**, it will have to be **converted** to feet per minute.

Smoke Tube *(Visuals 15 and 16)*

The smoke tube is used to show the direction and velocity of slow-moving air (below 120 feet per minute). It emits a smoke cloud which floats along with the air current to show the direction the airflow and the approximate velocity of the airflow.

The smoke tube contains a smoke-generating chemical. To use it, break off both ends of the glass tube and then squeeze the aspirator bulb to force air into the tube. A white cloud of smoke will come out of the tube and travel with the air current in the passage. This will show you the direction in which the air is flowing (in cases where the direction cannot otherwise be determined). If you are not wearing breathing protection when working with the smoke tube, you should be careful not to come in contact with the smoke. It is extremely irritating and can cause choking.



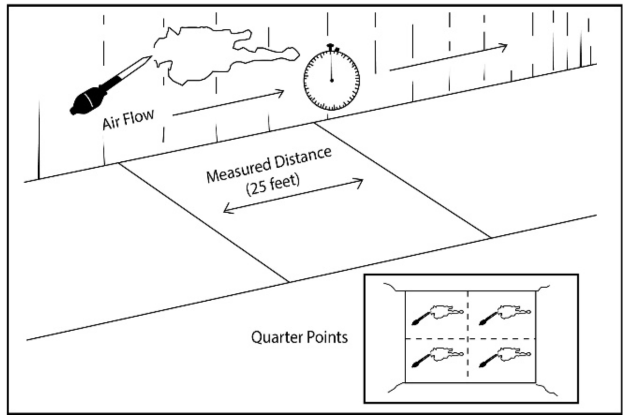
Visual 15 – Smoke Tube

There are two methods of measuring the velocity with a smoke tube. With one method, the reading is taken only at the center of the airway. This method is not very accurate as it gives only an approximate reading that is high because the center of an airway has the fastest moving air.

The more accurate method of determining the air velocity is to take readings at quarter points within the airway *(Visual 16)*. Divide the airway into four equal parts; the quarter points are at the center of each quadrant. This is done to determine the average velocity since it varies at different parts of the airway.

Measure a distance in a relatively straight and uniform airway; twenty-five feet is usually a suitable distance. This distance should be determined by how well the smoke cloud holds together and how well it can be seen.

1. Have the person with the smoke tube at the upwind point of the measured distance, and have another person with a stopwatch at the downwind point.
2. The person with the smoke tube releases a smoke cloud utilizing an aspirator bulb at each quarter point within the airway. The person with the stopwatch times each cloud from the moment it is released until it reaches the downwind point or line at the prescribed distance. The measurements are taken separately; the first cloud is timed, then the second.



Visual 16 – Using a Smoke Tube

Each velocity measurement in a quadrant should be repeated several times to determine an accurate average. Abnormal high and low measurements are discarded and the remainder averaged. A correction will need to be made to the averaged figure because the air travel at the quarter points will average about 10 percent high. To make this correction, either multiply the averaged figure by **0.10** and then subtract that from the averaged figure, or multiply the average by **0.9.**

- Determine the average area of the entry along the measured distance by multiplying the width times the height.
- Report the velocity and area measurements to the Command Center. They will calculate the quantity of airflow in cubic feet per minute.

Use this formula: Quantity (ft^3/min) = Area (ft^2) x Velocity (ft/min). Velocity is always measured in feet per minute (ft/min) for mine application.

Here is an example: The smoke tube reading is converted to feet per minute. If the measured distance is 25 feet, and it averages 23 seconds for the smoke cloud to reach the downwind point, the first step is to convert the 23 seconds to minutes (the decimal equivalent), so we can calculate the velocity using minutes:

$$\frac{23\ seconds}{60\ seconds} = 0.38\ minute$$

Then, the velocity can be calculated. Remember, velocity is found by dividing the feet by the minutes. In our example, the measured distance taken was 25 feet:

$$\frac{25\ feet}{0.38\ minute} = 65.7\ ft/min$$

Now that you have the velocity, the airflow quantity can be calculated. For this example, 200 ft^2 is used for the area measurement. The area is multiplied by the velocity (Area x Velocity = Quantity):

$$200\ ft^2 \times 65.7\ ft/min = 13{,}140\ ft^3/min$$

If you intend to use the smoke tube again in a short time, keep it tightly stoppered with a rubber cap or plug because the reagent is corrosive and tends to clog the tube openings.

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SMOKE TUBE DATA CONVERTED TO VELOCITY BASED ON

$$\mathbf{V} = \frac{distance\ (feet)}{time\ (seconds)} \times 60 \times 0.9 \ \ \textbf{From Bulletin 589}$$

Time	VELOCITY			Time	VELOCITY		
Sec	10 ft	15 ft	20 ft	Sec	10 ft	15 ft	20 ft
5.0	108	162	216	**15.0**	36	54	72
5.2	104	156	208	**15.2**	36	53	71
5.4	100	150	200	**15.4**	35	53	70
5.6	96	145	193	**15.6**	35	52	69
5.8	93	140	186	**15.8**	34	51	68
6.0	90	135	180	**16.0**	34	51	68
6.2	87	131	174	**16.2**	33	50	67
6.4	84	127	169	**16.4**	33	49	66
6.6	82	123	164	**16.6**	33	49	65
6.8	79	119	159	**16.8**	32	48	64
7.0	77	115	154	**17.0**	32	48	64
7.2	75	113	150	**17.2**	31	47	63
7.4	73	109	146	**17.4**	31	47	62
7.6	71	107	142	**17.6**	31	46	61
7.8	69	104	138	**17.8**	30	46	61
8.0	68	101	135	**18.0**	30	45	60
8.2	66	99	132	**18.2**	30	45	59
8.4	64	96	129	**18.4**	29	44	59
8.6	63	94	126	**18.6**	29	44	58
8.8	61	92	123	**18.8**	29	43	57
9.0	60	90	120	**19.0**	28	43	57
9.2	59	88	117	**19.2**	28	42	56
9.4	57	86	115	**19.4**	28	42	56
9.6	56	84	113	**19.6**	28	41	55
9.8	55	83	110	**19.8**	27	41	55
10.0	54	81	108	**20.0**	27	41	54
10.2	53	79	106	**20.2**	27	40	53
10.4	52	78	104	**20.4**	27	40	53
10.6	51	76	102	**20.6**	26	39	52
10.8	50	75	100	**20.8**	26	39	52
11.0	49	74	98	**21.0**	26	39	51
11.2	48	72	96	**21.2**	25	38	51
11.4	47	71	95	**21.4**	25	38	50
11.6	47	70	93	**21.6**	25	38	50
11.8	46	69	92	**21.8**	25	37	50
12.0	45	68	90	**22.0**	25	37	49
12.2	44	66	89	**22.2**	24	36	49
12.4	44	65	87	**22.4**	24	36	48
12.6	43	64	86	**22.6**	24	36	48
12.8	42	63	84	**22.8**	24	36	47
13.0	42	62	83	**23.0**	23	35	47
13.2	41	61	82	**23.2**	23	35	47
13.4	40	60	81	**23.4**	23	35	46
13.6	40	60	79	**23.6**	23	34	46
13.8	39	59	78	**23.8**	23	34	45
14.0	39	58	77	**24.0**	23	34	45
14.2	38	57	76	**24.2**	22	33	45
14.4	38	56	75	**24.4**	22	33	44
14.6	37	55	74	**24.6**	22	33	44
14.8	36	55	73	**24.8**	22	33	44

Review Questions and Answers

1. Discuss reasons why mine rescue teams should not alter ventilation without Command Center authorization.

    - *Altering the ventilation could force deadly gases into areas where survivors might be located.*
    - *It could force explosive gases over fire areas or hot spots and cause an explosion.*
    - *It could supply additional oxygen to a fire area and "feed" the fire.*
    - *It could also result in ventilation changes that would alter the air at the FAB.*

2. Discuss the conditions under which a smoke tube would be used to determine air velocities.

    - *The smoke tube is used to determine the direction and velocity of slow-moving air, below 120 feet per minute*

3. Discuss the conditions under which an anemometer would be used to determine air velocities.

    - *The medium-velocity (or "regular") anemometer is used to determine air velocities from 120 to 2,000 feet per minute. A high-velocity anemometer is used to determine air velocities between 2,000 and 10,000 feet per minute.*

Building Ventilation Controls

As previously stated, mine rescue and recovery work often involves building or rebuilding ventilation controls in the mine in order to re-establish ventilation. Therefore, it is necessary to know how to properly build ventilation controls, whether it be building a stopping or hanging line brattice. Some team members are skilled in building ventilation controls while others may have little or no experience. Whether or not you've done this type of work before, it's going to take time to get used to working while wearing your apparatus. It will be especially hard if working in smoke or trying to work rapidly to reach survivors as quickly as possible. Remember to NEVER make alterations or do any construction without the approval of the Command Center.

Constructing Temporary Stoppings/Bulkheads

When installing a temporary stopping/bulkheads in a crosscut, they should be erected a sufficient distance into the crosscut (at least 4 to 6 feet) to permit enough room for a permanent one to be built later.

The site for the temporary stopping/bulkheads should ideally have good roof and ribs, and little or no debris on the floor in order to obtain a good seal around them. Be sure to test the roof and bar down any loose material.

A post should be set at each rib and, depending on the width of the crosscut, more posts can be set between the ribs. Boards are nailed to the top and bottom of the posts to which the brattice or plastic can be attached, or loose material can be shoveled onto the bottom surplus of brattice or plastic to seal the bottom of the stopping. Non-sparking tools, shovels, nails, or spads must be used in mine atmospheres that are above 1% methane to reduce the chance an ignition due to a spark.

If available, “pogo sticks” (spring-loaded expandable metal rods much like a pole lamp) can be used instead of posts to erect temporary stoppings/bulkheads. These permit them to be built much faster since posts do not need to be cut and fitted. They could also be used along with posts in wide crosscuts to reduce the number of posts that would normally be needed.

If the mine has had an explosion, the team may encounter a great deal of debris, damage to stoppings/bulkheads, and hazardous roof and rib conditions. In order to restore ventilation under these conditions, teams might find it necessary to improvise and “control” the ventilation as much as possible.

Destroyed or damaged stoppings/bulkheads in crosscuts that are filled with debris or have large pieces of equipment or mine cars in them can be sealed so that ventilation can be moved ahead. In these cases, the team can hang brattice or plastic from the roof and cut the brattice to fit around the piece of equipment or obstruction. Loose material can then be shoveled onto the excess brattice at the bottom and onto the equipment to effect as tight a seal as possible.

When the rescue team is advancing ventilation toward trapped miners, the work must be done as quickly as possible. With practice, a mine rescue team can erect adequate temporary stoppings/bulkheads quickly and efficiently by utilizing teamwork and the proper materials.

Constructing Permanent Stoppings/Bulkheads

After ventilation is restored, permanent stoppings/bulkheads are built to replace temporary stoppings/bulkheads as soon as possible. Normally, the permanent stoppings/bulkheads are constructed outby the advancing FAB, so they can be built by barefaced work crews rather than mine rescue teams.

There are instances (such as in sealing a fire area) where the mine rescue team would be required to build a permanent stopping/bulkhead while under oxygen. The Mine Fires and Firefighting section of Module 5 will give more information about this task.

Air Locks

An air lock consists of two doors or two stoppings/bulkheads with flaps or doors in them which are in close proximity to each other in the same passageway. The purpose of an air lock is to separate two different atmospheres while still permitting miners to enter and exit without mixing the atmospheres. In order to maintain the air lock, one door must be kept closed while the other door is open.

In mine rescue work, air locks are normally put up to establish a FAB and enable teams to move forward into questionable air without contaminating the air at the FAB. Plus, air locks are used any time a team is required to break open a stopping/bulkhead or open a door when the conditions on the other side of that stopping or door are not definitely known.

Air locks are required prior to opening any barricade or door in irrespirable atmospheres behind which survivors may be located. When erecting an air lock, the team builds two stoppings/bulkheads as close together as possible, leaving enough space in between to allow room to fit the team and their equipment.

Line Brattice

Mine rescue teams may find it necessary to use line brattice to sweep noxious or explosive gases from a face area or to split an air current as while advancing ventilation. The line brattice can be installed by erecting posts or supports with boards along the roof to which the brattice can be attached. Or, the brattice can simply be attached to the roof with spads or held up with pogo sticks, if available.

If the brattice needs to hang only for a short time, the team can simply hold up the brattice, extending it into the area to be ventilated. In these situations, each team member should hold up a section of the line brattice getting it as close to the roof as possible.

Review Questions and Answers

1. Have the team members discuss why they need to be able to build temporary stoppings/bulkheads quickly and effectively.

    - *Re-ventilation is essential for the advancement of the FAB and the flushing out of dangerous gases. When miners are trapped, it is very important to be able to advance the FAB quickly in order to rescue the miners.*

2. Have the team members discuss how they would build a temporary stopping in a crosscut that has equipment in it.

    - *The brattice should be cut to fit around and over the equipment, and the seal secured with loose material from the floor, shoveled onto the excess brattice along the floor and on the equipment.*

General Review
Questions

Choose the correct answer to each of the following questions.

1. A smoke tube is a device used to:
    a. Determine oxygen content of the mine atmosphere.
    b. Determine direction and velocity of airflow.
    c. Detect carbon monoxide.
    d. Detect leaks in temporary stoppings/bulkheads.

2. The traverse method is used when:
    a. Taking a reading with a smoke tube.
    b. Taking a reading with an anemometer.
    c. Erecting a temporary stopping.
    d. None of the above.

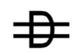
3. Mine rescue teams should alter existing ventilation:
    a. Only when directed to do so by the Command Center.
    b. When the team captain decides to do so.
    c. When they encounter high concentrations of methane.
    d. When they encounter smoke.

4. Mine rescue teams erecting temporary stoppings/bulkheads in atmosphere with elevated methane readings should:
    a. Use only inflatable seals.
    b. Leave a corner of the stopping/bulkheads open for the methane to exit.
    c. Use non-sparking tools, nails, and spads.
    d. Mine rescue teams should never enter such atmosphere.

5. During mine rescue team explorations, the main fan:
    a. Should be kept running.
    b. Should be continually monitored.
    c. Both of the above.
    d. None of the above.

6. Air locks are used by mine rescue teams:
    a. To establish a Fresh Air Base.
    b. When opening a door or knocking out a stopping/bulkheads behind which conditions are not definitely known.
    c. Before opening a barricade in bad air behind which trapped miners may be located.
    d. All of the above.
7. Two instruments commonly used to measure velocity of airflow in a mine:
    a. Smoke Tube and Regulator.
    b. Regulator and CO Detector.
    c. CO Detector and Anemometer.
    d. Anemometer and Smoke Tube.
8. Temporary stoppings/bulkheads built in a passageway should be placed at least 4 to 6 feet into the passageway in order that:
    a. A sufficient amount of space is available to construct a permanent stopping/bulkhead.
    b. It will be protected from further explosions.
    c. It will not be affected by fire if a fire should spread to that crosscut.
    d. All of the above.
9. “Pogo sticks” are devices that are used:
    a. To test the roof and rib.
    b. To measure air velocity.
    c. To determine the direction of airflow.
    d. As supports on which brattice cloth can be hung.

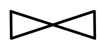
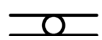
10. Match the term with its correct symbol:

	Ventilation Controls:	**Map Symbols:**
_____	1. Temporary Stopping/Bulkhead	A. 
_____	2. Line Brattice	B. 
_____	3. Overcast	C. 
_____	4. Main Fan	D. ¢
_____	5. Man Door	E. **R**
_____	6. Permanent Stopping	F. or
_____	7. Regulator	G. **D**
_____	8. Mine Door	H. 
_____	9. Box Check	I.  or 
_____	10. Check Curtain	J.

General Review
Answers

1. B
2. B
3. A
4. C
5. C
6. D
7. D
8. A
9. D

10.

Answer	Ventilation Controls:	Map Symbols:
F	1. Temporary Stopping/Bulkhead	A. 
J	2. Line Brattice	B. 
A	3. Overcast	C. 
B	4. Main Fan	D. ¢
I	5. Man Door	E. **R**
H	6. Permanent Stopping	F. or
E	7. Regulator	G. D
G	8. Mine Door	H. 
C	9. Box Check	I.  or 
D	10. Check Curtain	J.

Glossary

Air Lock – An area in the mine closed at both ends by two by two doors or two stoppings/bulkheads with flaps or doors in them. An air lock is used to prevent mixing of different atmospheres while still permitting miners to enter and exit.

Air Split – The division of an air current into two or more parts.

Airway – Any passage through which air is flowing.

Anemometer – An instrument used to measure medium-velocity (120-2,000 ft./min.) and high-velocity (2,000-10,000 ft./min.) air currents in a mine.

Area (of an airway) – Average width multiplied by average height of an airway, expressed in square feet.

Auxiliary Fan – A small, portable fan used to supplement the ventilation of an individual working place.

Box Check – A stopping with an opening in it to allow a conveyor to pass through; it is used to prevent intake or return air from flowing across the conveyor.

Check Curtain or Run-through Check – Brattice cloth, canvas, or plastic curtain used to deflect or direct air into a working place. Constructed in a manner to allow the passage of miners and machinery.

Crosscut – A passageway driven at right angles between an entry and its parallel air course(s) for ventilation purposes.

Entry – An underground passage used for haulage, ventilation, or as a manway; a coal heading; a working place where coal is extracted during the initial mining.

Face – The principal operating place in a mine; the working place where fresh ore or coal is exposed and extracted. A mine may have many operating faces.

Heading – An entry.

Inby – Toward the working face from a specified point; the opposite of outby.

Intake – The passage through which fresh air is drawn or forced into a mine or to a section of the mine.

Irrespirable – Unfit for breathing.

Line Brattice or Brattice Cloth – Fire-resistant fabric or plastic partition used in a mine passage to direct the air into the working place. Also called “line curtain” and “line canvas.”

Main Entry – The main haulage road.

Main Fan – A mechanical ventilator installed at the surface which operates by either exhausting or blowing (pushing) to induce airflow through the mine.

Man Door – Door installed in a permanent stopping/bulkheads to allow persons to travel from one entry to another.

Mine Door – A large hinged door used to close off a mine passage. Doors are usually installed in pairs to form an air lock.

Outby – Toward the shaft or entrance from a given point; the opposite of inby.

Overcast – Enclosed airway built at an intersection of mine passages that permits one air current to pass over another without mixing.

Quadrant – Any of four quarters into which something is divided.

Reagent – A substance that causes chemical activity.

Regulator – An adjustable door or opening in a stopping/bulkhead used to control and adjust the quantity of airflow in the mine in order to ensure proper distribution.

Return – The air course along which the ventilated air of the mine is returned or conducted to the surface.

Return Air – The air that has passed through all the working faces of a split and is on the way out of the mine.

Smoke Tube – Instrument used for determining direction and velocity of slow-moving air (below 120 feet per minute).

Stopping/Bulkheads – A permanent/bulkheads or temporary/bulkheads wall or partition constructed of incombustible material across a passageway to direct the ventilating air in its proper course and to separate the intake and return air.

Traverse – To move across. A traverse measure of air velocity is one that is taken by walking across an airway.

Undercast – An enclosed airway built at an intersection of mine passages that permits one air current to pass under another air current without mixing.

Velocity – Rate of airflow in linear feet per minute.

Advanced
Mine Rescue Team Training

Exploration

Module 4

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Course Objectives

A. The mine rescue team members will be able to prepare for and perform underground explorations under rescue and recovery conditions.

B. The team members will be able to:

   a. Explain the purpose of mine rescue exploration.
   b. Explain the reason for establishing and advancing the FAB.
   c. Demonstrate how to establish and advance the FAB.
   d. List and describe the types of equipment needed for mine rescue.
   e. Explain the purpose of team briefing and debriefing sessions, and list the information that should be included.
   f. Explore a section of the mine using the two primary methods of exploration.
   g. Demonstrate proper traveling procedures.
   h. Use gas testing devices.
   i. Explain the reason for progress reporting.
   j. Identify the items covered in a progress report.
   k. Demonstrate the progress report procedures.
   l. Explain the importance of mapping.
   m. Identify the items a team will map.
   n. Demonstrate proper mapping.
   o. Demonstrate proper set-up and use of real-time communications.
   p. Demonstrate proper use of electronic mapping equipment (if it is available for training).

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers.

A. Required Materials:

   a. Larger visuals and text-only visuals are provided in the Appendix; use these visuals while discussing the corresponding content.

   b. Pencil and paper for each team member.

   c. Communication System(s).

   d. Gas testing devices the team uses.

   e. Printed copy of the Briefing Questions found in this module.

   f. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams.

B. Suggested Materials:

   a. Communication equipment used by MSHA Mine Emergency Operations (MEO)

   b. Gas testing devices used by MSHA MEO

   c. Linkline

   d. Map board

   e. Laptop with Mapping Software used by MSHA MEO

   f. Chalkboard and/or flip charts

   g. PowerPoint program

Course Outline

A. Introduction
B. Examination of Mine Openings
C. Barefaced Exploration
D. The Fresh Air Base
    a. Establishing a Fresh Air Base
    b. The Fresh Air Base Coordinator
    c. Advancing the Fresh Air Base
E. Apparatus Teams
    a. Team's Role in Exploration
    b. Team Equipment
    c. Equipment Required by Law
    d. Other Equipment
F. Team Briefing Sessions
G. Preparing for Exploration
    a. Team Captain's Responsibilities
    b. Donning the Apparatus and Getting Under Oxygen
    c. Review Questions and Answers
H. Exploration Methods and Procedures
    a. Rapid Exploration
        i. Changing Conditions
        ii. Guidelines for Rapid Exploration
    b. Advance, Tie Across and Behind
        i. Advancing and Tying In
    c. Standard Exploration Procedures and Practices
        i. Team Checks
        ii. Rate of Travel
        iii. Traveling in Smoke
        iv. Traveling Through Ventilation Controls
        v. Traveling Through Water
        vi. Crawling or Climbing
        vii. Marking Route of Travel

viii. Marking Areas Explored
ix. Inspecting and Testing Roof and Rib
x. Visual Inspections
xi. Roof and Rib Tests
xii. Testing for Gases
xiii. Progress Reporting
xiv. Mapping
xv. Communication

d. Returning to the Fresh Air Base
e. Review Questions and Answers

I. Debriefing
J. Wireless Communications and Tracking Technologies

Introduction

"Exploration" is the term used to describe the process of assessing conditions underground and locating miners (or clues to their whereabouts) during a rescue or recovery operation.

Exploration is a broad topic. This module focuses on preparations for explorations, team briefings and debriefings, standard procedures for advancing inside the mine, and the equipment being using during exploration. **NOTE**: Rescuing survivors and recovering bodies are covered in Module 6.

Examination of Mine Openings

Before anyone goes underground, it's important to examine the mine openings to determine the safest route for entering the mine. Tests should be made for the presence of gases, smoke, and water in the shaft and other mine openings. Someone should make ventilation checks. If a mine has had an explosion, the cage, headframe, and signaling devices could be damaged.

Obviously, it's best to enter the mine using the safest intake airway. In a shaft mine, check the cage to make sure it’s operating properly. To test an automatic elevator, run it up and down the shaft manually several times.

After a fire, explosion, or inundation, large sections of the mine outby where the event took place can be relatively undamaged. These conditions make it possible to make an initial exploration barefaced. The team conducts explorations using this technique with their breathing apparatuses on their back ready to function. Putting on the apparatus prior to exploration allows the team to put on their face pieces quickly and get under oxygen if conditions make it necessary.

Barefaced exploration should be conducted only when the ventilation system is operating properly and frequent gas tests indicate sufficient oxygen and no buildup of carbon monoxide, methane or other dangerous gases. As with regular exploration, a backup team with apparatus should be stationed on the surface.

The purpose of such exploration is to establish the extent of damage and to quickly progress in good air to the point where the initial FAB will be established. Not being under oxygen, a barefaced crew will probably be able to advance and determine current conditions quickly. They may be able to cover moderate to large distances when conditions are good.

During barefaced exploration, the crew uses radios and/or the mine’s communication system to report their progress and findings to the surface. Once the exploring team goes a certain distance into the mine, Command Center will send a backup team underground to follow in case the exploring team experiences any problems. The underground backup team should remain at a predetermined distance behind the advancing team, and a third team should remain outside the mine to act as surface backup.

Barefaced exploration should stop at any point where disruptions in ventilation are found, or when gas tests indicate the presence of any carbon monoxide or other noxious gases, elevated readings of explosive gases, elevated methane readings, or oxygen deficiency. A barefaced crew should also stop exploration when they encounter smoke or damage.

A FAB is usually established at the point where conditions no longer permit barefaced exploration. The rescue team members and backup personnel are free to travel back and forth to the FAB without apparatus because the area has already been explored. Teams equipped with apparatus continue exploration from the FAB.

The Fresh Air Base

The Fresh Air Base (FAB) is the base of operations from which rescue and recovery work advances into irrespirable atmospheres. This is where apparatus crews begin their exploration of the affected area. It functions as a base of communications for the operation linking the team, the Command Center, and all support personnel.

Establishing a Fresh Air Base (FAB) *(Visual 1)*

Usually, the operation's initial Fresh Air Base will be established somewhere underground, and then advanced as the exploration proceeds. However, if underground damage is extensive, it may be necessary to establish the initial FAB on the surface. Whether it is placed underground or on the surface, it should be located as close as possible to the affected mine area, but situated where a supply of fresh air exists. Communications from the FAB to the surface should be secure.

When the FAB is set up underground, an air lock must be built to isolate the FAB from the unexplored area beyond it. The air lock allows the team to enter and exit the unexplored area without contaminating the FAB air.

Here are a few specific factors to consider when selecting a FAB site:

- Be sure it is located where it has a positive ventilation and fresh air.
- If the FAB is underground, it should be located so that a fresh air travelway is available to the surface. This travelway will be used to safely move people and supplies back and forth to the FAB. **If possible, there should be transportation available.**
- The site should be situated where it can link to the Command Center and the team by means of a communication system.

These factors are probably the most important, but there are other elements to take into consideration. For example, the area should be free of oil and grease and well rock dusted. It should be large enough to allow space for all who will be using to work efficiently. It's desirable to have a roof that's high enough for everyone to comfortably stand under and a level floor.

It is often recommended that all possible electrical conductors (track, pipe, wires, etc.) be severed so that the affected area beyond the FAB is isolated from any possible stray or direct current.

The FAB is normally equipped with supplies and other equipment needed for the operation. For instance, a typical FAB will have gas testing devices, equipment for detecting oxygen deficiency, and firefighting equipment; additionally, there are usually first aid supplies and oxygen therapy equipment as well as tools and replacement parts for self-contained breathing apparatus and a map of the affected area. If possible, the FAB should be supplied with benches, canvas, or brattice cloth on which the backup team can set their apparatus or other supplies.

The Fresh Air Base Coordinator *(Visual 2)*

There will be a Fresh Air Base Coordinator stationed at the FAB who is responsible for establishing and maintaining orderly operations. The FAB Coordinator plays a key role in ensuring that the entire operation runs smoothly and efficiently. It is absolutely essential that everyone at the FAB respect the Coordinator's authority and do whatever they can to help. It's critical that only those people necessary to the operation are permitted at the FAB.

The primary responsibilities of FAB Coordinator include the following:

- Monitor communications with the active rescue teams, perform maintenance on the communications as necessary, and ensure there is an established link between the working teams and the Command Center.
- All FAB communication should either be hard wired or provided with its own separate, encrypted system.
- The FAB Coordinator should not become a message relay point, unless there is a failure in the communications system.
- Follow the team's progress on the mine map and mark findings on the map as the team reports them.
- Coordinate and oversee the activities of all personnel who are at the FAB.

These primary responsibilities include a great number of duties that may be delegated to other personnel, but it's still the FAB Coordinator's responsibility to make sure these duties are carried out.

The Coordinator's duties typically include checking and logging equipment and materials as well as the time and name or number of teams going inby the FAB or returning to surface, checking the condition of the backup team for their readiness.

If a lifeline is used, it's usually the FAB Coordinator's responsibility to make sure someone is stationed at the FAB to monitor it. Additionally, the FAB Coordinator should make sure no unauthorized personnel or equipment are permitted to go inby the FAB.

An incoming FAB Coordinator who is relieving another Coordinator must be briefed on all the necessary up-to-date information to ensure the changeover goes smoothly. It's also the incoming FAB Coordinator's duty to check communications between the FAB and the Command Center to make sure the system is operating properly. The Coordinator reports his or her arrival at the FAB and ensures the Command Center logs the arrival time.

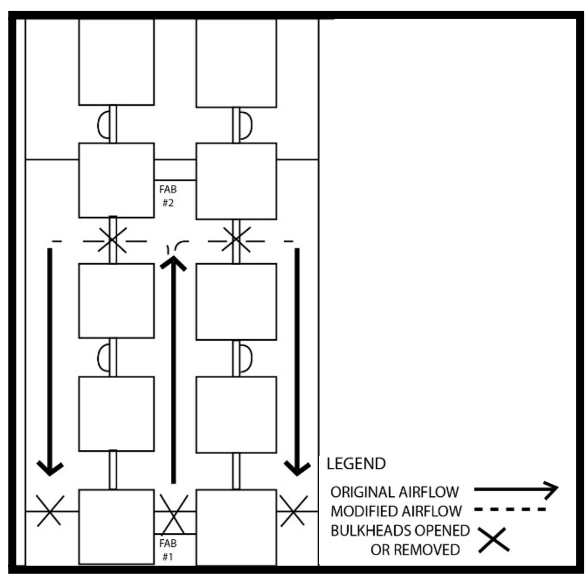
Sometimes, "runners" are stationed at the FAB to carry messages between the FAB and the Command Center in the event of a communication breakdown. The runners may be responsible for other tasks, such as taking gas samples to the surface or monitoring the lifeline.

Advancing the Fresh Air Base *(Visual 3)*

The Fresh Air Base is usually advanced closer to the affected area of the mine as soon as the areas inby the base are explored and re-ventilated. This ensures that the apparatus crews will begin their explorations as close as possible.

To advance the Fresh Air Base, the team will build a new air lock at the site of the new FAB and put up any temporary stoppings in parallel entries that are needed to seal-off the area so that fresh air can be advanced.

The team will need to repair any damaged ventilation controls in the area between the old Fresh Air Base and the new one. However, be sure to leave open the last stopping outby the new Fresh Air Base that goes to the return. If the stopping is intact, open it. This ensures the area can be properly flushed out and ventilated.



Visual 3 – Advancing the Fresh Air Base

Next, return to the old FAB to remove or open air locks and stoppings in parallel entries to permit air inby the old FAB and flush the area up to the new FAB.

Before everyone is moved to the new FAB, the area between the old and new one should be explored by a mine rescue team or by a crew of company, state, and Federal officials. Using gas testing devices, check all dead ends, intersections, and high places in the area to make sure it's adequately ventilated.

Once the entire area is explored, all appropriate checks have been made, and the area is declared safe, the team and other designated personnel can advance the FAB. If gases are found to have accumulated in areas that are difficult to clear by means of regular ventilation (very high or low spots, etc.), it may be necessary for the team to hold up the brattice so it channels the airflow directly into these areas.

Review Questions and Answers

1. What is a Fresh Air Base (FAB)?
    - *The FAB is the underground base of operations and starting point for rescue and recovery work into irrespirable atmospheres.*
2. What are the requirements for a FAB?
    - *The FAB must be situated where positive ventilation, fresh air, and a travelway to the surface can be used for people and equipment.*
    - *Communications systems linking it to the Command Center and to the mine rescue team.*
    - *It is also best if the area is well rock-dusted and free of oil and grease.*
    - *A level floor and a high roof that is comfortable to stand under.*
3. What are the three main duties of the FAB Coordinator?
    - *Handles communications with the team and the Command Center.*
    - *Maps the team's progress and findings.*
    - *Coordinates and oversees activities of all designated FAB personnel.*
4. How do you advance a FAB?
    - *Construct a new air lock and any stoppings/bulkheads in parallel entries that are needed, repair ventilation controls to the point where the new FAB is located, and provide an opening to the return.*
    - *Return to the old FAB and remove the air lock and any stoppings/bulkheads in parallel entries to ventilate the new area.*
    - *Prior to advancing everyone to the new FAB, a mine rescue team or designated crew will need to perform gas tests in all dead ends, intersections, and high places of the newly ventilated area.*

Apparatus Teams

Once the FAB is established, apparatus teams will be sent inby to explore the affected area. This may require only one or two trips inby, or it may continue through many team rotations. How many trips will be needed to complete the exploration (and how long it will take) will depend on the extent of the area involved and the conditions within the affected area.

Team's Role in Exploration

During exploration, the team travels in potentially hazardous atmospheres. Roof and rib conditions will be uncertain and perhaps hazardous. As the team progresses through the mine, they make gas tests, assess conditions, locate fires, and search for clues as to where survivors may be located. All findings are mapped and reported to the FAB as the team proceeds.

Team safety is always the first priority; the rescue of survivors comes second, and the third is mine recovery. During exploration, teams work according to a rotation schedule. One team will work inby while a second team will be stationed at the FAB as the "backup team." The third team, known as the "standby team," will be ready and waiting on the surface. Other teams may be scheduled to rest.

While a team is "at rest," it's important to allow time for their apparatus to be cleaned, tested, and prepared for use (and repaired, if necessary). It's important for team members to be well rested because rescue work is strenuous and demanding. It's recommended not to eat within an hour of the time you'll be wearing your apparatus, and you shouldn't drink alcoholic beverages for 12 to 18 hours before going under oxygen because it can cause you to be sluggish and impair your judgment and reflexes. Additionally, limit intake of stimulants (such as coffee, colas, etc.) because these substances increase heart and respiration rates.

Team Equipment

Team members use some of the same basic equipment that any underground miner uses. For example, each member will be outfitted with a hard hat, cap lamp, steel-toe shoes or boots, and a metal ID tag.

Wear a metal ring on your mine belt, so you can hook onto a lifeline or linkline; it is common practice for everyone to wear a watch and a Self-Contained Breathing Apparatus (SCBA).

Equipment Required by Law

Equipment and maintenance requirements in 30 CFR Part 49.6 and 49.16:

(a) Each mine rescue station shall be provided with at least the following equipment. Mine rescue stations serving underground anthracite coal mines, which have no electrical equipment at the face or working section, shall have at least the amount of equipment appropriate for the number of mine rescue team members.

(1) Twelve self-contained breathing apparatus, each with a minimum of 4 hours capacity (approved by MSHA and NIOSH under 42 CFR part 84, subpart H), and any necessary equipment for testing such breathing apparatus.

(2) A portable supply of liquid air, liquid oxygen, pressurized oxygen, or oxygen generating chemicals, and carbon dioxide absorbent chemicals, as applicable to the supplied breathing apparatus and sufficient to sustain each team for 8 hours while using the breathing apparatus during rescue operations.

(3) Two extra, fully-charged oxygen bottles for every six self- contained breathing apparatus.

(4) One oxygen pump or a cascading system, compatible with the supplied breathing apparatus.

(5) Twelve permissible cap lamps and a charging rack.

(6) Four gas detectors appropriate for each type of gas that may be encountered at the mines served. Gas detectors must measure concentrations of methane from 0.0 percent to 100 percent of volume, oxygen from 0.0 percent to at least 20 percent of volume, and carbon monoxide from 0.0 parts per million to at least 9,999 parts per million.

(7) [Reserved].

(8) One portable mine rescue communication system (approved under Part 23 of this title) or a sound-powered communication system.

   i. The wires or cable to the communication system shall be of sufficient tensile strength to be used as a manual communication system.

   ii. Communication systems shall be at least 1,000 feet in length.

(9) Necessary spare parts and tools for repairing the breathing apparatus and communication system.

(b) Mine rescue apparatus and equipment shall be maintained in a manner that will ensure readiness for immediate use.

(1) A person trained in the use and care of breathing apparatus shall inspect and test the apparatus at intervals not exceeding 30 days, and shall certify by signature and date that the inspections and tests were done.

(2) When the inspection indicates that a corrective action is necessary, the corrective action shall be made and the person shall record the corrective action taken.

(3) The certification and the record of corrective action shall be maintained at the mine rescue station for a period of 1 year and made available on request to an authorized representative of the Secretary.

Other Equipment

Beyond what is required by law, the other equipment the team will use depends on the situation. For instance, if rescuing survivors, the team needs to carry a stretcher or stokes basket, and an extra approved breathing apparatus for the rescued person. However, if the task is to build ventilation controls, the team needs to carry tools and other construction equipment.

Some of the materials needed to build ventilation controls (such as brattice cloth) may already be underground, so the team will simply pick up what is needed while progressing through the mine. This applies to other team tasks that require the use of materials already inside the mine.

Here are some examples of other equipment typically used during exploration:

- High-Range Multi-Gas Detectors - Detectors can be configured with an interface and radio to provide real-time gas readings, enabling the Command Center to continuously monitor a specific area for gases as opposed to having a team member remain in the area to monitor and communicate gas readings to the FAB and Command Center.
- Communications Equipment (including real-time system components)
- Ventilation measuring and air sampling devices such as anemometers, pressure gages, smoke tubes, syringes, etc.
- Lifeline – This refers to the powered communication/lifeline system used as a backup if the main system fails. The team’s communication line is normally used for this.
- Linkline – This is a line or rope (usually equipped with rings) that is used to hook team members together in smoke.
- Chemical Light Sticks – Teams may want to use these as "bread crumbs" to indicate areas of travel during exploration.

- Mapboard and Marker – The mapboard may be fitted with a Plexiglas cover to protect the map from water damage in wet mines.
- Roof testing device
- Walking Stick – The captain can use a walking stick to probe water depth or to avoid obstructions in heavy smoke.
- Stokes basket or stretcher and blankets
- First Aid Kit
- Fire Extinguisher
- Tools – May include a hammer, nails, axe, shovel, brattice cloth, and possibly a saw, and a wrench to open water line valves, tape measure, utility knife and channel locks. Always use non-sparking tools, nails, spads, etc.
- Extra approved breathing apparatus and/or a CAREvent (if missing miners are involved).
- Washers with streamers or flags attached for marking hazardous areas, such as bad roof.
- Carpenter's Apron – The captain may use an apron to carry a notebook, pen, and chalk while other members use them for carrying nails, hand tools, etc.
- Thermal Imaging Camera – This enables the location of "hot spots" that cannot be seen with your eyes. It works extremely well, especially in smoke, to quickly locate miners and/or fires. Thermal imaging camera shall be used **according to the plan approved** by the mine operator for mine rescue and recovery operations. It is non-permissible which means it is **Not** MSHA-Approved and should not be used in areas underground where a spark could cause a fire or explosion (such as inby the last open crosscut and in the return).

Team Briefing Sessions

Before the team goes underground, they must attend a briefing session. This usually takes place at the Command Center and is conducted by a briefing officer and a briefing committee. The briefing committee is composed of company and Federal officials. It will include state and union representatives, where applicable.

The Command Center personnel are responsible for conducting briefing sessions and determining who should be included in the sessions. It is suggested that the team captain, map man, and the team's trainer (possibly) be included.

At the briefing, the team needs to be informed about what has happened and what conditions currently exist. The briefing officer will give the captain the team's assignment which specifies what areas the team will explore. The briefing officer will issue the team an up-to-date mine map and give a time limit within which the work can be completed and the team should arrive back at the FAB.

The information exchange between the Command Center and the mine rescue teams is extremely important to the successful completion of the assignment. However, it must be emphasized that the Command Center makes the final decisions regarding all aspects involved in the operation.

The safety of the team is dependent upon accurate, up-to-date information regarding conditions in the mine. The team should ask questions concerning items about which they are unsure, and they need to express to Command Center personnel any concerns they have with their assignments.

NOTE: Print the following Briefing Questions as a handout to give to each team member.

Briefing Questions

- Is the evacuation complete?
- Are any miners missing, if so, how many, and what are their possible locations?
- What is known about the cause of the disaster?
- Is your team the first one to explore?
- Have State and Federal officials been notified?
- Are guards stationed at all mine entrances?
- Is the ventilation system operating? Is it an intake or exhaust system?
- Are attendants posted at the surface ventilation controls?
- Have air samples been taken? If so, what are the results?
- Will there be a backup team ready at the FAB and reserve teams on the surface?
- What are the team's objectives and what is their time limit?
- What existing conditions are known (roof conditions, water, gas, etc.)?
- Is the mine's communication system operating?
- Is it being monitored?
- What other types of communications equipment will team members be required to use during rescue/recovery operations?
- Have team members been trained on the set-up and operation of real-time communications/tracking systems to be used during mine rescue and recovery work?
- Is power to the affected area on or off?
- Is there battery-powered or diesel equipment or a charging station in the affected area? The team should be aware that battery-powered or diesel equipment may still be running **even though power to the area has been cut off.**
- What type of equipment is in the area? Where is it located?
- Where are compressed air and/or water lines located?
- Are they in operation? Are valves known to be open or closed?
- What type of firefighting equipment is located underground? Where is it?
- What tools and supplies are available underground? Where are they?
- In the area to be explored are there storage areas for oil, oxygen, acetylene tanks, or explosives?

Preparing for Exploration

Team Captain's Responsibilities

Before proceeding to the FAB, the captain's responsibility is to ensure the team, its equipment, and its apparatus are ready to go. The captain should:

- Check each team member's physical condition, to make sure each is physically fit to wear the apparatus and to perform rescue work.
- Team members must be clean-shaven before entering the mine with an apparatus. Failure of a member to be clean-shaven will result in that member not being allowed underground or serve as a surface backup.
- Ensure that all apparatus have been tested, checked (including confirmation that the CO_2 Scrubber is properly filled according to OEM recommendations), and are operating properly.
- Ensure the team has all necessary tools and equipment (including the captain's own supplies, such as notebook, pencil, chalk, etc.).
- Check battery level of radios, gas detectors, and communications systems.
- Determine which team member(s) will check radio signal strength and monitor the communication system's connection to FAB and the Command Center.
- Make sure the team understands the briefing instructions and what their individual jobs will be.

Before traveling inby the FAB, it's the captain's responsibility to make sure the team is prepared. The captain should:

- Ensure the gas-testing equipment, communication equipment, signaling equipment, and stokes basket or stretcher have been checked by the designated people.
- If not the first team to explore, obtain up-to-date information about how far the last team advanced and what they found.
- Ensure your team's map person gets an updated map from either the last team's map person or the FAB Coordinator.
- Check battery level of radios, detectors, and communications systems.
- Synchronize watches with the FAB Coordinator.
- Discuss the type of communication system that will be used with the FAB Coordinator.
- Ensure the radio signal strength remains consistent throughout exploration, determine **(IN ADVANCE)** at what intervals and/or locations signal strength will be checked.

Donning the Apparatus and Getting Under Oxygen

Once all preparations and last-minute checks have been made, including a check to ensure all team members have CO_2 scrubbing absorbent in the breathing apparatus, each team member is ready to put on their apparatus and get under oxygen. **NOTE: Review the team's procedure** for getting under oxygen.

Just before the team begins to travel inby the FAB, the captain needs to write down the departure time. The captain may have the map person to note the time on the map for later reference.

Review Questions and Answers

1. What equipment is a mine rescue team required to have?
    - *In addition to the normal PPE, the team wears a breathing apparatus and two detecting devices (or multi-gas detector) for each gas they may encounter, and a communication system.*
2. What type of information is normally covered in a team briefing and/or what questions should team members ask?
    - *Evacuation report—missing miners and possible locations?*
    - *What may have caused the disaster?*
    - *Are they the first team to go underground?*
    - *Have State and Federal authorities been notified?*
    - *Is property guarded?*
    - *What is the ventilation system (fans) and gas conditions at returns?*
    - *Is a backup team available?*
    - *What are the team's objectives and time limit?*
    - *What are known conditions?*
    - *What is the status of the mine's communication system?*
    - *Is power in the mine on or off?*
    - *What equipment is in the affected area? Is there diesel, battery-powered, equipment, or a charging station?*
    - *What is the location and/or condition of air and waterlines?*
    - *What type of firefighting equipment and where is it located?*
    - *Where are tools and supplies located underground?*
    - *Are there storage areas for oil, oxygen, acetylene, or explosives in the area to be explored?*

Exploration Methods and Procedures

Every emergency is different and presents its own problems. Although it's difficult to tell exactly what you'll be doing during an exploration, there are some accepted methods and procedures for carrying out basic exploration work which have developed over time.

There are two primary methods of mine emergency exploration for which the team will need to practice and prepare:

1. Rapid Exploration and
2. Advance, Tie Across and Behind

Rapid Exploration

Rapid Exploration requires the use of radios and can be used only in areas that are CLEAR OF SMOKE. This exploration method allows the mine rescue team to split up and explore multiple (adjacent) entries simultaneously while maintaining in constant radio contact with their other team members, the FAB, and the Command Center**.** When contaminants are present and team members are under oxygen, no team member should travel alone.

Using this method, it is common practice for the team members to travel one crosscut, then communicate information (via hand-held radio) to the FAB **and** the Command Center simultaneously if the system permits.

When permanent stoppings, equipment, or materials are found in crosscuts and causes a visual obstruction between two adjacent entries, **at least two** team members should travel together in these entries and maintain radio contact with the rest of the team. When using this method to explore, **ALWAYS** maintain radio communication between the team members. If communication is interrupted for any reason, exploration **stops** until it is reestablished. If a team encounters smoke, they MUST return to the communication/lifeline system (lifeline).

Changing Conditions

The team may encounter changing conditions or circumstances that would require them to immediately reassemble and continue exploration using the "Advance, Tie Across and Behind" method. These changing conditions include:

- Rapid change in mine atmosphere.
- Smoke that limits visibility.
- Discovery of a fire.
- Discovery of a Refuge Alternative or Rescue Chamber.
- Discovery of a victim requiring assistance, including first aid and/or extrication.

- Team member experiences a “problem” such as apparatus malfunction or physical issues.
- Travel in an entry is blocked.

If any of this happens, the affected team members need to travel to an adjacent entry and advance in **that** entry until they can gain access to their assigned entry. Once the team member regains access to their assigned entry, they need to tie in behind them and resume explorations.

Guidelines for Rapid Exploration

If mine rescue teams are to be deployed using the Rapid Exploration method:

- A wireless communication system must be in place and operating.
- The communication system’s radio signal strength must be monitored.
- Radio communication must be maintained between ALL exploring team members, the FAB, and the Command Center.
- All team members must be familiar with and have up-to-date training on the wireless communication system to be used.
- Must have a minimum of two persons per entry to be explored: one person operating radio and one person monitoring the gas detector.
- There must have “good” visibility in the areas to be explored.
- Teams must map relevant information in all entries explored.

Advance, Tie Across and Behind

This more commonly used method of exploration has been a standard procedure for many years whenever mine rescue teams encounter smoke. Using this method, the team travels closely together on a sound-powered communication and/or lifeline system (cable and cable reel), referred to as the “lifeline.”

Advancing and Tying In

“Tying In” is the process by which you systematically explore all crosscuts and adjacent entries while advancing to ensure the team is never inby an unexplored area. Using this method, you “tie in” as you advance.

As you advance within the affected area, it’s recommended to use the least obstructed travelway and stay in intake air whenever possible. Until each entry and crosscut has been explored, there is no way of knowing what the conditions are in these areas. For example, there may be a fire located in an adjacent entry which could spread and cut off your escape. By tying in, you are ensuring there is never any unexplored area between you and the FAB. Even though you know (or think you know) where survivors are located, or where a fire or explosion has originated, it’s absolutely essential to tie in while advancing. As your team advances underground, the captain always takes the lead, followed by the other team members. It's standard practice for the team captain to enter unexplored areas ahead of the rest of the team to check roof and rib conditions.

In most cases, the co-captain will be the No. 5 person. In this position, the co-captain can easily keep an eye on the other team members to ensure they're proceeding without difficulty. The co-captain can quickly halt the team if anyone appears to be having trouble.

The Command Center must **ALWAYS** consider, first and foremost, the safety of mine rescue teams and all other personnel involved in the operation. In mine rescue and recovery work, conditions could change very quickly. A hasty or misguided decision could mean **disaster and the loss of life**. During exploration, the team's safety **MUST ALWAYS** be the **first priority**.

Standard Exploration Procedures and Practices

Team Checks

Regardless of the method the team uses to explore, one standard procedure used is the "team check." There are three main reasons for the team check:

1. To make sure each team member is fit and ready to continue.
2. To ensure each team member's apparatus is functioning properly.
3. To give the team a chance to rest.

The captain conducts the team checks by simply halting the team briefly, asking each member how they feel and checking their apparatus. It's recommended that these team checks be conducted every 15 to 20 minutes. However, the team may not be able (or may not find it feasible) to stop this often. It is recommended to make the first stop for a team check just inby the FAB.

If a team member is feeling unfit to travel or an apparatus is malfunctioning, the team member should communicate this immediately to the rest of the team. Delay in relaying this information to other team members could put the entire team in jeopardy if the issue worsens while advancing.

Communication between team members is critical, and a true assessment of one's condition or state of equipment must be known by all team members as soon as possible, so corrective actions can be taken.

This first team-stop inby the FAB allows a check to ensure all components of the Communication and Tracking Systems are functioning properly. If the team has donned their apparatus, team captains note each member's gauge reading at each rest stop and reports the lowest reading to the FAB and the Command Center. The lowest reading is used as a reference to determine when the team should return to the FAB.

In addition to checking each team member and their apparatus, team stops allow the team a chance to rest. If the team is searching for survivors, you'll probably want to advance rapidly, but rest stops are still important; be sure to allow time for them. Rest stops are also important (perhaps more so) on the return trip. The team will usually be more tired once they've completed their work. Don't forget to allow time for team checks during the travel back to the FAB. How long to stop for each check will be determined by the conditions encountered and the work being performed.

Rate of Travel

The speed or rate of travel underground is usually determined by the team captain. The pace will change continually while exploring and will depend on the changes in the surrounding conditions that occur as the team advances. The travel rate will depend on a number of factors. Poor visibility slows you down as will an obstructed or inclined travelway. The team won't be able to move as quickly if carrying something, such as heavy equipment or an injured person.

The team will naturally be tired on their trip back to the FAB, or if they've been doing strenuous work. The captain should adapt the rate of travel for these situations, and both the captain and tail-captain (5-man) need to very mindful of rest stops for their team members.

Traveling in Smoke

Traveling in smoke always presents difficulties. The biggest problem is not being able to see where you're going as easily. The smoke may be light enough that it limits visibility only slightly, like a light fog or mist. However, it can be so dense that it will completely obscure everything around you.

Dense smoke can conceal the roof, ribs, and other reference points normally used to guide you from place to place and can cause what's known as "spatial disorientation." When spatial disorientation occurs, you lose your sense of "which end is up," so to speak. You may bump into things and perhaps even completely lose your balance and fall down.

For these reasons, when mine rescue teams travel in smoke, all members **must** be joined together by a linkline and attached to a lifeline.

The captain can use a walking stick that is attached to the person through a wrist lanyard or gear keeper as an aid in checking the area in front of the team for roof falls and other obstructions.

There are two methods used to increase visibility while traveling in smoke.

1. Remove your cap lamp and hold it at waist level. It can produce glare in smoke because it sits above eye level. If you've ever tried to travel through dense fog with your car's high beams on, you know how difficult it is to see; low beams produce less glare.

2. Let the lamp hang from its cord to light up the rail or rib that you're moving along. This technique helps you see a little easier because the smoke is usually closer to the mine floor.

If smoke is making visibility very poor, keep in constant physical contact with a rail, a compressed air or water line, or the rib to feel your way.

In certain circumstances (under the direction of the Command Center) conditions may allow the use of a Thermal Imaging Camera in smoke **(less than 1% of methane in the area affected).** When used properly, they can greatly enhance the efficiency and effectiveness of rescue/recovery teams. Remember that these cameras are not MSHA-Approved (non-permissible). Any thermal imaging camera shall be used according to the plan approved by the mine operator for mine rescue and recovery operations. The Command Center should be informed when you consider using one. ALWAYS follow the manufacturer's instructions for use.

Traveling Through Ventilation Controls

As the team advances, you may find it necessary to determine conditions on the other side of doors, man doors, or stoppings, or you may need to travel through them. This is normally done **only** on Command Center orders.

Before going through a ventilation control, the team should first attempt to determine what conditions exist on the other side of it by feeling for heat and looking for smoke. Erect a temporary stopping outby before opening and traveling through any stopping that is inby where the conditions are not **definitely** known. This provides an air lock, so the atmospheres will not mix or alter the current status of the ventilation.

Traveling Through Water

When your team encounters water, the Command Center will usually decide how to deal with the problem. The captain can probe the water depth with a walking stick, if necessary. If the water is not too deep and you can get through it without endangering the team, you will probably just travel through it. It is recommended not to travel through water that is more than knee deep (less in low coal). Using an alternate route may be a better option.

An alternative is pumping it out if you have pumping equipment and the gas conditions in the area permit it. Set up the pump at the FAB (or outby) with non-conducting suction lines leading to the water.

There are hazards associated with pumping water. The water may contain hazardous, water-soluble gases which can be released into the "good" atmosphere outby the FAB. Air that's sucked into the line could carry hazardous gases as well. It is **extremely important** to know the gas conditions at the site.

Crawling or Climbing

While advancing, it may be necessary to crawl or to climb inclines or ladders. This fatigues the team, so only do it when absolutely necessary.

Marking Route of Travel

Even though the lifeline trails behind marking the route as the team advances, the captain or co-captain marks the team's route with chalk or spray paint at key points. Here's how it's done:

- As the team proceeds, the captain or co-captain marks an arrow along the rib at each intersection where your direction of travel changes. The head of the arrow points toward the FAB.

- As the team returns to the FAB, the captain or co-captain draws an "X" through each arrow to show that the team has retreated.

There are two reasons for marking the route of travel: (1) It helps the team find its way back to the FAB, and (2) if a backup team is sent to look for you, it shows them which way you traveled.

Marking Areas Explored

While advancing, the captain marks explored areas by initialing and marking the date on the faces, entries, crosscuts, impassable falls, barricades, stoppings/bulkheads, and at other points where conditions do not permit the team to advance. All of these places should be noted on the map. Marking areas as you explore provides a visual record of what the team did and found.

Inspecting and Testing Roof and Rib

While exploring, the captain takes the lead, inspecting and testing the roof and rib before the team advances into the area.

Visual Inspections

The team captain constantly conducts visual inspections of the roof and ribs while advancing unless heavy smoke makes it impossible. Roof inspections should be made rib to rib. At each face, the captain inspects the face and ribs.

Roof and Rib Tests

Roof tests are conducted when visual inspection indicates the roof or rib is unsafe or in areas where roof conditions are known to be bad and at faces. It may be necessary to test areas where smoke is thick. Poor or unsafe conditions, such as falls of roof or ribs, indicate the need to test (test before extinguishing fires). In addition, the captain makes roof and rib tests when the team erects a line curtain, builds an air lock, or builds a stopping. If conditions permit, roof tests are made rib to rib. If bad roof is encountered, it may need to be timbered before advancing under it. If space permits, simply detour the bad roof by walking around it.

It's standard practice to mark this hazardous area with chalk or some other type of marker, and note the location on the mine map. This makes the hazardous area easy to spot, so it can be detoured again as the team retreats. Although teams use different methods of marking bad roof, leave them in place when retreating, so they serve as a warning to other teams entering the area.

Testing for Gases

Monitoring the mine atmosphere for oxygen, methane, and carbon monoxide is another important element of exploration. Depending on the mine type and the specific situation, there may be a need to test for other gases as well. These tests should be taken at each intersection encountered, at the furthest point of travel into each crosscut, at each dead end, and at the face of each section explored. **Note**: Module 2 gives detailed information on various gases.

It's necessary to conduct gas tests on the other side of doors, curtains, or stoppings/bulkheads prior to traveling through them, especially where there are unknown conditions on the other side. If smoke (or dangerous gas conditions) is encountered, the gas levels shall be frequently monitored while advancing.

When using the wireless communication system, high-range, multi-gas detectors with specialized software and interface, teams can transmit gas readings in "real-time" directly and accurately to the Command Center. It allows for continuous monitoring for gases in specific areas without leaving mine rescue personnel behind to monitor and report gas readings.

Progress Reporting

Information the team relays to the FAB and Command Center during exploration is known as the "progress report." Progress reports keep the Command Center and other personnel directing the operation up-to-date on what your team is doing, where you are, and what you've found. Once the progress report is communicated, the information is used as a basis for making further modifications to the rescue and recovery plan.

The progress report keeps track of your team, so a backup team will know where to find you. The report includes information such as the team's condition, the condition of each member's apparatus, the team's location, and their progress.

As you advance, report the condition of ventilation controls and auxiliary fans. If they are damaged, be specific as to what type of damage they've received and how extensive it is. If doors or stoppings/bulkheads are blown out, report what direction they have blown. Report any damage caused by fire, explosion, or other condition. If you encounter "coking" or coke streamers, report both their location and size. "Coking" as mentioned here, refers to a grey-black residue that is sometimes left behind when coal is burned in the absence of oxygen. Its presence indicates the area has been subjected to extremely high temperatures.

A progress report should include roof and rib conditions, gas conditions, or an encounter with smoke or water. Report the location of tools, materials, and other equipment encountered as you progress. Report whether the power switch is on or off on the tools or equipment. Report the condition of compressed air and water line valves (open or closed) and be sure to include the location of explosive magazines, storage areas for oil, oxygen, and acetylene cylinders.

Report the location and examine the contents of any dinner buckets found because these may offer important clues as to the whereabouts of survivors. Miners are taught to leave notes in their dinner buckets telling where they are if they become trapped.

If you locate survivors or bodies, report it immediately to the FAB and the Command Center. In the progress report, include any other significant conditions, materials, or evidence the team encounters during exploration. When you report anything to the FAB, clearly and correctly identify the location.

Mapping *(Visuals 4, 5, and 6)*

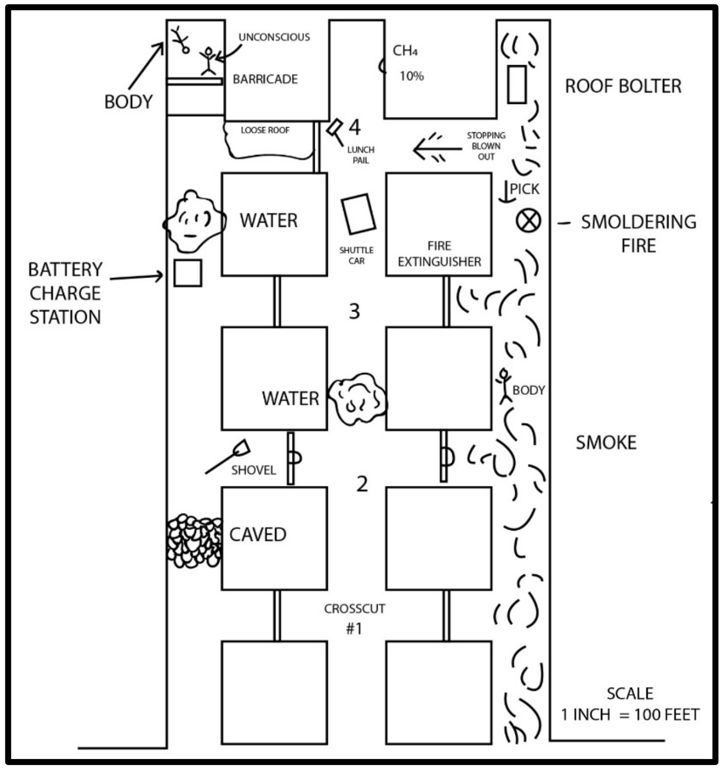
As the team advances, the map person records what the team encounters by marking the information on a mine map. At the same time, the FAB Coordinator marks a mine map with your findings based on what you include in the progress report. The same information is relayed to the Command Center, where a third map is marked with the team's findings.

This "simultaneous mapping" provides the FAB and the Command Center with a visual record of what is happening underground. Accurate, up-to-date maps are critical to a rescue operation. The map person and the Command Center Attendant should practice together to better develop their method of simultaneous mapping.

Officials in charge on the surface use these maps as a basis for making decisions and providing the team with instructions.

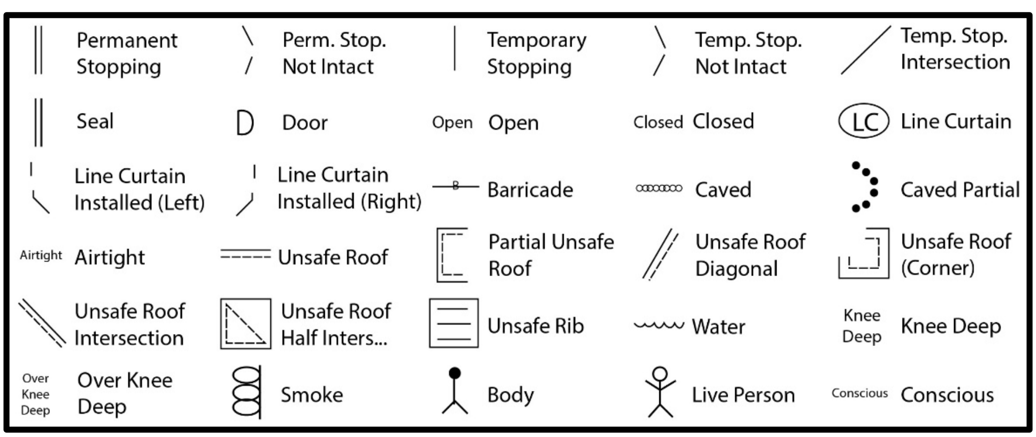
Below is a list of the type of information that should be marked on the map as the team explores. **NOTE**: Use Visual 4 to point out each marking.

1. Bad roof
2. Water
3. Smoke
4. Gas readings
5. Water lines and compressed air line valves
6. Firefighting equipment
7. Any equipment and tools
8. Positions and types of power equipment
9. Survivors and Bodies
10. Storage areas
11. Dinner buckets
12. Condition of ventilation controls
13. Evidence of fire and/or explosion
14. Any other significant conditions, materials, etc.



Visual 4 – Marking the Map

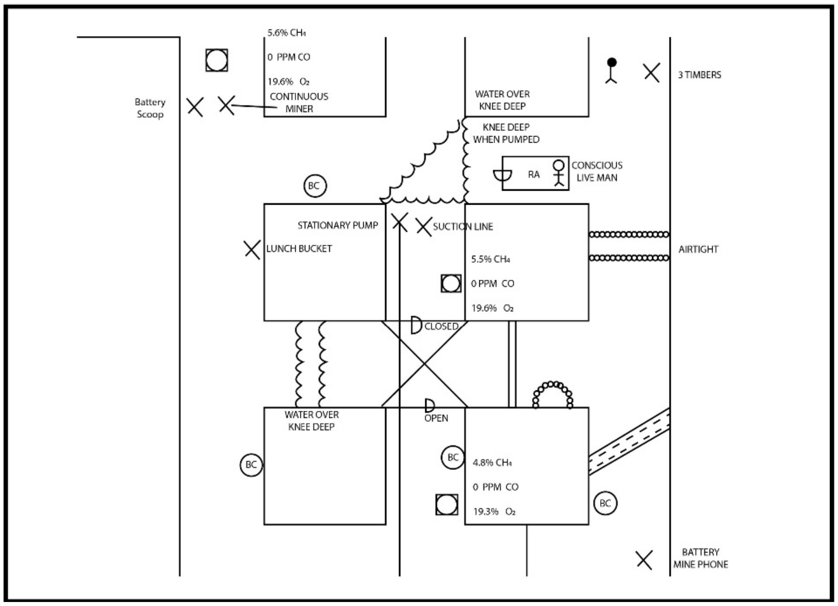
Before exploring, take time to establish a uniform set of map symbols and learn to use them, and be familiar with the scale of the map. Before going underground, ensure you have an adequate mapboard to place under the map.



Visual 5 – Click/Drag Mapping Software Symbols

ALL teams should be trained to use the computer-assisted, electronic mapping systems like those used by MSHA's Mine Emergency Operations (MEO) Division of the Technical Support Program Area. This system incorporates software that includes “click and drag” mapping symbols. Computer-assisted mapping is also included in the National Mine Rescue Contest Rules.

An updated AutoCAD map should be supplied to MSHA’s MEO, which they would use as a base map in their Underground Communication System (USC) software for mapping purposes. This software allows for mapping functionality very similar to the click-and-drag method used in contests with Microsoft Visio®.



Visual 6 - Sample Map Using Mapping Software Symbols

Communication

During mine emergency rescue and recovery operations, effective communication is vital. It is extremely important that teams develop effective skills and methods of communicating among themselves, other teams, the FAB, and the Command Center.

The backup team members should be included in all communications and briefing(s) for the active team(s); this keeps the backup team informed and fully aware of everything that is found and reported by the active team members.

Communication Systems

Discuss and/or demonstrate the Underground Communication and Tracking System used by MSHA’s Mine Emergency Operations (MEO). Provide and facilitate set-up and use of the equipment, when available.

A secure and reliable communication system, utilizing a sound powered communication/lifeline cable and/or radios, must be established and maintained between the mine rescue teams, FAB, and the Command Center.

For radio communications, agree (in advance) on which team members will check and monitor the radio signal strength and connection to the FAB during the rescue operation. You'll need to:

- Ensure that clear radio communication is maintained at all times.
- Determine, in advance, at what intervals and/or locations that signal strength will be checked.

When using radios during exploration, use standard radio terminology and protocol for transmitting and receiving messages. For example, when you call out information:

- Identify the receiver; then identity yourself.
- Always confirm messages received.

Communication with the Fresh Air Base and Command Center

It is essential to stay in contact with the FAB and the Command Center, so the team can report their progress and to receive further instructions as they advance. At a minimum, teams use either sound or battery-powered communication equipment. One team member, usually the No. 5 person, wears the equipment, and is responsible for sending information to the FAB and relaying the FAB instructions to the team.

Using the Lifeline Cable to Communicate *(Visual 7)*

If the team's communication system fails, communicate with the FAB by tugging or pulling on the communication/lifeline system cable. The system's cable must meet requirements set forth in 30 CFR Section 49.6 and 49.16.

At the Fresh Air Base, there should be a lifeline attendant who unwinds the communication line and monitors it to ensure it is not snagging or getting caught on anything. Teams are usually instructed to return to the FAB **immediately** if their communication system fails**.** On the return trip (or if the team is unable to return immediately) they may need to use of lifeline signals.

If the team loses voice contact with the FAB, it is the attendant's job to receive and send signals back and forth to the team by means of the lifeline.

- One pull or tug on the lifeline indicates stop;
- Two indicates advancing;
- Three indicates retreating; and
- Four indicates an emergency or distress.

If the team is stopped at one location for an extended period, or if it is performing a specific task, such as building a stopping or clearing a roadway, it is common practice for the FAB to signal one long pull about every five minutes to check on the team's condition. The team should then acknowledge that they are all right by returning the signal.

When using the lifeline to communicate with the FAB, the captain's signals to the team should also be relayed back to the FAB. The No. 5 person relays the captain's signals to the FAB by repeating them on the lifeline and then waits for the FAB to acknowledge that it has received the signal before sounding a response to the captain's signal. All this is done before the team executes the instructions dictated by the signal.

This is a lot less complicated than it sounds; here's how it works:

- The captain signals to stop in order to halt the team.
- For the benefit of the FAB, Member No. 5 repeats the captain's signal by tugging once on the lifeline.
- The FAB attendant then acknowledges receiving the signal by sending it back to the team.
- Upon receiving acknowledgment from the FAB, Member No. 5 signals it to the captain.
- When the signal is returned, the Captain knows that:
    1. The No. 5 person heard the captain's signal;
    2. The signal has been relayed to the FAB; and
    3. The FAB acknowledged by a return signal.
    4. The team may proceed to execute the command dictated by the signal.

Problems with the Use of the Lifeline

Using the lifeline as a signaling device can present problems. It becomes more difficult to signal with the lifeline if the team has advanced a great distance from the FAB. When the team travels up headings, crosscuts, and entries, the lifeline drags has a tendency to get caught as it travels around corners. Debris and other obstructions encountered may snag the line and limit its use. Using a carabiner or pulley helps mitigate the problem.

Returning to the Fresh Air Base

Typically, more oxygen is needed for the return trip than is needed for the advancing trip. The team needs to pace its work because returning to the FAB on time is important. Remember, the team will be fatigued, so the return trip usually takes longer. Therefore, longer and more frequent rest stops are needed. Carrying a survivor also makes the return trip slower. Take all of these in consideration when planning how much oxygen is needed for the return trip.

The time a team spends underground is usually limited to two hours or less. The exact amount of time is determined both by the underground conditions and the type of apparatus being used. The distance you can advance depends on underground conditions. However, it is often recommended to limit your advance to 1,000 feet. **NOTE**: If your state sets a limit for advance during exploration, be sure to mention the regulation that applies to that at this time.

If the team is late getting back to the FAB and has stopped communicating, a backup team will be sent to look for them even if it means delaying the entire operation. So, if you're going to be late, communicate your intentions to the FAB and Command Center.

Under certain circumstances even when working well within the time limits originally set, your captain may order the team to return immediately to the FAB if:

- A team member's apparatus malfunctions.
- Gas conditions present an imminent explosion hazard.
- There is a fire that will not extinguish.
- There is excessive water.
- There is bad roof that is impossible to detour and too hazardous to secure.

There are certain other conditions that won't necessarily require retreat, but will hinder your team's progress and slow down the team. Such as:

- Encountering water or dense smoke.
- Climbing a steep incline or ladder.
- Crawling even for a short distance.

The team may be permitted to advance under these conditions if it's definitely known that a life will be saved by the action, and if you have the approval of the officials in charge of the operation.

Review Questions and Answers

1. What team signals are used during exploration?
    - *One—stop, two—advance, three—retreat, four—emergency*
2. List four factors that affect a team's rate of travel.
    - *Falls and obstructions, water, smoke, fatigue, amount/weight of equipment carried, degree of slope*

3. Describe how a team marks its route of travel on advance and retreat.
    - *As you advance, the captain or co-captain draws or paints an arrow along the rib at all intersections where your direction of travel changes. (The head of the arrow points toward the FAB.) On retreat, the captain or co-captain puts an "X" through each arrow.*

4. List findings that should be marked on a mine map.
    - *Dinner buckets, bad roof, water, smoke, storage areas, gas readings, valves on air and water lines, firefighting equipment, equipment and tools, power machinery, condition of ventilation controls, survivors, bodies, other significant conditions and materials.*

Debriefing

When you return to the FAB, the team captain will confer with the FAB Coordinator and the incoming team captain to communicate what the team encountered. At this time, they compare maps to ensure their markings correspond. The information the team captain transfers to the backup team includes such things as the traveling conditions encountered, how far you traveled, what gases were encountered, and the roof and rib conditions.

If the team built stoppings/bulkheads, the captain explains what was constructed and what remains to be completed. Be specific about equipment and supplies left in the area. The captain may also make suggestions as to what equipment the ingoing team should take with them.

Once on the surface, your team will attend a debriefing session. Like the briefing session, the debriefing is set aside for information gathering. This time, however, your team **provides** the information; you inform the debriefing official or committee of what you did, saw, and found during exploration. Besides reviewing your team's findings, you'll review the team's map to ensure the markings correspond with the master map. During the debriefing, you are giving general guidance on what you should and should not say to media representatives and to others.

The debriefing session is a very important aspect of exploration. Often, significant details that appeared to be unimportant were simply overlooked in your progress reports, but come out during this debriefing session. The following is a list of important information the Command Center should receive from the team:

- Percentage of assignment completed.
- Location on map of their stopping point (Furthest Point of Advance or FPA).
- Location and Identity of any persons encountered and left in the mine.
- Potential ignition sources encountered (fires, batteries or other sources).
- Ventilation system condition, including the condition of ventilation controls.

- Any condition that hindered or stopped team travel.
- Any specific notable conditions or problems while exploring.
- Any problems with your equipment.
- Additional supplies, including potable water, needed at the FAB.

Review Questions and Answers

Discuss the answers with the team so they fully understand the material covered in this section.

1. Under what conditions/situations might the team captain order your team to return to fresh air immediately?
    - *Malfunctioning apparatus, hazardous roof that cannot be secured, presence of gases that produce an imminent explosion hazard, fire that cannot be extinguished, excessive water.*
2. What information is usually transferred from the outgoing team to the backup team at the FAB?
    - *Markings on mine maps, damages, distance traveled, gas conditions, roof and rib conditions, stoppings/bulkheads constructed, equipment or supplies left in the area, and any other important information.*
3. Why is the debriefing session important?
    - *It provides the surface officials with more detailed information, ensures all important findings are mentioned, provides time to check team's map against master map, and instructs team as to what they should or should not say to media representatives and others.*

Wireless Communications and Tracking Systems

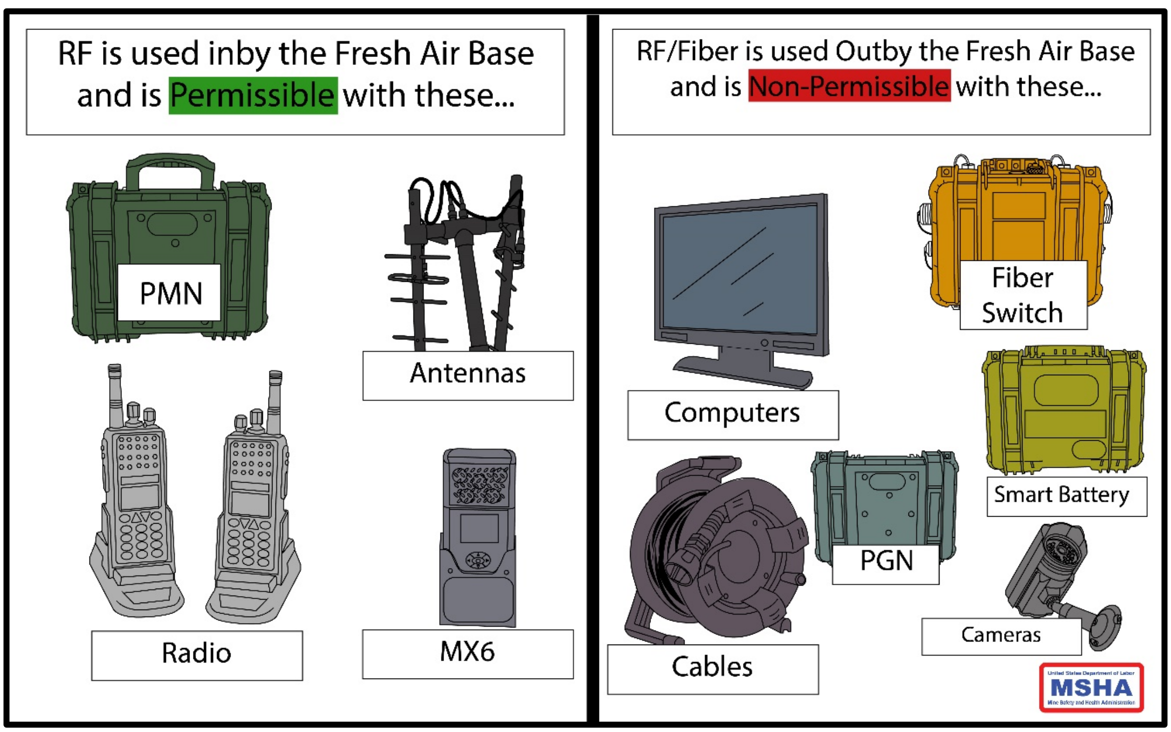
In addition to the Computer-Assisted Mapping, there has been technology developments in mine rescue communications and tracking systems that are now utilized. This system can be deployed to allow for direct, real-time communication between all team members and the Command Center.

These systems enable direct and simultaneous communication between the advancing mine rescue teams, Command Center, FAB, and backup mine rescue teams.

The Command Center now has the capability to continuously monitor (in real time) the progress of the advancing team, along with gas readings from sensors and detectors left in specific areas by mine rescue teams and personnel. As the team advances, or if they are forced to retreat, the sensors will continue to transmit data back to the Command Center.

Underground Communication System Components should always be maintained and used according the manufacturer's recommendations. Equipment needed:

- Gateway
- Yagi or Disc Antenna
- Fiber Switch
- Smart Battery
- Cable Set
- Fiber connection from a fiber reel
- IWT Radios (Minimum: 2)
- Portable MESH Node (PMN)



Visual 8 - Communication System Components

NOTE: If training with multiple teams, create a scenario to help team members better understand the decision-making process of the Command Center. For example:

- Assign *Team A* to explore while members of *Team B* coordinate and direct exploration activities from the FAB and/or Command Center.
- When team A completes their assignment, they return to the FAB and/or the Command Center where Team B will conduct a debriefing session.
- Then, have them switch responsibilities so that *Team B* can explore while *Team A* directs them from the FAB and/or Command Center.

NOTE: Refer to IG 7a – Advanced Skills Training Activities for Coal Mine Rescue.

General Review
Exploration

Choose the correct answer to each of the following questions.

1. Prior to rescue team exploration, the first step to take after a disaster is to:
   a. Examine all mine openings.
   b. Establish a Fresh Air Base.
   c. Proceed as far as possible into the mine without apparatus.
   d. None of the above.

2. The purpose of rescue team exploration is to:
   a. Determine conditions underground.
   b. Locate missing miners.
   c. Locate clues or indications of missing miners' locations.
   d. All of the above.

3. If at all possible, entry into the mine should be made on:
   a. A return airway.
   b. An intake airway.
   c. The main haulageway.
   d. The belt entry.

4. Barefaced exploration should be attempted only when:
   a. No breathing apparatus is available.
   b. Miners are trapped in the mine.
   c. A backup mine rescue team with apparatus is immediately available.
   d. A Fresh Air Base is established.

5. In advancing a Fresh Air Base, after you put up the new air lock, the team should:
    a. Come out of the mine.
    b. Perform gas tests in all dead ends and high places between the old and new FAB ensuring all gases have been flushed out of the area.
    c. Proceed inby the new Fresh Air Base to explore and let other workers check for any gases outby the new Fresh Air Base.
    d. Shut off and remove your apparatus since you are in fresh air and will no longer need it.

6. When exploring in heavy smoke, it is recommended that the team:
    a. Use a linkline to hook all team members together.
    b. Follow along the rail to aid their progress.
    c. Keep in contact with the side to aid their progress.
    d. All of the above.

7. Prior to a mine rescue team passing through a door or stopping/bulkhead behind which conditions are not definitely known, they should:
    a. Ask the FAB to send in the backup team.
    b. Erect an air lock to prevent the mixing of atmospheres.
    c. Open the door or stopping/bulkhead, and wait at least 10 minutes so that any harmful gases are diffused.
    d. Never enter such areas.

8. Gas readings should be taken:
    a. At all intersections.
    b. At any dead end or face area.
    c. At the furthest point of travel in any entry or heading.
    d. All of the above.

9. The captain should mark the date and his or her initials:
    a. Each time the team stops for a rest.
    b. Every 50 feet.
    c. Every 200 feet.
    d. On all explored areas (faces, entries, crosscuts, impassable falls, barricades, stoppings/bulkheads, etc.)

10. Dinner buckets encountered during exploration are important because:
    a. They can contain food and/or water for the rescue team.
    b. They may contain notes that would indicate the whereabouts of survivors.
    c. They indicate where miners ate their dinner.
    d. None of the above.

11. If a team member experiences problems with his or her apparatus inby the Fresh Air Base, the team member should:
    a. Be immediately sent back to the Fresh Air Base.
    b. Be sent back to the Fresh Air Base with another team member.
    c. Switch to the apparatus that was carried on the stretcher or stokes basket.
    d. With the entire team, return immediately to the Fresh Air Base.

12. Debriefings are held to:
    a. Inform news reporters of developments.
    b. Inform family members of developments.
    c. Review the rescue team’s findings after they have returned from underground.
    d. All of the above.

General Review
Answers

1. a
2. d
3. b
4. c
5. b
6. d
7. b
8. d
9. d
10. b
11. d
12. c

Glossary

Air Lock – An area in the mine closed at both ends by doors or stoppings/bulkheads with flaps or doors in them. Used to prevent mixing of different atmospheres while still permitting miners to enter and exit.

Backup Team – Rescue team stationed at the FAB as a "backup" for the working team inby the FAB.

Briefing – Session held before a team goes underground to inform team members of conditions underground and give them their work assignment.

Debriefing – Session held when a team returns to the surface after completing an assignment to review what they saw and did.

Fresh Air Base (FAB) – Base of operations from which the rescue and recovery teams can advance into irrespirable atmospheres.

Lifeline – Rope line or cable from communications system that links the team to the FAB. It may be used as a manual communications system to the FAB [30 CFR 49.16(a)(8)].

Linkline – Line that links team members together. Used in smoke; it is usually a rope about twenty-five feet long with rings onto which each team member will hook.

Progress Reporting – Information the team relays to the FAB as it proceeds.

Standby Team – Team scheduled to be on the surface in ready reserve when rescue teams are working underground.

Tying In – Systematic exploration of all crosscuts and adjacent entries so that the team is never inby an unexplored area.

Advanced Mine Rescue Team Training

Fires, Firefighting, and Explosions

Module 5

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Course Objectives

A. The mine rescue team will be able to competently fight a mine fire and assess underground conditions during a fire and after an explosion.

B. Team members will be able to:

   a. Describe the components of the fire tetrahedron.
   b. List and describe the 5 classifications of fires.
   c. Use firefighting equipment.
   d. Explain how to locate and assess a mine fire.
   e. Demonstrate proper techniques for fighting a fire directly.
   f. Explain the proper techniques for sealing a mine fire.
   g. Explain and describe the causes and effects of explosions.
   h. Explain and demonstrate the proper procedures for assessing conditions following an explosion.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers.

A. Required:

   a. Larger visuals and text-only visuals are provided in the Appendix; use these visuals while discussing the corresponding content.
   a. Pencil and paper for each team member
   b. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams

B. Suggested:

   a. Firefighting equipment the team will use, or pictures of the equipment if it is not available
   b. Chalkboard and/or flip chart
   c. Laptop with a PowerPoint Program

Course Outline

A. Introduction
B. Fires
    a. Fire Tetrahedron
    b. Fire Classifications
C. Firefighting Equipment
    a. Dry Chemical Extinguishers
        i. Hand-Held Extinguishers
        ii. Extinguishers on an Obstacle Fire
        iii. Wheeled Extinguishers
    b. Rock Dust
    c. Water
        i. Waterlines
        ii. Fire Cars
        iii. Fire Cars with Low Expansion Foam
        iv. Applying Water to Fires
    d. High Expansion Foam
        i. Description
        ii. Foam Generators
    e. Review Questions and Answers
D. Firefighting
    a. Before Going Underground
    b. Locating Fires and Assessing Conditions
    c. Direct Firefighting
        i. General Procedures
        ii. Electric Shock and Electrocution
        iii. Toxic and Asphyxiating Gases
        iv. Oxygen Deficiency
        v. Explosive Gases
        vi. Heat, Smoke, and Steam

d. Indirect Firefighting
    i. Sealing Underground
    ii. Temporary Seals
    iii. Permanent Seals
    iv. Sealing on the Surface
e. Review Questions and Answers

E. Explosions
  a. Causes and Effects
  b. Before Going Underground
  c. Indications of Explosion and Assessment of Conditions
  d. Review Questions and Answers

Introduction

Fighting a mine fire may be one of the most frequent duties the team performs. Fires in underground mines are particularly hazardous not only because they produce toxic gases and heat, but they also produce smoke, pose an explosion hazard, and create oxygen-deficient atmospheres.

In this module we will talk about fires and explosions in the mine, how they occur, and how they affect the job of the mine rescue team.

Fires

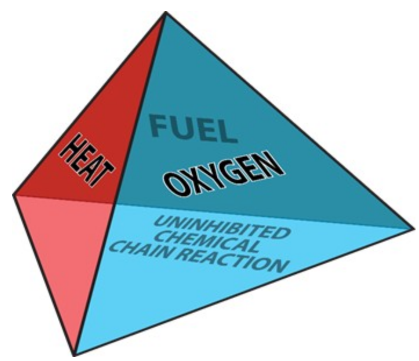
Most fires are the result of a chemical reaction between a fuel and the oxygen in the air. Material such as wood, coal, methane, gas, oil, grease, and many plastics will burn when ignited in the presence of air.

Fire Tetrahedron *(Visual 1)*

A fire triangle was previously used to represent the elements of a fire. This has been replaced by the fire tetrahedron.

The fire tetrahedron is a four-sided geometric representation of the four factors necessary for fire:

1. Fuel (any substance that can undergo combustion).
2. Heat (heat energy sufficient to release vapor from the fuel and cause ignition).
3. Oxidizing agent (air containing oxygen).
4. Uninhibited chemical chain reaction (sufficient exothermic reaction energy to produce ignition).



Visual 1 – Fire Tetrahedron

The fuel/air ratio must be within the flammable limits which describes the amount of vapor in air necessary to propagate flame. Removing any of these four factors will prevent, suppress, or control the fire.

Fighting a fire with water removes the heat. Smothering the fire with noncombustible material such as rock dust, removes the oxygen. Sealing off the fire area is another way of removing oxygen. Loading out hot materials from the fire area removes the fuel.

Another way to extinguish a fire is by stopping the chemical reaction between the fuel and the oxygen. Dry chemical extinguishers operate on this principle. They function to chemically inhibit the oxidation of the fuel.

Exactly how a fire will be fought is usually determined by the materials that are burning and the conditions in the fire area. Consequently, a large part of your job will be to explore the mine and assess the condition of the fire, so the Command Center can decide how to go about fighting the fire.

Fire Classifications *(Visual 2)*

For firefighting purposes know the type of fire you are fighting. The National Fire Protection Association classifies fires into five classes.

Class A fires involve ordinary combustible materials such as wood, coal, plastics, paper, and cloth. They are best extinguished by cooling with water or by blanketing with certain dry chemicals. Think of Class A fires as those that leave Ashes.

Class B fires involve flammable or combustible liquids such as gasoline, diesel fuel, kerosene, and grease. Typical Class B fires can occur where flammable liquids are spilled or leak out of mechanical equipment. They are best extinguished by excluding air or by special chemicals that affect the burning reactions. Class B fires contents are materials that will Boil.

Class C fires are electrical fires. Typical electrical fires include electric motors, battery equipment, battery-charging stations, trolley wires, transformers, and circuit breakers. They are best extinguished by non-conducting agents such as carbon dioxide and certain dry chemicals. If the power has been cut-off to the burning equipment, the fire can be fought as though it is a Class A or B fire. Think of Class C fires as those that involve Current.

A	Common Combustibles	Wood, Paper, Cloth, etc.
B	Flammable Liquids and gases	Gasoline, Propane and Solvents
C	Live Electrical Equipment	Computers, Fax Machines
D	Combustible Metals	Magnesium, Lithium, Titanium
K	Cooking Media	Cooking oils and Fats

Visual 2 - Five Classes of Fires

Class D fires involve combustible metals such as magnesium, titanium, zirconium, sodium, and potassium. Special techniques and extinguishers have been developed to put out these fires. Normal extinguishers generally should not be used on a Class D fire since they could make the fire worse. Class D fires are not frequently found in coal mines.

Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens. These are best extinguished by a special wet chemical extinguishing agent.

Firefighting Equipment

Mines usually have a number of different types of firefighting equipment available:

- Dry chemical extinguishers
- Rock dust
- Water
- High expansion foam

NOTE: See **30 CFR Part 75 Subpart L – Fire Protection and Part 57 Subpart C - Fire Prevention and Control** for further details regarding the Federal requirements on firefighting equipment. If the team uses other equipment, discuss that equipment in addition to these materials. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams.

Dry Chemical Extinguishers

Dry chemical extinguishers put out fires by stopping the chemical reaction between the fuel and oxygen (which produces the flame). The dry chemical agents work to inactivate the intermediate products of the flame reaction, resulting in a decreased combustion rate (rate of heat evolution) and thus extinguishing the fire.

There are basically two types of dry chemical extinguishers: hand-held and larger wheeled extinguishers. Hand-held extinguishers range in size from about 2 to 55 pounds. Wheeled extinguishers can weigh from 75 to 350 pounds. These consist of a large nitrogen cylinder, a dry chemical chamber, and a hose with an operating valve at the nozzle.

NOTE: Adding supplement material with specific information on the type and size of the hand-held extinguishers and wheeled extinguishers the team uses is recommended. **Always follow the manufacturer's recommendations.**

It is generally recommended that mine rescue teams use multi-purpose dry chemical extinguishers which contain monoammonium phosphate because they are effective on Class A, B, or C fires. Plus, having monoammonium phosphate extinguishers eliminate the team's need for a separate extinguisher for each class of fire that may be encountered.

Hand-Held Extinguishers *(Visual 3)*

Before using any type of hand-held extinguisher, check the label on the side of the extinguisher. Be sure to use the correct one for the fire you will be fighting. Using the wrong type could result in spreading a fire rather than extinguishing one. Always follow manufacturers' recommended procedures when energizing a cartridge type fire extinguisher.

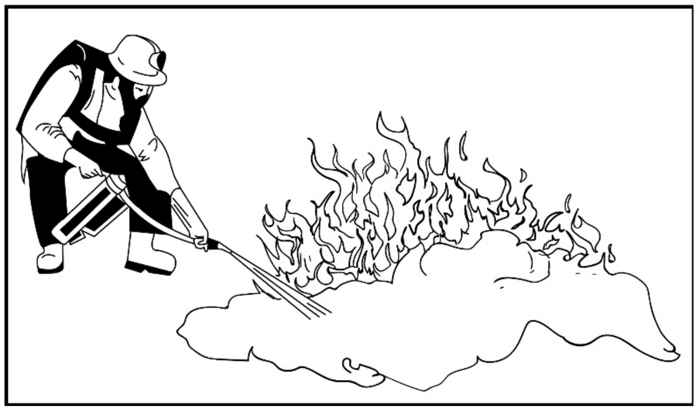
The extinguisher's label provides the proper distance that it will be most effective at fighting the fire. Most small dry chemical extinguishers are effective 5 to 8 feet from the fire; larger units have ranges of 5 to 20 feet.

You will not put out the fire using an extinguisher that is effective for 5 to 8 feet while standing 10 to 15 feet from the fire. It may waste both valuable time and the contents of the extinguisher.

To operate a hand-held extinguisher, grasp it firmly and approach the fire from the intake air side while holding the nozzle downward at a 45-degree angle. You should stay low to avoid any rollback of the flames and try to get within 6 to 8 feet of the fire before discharging the fire extinguisher.

Use the **PASS** system for operating a fire extinguisher.

- **P**ull the safety pin.
- **A**im hose/nozzle at the base of the fire.
- **S**queeze handle to discharge.
- **S**weep rapidly side to side to extinguish the fire.



Visual 3 – Using a Hand-Held Fire Extinguisher

There should be a second extinguisher nearby, and never turn your back to the fire after it has been extinguished due to possible re-ignition.

To effectively and quickly put out the fire, direct the stream of dry chemical about 6 inches ahead of the flame edge. Begin far enough away to allow the discharge stream to fan out and use a deliberate side-to-side motion as you cover the fire with the dry chemical. Each sweep should be slightly wider than the fires edge.

As you put out the fire closest to you, advance slowly toward the fire, forcing it back. Always be on the alert for possible re-ignition even though it appears to have been extinguished. The discharge time of hand-held extinguishers varies from 8 to 60 seconds depending on the size and type. A 30-pound extinguisher normally lasts 18 to 25 seconds. As a safeguard, maintain control of it, so you don't expose other people to the dry chemical.

Extinguishers on an Obstacle Fire

If you encounter an obstacle fire with flaming equipment at its center, the fire should be fought by two people using hand-held extinguishers. It is difficult and sometimes impossible for one person to put out this type of fire.

The two firefighters should approach the fire together from the intake air side while holding the extinguisher nozzle downward at a 45-degree angle. Both streams of dry chemical should be directed at 6 inches ahead of the flame edge.

The two firefighters should split up and slowly advance around each side of the obstacle while trying to keep up with each other as much as possible. Each person should cover two-thirds of the fire area using a side-to-side sweeping motion. When the fire appears to be extinguished, both firefighters should remain on the alert for a short time in case the fire re-ignites.

Wheeled Extinguishers

To operate the wheeled extinguisher, first open the valve on the nitrogen cylinder. This forces the dry chemical through the hose to the nozzle. Control the hose discharge by adjusting the nozzle operating valve.

The method for approaching the fire and putting it out is the same as the method used with the hand-held extinguisher. Use a sweeping motion and direct the dry chemical stream to about 6 inches ahead of the flame edge.

Rock Dust

Rock dust is a fire extinguisher material that is readily available in most areas of the mine. It smothers the fire by eliminating the oxygen. Rock dust can be used on Class A, B, or C fires.

Rock dust is most successfully used to fight a fire when applying it by hand to the fire or by shoveling it onto the fire.

Rock dusting machines are usually available in the mines; however, they should not be used when a fire is involved because they generate air to disperse the rock dust. This air could fan the fire and increase its intensity.

Water

Water acts to cool the fire and removes the heat from the fire tetrahedron. Water is an effective extinguishing agent on Class A fires. In most mines, the water needed to fight fires can be provided by two sources: waterlines and fire cars.

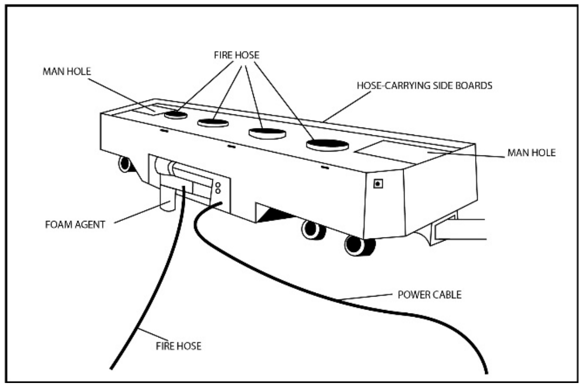
Waterlines

In working sections of the mine that produce over 300 tons per shift and that do not have portable firefighting equipment, waterlines are required. Under Federal regulations, waterlines are required to extend to each section loading point and to be equipped with enough fire hose to reach each working face.

When fighting a Class A fire and a waterline is available, simply hook up the fire hose to the waterline.

Fire Cars *(Visual 4)*

Fire cars (water cars or chemical cars) are available in some mines. These may be mounted on tires or flanged wheels and can be pushed or pulled to the fire area. The components of a fire car can vary from a water tank, pump, and hose to a more elaborate version that contains a wider selection of firefighting equipment such as water, large chemical extinguishers, hand tools, brattice cloth, and rock dust.



Visual 4 - Fire Car

Fire Cars with Low Expansion Foam

Some fire cars contain a foam agent that can be hooked up to the water hose along with a special foam nozzle to produce low expansion foam. The foam works to extinguish the fire by simultaneously smothering and cooling it.

Low expansion foam is very wet and heavy. It does not move down an entry as high expansion foam does. Low expansion foam can only be used when you're close enough to the fire to force the foam directly onto the fire.

NOTE: Supplement this with more specific information on the low expansion foam the team uses. Always follow the manufacturer's recommendations.

Applying Water to Fires

The best way to fight a fire with water is to aim the water stream directly at the burning material. Use a side-to-side sweeping motion to wet the entire burning surface. Where possible, break apart and soak any deep-seated fires and stand by to extinguish any remaining embers.

Several different kinds of water nozzles are available for the hose. Some produce a solid stream of water, some produce a fog spray, and others are adjustable (like a garden hose nozzle) to produce a solid stream or a spray. Solid stream nozzles are best to use when it is necessary to project the water a long distance. For shorter distances, a fog spray is better to use because it usually will extinguish a fire more quickly than a solid stream.

High Expansion Foam

High expansion foam is used mainly to contain and control the fire by removing two parts of the fire tetrahedron - oxygen and heat. The tremendous volume of the foam acts to smother and cool the fire at the same time. Foam is useful only in fighting Class A or B fires. It can travel long distances to a fire without breaking down due to the foam being light and resilient.

As a result, it is very effective and used most commonly in controlling stubborn localized fires that cannot be approached at a close range because there is too much heat or smoke or the fire is spreading too rapidly. When using foam, firefighters can be quite a distance from the actual fire. Five hundred feet is a common distance although there have been successes in the past where foam was used from more than 1,500 feet.

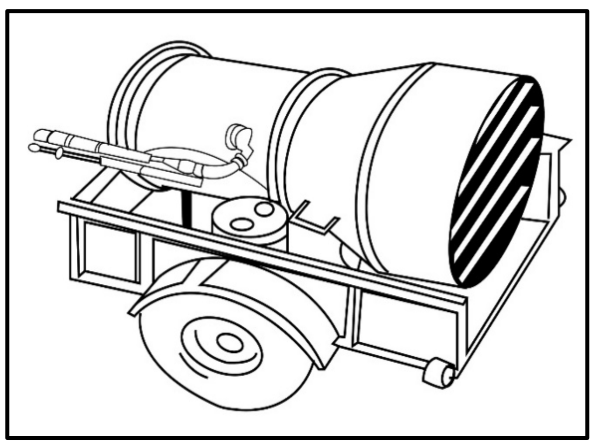
High expansion foam is normally used just to control a fire. Once conditions permit, teams are usually sent in to fight the fire more directly. It is recommended that teams do not travel through foam-filled areas. Before entering such an area, teams should clear the foam as much as possible. One way of doing this is to use a solid stream of water to knock the foam down and clear the area.

Some foam generator manufacturers recommend that personnel should not travel through foam since hearing becomes difficult, vision is blocked, and breathing becomes uncomfortable. There is the added hazard of slipping and falling in the foam. Some manufacturers recommend that personnel do not wear self-contained breathing apparatus, gas masks, or other breathing apparatus into the foam. However, **if the team *must* travel through foam, it is essential they use a linkline to ensure that no one gets lost in the foam.** It is important that the team travel along the track or rib where the best footing is most likely to be.

Foam Generators *(Visual 5)*

The high expansion foam is made by mixing water, air, and a foam concentrate or detergent in a foam generator. Foam generators are portable and come in different sizes with different foam-producing capacities. The smaller models may be hand-carried by two people or wheeled into position. Larger models may be mounted on rubber tires or transported on a track-mounted mine car.

There are water-driven models and electric- or diesel-powered models. In the water-driven models, the foam is produced as the water or detergent mixture is pushed by water pressure through nylon netting or screen. Other models have a blow fan to produce bubbles and push them out.



Visual 5 - Foam Generator

How to Use a Foam Generator

There are different models of foam generators; each model has its own method of operation. This section only supplies general information; include specific information on how to operate the model that the team will be using; always refer to and follow the manufacturer's recommendations.

There are different methods of using foam to fight a fire. In one method, the foam generator is positioned outby the fire, and plastic tubing is attached to the foam outlet. The tubing is designed to unroll as the foam passes through it, leading the foam directly to the fire area. Another method is to first create a confined area, so the foam can be pumped onto the fire to completely fill or plug the fire area. This is done by building a stopping with an opening for the foam generator. The foam generator is set up at the opening and braced or fastened down if possible. The generator can then be started, and foam will begin filling the area. Sometimes plastic tubing is attached to the generator to direct the foam to the fire area.

If needed, a team can use the generator in stages, moving it closer to the fire as the fire is brought under control. Before traveling through a foam-filled area, knock down the foam with water to clear a path to safely walk along.

Review Questions and Answers

1. Discuss the characteristics of the five classes of fires and what extinguishing agents should be used when fighting each of them.
    - *Class A fires are those that involve ordinary combustible materials such as wood, plastics, paper, and cloth. They are best extinguished by cooling with water or by blanketing with certain dry chemicals.*
    - *Class B fires involve liquids such as gasoline, diesel fuel, kerosene, and grease. They are best extinguished by excluding air or by special chemicals that affect the burning reactions.*
    - *Class C fires are electrical fires and are extinguished by non-conducting agents such as carbon dioxide and certain dry chemicals.*
    - *Class D fires involve combustible metals such as magnesium, titanium, zirconium, sodium, and potassium. They are extinguished by special extinguishing agents designed for such applications.*
    - *Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens. These are best extinguished by a special wet chemical extinguishing agent.*
2. Discuss each piece of equipment, location, and how to use each to fight underground fires.
    - *Hand-held extinguishers*
    - *Wheeled extinguishers*
    - *Water cars*
    - *Fire cars*
    - *Waterlines*
    - *Foam machine*

Firefighting

Before Going Underground

When a team begins to explore or fight a fire, it should be concerned with two main things - spreading of the fire and the possibility of an explosion. Before going underground, the team should make sure that the main fan is running, that a guard is monitoring the fan operation, and that tests are being made at the main returns for gases that may be present in the mine.

It is important to monitor the levels of oxygen, carbon monoxide, and any explosive gases. Ventilation should always be continued through the mine during a fire in order to carry explosive gases and distillates away from the fire area and to direct the smoke, heat, and flames away from the team.

No sudden changes should ever be made to the ventilation. If the main fan is off or destroyed, the Command Center will need to make careful plans before starting the fan, and everyone should be out of the mine before the fan is started.

Before going underground, the team should know all possible **ignition sources** that may exist in the affected area, such as battery-operated or diesel equipment. Find out if there are any underground **storage areas for explosives, oil and grease, or oxygen or acetylene cylinders** in or near the affected area.

If there is **electrical power** to the affected area, it is usually recommended to disconnect it to prevent the arcing caused by damaged cables from becoming an ignition source. Disconnecting power could cause the loss of power to auxiliary fans or booster fans underground. Power will also be lost to other electrically powered equipment, such as a pump; losing a pump could result in major flooding. These are some factors the Command Center takes into consideration when deciding whether to disconnect the power.

Most of this information should be available to the team at the time of their briefing. However, some of the very specific information about what is in or near the affected area and whether equipment has been left energized can only be determined by the exploration teams as they advance. **NOTE:** Briefing Information is covered in Module 4 – Exploration.

Prior to and immediately after firefighting, each team member needs a carboxyhemoglobin test to determine how much carbon monoxide (CO) is in their bloodstream. Each member's onsite CO rate should be compared to their base rate obtained annually during their physical examination to determine if dangerous levels are present. If a team member has absorbed too much CO, they should not be permitted to reenter the mine until the CO level is reduced. For this test, a small amount of blood is drawn and tested for the presence of carbon monoxide.

Locating Fires and Assessing Conditions

Two of the main exploration objectives during a fire are locating it and assessing the conditions in and near the fire area. Once the conditions are known and reported to the Command Center, the officials can determine how the fire should be fought. They will want as much information as possible about the fire: where it is, what's burning, how large it is, and what the conditions are near the fire area.

Before entering the mine, there may already be information about the fire location. The first report of a fire will often have been from miners working near the fire area. They may have reported seeing smoke and/or flames before evacuating the mine. These reports help pinpoint the location of the fire and determine its magnitude. Carbon monoxide and/or smoke coming from the main fan or main return are obvious indications that a fire exists.

Lab analysis of air samples from the main fan or return will give an accurate analysis of the gases that are present and help provide information on what is burning. The amount of carbon monoxide found in the sample gives some indication of the magnitude of the fire.

Some information can only be obtained by rescue teams exploring the mine. The teams can roughly pinpoint a fire and assess its magnitude by reporting where and how heavy the smoke is and by feeling stoppings/bulkheads and doors for heat. If a small fire is encountered while exploring, extinguish it immediately by using fire extinguishers, rock dust, or water from a nearby waterline. Dealing with larger fires requires more equipment and careful planning.

During exploration, gather as much information as possible about the conditions in or near the fire area. Report all information to the Command Center as soon as possible in order to keep the officials up-to-date with the team observations.

Take gas readings in the returns near the fire area to determine if the mine atmosphere is potentially explosive. Some damage to ventilation controls are expected during a mine fire, so be aware of their condition. Always check the roof and rib conditions carefully in the fire area because the heat can weaken them.

With all this information, the Command Center will have a fairly good indication of where and how large the fire is. Officials will then be able to decide how to control or extinguish the fire - whether to fight it directly or indirectly by sealing the mine.

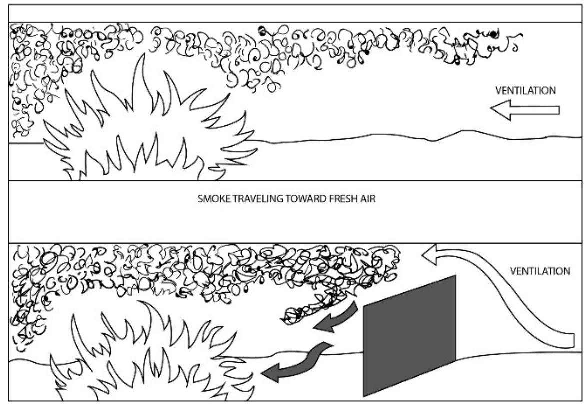
Direct Firefighting *(Visuals 6 and 7)*

Fighting a fire "directly" means that an extinguishing agent is put directly onto the fire to put it out. This usually means that firefighters will have to get relatively close to the fire in order to use fire extinguishers, water, rock dust, or foam.

When fighting a fire directly, always approach and fight it from the intake air side, if possible. This ensures the smoke and heat will be directed away from the team.

If the fire begins to back up against the intake air in search of oxygen, put up a “transverse” brattice from rib to rib leaving an open space at the top. This increases airflow at the roof and slows down the progress of smoke and flame into the intake air current.

The brattice should cover about half to two-thirds of the area from the floor to the back. Do not run the brattice too high or it will cut off airflow over the fire which could result in an explosion.



Visual 6 – Transverse Brattice

If heat, smoke, and ventilating air currents permit, water is the most desirable and efficient means of fighting a fire, provided it is not an electrical fire. To fight a fire with water there must be a sufficient water supply, sufficient water pressure, and available hose lengths to reach the fire. When it is impossible to approach the fire for direct firefighting, foam or water can be pushed over the fire area to slow down the fire which will allow the team to get closer to in order to fight it more directly.

Hazards of direct firefighting include electric shock, electrocution, toxic and asphyxiating gases, oxygen deficiency, explosive gases, heat, smoke, and steam.

Electric Shock and Electrocution

Electric shock and electrocution are hazards to firefighters using water, foam, or other conductive agents to fight a fire. For this reason, it is usually recommended that the power to the fire area be cut off regardless of the type of fire. This is done not only to eliminate the electrical hazard, but also to cut the power to any electrical components that may be involved in the fire.

Toxic and Asphyxiating Gases

Carbon monoxide is toxic and is produced by fires due to incomplete combustion of carbon materials during the burning process. Fire produces carbon dioxide even though it is a product of complete combustion. Carbon dioxide is an asphyxiant. Breathing large amounts of it causes rapid breathing and insufficient intake of oxygen. Too much in the bloodstream can cause unconsciousness and death.

Other gases such as hydrogen sulfide are even more toxic than carbon monoxide. They are produced by burning rubber, neoprene, or polyvinyl chloride (PVC) which are frequently found in electrical cables, conveyor belts, or tires on machinery. Even small fires can be extremely toxic; therefore, it is important to wear a breathing apparatus when encountering underground fires.

Oxygen Deficiency

Fire consumes large quantities of oxygen, so wear the breathing apparatus when dealing with mine fires.

Explosive Gases

The buildup of explosive gases, such as methane and hydrogen, are very real hazards for teams during direct firefighting. That is why it is so important to maintain a sufficient and consistent flow of air over the fire area.

Methane is the most common explosive gas found in coal mines. Its explosive range is 5 to 15 percent when there is at least 12.1 percent oxygen present.

Hydrogen is highly explosive in mine atmospheres. Its explosive range is 4.0 to 74.2 percent when there is at least 5 percent oxygen present. It is produced by the incomplete combustion of carbon materials during fires. Additionally, hydrogen can be liberated when water or steam comes in contact with hot carbon materials like when water, water mist, or foam is used to fight fires.

Small hydrogen explosions (known as hydrogen pops) are fairly common in firefighting. The bigger hazard with hydrogen is the possibility of it accumulating to a large enough extent to cause a violent explosion. Adequate ventilation over the fire area will help prevent the buildup of these and other explosive gases.

The fan should **never be stopped or reversed** while teams are underground because it could force unburned distillates back over the fire area; thus, increasing the magnitude of the fire. If the fan slows or stops, teams should immediately leave the fire area. If it continues to run slowly (or remains stopped) or if explosive concentrations are detected in the return air of the fire, teams and other underground personnel should leave the mine entirely before the fan is restarted.

Heat, Smoke, and Steam

Heat, smoke, and steam are other hazards to the team and will determine how close and how long the team can work. Working in a hot, smoky, or steamy atmosphere can be extremely uncomfortable.

Smoke not only limits visibility, but it also causes disorientation. Even walking is difficult due to not being able to judge your position in relation to the surroundings as you normally do. This lack of orientation may cause you to lose your sense of balance. Working in a hot and/or steamy atmosphere tends to exhaust you quicker and cause additional stress on your system, especially when you're working hard.

Heat tends to weaken the roof in the fire area, especially in mines where head coal is left. To protect yourself from weak roof, test the roof near a fire area frequently and bar down any loose material.

During firefighting smoke and steam will be less dense near the floor of the mine and worse near the roof of the mine. Adequate ventilation over the fire area should carry the smoke, heat, and steam away from the team. Again, if it begins to back up against the flow of intake air, put up a transverse brattice *(Visual 6)*.

Indirect Firefighting

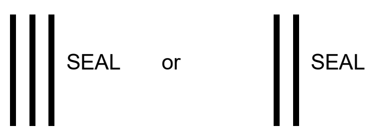
Fighting a fire directly can be ineffective or not possible due to hazards such as high temperatures, bad ground, or explosive gases. In these cases, it may be necessary to fight the fire from a distance, or "indirectly" by sealing the fire or by filling the fire area with foam or water. The indirect methods work by excluding the oxygen. The foam or flood of water also serves to cool the fire.

These indirect methods allow the firefighters to remain at a safe distance while they work to control and fight a large or otherwise unapproachable fire.

Sealing Underground

The purpose of sealing a fire is to contain it to a specific area and to exclude the oxygen and eventually smother it. Sealing can be done to isolate the fire so that normal mining operations can be resumed in other areas of the mine. Sealing mine fires underground is a complex issue to which no one set of procedures will apply. There are many factors that determine the methods used and the eventual success of the sealing operation.

There are two types of seals: temporary and permanent. Temporary seals are often put up before permanent seals are erected in order to seal off a fire area as quickly as possible. Usually permanent seals are then constructed outby the temporary seals to seal off the fire area more effectively. The map symbol for seal is three straight lines or two straight lines with the word "SEAL" printed after them. **NOTE:** Draw these symbols on a chalkboard or flip chart, if possible.



Temporary seals are built to be fairly airtight. They are usually constructed of brattice cloth, concrete blocks, metal panels, or boards.

Permanent seals are built to specifications in the engineering design, and designed to withstand a minimum of 50 psi or 120 psi dynamic force resulting from an explosion. A permanent seal can be constructed using a variety of materials. The most commonly used materials in approved seals are lightweight cementitious material, reinforced concrete, glued concrete blocks, or solid concrete plug.

The officials at the Command Center will decide what types of seals to erect based on all the information they have concerning the fire. Some factors that the Command Center considers when planning to seal a fire are:

- The **volatility of the coal seam**. High volatile coal seams burn much faster than low or medium volatile coal. Sealing a fire that involves high volatile coal is often necessary because fighting the fire directly is very difficult.

- The **amount of methane liberated by the coal seam**. The potential for explosion increases as the methane count increases.

- The **location of the fire and the area involved**. This determines the number of seals necessary and where they should be placed.

- The **presence of head coal and composition of roof strata**. In mines where head coal is left, a fire will spread more rapidly. Certain roof strata is greatly weakened by fire and heat and may be too hazardous for the team.

- The **availability of construction materials and the means of transporting them to the sealing sites**. This factor affects the type of seal that will be built. Oftentimes in urgent situations, seals (especially temporary seals) are built with materials that are readily available.

- The **building sites for the seals**. These sites are determined by the fire location, how fast it is spreading, the ability to control ventilation in the fire area, the gas conditions present, and the volatility of the burning coal seam.

Fires involving high volatile coal are often sealed more than 1,000 feet from the fire while fires involving low volatile, non-gassy coal are sealed close to the fire.

One reason seals are erected as far as possible from a high volatile coal fire (1,000 feet more) is to allow sufficient time for the rescue teams to leave the mine before an explosive gas mixture forms inby the seals. In short, the Command Center decides where, **approximately**, to build the seals, what materials to use, and in what order to build the seal(s). As for the team's responsibilities in sealing, it's up to the team to pick the **exact** site within the designated entry or heading for building each of the seals and to do a good job in constructing the seals.

When picking a site for temporary seals, look for good roof and even roof and rib surfaces. When building a temporary seal, always build it far enough into the entry or crosscut to allow enough room and good roof outby it, so a permanent seal can be built. If the only site available for sealing has bad roof, it may be necessary to bar it down and support it with posts before beginning to build the seal.

Temporary Seals

Temporary seals can be built using Metal Paneling, Brattice Cloth, Concrete Blocks, and Wood.

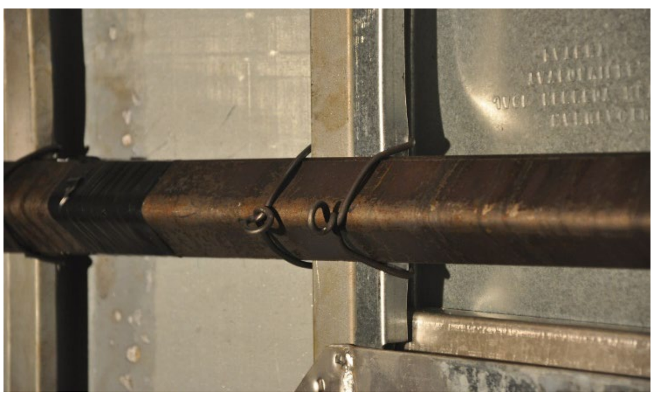
Types of Temporary Seals *(Visuals 8-1, 8-2, and 8-3)*

1. **Metal Paneling** is also called a "Kennedy" Stopping. The panels are 12 inches wide and are adjustable in height sizes of 4 to 8 feet and 6 to 10 feet.

   Four (4) rails must be installed from rib to rib, and the rails are hitched into the ribs at about 3 feet from the roof and 3 feet from the floor. A "panel jack" is attached to the bottom of the panel and under the top of the panel. A piece of Styrofoam is placed on the top of the panel, and then the panel is "jacked" or raised to fit firmly against roof.

Visual 8-1 - Jack

   Once jacked up, the panel is attached to the rails through the use of a securing hook, 2 on each side at the rails; the hook is twisted to secure the panel to the rails. This process is continued until the entire width of the entry or crosscut is covered with panels. After all panels are installed, a fireproof sealant must be applied to cover the Styrofoam at the top and to seal any opening between and around the panels.



Visual 8-2 - Hooks on Rail

Visual 8-3 - Stopping with Sealant

2. **Brattice Cloth Temporary Seals**

   There are three ways to erect brattice seals. With the first method, the brattice, canvas, or plastic can be attached to the roof and ribs with spads. The surplus brattice at the bottom is weighted with timbers or other loose material to keep the seal closed.

   The other two methods require nailing the brattice to a framework of posts and boards that are set in a solid and well-squared location. The brattice is cut and nailed to the framework and to the ribs, if possible.

   To obtain maximum tightness, it may be necessary to foam the edges of the seal and to shovel loose material against and along the bottom. With reasonable care, a brattice cloth seal can be constructed that will allow only slight air leakage.

   Where time is not a serious factor and a fairly tight seal is required, a more substantial brattice cloth seal can be erected. To build this seal, set posts about one foot from each rib and one or more posts in between. Be sure to set the posts firmly on solid ground. Nail boards across the top, center, and bottom of the posts. The boards should extend from rib to rib, and place the top and bottom boards as near as possible to the roof and floor.

   When ribs are irregular, short boards (extending from the top to the center boards and from the center to the bottom boards) are nailed along both sides of the framework. They should roughly follow the rib curvature.

   A piece of brattice cloth, canvas, or plastic should be nailed to the boards. The material should be cut large enough to cover the opening, with a small surplus on the sides, top, and bottom. It may be necessary to double or triple the thickness of the material to improve the air tightness of the seal.

   To close small openings around the edges of the seal, small pieces of boards should be used to push the brattice cloth into all irregularities of the roof, ribs, and floor and should be nailed into place.

   To obtain maximum tightness, it may be necessary to caulk the edges of the seal and to shovel loose material against and along the bottom. With reasonable care, a brattice cloth seal can be constructed that will allow only slight leakage of air.

3. **Concrete Block Temporary Seals**

   Concrete block seals can be put up fairly rapidly especially if they are laid dry. To lay them dry, the blocks should be built up on a solid bottom, one layer at a time. The last layer of blocks should be wedged between the top of the seal and the roof. Caulk the edges of the seal with cement or other suitable caulking material. Seal the edges and plaster the seal with cement or other suitable sealing material to make it as airtight as possible.

4. **Wood Temporary Seals**

   Various kinds of boards can be used to construct wood seals. Usually, rough boards of various widths and about one inch thick are used. However, if a tighter seal is desired, it is better to use tongue-and-groove boards or shiplap boards. Nail boards horizontally on a framework of rib and center posts. Wedge the posts inward and hitch in the bottom. If possible, dig a shallow hitch in the roof, ribs, and floor. The boards should be fitted snugly into the hitch as the seal is erected.

   The boards can be overlapped at the center of the seal if they are too long to fit perfectly. This will save time by eliminating the need to saw the boards.

   If using ship-lap boards, nail them onto the framework, starting from the top and overlapping each board while working your way down. After the boards have been nailed to the framework, the edges of the seal should be caulked with cement or other suitable caulking material.

   If rough lumber is used and sufficient brattice cloth is available, the entire surface of the seal needs to be covered with a layer of the cloth. If brattice cloth is not available, seal the edges and plaster the seal with cement or other suitable sealing material to make it as airtight as possible.

Considerations for Temporary Seals

- **Air Sampling Tubes**

  When building temporary seals, include provisions in some of the seals for collecting air samples within the sealed area. Non-metallic pipes or tubes with valves on them are used for this purpose - usually 3/8 inch Tygon tubing because it is light and flexible.

  This air sample tube can be placed anywhere in the seal and should extend at least to the second crosscut inby the seal in order to get a good representative sample of the air that is close to the fire. Depending on the situation, this can vary from about 40 to 100 feet.

  The tube can be suspended from the roof by tying it to timbers or roof bolts. The number of seals in which air sampling tubes should be placed will depend on the sealed area, the number of seals used, and their positions.

- **Ventilation** *(Visual 10)*

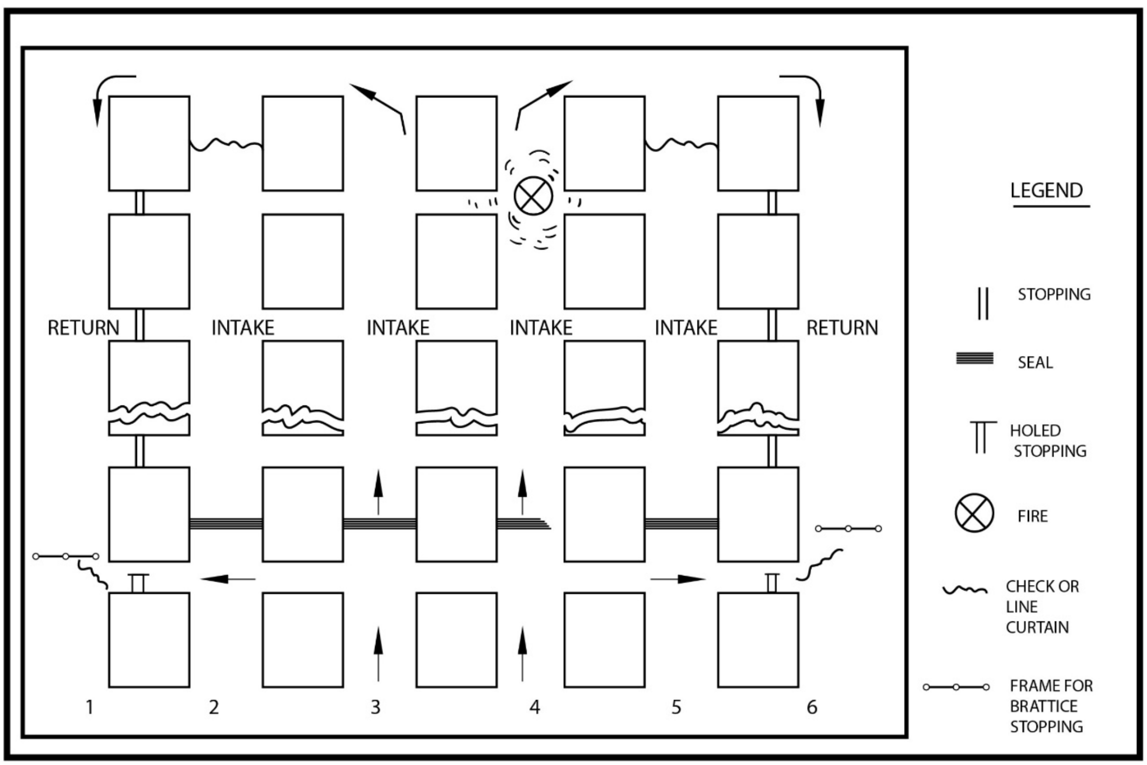
  When building temporary seals, one of the most important things is ventilation. Ensure that there are no abrupt ventilation changes over the fire area. A steady airflow must continuously move over the fire to carry away explosive gases, distillates, heat, and smoke.

  When sealing a mine fire, the only way to keep the air flowing over the fire area is to leave one intake airway and one return airway unsealed while other airways are being sealed. Then, as a final step, the last intake and return can be sealed simultaneously. This will enable ventilation to continue over the fire area until both seals are completed.

Sometimes two teams are used to simultaneously seal the last intake and return. The teams should be in constant communication with each other or with a coordinator in order to synchronize the simultaneous construction.

Usually, fires are sealed far enough from the fire, so the heat and pressure in the sealed area do not affect the seals. In some cases, however, the only site available is close to the fire area where the heat and smoke are very intense in the returns. As a result, the mine rescue teams will not be able to work in the returns for very long. In such a situation, the fire area can be systematically sealed to protect the team as much as possible.

Entries 2, 3, and 5 (Visual 10) can be sealed first. Entry 4 will be the last intake entry to be sealed. When Entries 2, 3, and 5 are sealed, the surplus intake air can be coursed by a brattice line to the returns, one at a time. The teams can then construct the framework for the return seals while working on the FAB side of the curtain.



Visual 10 – Sealing Procedure

Posts can be set, framework nailed on, and double or triple thickness of brattice cloth cut to fit the framework. The cloth is then rolled up and nailed to the tops of the framework, not to be dropped until the very end of the sealing operation. This can be done by two team members at a time, with the other team members in fresh air only a few feet away.

When Entries 2, 3, and 5 are sealed, the last seal in entry 4 can be built. While it is being built, only necessary help should be retained – the surplus should be sent out of the mine.

When the intake seal is finished, the pressure will be reduced in the returns and the brattice curtains can be immediately dropped by the rescue teams, spaded to the ribs and weighted at the bottom – all within a couple of minutes. The teams then immediately leave the mine.

If the seals do not hold due to the heat or pressure within the sealed area, the fire area will have to be resealed further away from the fire.

- **Explosions**

  If an explosion is likely to occur after the seals have been erected, arrangements should be made to close the last seals after all personnel are out of the mine. This can be done by leaving hinged doors (similar to drop doors) that will close automatically in one or more of the seals, usually the last intake seal to be erected.

  These doors can be temporarily held open with a counterbalance in the form of a perforated bucket filled with water. The holes in the bucket should be made so that sufficient time elapses before water drains. This will allow time for personnel to reach the surface before the door or doors close to complete the seals.

  When fires are being sealed in gassy or dusty mines, it is essential to apply a thick coating of rock dust to the ribs, roof, and floor of entries, crosscuts, etc., for several hundred feet outby the seal, and, if possible, inby the seal. Hence, in the event of an explosion around the fire, there will be less chance of propagating a coal-dust explosion.

- **Isolation**

  It is important to isolate the sealed area in as many ways as possible. This means that all power cables and water and/or air lines going into the sealed area should be removed or severed from the sealed area. It is also advisable to remove a section from the track or any other conductors leading into the sealed area.

Permanent Seals

A mine cannot be returned to production until the sealed area has been closed off with permanent seals. Usually, after temporary seals are erected, a waiting period of about 72 hours is recommended before beginning construction on permanent seals.

Permanent seals must be built according to an approved seal design with proper installation and certification. Seal designs are very specific and the Installation Guidelines for whichever seal is being built must be followed.

There are a myriad of approved permanent seals that are designed to withstand either a minimum of 50 psi or 120 psi dynamic force application from an explosion. The material these seals are built with include lightweight cementitious material, reinforced concrete, glued concrete blocks, and a solid concrete plug.

The specific construction techniques that are to be followed during the construction of a permanent seal will be prescribed in the approved Installation Guidelines. It is important that all aspects of these Guidelines are followed. Any deviation from these guidelines may be cause for rebuilding the permanent seal.

Considerations for Permanent Seals

- **Isolation**

  When permanent seals are installed, the area inby the seals must be isolated from the rest of the mine just as with temporary seals. This means that all cables, lines, or track that were removed or severed for the temporary seal must be removed or severed for the permanent seal. Sometimes will already have been completed when the temporary seals were built, so you may not need to take care of it when you build the permanent seals.

- **Air Sampling Tubes**

  The permanent seals must have provisions for collecting air samples within the sealed area, just as the temporary seals do.

  If air sample tubes were installed in the temporary seals, it will only be necessary to extend those tubes and valves to the permanent seals if they do not already reach.

- **Taking Air Samples**

  After the fire area is sealed, it may be necessary to take air samples of the air that is behind the seal so that the quality of the air can be assessed. The best time to collect an air sample is when the sealed area is under positive pressure or “breathing out.”

Pressures within and without sealed areas generally will vary with temperature and barometric changes. These differences in pressure are usually described as “breathing in” (negative pressure in sealed area), “breathing out (positive pressure in sealed area), or “neutral” (no difference in pressure).

If the sealed area is breathing out when collecting an air sample, let the pressure evacuate the air from the sealed area for a while before getting the sample. This will ensure that you get a good representative sample of the air that’s in the fire area, not the air that’s right next to the seal.

If the sealed area is in-gassing or neutral, use a small permissible pump to evacuate enough air from the sealed area to ensure that you collect a good representative sample of the air that’s in the fire area.

Sometimes, seals are situated so far away that the air near the seals has an altogether different composition from the air near the fire. In these cases, air samples are usually not collected at the seals because they would not be accurate. Instead, a two-inch bore hole from the surface or another level to the fire area can be used to obtain air samples.

NOTE: Additional information on collecting air samples is found under Mine Gases in the “Air Sampling” section of Module 2.

Gases Produced by the burning of Rubber, Neoprene, and PVC	**Maximum Allowable**	
	PPM	**Percent**
Carbon Monoxide	50	.005
Chlorine	1	.0001
Hydrogen Chloride	5	.0005
*Phosgene	0.1	.00001
Sulphur Dioxide	5	.0005
Hydrogen Sulfide	10	.001
Nitrogen Dioxide	5	.0005
Ammonia	50	.005
Hydrogen Cyanide	10	.001
*Arsine+	0.05	.000005
*Phosphine+	0.3	.00003

*Note the deadliness of these gases as compared to Carbon Monoxide.

+These gases will be found only if the carcass (foundation) is impregnated with certain fungicidal or fire-retardant compositions.

Source: “Investigations into Underground Fires.” Safety in Mines Research Establishment, Buxton, England.

Sealing on the Surface

Although it may be possible to seal a fire in a gassy section of a mine without a subsequent explosion during or shortly after sealing operations, undoubtedly the safest method is to seal the mine openings at the surface. On these occasions, any mine openings to the surface are plugged up and sealed as best as possible.

- **Remote Sealing**

  Another method of sealing a fire from the surface is to pump sealing material down through boreholes to the fire area. This is usually done within a mine that has already been sealed on the surface, making it possible to establish effective temporary seals in a distant part of a large mine where a fire raged.

  Remote sampling should be done to determine if the atmosphere in the temporarily sealed area is explosive. Inert gases can be added remotely if needed to make the area non-explosive. When the area is non-explosive, the mine can be safely re-entered and permanent seals erected.

  By establishing these temporary seals, it may be possible to re-establish ventilation throughout the rest of the mine without disturbing the fire area during initial recovery of the mine.

- **Foaming the Fire Area**

  Foam can be used indirectly on a fire in an attempt to bring the fire under control so that more direct extinguishing methods can be used. In these instances, the foam generator is set up a distance from the fire. The foam is then pumped down to the fire to smother and cool it.

  At times it is necessary to construct a temporary stopping around the foam generator to create a confined area into which to pump the foam. Once conditions permit, the generator can be moved closer to the fire, or the team members can move in to fight the fire directly.

- **Flooding the Mine**

  Another method of indirect firefighting is flooding the sealed fire area with water. This is not done very often and, when it is, it is used as a last resort since it makes any later recovery work difficult.

Review Questions and Answers

1. Discuss why the fan should be kept running during underground firefighting.
    - *To ensure that explosive gases and distillates are carried away. This decreases the chance for an explosion to occur.*
    - *To direct smoke, heat, and flames away from the team.*

2. Discuss a method of controlling the backup of a fire against the ventilating current (intake air) while fighting it directly.

    - *A transverse brattice can be installed rib to rib in the entry, with open space near the roof.*
    - *This brattice forces the ventilating air current to the upper portion of the passageway and thus slows down the progress of smoke and flame into the intake air current.*

3. Discuss why burning conveyor belts, cable insulation, and tires are particularly hazardous to firefighters.

    - *They emit extremely toxic gases as they are decomposed by the fire.*
    - *Many of these gases are more dangerous than carbon monoxide. Breathing apparatus should be worn when fighting this type of fire.*

4. Discuss other hazards the team should consider when fighting a fire directly.

    - *Electrocution*
    - *Toxic and asphyxiating gases*
    - *Oxygen deficiency*
    - *Explosive gases*
    - *Heat, smoke, and steam*

5. Discuss reasons why a mine fire would be sealed rather than fought directly.

    - *Attempts to fight directly are ineffective*
    - *Insufficient materials to fight fire directly*
    - *Fire of too great a magnitude*
    - *Roof conditions are too dangerous*
    - *Buildup of explosive gases*
    - *Location of the fire*

6. Discuss why it is recommended that the last intake and return seals be erected and closed simultaneously.

    - *It lessens the possibility of explosive gases building up in the fire area.*

7. Discuss why all waterlines, power cables, and track leading into a sealed area should be severed or removed before sealing a fire area.

    - *This practice ensures that the sealed area is completely isolated from the other areas of the mine and possible ignition sources.*

Explosions

Cause and Effect

Explosions are very similar to fires in terms of what causes them. Just as with a fire, three elements must be present for an explosion to occur: fuel, oxygen, and heat (ignition). Explosions can only occur if these three fire tetrahedron elements are present at the same time. To avoid an explosion, the elements must be kept away from each other.

The fuel for an explosion can be an explosive mixture of gas, a sufficient concentration of coal dust, or a combination of both. Explosions in coal mines are most often caused by the ignition of methane, coal dust, or a combination of both. The source of ignition is commonly sparks, an electric arc, an open flame, or misuse of explosives.

Explosions can cause significant damage. Roof supports may be blown out, ventilation controls damaged or destroyed, machinery twisted and scattered, and numerous fires ignited. The other main problems associated with explosions are hazardous roof conditions and spreading fires.

Once an explosion has occurred, there is always the possibility of further explosions. Further explosions are possible because once the ventilation system is damaged by the first explosion, explosive gases can accumulate and be ignited either by fires that have developed or by other ignition sources, such as arcing from a damaged cable. Coal dust being stirred up by the first explosion can propagate further explosions.

Before Going Underground

Before any team begins rescue work in a mine where an explosion has occurred or is suspected of having occurred, the Command Center will make sure that the mine is relatively safe to enter and that as many hazards as possible have been eliminated.

The types of things to be concerned about are the same types of things we discussed about preparing to go into a mine to explore or to fight a fire:

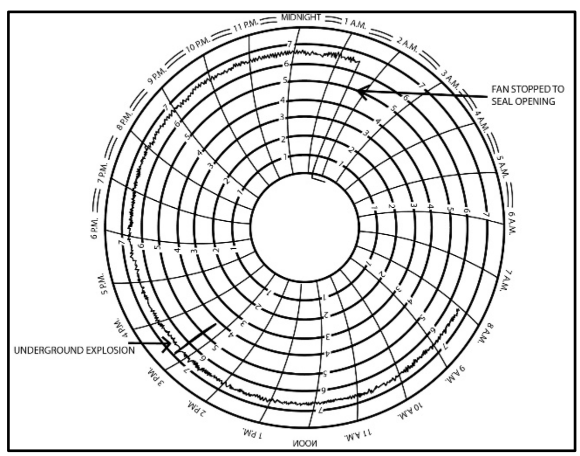
- The team should make sure that the main fan is running, that a guard is monitoring the operation of the fan, and that tests are being made at the main returns for any gases that may be present in the mine. Ventilation is necessary to prevent the buildup of explosive gases. Keeping the main fan running will ensure ventilation at least up to the point where underground controls have been damaged or destroyed. Testing for CO and explosive gases at the mine openings is essential so that a determination can be made by the Command Center whether the mine is safe to enter.

- It is usually recommended that the power to the affected area of the mine be cut off. Damaged cables arcing is a possible ignition source for further explosions or fires. However, disconnecting the power affects auxiliary ventilation and the operation of any electrically-powered equipment such as a pump. The Command Center will take these factors into consideration.
- The team needs to know of any possible ignition sources that may exist underground. This could include battery-operated or diesel equipment that may have been left running. Any fires that developed from an explosion are also possible ignition sources for further explosions.
- If there are any underground storage areas for explosives, oil and grease, or oxygen or acetylene cylinders, you need to know about them.

Indications of Explosion and Assessment of Conditions

Officials cannot determine if an explosion occurred until rescue teams explore and assess the conditions. Reports of a suspected explosion along with elevated carbon monoxide readings at mine openings are good indications that an explosion has occurred. However, the ventilation system may be disrupted or the gas may have been ventilated out before the rescue teams arrived.

Sometimes a major roof fall, rock bump, or rock burst can be initially mistaken as an explosion. The first indications that an explosion has occurred may be reports from miners in nearby sections who felt a sudden movement of air, noticed smoke or dust in the air, or heard the sound of the explosion. Another indication of an explosion is a jump in the pressure on the recording chart for the main fan.



Visual 11 - Fan Chart

Teams may want to re-enter the mine immediately to determine the conditions, but, teams need to be patient and let the Command Center assess the situation to determine the risk of re-entry. Once an explosion has occurred, there is always the possibility of additional explosions.

Here are some indications that will help determine if an explosion has occurred:

- Afterdamp and toxic and explosive gases in the main returns.
- Blown out stoppings/bulkheads and roof supports:
    - The damaged or blown out ones should be carefully examined.
    - The direction in which it has blown helps indicate the direction of the force of the explosion.

- Even if stoppings/bulkheads are not destroyed, indications of blocks having been moved should be noted, especially when the stoppings/bulkheads are across entries near intersections (the movement of blocks in crosscuts is seldom significant).
- Overturned equipment
- Evidence of "coking" and "coke streamers" and their size. Coke is produced when coal is burned in the absence of oxygen.
- Roof falls
- Coal dust or soot on rock-dusted surfaces (this may be the first evidence of an explosion that occurred inby that point)
- Film of dust on mine rail (for same reason)
- Smoldering fires and scorched material

Normally, the initial role of the rescue team after an explosion is to explore and assess conditions. Once this is completed, the teams will begin the process of reestablishing ventilation and recovering the mine. If it is too hazardous for teams to explore and re-ventilate safely, the team will usually be instructed to seal the area or seal the entire mine.

Review Questions and Answers

1. Discuss the necessary factors that must be present in order for an explosion to occur.
    a. *An accumulation of gas within its explosive range (fuel);*
    b. *Sufficient oxygen; and*
    c. *A source of ignition (heat).*

2. Discuss the chief concerns of a mine rescue team when exploring a mine following an explosion.
    a. *Disrupted ventilation*
    b. *Possibility of additional explosions*
    c. *Possibility of fires*
    d. *Damaged energized electrical systems becoming ignition sources*
    e. *Accumulations of toxic and explosive gases*
    f. *Altered roof and rib conditions*

3. Discuss evidence that the exploring team might encounter that would indicate an explosion has occurred in the mine.

    a. Disrupted ventilation

    b. Presence of afterdamp and other toxic and explosive gases in return airways

    c. Blown out or damaged roof supports and/or stoppings/bulkheads

    d. Damage to machinery and equipment (cars off track, machinery out of place or overturned)

    e. Evidence of coking and coke streamers

    f. Roof falls

    g. Darkened rock dusted surfaces

    h. Dust on mine rail

    i. Presence of small fires or scorched material

General Review
Fires, Firefighting, and Explosions

Choose the correct answer for each of these questions.

1. Explosions in coal mines are most often caused by ignitions of:
   a. Carbon Monoxide.
   b. Hydrogen.
   c. Methane.
   d. Sulfur Dioxide.
2. The first indications that an explosion has occurred are often very similar to those of:
   a. An inundation of water.
   b. A large roof fall.
   c. A fan stoppage.
   d. All of the above.
3. A positive indication that a fire exists in a mine is:
   a. Carbon monoxide and/or smoke in the return airways.
   b. Methane and carbon dioxide in the return airways.
   c. Lowered oxygen content in the return airways.
   d. A disruption in normal ventilation.
4. Burning materials that give off extremely toxic gases in addition to carbon monoxide are:
   a. The coal seam itself.
   b. Hydraulic fluids.
   c. Neoprene and other synthetic rubber compounds.
   d. All of the above.
5. The preferred type of hand-held extinguisher for teams is a dry chemical type that contains:
   a. Sodium Bicarbonate.
   b. Potassium Chloride.
   c. Carbon Tetrachloride.
   d. Monoammonium Phosphate.

6. A monoammonium phosphate extinguisher is effective in fighting:
    a. Class A fires.
    b. Class B fires.
    c. Class C fires.
    d. All of the above.
7. Foam generators are effective in controlling mine fires in that they:
    a. Limit the amount of oxygen reaching the fire area.
    b. Cool the burning materials.
    c. Can be effective when set up long distances from the actual fire.
    d. All of the above.
8. Seals in high volatile coal seams are often placed:
    a. 10 feet from the fire area.
    b. 100 feet from the fire area.
    c. 1,000 feet or more from the fire area.
    d. 10,000 feet or more from the fire area.
9. Probably the best material to use for sealing a mine fire is:
    a. Brattice Cloth.
    b. Cement Blocks.
    c. Tile or Bricks.
    d. Tongue-and-Groove Lumber.
10. Non-metallic tubes or pipes are inserted in temporary and permanent seals for the purpose of:
    a. Checking for smoke.
    b. Bleeding off excess pressure from the sealed area.
    c. Collecting air samples from the sealed area.
    d. Ventilating the sealed area.

General Review
Answers

1. c
2. b
3. a
4. c
5. d
6. d
7. d
8. c
9. b
10. c

Glossary

Class A Fires – Fires involving combustible materials: wood, plastics, paper, and cloth. Extinguished best by cooling with water or by blanketing with dry chemicals.

Class B Fires – Fires that involve flammable or combustible liquids such as gasoline, diesel fuel, kerosene, and grease. They are best extinguished by excluding air or by special chemicals that affect the burning reactions.

Class C Fires – Fires that involve electricity. They are best extinguished by non-conducting agents such as carbon dioxide and certain dry chemicals.

Class D Fires – Fires involving combustible metals (magnesium, titanium, zirconium, sodium, and potassium). Special techniques and extinguishers have been developed to put out these fires.

Class K Fires - Fires that involve combustible cooking media such as oils and grease commonly found in commercial kitchens. A special wet chemical extinguishing agent should be used for extinguishing and suppressing these extremely hot fires that have the ability to reflash.

Direct Firefighting – Method of firefighting where dry chemical extinguishers, water, rock dust, or foam are put directly onto the fire to extinguish it.

Fire Tetrahedron – Tetrahedron used to illustrate the four elements necessary for fire to occur: fuel, oxidizing agent, heat, and uninhibited chemical chain reaction.

Head Coal – The top portion of a coal seam left unmined to be mined later.

High Expansion Foam – Foam used in firefighting that is light and resilient and can travel long distances without breaking down. It is made by mixing water, air, and a high expansion foam concentrate or detergent in a foam generator.

Hydrogen Pops – Small explosions of hydrogen gas.

Indirect firefighting – Firefighting method where the fire area is sealed or filled with foam to exclude oxygen or using water and foam to cool the fire.

Low Expansion Foam – Foam used in firefighting that is wet and heavy. It must be forced directly onto the fire. It is made by mixing a low expansion foam concentrate or detergent with water in a foam nozzle attached to a fire hose.

Rock Bump – Sudden, violent release of coal from pillars; causes earth tremors.

Rock Burst – An explosive breaking of coal or rock in a mine due to pressure.

Volatile Coal – Coal that gives off gases and vapors when heated; the low ranking lignite gives off more volatile matter than anthracite which is a higher rank.

Advanced
Mine Rescue Team Training

Rescue of Survivors
Recovery of Bodies

Module 6

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Course Objectives

A. The mine rescue team will follow proper procedures for rescuing survivors and recovering bodies following a mine disaster.

B. The team members will be able to:

   a. Describe factors that help determine the location of possible survivors during a mine emergency.
   b. Describe procedures for entering a refuge chamber or a barricade behind which survivors may be located.
   c. Describe the possible physical and psychological condition of survivors during a mine emergency.
   d. Describe proper procedures for transporting survivors.
   e. Describe procedures for marking locations and identities of bodies.
   f. Recognize the possible conditions encountered when recovering bodies following a mine disaster.
   g. Describe the procedures for extricating, disinfection, and tagging bodies, and placing them in body bags following a mine disaster.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers.

A. Required:

   a. Pencil and paper for each team member
   b. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams

B. Suggested**:**

   a. Any rescue or recovery equipment that the team will be using, or pictures or slides of the equipment if it is not available
   b. Chalkboard and/or flip chart
   c. Laptop with a PowerPoint Program

Course Outline

A. Introduction
B. Rescuing Survivors
    a. Locating Survivors
    b. Opening Refuge Chambers, Refuge Alternatives, or Barricades
    c. Injured Survivors
    d. Psychological Factors for Survivors
C. Bringing Out Survivors
    a. Miners Found in Open Areas
    b. Miners Found in a Barricade or Rescue Chamber
D. Psychological Factors for Mine Rescue Workers
    a. Signs of Stress
E. Body Recovery
    a. Locating the Dead and Marking the Area
    b. Condition of Bodies
    c. Handling Bodies
    d. Surviving Families
    e. Review Questions and Answers

Introduction

This training session is about how to rescue survivors and recover bodies when a mine disaster has occurred. Rescuing survivors might very well be the most rewarding part of the job of a mine rescue team while recovering bodies is a task everyone hopes they never have to face.

There is little that prepares you emotionally for these two tasks. However, by learning what you might see and conditions you might encounter should better prepare you in handling these situations.

Rescuing Survivors

Locating Survivors

Before going into a mine to search for missing miners, the team should seek answers to the following questions:

- How many miners are missing?
- What are the latest tracking locations for each missing miner?
- In what section or sections were they supposed to be working?
- Where are the escape routes in the mine?
- Where are the refuge alternatives or refuge chambers located?
- Where are miners likely to barricade?
- Are there any ventilation boreholes that miners may go to obtain fresh air?

Injured survivors unable to walk out on their own may be found in open passageways or along the escape routes. They may be trapped behind falls, other obstructions, or under a piece of equipment. They may be in a refuge alternative, refuge chamber, or they may have barricaded in an area with fresh air.

When searching for survivors, it is important to look and listen for clues. Miners who barricade will usually try to leave indications of where they are to aid rescuers in finding them. For instance, they may put a note in a dinner bucket, draw an arrow along the side, or mark a rail indicating the direction rescuers should look.

When approaching a refuge chamber, look for a strobe; seeing a strobe indicates that miners are present. On the outside of refuge alternative or barricade, trapped miners may have written how many people are inside the chamber or barricade as well as the date and time they went inside. Another clue is articles of clothing or possessions, such as the case or cover of a self-rescuer dropped along the way.

While locating something like this would not indicate the direction the survivors were traveling, it would show that someone had been in the area. In some instances, teams may find fresh footprints in the dust from an explosion or in rock dust in the seldom traveled areas indicating the direction survivors had taken.

When **listening** for clues, be on the alert for any noise, such as voices or pounding on rails or pipes. When survivors are located, their location, identities (if possible), and condition should be reported immediately to the Command Center. The Command Center can then send a backup team with the needed equipment, such as stretchers or breathing apparatus. The date, time, and location needs to be marked on the rib where survivors were found as well as marked on the team map.

Opening Refuge Chambers, Refuge Alternatives, or Barricades

When a refuge alternative (RA, refuge chamber, or barricade) is located, try to determine as quickly as possible whether the miners inside are still alive and conscious. Do this by establishing verbal communication or by creating noises so that those inside can respond. If there is no response, do not assume the miners are dead; they could be unconscious. If you get a response, ask how many miners are inside and their conditions. This will give a better idea of what medical supplies will be needed. Ask if they used their self-rescuers, and how long they have been inside the RA.

The safest procedure for getting survivors out is usually to advance fresh air to the barricade by the quickest means possible. Once the fresh air is advanced, the barricade can be opened. Sometimes it may be necessary to rescue the survivors before fresh air can be advanced to them.

Refuge alternatives will have an integral air lock built in. For instance, fresh air cannot be advanced to the survivors if a fire is spreading and moving in their direction. In these cases, an air lock should be established outside the refuge chamber or barricade before it is opened.

The Command Center will determine whether to advance fresh air or build an air lock. The Command Center will make its decision based on all existing conditions in the area and available information on the condition of the survivors.

If it is decided to establish an air lock, the team will build a stopping with a flap in it as close as possible to the RA, refuge chamber, or barricade. The air lock needs to be small to minimize the amount of contaminated air that will enter when opened; it should be just large enough to allow all team members to move comfortably and allow all their necessary equipment, such as a stretcher, to fit.

Once the stopping is constructed, the barricade can be opened. An opening large enough to admit the team and a stretcher should be made in the barricade and covered immediately with canvas to keep the air within it as safe as possible. When going through the air lock, every effort should be made to admit as little outside air as possible.

Injured Survivors

After survivors are found, the next step is to get them to safety and fresh air as quickly as possible. In some cases, survivors may need emergency first aid treatment before they can be transported.

Caution should be utilized through the use of Body Substance Isolation (BSI) precautions. A simple and effective means of protection can be achieved through the use of protective gloves by the rescue workers. Gloves provide a barrier between the hand and contamination. Gloves are put on:

- Immediately before contact with any patient's mucous membranes.
- Immediately before contact with any patient's non-intact skin.
- When performing vascular access procedures.
- To avoid any contact with moist body substances.
- When handling or touching surfaces or items contaminated with body substances.

Effective infection control precautions provide protection to both patients and rescue workers. Whenever precautions are used to protect rescue workers, the impact on the patient must also be considered. (i.e., using fresh, clean sterile gloves immediately before touching the patient's mucous membranes). Latex-free personal protective equipment is available.

NOTE: First aid procedures are **not** covered in this program**.** There are several courses already available for teaching first aid.

Psychological Factors for Survivors

When survivors are found, their behavior may range from apprehensive to uncontrollable hysteria. The best way to relieve psychological stress in most survivors is to communicate with them as soon as possible. **More importantly, the communication MUST be continued.**

If a survivor loses communication with the rescue team, they may feel abandoned and try to escape to fresh air even though it is unsafe. If survivors are acting irrationally, it may be necessary to restrain them in order to protect them from injury. There have been instances where **survivors have tried to pull off a facepiece from a rescue team member**. There have even been cases where rescue team members have endangered themselves by unthinkingly pulling off their facepieces to give oxygen to a survivor while in bad air.

Whether survivors are showing signs of hysteria or not, they should never be left alone. Make every effort to assure them that they will be helped. Even if they appear to be in good shape, survivors will need your assistance and support in leaving the mine, so they should never be allowed to walk out unaccompanied.

Bringing Out Survivors

Miners Found in Open Areas

If survivors are found in contaminated or questionable air, they will need to be given breathing protection if they are to be transported to fresh air. If survivors are able to walk, they should be positioned between two rescue team members and guided out to fresh air. If the person is unable to walk, a stretcher will have to be used to bring that person out.

Miners Found in a Barricade or Rescue Chamber

The mine map, if accurate, will show the condition of the area **before** the event occurred and possibly the extent of the barricaded area and other areas of access to the barricaded area. Persons utilizing the mine map must **remember that the preexisting mapped conditions may have changed** prior to the event**,** due to the event, or by miners after the event.

- Test the atmosphere in the affected area to determine if the atmosphere is respirable or irrespirable and report to the FAB/Command Center. The area surrounding the barricade or rescue chamber may have to be cleared of noxious gases before a person without breathing protection can be removed from a barricade or rescue chamber.
- Determine, if possible, the condition of the person or persons located within a RA, barricaded area or a rescue chamber, and report to the FAB/Command Center. The Command Center may dictate the means of communicating this type of information, and the team should adhere to this means of communication.
- It is recommended that the conditions (location of live persons, bodies, etc.) within a barricade be accurately mapped and any potential evidence should be left as undisturbed as possible.

If survivors found in a rescue chamber or behind a barricade can walk, provide them with the necessary breathing apparatus and assist them to fresh air. If they are unable to walk, they will need to be carried out on stretchers.

When a number of survivors are found in a RA or behind a barricade, a backup team will probably be sent to expedite the rescue effort and bring everyone out at the same time. Otherwise, the team will bring the survivors out on stretchers one at a time and will repeat the process until all miners are brought to fresh air. The following details the best methods to follow:

- The stretcher should be brought into the RA or behind a barricade and checked to be sure that it will bear the weight of a person.
- The individual chosen to be brought out first should be given the necessary breathing protection and carefully loaded onto the stretcher.

- The rescue team should then carry the stretcher through the air lock and proceed to fresh air by the shortest and quickest route.
- Every effort should be made during this process to prevent irrespirable air from entering the barricade.

Psychological Factors for Mine Rescue Workers

Mine emergencies can pose substantial psychological and emotional difficulties for the responders, their families, and other persons assigned to the operation. Remember:

- No one who sees a disaster is untouched by it.
- It is normal to feel anxious about your safety.
- Profound sadness, grief, and anger are normal reactions.
- Acknowledging our feelings helps us recover.
- Focusing on our strengths and abilities will help us heal.
- Accepting help from community programs and resources is healthy.
- Everyone has different needs and different ways of coping.

Persons in charge of mine rescue teams should consider providing a critical incident stress debriefing throughout and after the emergency. Many team members suffer some form of post-traumatic stress and are hesitant to seek help or counseling.

Team trainers should be familiar with signs and symptoms of stress-related illnesses. Even if they are not showing symptoms, you should advise them to seek EMS Management Agency or the Red Cross assistance. Survivors have been through a traumatic situation and may need counseling as well.

Signs of Stress

- Difficulty communicating thoughts
- Difficulty sleeping
- Difficulty maintaining balance
- Easily frustrated
- Increased use of drugs/alcohol
- Limited attention span
- Poor work performance
- Tunnel vision/muffled hearing

- Colds or flu-like symptoms, headaches or stomach problems
- Disorientation or confusion, difficulty concentrating
- Depression, sadness, feelings of hopelessness
- Mood swings, crying easily
- Overwhelming guilt and self-doubt
- Fear of crowds, strangers, or being alone; reluctance to leave home

Body Recovery

Locating the Dead and Marking the Area

When a body is located, report the location to the Command Center. The body's location and position need to be marked on the mine map and on the roof or rib close to the body. It is suggested to use chalk or paint to outline the body or paint, or at least mark where the head and feet are. If the floor is too muddy to mark, draw the position of the body on paper or on the mine map. If there is more than one body, add an identifying number to each. This number should also be marked on the map and on the roof and rib closest to the body.

When a body is first located, every effort should be made not to disturb any possible evidence. Evidence will be important later in the ensuing investigations. Usually, the first team that discovers a body is not the team that actually does the body recovery work. The recovery of bodies may wait until fresh air is advanced, or it may be decided to bring the bodies out immediately. Either way, a fresh team will probably be sent to handle the work.

Condition of Bodies

Recovering bodies is a somber and difficult task, and it is worse when there had been hope of finding the miners alive. Realize that for the spouses and other family members involved, it is important to be able to bury their loved ones.

Recovering bodies is a job everyone hopes they never have to face. Unfortunately, there's little that prepares rescue teams for what they will be encountering. In some cases, bodies will have no obvious injuries, while others may be badly burned, disfigured, or dismembered.

If the bodies are not recovered soon after death, they will begin to decompose. In addition to the gruesomeness of a decomposed body, there will be a stench from the rotting flesh and other body parts. In past recovery operations, teams have chosen to use breathing apparatus even when they were working in good air in order to avoid the odor.

Expect to see some very unpleasant sights when recovering bodies. After death, the body goes through various changes and stages of decay. Some of the factors that influence body deterioration and the changes that occur are:

1. **Air temperature** – How quickly the body begins to decay will depend on the temperature in the area. For instances, a body at freezing temperatures can be preserved for weeks, and a body at 70° F (21° C) or higher will decay very rapidly. The temperature in a coal mine is usually 50 to 60° F (10 to 15.5° C). Therefore, putrefaction (decay) may not begin for 10 or 12 hours after death.

   The parts of a body that are exposed to air will decay faster than the parts that are covered, for instance by clothing. A body lying face up could have the face badly decomposed, but the back of the head which was against the ground could still have hair.

2. **Body size** – The more muscular the individual, the sooner rigor mortis (rigidity of skeletal muscles) will develop, probably within 4 to 8 hours. The more obese the individual, the longer it takes before rigor mortis will develop, probably within 6 to 10 hours. However, an obese individual will begin the putrefaction (decay) process sooner than a muscular individual.

3. **Body Fluid** – The body is 80 percent liquid. During decomposition, the fluid breaks down and creates gas pressure. Fluid may be forced out of the mouth, nose, ears, or other orifices. Blisters will form under the skin and cause the body to swell. Some bodies retrieved after a mine disaster have been so swollen that the clothing begins to split.

   The body must be handled very carefully or the skin could rupture. If the rescuer is not careful, the skin will pull off. In some cases, the skin has actually been pulled off the hand and resembles a hand-like glove, complete with fingernails and creases at the knuckles.

4. **Smell** – There probably will not be any decay odor for the first 4 to 8 hours following death. Once the putrefaction process begins, so does the smell. The smell is the result of decay and the gases escaping the body. When a body is moved, the smell becomes stronger. When the body is brought out of the mine to dry warm air, the smell is overwhelming.

   In general, a body that suffered a great deal of physical trauma (such as by a rock fall) will decay faster and have a much worse odor than the body of a person who died due to poisonous gases. Further, a body that suffered abdominal or genital injuries will smell worse than the body of a person who only had head injuries.

   As long as you wear a self-contained breathing apparatus while recovering the bodies, you will not be affected by the odors. Wearing a handkerchief around your face will not keep out the strong decaying smell.

5. **Body color** – The dead body turns dark where the blood pools. If the victim is lying face down, the front of the body will be dark. However, if the accident is the result of an explosion, the victim may be covered with soot causing the discoloration to not be as apparent.

6. **Water, drowning** – A body in cold water will remain in almost perfect condition for 2 or 3 days. Then, it begins to swell. After taking the body out of the water and exposing it to air, it will begin decaying almost immediately.

7. Most of the time the body will remain under the water for the first 2 days, and then it will float. The body floats because of the gases that build up within the body.

These are all very unpleasant things the team may have to deal with. Some team members will be better able to cope with recovering bodies than others. In the past, teams composed of volunteers were usually sent in to do body recovery work. The volunteer crew may be one particular team, or it may be made up of team members of different teams.

Rescue workers, especially those recovering bodies for the first time, may very well begin to feel sick or apprehensive. The best advice is to work with a businesslike and professional attitude. Most of your reactions will be due to the senses of sight and smell; try to overcome these sensory reactions.

One reaction that may help is the body's production of adrenaline. Adrenaline is a hormone that is part of the body's natural defense system that can be produced on a split second's notice. It helps one to cope amazingly well with traumatic or frightening situations. Adrenaline stimulates the heart and increases muscular strength and endurance. If the adrenaline is flowing, you may find yourself with more strength and courage than you thought you were capable of having.

Feeling nauseous with the apparatus on is not safe, so don't try to bluff your way through it. If you are in unsafe air and vomit into your face piece, you will not be able to take off your face piece. Keep in mind that even some of the best rescue team members have had difficulty dealing with dead bodies. So, be honest and let your captain know if you are experiencing nausea which you cannot control. If you pass out or go down, you become a detriment to your team.

Handling Bodies

Normally, before bodies are brought out of a mine, they are placed in rubber body bags and brought out on stretchers. If body bags are not available, the bodies can be wrapped in brattice cloth or canvas.

Do not examine the victim's clothing for personal possessions unless you have the team captain's approval. Nothing should be removed from a body except in the presence of witnesses, and a written record is made of the material removed.

Usually, all personal belongings such as a lunch bucket, cap lamp, and self-rescuer are brought out along with the body. This is important since miners, especially those who barricaded themselves, may have written notes to their loved ones on or in their lunch buckets or other personal items.

The location of these items should be marked on the mine map and on the roof or rib. If the location and position of the body and the identifying number have not already been marked in the mine and on the mine map, this should be done by the body recovery crew before removing the body. A tag listing the identifying number and the location where each body was found should be attached to each body bag.

When dealing with bodies that have been underground awhile, wear rubber gloves. The bodies should be sprayed well with a disinfectant before touching or handling them. This disinfectant will usually be provided for the teams.

One of the main concerns in body recovery work is to not cause further damage to a body in the process of bringing it out of the mine. Bodies recovered shortly after death usually will not present many problems since decomposition may not have begun. Rescuers can lift by the shoes and armpits to place the victims in body bags. However, be extra careful handling decomposing bodies because the ligaments, muscles, and tendons have begun decaying, so pulling on an arm, leg, or foot may cause it to detach. If the shoe comes off, part of the skin may remain in the shoe. If the leg pulls out of the socket, a cracking noise may be heard.

One of the best methods for transferring a decomposed body into a body bag is to place a sheet of brattice or plastic next to the body, then roll the body on to it by using either your hands or a board or something similar. Once the body is on the sheet, lift the four corners of the sheet and place it along with the body into the body bag. If you have to straighten limbs that are stiffened by rigor mortis to get the body into a body bag, you will have to use some force. Nevertheless, just be careful not to cause unnecessary damage to the body.

In cases where bodies are entangled in debris or buried under falls, the bodies will need to be extricated slowly. Extrication work performed in close proximity to body parts should be done by hand to ensure the body is not further damaged. If an extra limb or part of a body is found by itself, put it in a body bag and mark the bag with what it contains, so it can later be matched with the correct body.

Surviving Families

Recovering the bodies of the dead provides some emotional closure for the family, and prevents the need to petition the court to have their loved one declared dead for legal and insurance reasons. Knowing this, the team can feel their efforts help ease the pain and suffering of the families.

Review Questions and Answers

1. Discuss clues that aid the mine rescue teams in locating survivors during a mine emergency.

    a. *Notes left in lunch buckets.*

    b. *Arrows drawn on rib or rail.*

    c. *Pounding sounds on a rail or pipe.*

    d. *Self-rescuer covers or cases, or discarded self-rescuers. Miner's personal items left or discarded.*

    e. *Evidence of footprints in dust.*

2. If miners are missing after a fire or an explosion, discuss the critical information that your team will need during the briefing.

    a. *Number of missing miners.*

    b. *Section or sections where they were working.*

    c. *Escape routes used from those sections.*

    d. *Likely places where miners would erect barricade.*

    e. *Location of ventilation boreholes where miners could obtain fresh air.*

3. Discuss the procedures a rescue team would employ to enter a refuge chamber or barricade behind which miners are located.

    a. *Try to establish communication with the miners.*

    b. *If possible, advance fresh air to the area; if it is NOT possible, erect an air lock before entering the refuge chamber or barricade.*

    c. *When opening a barricade, use as small an opening as possible and cover it with a flap to prevent contamination of the atmosphere.*

4. Discuss the usual procedure to follow when a body is encountered during exploration.

    a. *Report body location to the Command Center. Mark the position and location of body on map.*

    b. *Mark location in mine.*

    c. *Attach identifying number to body bag.*

    d. *Remove nothing from the body or surrounding area. Keep all personal belongings of the miner with the body.*

Glossary

Air Lock – An area in the mine closed at both ends by doors or by stoppings/bulkheads with flaps or doors in them. Used to prevent mixing of different atmospheres while allowing miners to enter and exit.

Barricade – Enclosed part of mine to prevent inflow of noxious gases from a mine fire or an explosion. This may be done by doors or by building one or more airtight walls using any available material, such as rock, wood, brattice cloth, mud, clothing, etc., so as to enclose a maximum quantity of good air.

Extricate – To disentangle.

Hysteria – Uncontrollable outburst of emotion or fear.

Putrefaction – The decomposition of organic matter by bacteria, fungi, and oxidation, resulting in the formation of foul-smelling products.

Refuge Chamber – An airtight, fire-resistant room in a mine, used as a method of refuge in emergencies by miners unable to reach the surface.

Rigor M**ortis** – The progressive stiffening of the muscles that occurs several hours after death as a result of the coagulation of the muscle protein.

Trauma, **Physical** – Injury to living tissue.

Trauma, **Psychological** – Disordered psychic or behavioral state resulting from mental or emotional stress or physical injury.

Triage – System of assigning priorities of medical treatment to injured people.

Advanced Mine Rescue Team Training

Mine Recovery

Module 7

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Course Objectives

A. The mine rescue team will be able to effectively participate in a recovery operation after a mine disaster.

B. The team members will be able to:

   a. Explain and demonstrate the steps for re-establishing ventilation after a fire or explosion.

   b. Explain and describe supplementary work necessary to restore the affected areas to normal operations.

Course Materials

In addition to the following materials, incorporate other current supplemental mine rescue instructional materials, handouts, and/or methods that will increase the effectiveness and retention of the training. During the review questions and answers sections, pose the question and allow time for them to formulate their answers. For comprehension and retention purposes have an open discussion about the reasoning behind their answers.

A. Required

   a. Larger visuals and text-only visuals are provided in the Appendix; use these visuals while discussing the corresponding content.

   b. Pencil and paper for each team member

   c. IG 7a – Advanced Skills Training Activities for Coal Mine Rescue Teams

B. Suggested:

   a. Chalkboard and/or flip chart

   b. PowerPoint Program

   c. Laptop Computer

Course Outline

A. Introduction

B. Assessing Conditions

C. Re-establishing Ventilation After a Fire or Explosion
   a. Unsealing a Fire Area
   b. When to Unseal
   c. Preconditions for Opening a Sealed Fire Area
   d. Preparations for Opening a Sealed Fire Area
   e. Re-ventilation Methods Used for Unsealing a Fire Area
      i. Progressive Ventilation
      ii. Direct Ventilation
      iii. Preventing a Buildup of Gases in the Fan House
   f. Re-ventilation after a Fire or Explosion
      i. Considerations
      ii. Progressive Ventilation
      iii. Obstructed Passageways
   g. Review Questions and Answers

D. Clearing and Rehabilitating the Affected Area
   a. Roof and Rib Control
   b. Pumping Water
   c. Clearing Roadways and Track
   d. Loading Out Falls and Hot Debris
   e. Restoring Power
   f. Re-establishing the Communication System
   g. Review Questions and Answers

Introduction

Specific procedures and methods of mine recovery are determined by the needs of an actual recovery operation. This module gives mine rescue team members a general overview of what those methods and procedures are, and a basic explanation of what a recovery operation involves.

The main objective of recovery work is to put the mine or affected area of the mine back in operation as soon as conditions permit after a mine disaster. Depending on the conditions, recovery operations can range from a few days' work re-establishing ventilation on a section to many months of costly re-ventilation and rehabilitation work throughout an entire mine.

The role as a mine rescue team member in recovery work varies as the operation progresses and conditions change. Until ventilation is re-established in the affected area, apparatus crews will be needed to assess conditions, rebuild stoppings/bulkheads, and (where necessary) clear debris and stabilize the roof and ribs.

Once ventilation has been re-established and fresh air is advanced, non-apparatus crews can take over the rehabilitation and clean-up effort.

Assessing Conditions

In order to plan a recovery operation, there must be an initial assessment of the underground conditions. As work progresses, rescue teams will be making updated reports on the conditions and damages they encounter. Assessment of conditions is necessary for the team's safety and also to determine how much rehabilitation work is needed to recover the affected area.

NOTE: List the topics covered in an assessment on a chalkboard or flip chart, so the team can easily follow along with the discussion.

One of the main things the team will be checking is the extent of damage to the ventilation system. This includes checking the condition of each of the ventilation controls and any auxiliary fans and tubing.

As the team explores and re-ventilates an area, check gas conditions and roof and rib conditions. Also, check the condition of the track, waterlines, power lines, and phone line, and look for evidence of flooding, flood damage, and smoldering debris or hot spots in a fire area.

Re-establishing Ventilation after a Fire or Explosion

Re-establishing ventilation and bringing fresh air to an area damaged by fire or explosion is the main task of mine rescue teams in a recovery operation. Once this is done, regular work crews can help with the recovery effort.

In a fire area that has been sealed, this means unsealing the area, assessing the damage, and repairing and rebuilding the ventilation system. If the area has not been sealed, re-establishing ventilation is easier. It involves simply assessing the damage and making the necessary repairs to re-establish normal ventilation.

In an area damaged by an explosion, the task is the same: assessing damages and repairing ventilation controls. After an explosion, though, a great deal of construction work is usually needed to restore ventilation to proper functioning.

Unsealing a Fire Area

Unsealing a fire area requires careful planning because opening seals prematurely can cause a re-ignition or an explosion. A step-by-step plan for unsealing a fire area is developed by company mine officials with the advice of federal, state, and union representatives. While the team does not plan the operation, it is important to know what the considerations and potential problems are.

When to Unseal

Determining the exact time to unseal a fire area is based on the laws of physics and chemistry, as well as on experience and sound judgment. A reasonably accurate analysis and interpretation of the gases present in a sealed area is possible through proper sampling techniques and with the aid of a chemist experienced in this work. In addition to the gas conditions, other factors must be taken into consideration when choosing the safest time to unseal a fire area.

The main factors governing the time for unsealing a fire area are *(Visual 1)*:

1. Extent and intensity of the fire at the time of sealing.
2. Characteristics of the burning material and surrounding strata.
3. Tightness of the seals.
4. Effect of barometric pressure on the enclosed area.
5. Effect of temperature on the enclosed area.
6. Location of the fire area with respect to ventilation.
7. Gas conditions as indicated by analysis of air samples taken behind the seals. Usually, the gases analyzed are oxygen, carbon dioxide, carbon monoxide, methane, hydrogen, and nitrogen.

In addition to analysis of these factors, local conditions (such as the proximity of gas wells to the fire area and the extent of the region under seal) must be considered. Typically, more time is needed before unsealing a large area.

Preconditions for Opening a Sealed Fire Area *(Visual 2)*

Although each situation is different, experience indicates that **no attempt** should be made to unseal a fire area until**:**

1. The atmosphere's oxygen content in the sealed area is low enough to make it inert;
2. Carbon monoxide (gas that indicates combustion) has disappeared or nearly disappeared behind the seal; and
3. The area behind the seals has been given enough time to cool, so air introduced during the unsealing operation will not rekindle the fire.

Achieving these goals may be difficult, and it may require a great deal of time.

Preparations for Opening a Sealed Fire Area *(Visual 3)*

Opening a sealed fire area requires these preparations:

1. Adjustments in ventilation need made, so toxic and explosive gases released from the sealed area are directed into the main returns. Someone should be **monitoring gas levels at the main returns.**

   When determining when to unseal an area where a fire is suspected, gases are remotely monitored over time. The gases that indicate combustion (CO, H_2, ethane, etc.) would have "trended" downward from the initial event.
2. An observer should be at the main fan ensuring it is operating and continues to operate correctly. If it slows down or has malfunctions, the teams underground should be **withdrawn immediately**. If it is electrically driven and exhausting, precautions need to be taken, so the **explosive gases do not come in contact with the fan motor or any other electrical equipment** used to operate it.
3. Checks should be made to ensure all electrical power in the sealed area has been disconnected. Also, power in the return airways near the sealed area should be locked out.
4. In bituminous coal mines, all entries and crosscuts leading to and from the sealed area should be heavily rock dusted. This should be done for a considerable distance outby the sealed area to be opened.
5. Withdraw **all unnecessary people** from the mine.

When exploring a sealed area, the atmosphere should be monitored remotely utilizing sample boreholes installed in the affected area.

Re-ventilation Methods Used for Unsealing Fire Areas

There are two basic re-ventilation methods that can be used when unsealing a fire area: Progressive ventilation and direct ventilation. Progressive ventilation is the re-ventilation of a sealed area in successive blocks by means of air locks. Direct ventilation is the re-ventilation of the entire sealed area at once.

Progressive ventilation was traditionally the most common method of unsealing a fire area in coal mines. The costs associated with the large number of teams needed for air locking has led to a trend of direct ventilation. The advantage of progressive ventilation is that gas conditions can be carefully controlled, and the operation can be halted at any point in which conditions become hazardous. The disadvantage of progressive ventilation is that it is a slow process.

With direct ventilation, recovery is quicker than it is with progressive ventilation, but gas conditions are **less controlled**. Before using direct ventilation, there should be conclusive evidence that the fire has been extinguished.

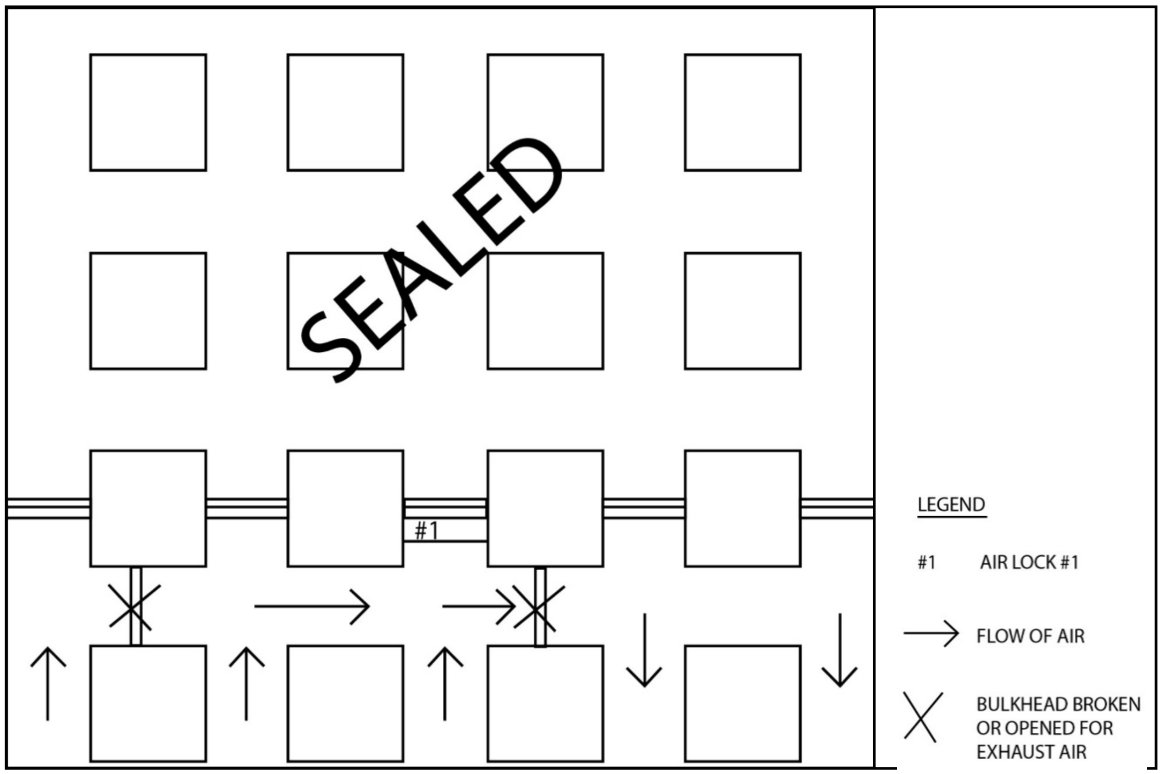
Progressive Ventilation *(Visuals 4 and 5)*

Progressive ventilation is the usual method when the sealed area is large, the fire is extensive, or bodies must be removed. With this method, the sealed area is explored and re-ventilated in successive blocks using air locks. As long as conditions remain favorable, the work can continue until the entire area is recovered.

An air lock is made by building two stoppings/bulkheads **10 to 15 feet apart** (approximately). Each stopping should have a door or flap in it so that teams can enter and exit the sealed area. One opening in an air lock **must be kept closed while the other is open** to prevent mixing of the two atmospheres. The distance should be small to limit the amount of air that could enter the sealed area. However, there must be enough room in the air lock to accommodate the team members and their equipment.

Air locking operations should NEVER be undertaken until the oxygen content behind the sealed area has been reduced to a maximum of two percent. During progressive ventilation, a certain amount of air will unavoidably enter the area behind the seals. As the work continues, oxygen and explosive gas levels must be carefully monitored, and the operation halted if conditions become dangerous.

Recovery by progressive ventilation is very similar to advancing a FAB, but it is usually a slower operation because of the damage normally found in a sealed area. The first step in progressive ventilation is to build a stopping at one of the seals on the intake side of the fire area to create an air lock.



Visual 4 - Sealed Area and First Air Lock

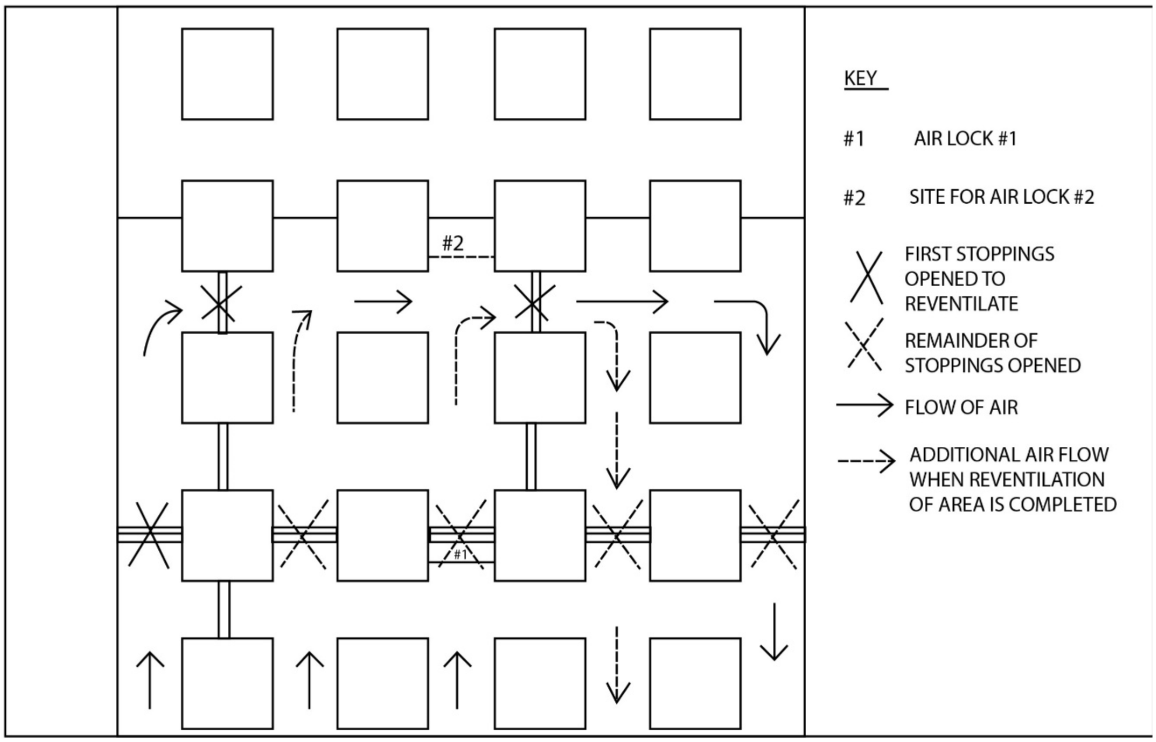
Air locking operations should always begin on the intake side of the fire. Once the air lock is completed and conditions are right for entering the sealed area, a team with apparatus can enter the air lock and break out an opening in the seal.

It may be necessary to wait after removing the first few blocks from a seal for the pressure to stabilize. After the seal is opened, an apparatus team or a rotation of teams can enter the sealed area to explore and assess conditions up to where the next air lock will be built.

The distance between air locks is usually between 200 and 500 feet depending on the conditions encountered and the amount of construction work needed to prepare the area for re-ventilation.

During exploration, the team should note conditions in general. They should take temperature readings and make the necessary tests for oxygen, carbon dioxide, carbon monoxide, and methane. When requested, they should collect air samples. They should also take measurements for the new air lock that will be built and any additional stoppings that will be needed in parallel entries to seal the area.

Once the exploration and assessment is complete, a team(s) can be sent in to construct the first stopping/bulkhead of the new air lock and put up any additional stoppings/bulkheads needed in the parallel entries to reseal the area. They will need to prepare the area between the two air locks for re-ventilation. This involves repairing ventilation controls and making the necessary changes to direct the air to a return airway.



Visual 5 - Re-ventilation of an Area

Before the team leaves the area being prepared for re-ventilation, a final check should be made for any possible fires. Once the team is out of the area, it can be re-ventilated. Generally, a seal on the return side is opened first followed by one of the seals on the intake side.

The return air should be kept below the lowest explosive limit of methane and oxygen. If conditions are good, the rest of the original seals can then be opened. This process of putting up air locks and working through them to explore and re-ventilate an area can be continued until the entire area is recovered.

As the work progresses, frequent tests should be made to determine gas conditions in the sealed area and at the returns of the areas being recovered. The main concern is the possibility of an explosion or the rekindling of the fire. After the work has progressed close to the seat of the fire, it may be decided to load out heated materials through the air lock before attempting re-ventilation. As long as all signs indicate the fire has been extinguished, the final sealed area can be re-ventilated. The gases should be removed as quickly as possible.

Direct Ventilation

The other method for recovering a sealed fire area is by direct ventilation. Before using direct ventilation, there should be **conclusive evidence that the fire has been extinguished**. With this method, the affected area is recovered and re-ventilated as a whole rather than by successive blocks. As a result, recovery is accomplished more quickly than with progressive ventilation, but gas conditions are less controlled.

The first step is to build an air lock at an intake seal. Then an apparatus team or, if necessary, a rotation of teams will take temperature readings and test for oxygen, carbon monoxide, carbon dioxide, and methane. The team will probably be asked to collect air samples as well.

After completing testing and observation of the area, the team will return to the FAB. If the conditions are favorable, the unsealing can begin. A seal on the return side should be broken open, and the air lock opened to admit air. The area can then be ventilated. Any combustible gases in the main exhaust should, if feasible, be kept below the lowest explosive limit.

When using direct ventilation, be sure that **all unnecessary personnel are out of the mine before air is actually directed into the sealed area**. The remaining personnel needed to open the seals should then come out as quickly as possible once the seals are opened.

The time for persons to re-enter the mine is governed by the quality of the return air as indicated by periodic sampling and analysis. The Command Center will determine when conditions appear safe to reenter. If the sealed area is extensive, it's advisable that a rescue team wearing apparatus be the first to reenter. The team should check for and flush out any standing gases from the fire area.

When direct ventilation is used to recover mines that have been sealed on the surface, the procedure is basically the same except an air lock is not used. Just as with underground unsealing, surface seals (one on the intake and one on the return) should be opened at about the same time. Then, when it is decided that it is safe, apparatus teams can explore and re-establish ventilation.

Preventing a Buildup of Gases in the Fan House

If the mine is using an exhausting fan, some provision should be made to prevent the buildup of explosive gases in the fan house. One technique is to ventilate the fan house. An auxiliary fan can be set up a short distance from the fan house with tubing extending into the fan house.

Another technique is to control the volume of air being drawn out of the mine. This can be done by using the explosion doors as a regulator.

Re-ventilation after Fire or an Explosion

The objective of re-establishing ventilation after an explosion is to rid the mine of explosive or potentially explosive gas mixtures and restore normal ventilation and normal amounts of oxygen to all workings without propagating another explosion.

Considerations *(Visual 6)*

During re-ventilation work, an observer should be stationed at the main fan to ensure it is operating correctly and to warn the team of any malfunctions. Someone should be monitoring gas levels at the main returns.

Areas of concern:

- Concentrations of explosive gases: Are they below, within, or above the explosive ranges?
- Percent of oxygen present: Will it support life? Is it low enough to prevent another explosion?
- Are possible ignition sources being considered and eliminated - electrical power, battery-powered equipment, possible fires and hot spots, sparks from tools and team equipment, etc.?

Progressive Ventilation

Re-ventilation after an explosion is usually accomplished by progressive ventilation. A FAB is set up, and stoppings/bulkheads are built in parallel entries to isolate the affected area. Then, an apparatus team enters the affected area through an air lock (the FAB) to explore and assess conditions. This is basically the same as unsealing a fire area by progressive ventilation.

As long as conditions remain favorable, teams can build a new air lock inby the old one, build any other stoppings/bulkheads needed in parallel entries, and prepare the area being recovered for re-ventilation. The teams should be sure to make the necessary adjustments to direct air from the re-ventilated area to a return.

While exploring and preparing an area for re-ventilation, teams should be on the alert for and eliminate any possible ignition sources. Once the new air lock is put up and gas conditions are checked, normal ventilation can be advanced to that point by taking down the old air lock and opening an airway to the return so that air can circulate through the area. Teams can continue this procedure until the entire area is re-ventilated.

The size of the area re-ventilated will depend on the conditions the teams encounter. Where damage is slight, a team will be able to re-ventilate a large area. However, a team may only be able to do two or three blocks at a time when the damage is extensive and much work must be done to repair ventilation controls.

The re-ventilation process will be slower where travel is difficult or where hazardous roof and rib conditions require timbering and other support. Once re-ventilated, barefaced labor crews can normally finish the rehabilitation needed in that area. The apparatus teams can prepare the next area for re-ventilation.

Obstructed Passageways

During re-ventilation, if entries are obstructed by falls, debris, or equipment, it may be hard to travel through them to advance the ventilation. In these cases, the team would normally try to bypass or circumvent those entries and come in behind the obstruction to erect the stoppings/bulkheads.

There have been situations where all entries have been obstructed by falls. In some instances, teams have re-ventilated as close as possible to the area and then used permissible machinery and tools to clear an entry. While this is being done, line brattice can be used to ventilate the area in the same manner that a face area would be ventilated during normal production.

In other cases where falls were extensive, access was gained to the obstructed area by mining through the solid from the closest unobstructed entry. In these cases, the teams have mined to within a few feet of breaking through the solid. At that point an air lock was put up, the power turned off, and all unnecessary personnel removed from the mine. Then, a team with apparatus on went through the air lock and hand mined the last few feet.

These two procedures are described as examples of methods of recovery that have been used successfully in the past. Any decision to use such methods would normally rest with the officials in charge of the operation. The risks, benefits, costs, etc., would all have to be carefully considered before implementing such a plan.

Review Questions and Answers

1. Discuss the two methods of re-ventilating a sealed fire area, and the advantages and disadvantages of each.
    - *The advantage of progressive ventilation is that gas conditions can be carefully controlled, and the operation can be halted at any point where conditions seem hazardous. The disadvantage is that it is a slow process.*
    - *Direct ventilation is quick, but should only be used if there is **conclusive evidence that the fire is out.** Direct ventilation **must** be used if the mine was sealed on the surface.*

2. Discuss the three preconditions for opening a sealed fire area.

    - *The oxygen content of the atmosphere in the sealed area should be low enough so that an explosion is impossible.*
    - *There should be no carbon monoxide, indicating that the fire is out.*
    - *The sealed area should have cooled enough so that the fire is not rekindled when the area is re-ventilated.*

3. What preparations should be made before opening a sealed area?

    - *Adjustments in the ventilation system are needed so that toxic and explosive gases released from the sealed area are directed into the main returns.*
    - *Someone should observe the operation of the main fan and alert the people working underground if the fan slows down or malfunctions. Someone should monitor gas levels from the main returns.*
    - *All electrical power in the sealed area should be cut off, as well as the power in the return airways near the sealed area.*
    - *In bituminous coal mines, all entries and crosscuts leading to and from the sealed area should be well rock dusted.*
    - *All unnecessary personnel should be withdrawn from the mine.*

4. Discuss three possible methods of recovering an area of the mine that has obstructed entries.

    - *Bypass the entry and come in behind it.*
    - *Re-ventilate as close as possible and then clear the obstruction with permissible machinery and tools. While this is being done, line brattice can be used to ventilate the area.*
    - *Mine through the solid almost to the point of breaking through; then, build an air lock. A team with apparatus can go through the air lock and hand mine the last little bit.*

Clearing and Rehabilitating Affected Area

As the rescue teams advance ventilation, they will be doing construction and clean-up work. In addition to building and repairing damaged ventilation controls, it may be necessary to load out falls and hot materials, stabilize roof and rib conditions, pump water, clear roadways, and restring communication lines.

Once ventilation has been re-established in an area, labor crews can take over the bulk of the clean-up effort. Until then, this work must be done by apparatus crews for safety reasons and in order to continue to advance the recovery effort.

Roof and Rib Control

Fires, explosions, and other disasters frequently result in weakened roof and rib conditions. Rescue teams need to carefully assess roof and rib conditions during recovery work. Extensive timbering and cribbing may be needed to stabilize conditions prior to advancing ventilation.

Pumping Water

Often in recovery operations, rescue teams will encounter large accumulations of water that must be pumped out. There are two ways of accomplishing this. One way is for the team to advance fresh air to the area and then pump out the water.

If the team needs to clear the area before advancing fresh air that far, they can use non-conducting suction lines with a pump set up in fresh air to pump out the water if gas conditions permit. When using this procedure, careful analysis should be made of the gas conditions in the area being pumped. Water soluble gases will be pumped out along with the water. If the line loses suction, toxic or explosive gases from the contaminated atmosphere could be drawn out.

When advancing into an area that has been inundated with water, teams should pay special attention to roof and rib conditions. Roof falls are likely in such areas.

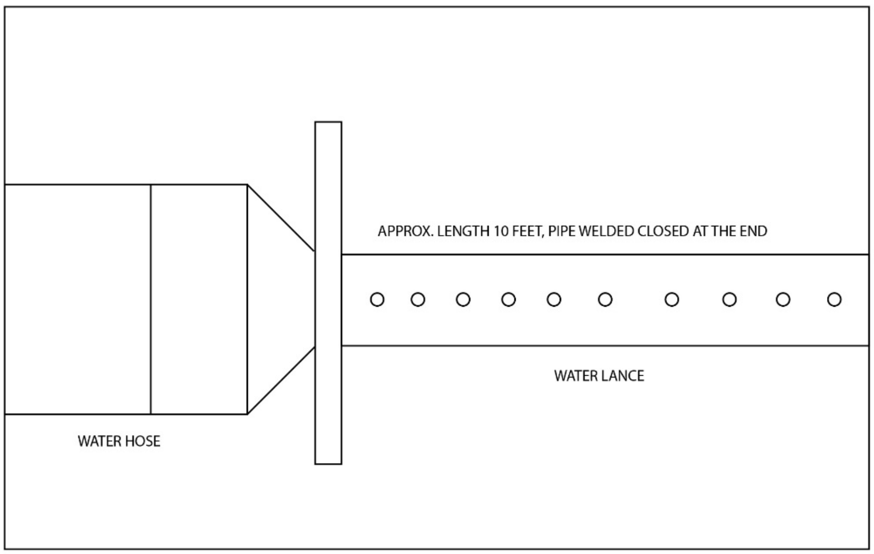
Clearing Roadways and Track

Roadways and track will need to be cleared and restored to use as quickly as possible. Once this is done, it will be much easier to bring in the materials that are needed for the recovery and clean-up effort.

Loading Out Falls and Hot Debris *(Visual 7)*

Usually, the practical means of dealing with debris found during recovery is to load it onto shuttle/mine cars, and haul it out of the mine – especially any heated debris found after unsealing a fire area. Wetting (before and during the loading operation) and removing the heated material is the best method of preventing a fire rekindling.

In situations where large areas of heated roof rock have fallen, water lances can be driven into the debris to aid in cooling it. Water lances are pipes about 10 feet long with holes cut along the length of the pipe. The lance attaches to a regular hose line. Once the rock has cooled, it can be broken up and loaded out.



Visual 7 - Water Lance

Restoring Power

Power is usually restored progressively by an electrician as the ventilation is advanced. Once power has been restored in an area, the rehabilitation work can proceed much more efficiently because there will be power for transporting materials, equipment, and workers.

Re-establishing the Communication System

As fresh air is advanced, the mine's communication system should be repaired or a substitute system advanced to aid in expediting the recovery operation.

Review Questions and Answers

1. Discuss the tasks normally involved in recovering a mine or section of a mine following an explosion, fire, or other mine disaster.

    - *Re-Establishing Ventilation*
    - *Securing Roof and Ribs*
    - *Pumping Water*
    - *Clearing Falls and Debris*
    - *Loading Out Hot Materials*
    - *Restoring Electrical Power*
    - *Restoring the Communication System*
    - *Restoring Track and/or Beltways*

2. Discuss how they could remove standing water from an unventilated area.

    - *If gas conditions permit, the team can pump the water using non-conducting suction lines and a pump set up in fresh air.*
    - *Careful gas tests should be made before beginning the operation. Water soluble gases would be pumped out along with the water.*
    - *If the line loses suction, toxic or explosive gases from the contaminated atmosphere could be drawn out.*

Glossary

Air Lock – An area in the mine closed at both ends by doors or by stoppings/bulkheads, with flaps or doors in them. Used to prevent mixing of different atmospheres while allowing miners to enter and exit.

Direct Ventilation – Re-ventilation of the entire sealed area at once.

Progressive Ventilation (or stage ventilation) – Re-ventilation of a sealed area in successive blocks by means of air locks.

Water Lance – A pipe about 10 feet long with holes along the length of it with a fitting to attach to a hose line.

Advanced
Mine Rescue Team Training

Mine Rescue Activities

Module 8

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Introduction

This module contains training activities that are suggested for use in conjunction with the Advanced/Refresher Mine Rescue Training Modules. Some activities can be integrated into the training. Others are full training sessions in themselves and can be used to supplement the module training.

The purpose of these activities is to help trainers build competent mine rescue teams. Some of the activities focus on individual team members' ability to perform basic skills, such as operating firefighting equipment. Other activities focus on the team as a unit and to respond appropriately to realistic mine rescue situations and assignments.

Each activity is broken down into its component parts:

- Purpose of the Activity.
- Type of Activity (e.g., underground work problem or classroom discussion).
- Materials Needed.
- Arrangements to Make in Advance.
- Description of the Activity (e.g., directions for trainer and/or the team, and what to emphasize).
- Evaluation of the Activity.

The activities are labeled according to level of complexity. Level 1 activities are basic while Level 2 activities are more complex. A trainer working with an inexperienced team will find both Level 1 and Level 2 activities useful. With a more experienced team, the trainer may want to skip some of the Level 1 activities.

The training areas covered in each activity are listed on a chart following this introduction to assist in choosing appropriate activities for the team.

Role of the Team Trainer

In choosing and planning an activity, there are factors that should be considered:

1. Check the purpose of the activity. Does the team need practice in this area?
2. Is activity appropriate to the skill level of the team?
3. Should the activity be altered or tailored to make it more useful?
4. Is the equipment needed for the activity available?
5. Are arrangements needed for using surface or underground facilities?
6. Will people other than the team members be needed to set up and carry out the activity (e.g., bench person)?

7. How much time will be needed to prepare for, complete, and clean up from the activity? When estimating the time, be sure to include time for:
    a. Preparing and testing the apparatus (if used).
    b. Traveling to the area where the activity will be held.
    c. Preparing area for activity (if necessary).
    d. Completing activity.
    e. Restoring area to original condition after the activity (if necessary).
    f. Cleaning, recharging, and storing apparatus (if used).
    g. Critiquing team's performance.
    h. Questions, answers, and discussion.

Evaluating Team Performance

The evaluation is an extremely important part of the learning process. The time spent is not only necessary, but vital to the team's development and improvement. Always involve all team members in discussions.

There are three steps for effectively evaluating the team's performance:

1. Observe and record performance.

    During the performance of each activity, the team trainer or someone working with the trainer should evaluate the team or the individual members, whichever is appropriate for the activity. With each activity, an evaluation checklist is provided with suggested questions. List any problems the team encountered.

2. Review the observation results with the team.

    This review session should be held as soon as possible after they completed the activity. Discuss both the positive and negative aspects of their performance and the list of problems they encountered. Allow time for them to brainstorm ways to improve and/or ask questions about their performance, the activity, or the evaluation.

3. Recommend future training.

    After the review session, begin thinking about training needs of the team. Based on the observations during the activity, recommend areas the team needs more knowledge or practice. This could include reviewing needed information from a module (e.g., team needs more knowledge of SO_2 gas), altering a future activity to give them more practice in specific areas (e.g., communication), or just providing them practice time performing the various tasks (e.g. taking gas readings).

Main Training Areas Covered in Each Activity

Activity	Level	Apparatus	Surface Organization	Mine Gases	Mine Ventilation	Exploration	Fires, Firefighting, and Explosions	Rescue of Survivors, Recovery of Bodies	Mine Recovery
#1 Using Gas Detectors	1			✓					
#2 Assessing Gas Conditions	1			✓					
#3 Interpreting a Ventilation Map	1				✓				
#4 Using an Anemometer Underground	2	✓			✓				
#5 Building Temporary Bulkheads	2	✓			✓				
#6 Practicing Exploration Duties	1	✓		✓		✓			
#7 Carrying Out an Exploration Assignment	2	✓		✓		✓			

Main Training Areas Covered in Each Activity

Activity	Level	Apparatus	Surface Organization	Mine Gases	Mine Ventilation	Exploration	Fires, Firefighting, and Explosions	Rescue of Survivors, Recovery of Bodies	Mine Recovery
#8 Using Hand-Held Dry Chemical Extinguishers	1						✓		
#9 Firefighting Practice Session	2	✓					✓		
#10 Assessing Fire and Post-Explosion Situations	1		✓	✓	✓	✓	✓		
#11 Using a Foam Generator Underground	2	✓					✓		
#12 Using an Air Lock to Rescue a Survivor	2	✓			✓			✓	
#13 Determining Hazards and Procedures in a Recovery Operation	1			✓	✓	✓			✓
#14 Mock Disaster	2	✓	✓	✓	✓	Depending on the problem, one or more of these topics will be included.			

Activity 1
Using Gas Detectors

Level 1

A. **Purpose**: To practice taking gas readings with portable detectors.

B. **Type**: Classroom or outdoor work problem

C. **Materials**:

- Gas detectors and extra tubes (follow manufacturer's instructions for the proper use of each device).
- Gas testing boxes and gas cylinders

D. **Arrangements**: Set up test boxes and gas cylinders in such a way that they can rotate taking gas readings. Create an oxygen-deficient atmosphere by putting CO_2 in a test box. If test boxes are not available, have each go through the motions of making the tests in normal air.

E. **Description**: Show how to prepare and use each portable detector. Provide guided practice by allowing each to practice operating the portable detectors several times while assisting them. Then, allow them independent practice by giving them time to practice without assistance.

F. **Emphasize the Following during the Activity:**

- Proper preparation of detector (zero adjustment, battery check, correct tube, etc.).
- Proper procedure in taking the reading (proper height, according to specific gravity, and proper use of instrument).
- Accurate reporting of the findings.

G. **Evaluation**:

Gas Detector:						
Did team member:	#1	#2	#3	#4	#5	#6
1. Prepare testing device properly?						
2. If applicable, use correct detector tube and insert it properly?						
3. Know where to test for gas?						
4. Follow correct procedure in using the detector?						
5. Read the results of the test correctly?						

Comments, problems, and recommendations:

Activity 2
Assessing Gas Conditions

Level 1

A. **Purpose**: To practice identifying gases present in mine rescue situations and interpreting the hazards that each presents.

B. **Type**: Classroom discussion

C. **Materials**: Gas chart visuals from Training Module 2 *Mine Gases*.

D. **Arrangements**: *Optional* – Hand out copies of gas charts from the *Mine Gases* module.

E. **Description**: Describe possible mine rescue situations to the team. Either create unique situations, use the sample situations provided, or adapt some of the sample situations to be more specific to the team's mine.

F. **Team Discussion**:

- What gases are likely to be present as a result of the known conditions?
- What dangers do these gases present?

G. **Sample Situation 1**: An area of the mine has been sealed for several months to extinguish a fire. The team needs to unseal the area. What gas conditions might be encountered when reentering the area, and what hazards would these gases present?

- ***Gas Conditions:***
    - *O_2 deficiency; Elevated CO_2 and N_2*
    - *Elevated CH_4 (if methane is possible in the mine)*
    - *In some mines, H_2S and SO_2 are possible.*
- ***Hazards**:*
    - *Irrespirable atmosphere*
    - *Opening seals could introduce O_2 and cause a re-ignition of the fire or cause an explosion*
    - *Although not previously detected, SO_2 and H_2S could be liberated by pumping or walking through water. Both are toxic.*

H. **Sample Situation 2**: A large fire has been burning at a battery charging station for about 10 minutes. What gas conditions could be encountered during firefighting, and what hazards do these gases present?

- ***Gas Conditions:***
  - *Oxygen deficiency*
  - *Elevated CO, CO_2*
  - *Smoke*
  - *Gases from battery charging station (NO_2, H_2)*
- ***Hazards**:*
  - *Irrespirable atmosphere (oxygen deficiency, presence of CO and NO_2)*
  - *Possibility of an explosion (elevated CO and H_2)*
  - *Poor visibility (smoke)*

I. **Sample Situation 3:** The assignment is to explore an inactive level. What gas conditions could be encountered, and what hazards would these gases present?

- ***Gas Conditions:***
  - *Oxygen deficiency*
  - *Elevated CO_2, N_2, and CH_4 (if methane is possible in the mine)*
- ***Hazards**:*
  - *Irrespirable atmosphere*
  - *Possibility of an explosion*

J. **Sample Situation 4**: A methane explosion occurred in a working area. What gas conditions could be encountered in the exhaust airway, and what hazards would these gases present?

- ***Gas Conditions:***
  - *O_2 deficiency*
  - *Elevated CO, CH_4, CO_2, NO_2, H_2, and heavy hydrocarbons (ethane, butane, propane)*
- ***Hazards**:*
  - *Irrespirable atmosphere*
  - *Possible further explosions*

K. **Evaluation**: Make copies for each situation used.

Assessing Gas Conditions:		
Did the team:	Yes	No
1. Correctly identify the gases likely to be present?		
2. Correctly determine the hazards associated with the identified gases?		

Comments, problems, and recommendations:

Activity 3
Interpreting a Ventilation Map

Level 1

A. **Purpose**: To develop skills in reading and interpreting ventilation maps.

B. **Type**: Classroom discussion

C. **Materials**:
   - Level or section map showing ventilation (use a site-specific map)
   - Laptop computer
   - Pencils

D. **Arrangements**: Hand out copies of a level or section map showing ventilation and, if possible, show the map in a PowerPoint, so the specific areas can be pointed out during the discussion.

E. **Description**:
   - Have team members describe how the air is coursed through the level or section; discuss the use of regulators and auxiliary fans and tubing (if used).
   - Have them describe how the air gets to and from the mining areas and into the exhaust airways.
   - Add a problem to the map that affects the ventilation and have them describe how it affects ventilation. This “problem” could be:
     - An auxiliary fan that’s down, or tubing that’s down.
     - A bulkhead that’s blown out.
     - A ground fall that has obstructed a particular area.
     - A mine door that was left open or that failed to close automatically.

F. **Evaluation**:

Interpreting the Ventilation Map:						
Did the team member:	#1	#2	#3	#4	#5	#6
1. Trace the flow of air through the level or section correctly?						
2. Identify each ventilation control by name and function?						
3. Reinterpret the mine's ventilation correctly after the "problem" (change) was added to the map?						

Comments, problems, and recommendations:

Activity 4
Using an Anemometer Underground

Level 2

A. **Purpose**: To develop skills taking air measurements and readings using an anemometer as well as practice working as a team while under oxygen.

B. **Type**: Underground work problem

C. **Materials**:

- Anemometer
- Smoke tube and stopwatch
- Tape measure
- Paper and pencil
- Apparatus

D. **Arrangements**: Make arrangements for the team go to an area underground where they can practice taking air readings and cross sectional measurements. Take the readings and measurements in advance, and calculate the airflow in cubic feet per minute, in order to be prepared to answer questions.

E. **Description**:

- Explain they will be going underground to take readings with an anemometer. Emphasize the following in describing this activity:
  - Proper procedure in taking reading
  - Reporting the findings correctly
  - Working under oxygen
- Have team members or the bench person prepare the apparatus. When ready, the team should go under oxygen. Have the captain take the team underground to the pre-arranged site to take air readings with an anemometer and to measure the area of the airway. Allow each member to practice taking readings and measurements.
- The trainer should accompany the team and role play as an official at the Command Center, so they can practice reporting their findings to the command center.

F. **Evaluation**:

Interpreting the Ventilation Map:						
Did the team:	**Yes**			**No**		
1. Pick a good location for taking the reading?						
2. Take area measurements correctly?						
Did the team member:	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
1. Hold the anemometer correctly?						
2. Stand so as to keep air resistance to a minimum?						
3. Traverse the airway properly to get an average reading?						
4. Take the measurement for one minute?						
5. Read the dials correctly?						
6. Work and breathe well with the apparatus on?						
Did the captain:	**Yes**			**No**		
1. Stop the team for apparatus checks when appropriate?						

Comments, problems, and recommendations:

Activity 5
Building Temporary Bulkheads

Level 2

A. **Purpose**: To develop skills in building temporary bulkheads and to practice working together as a team while under oxygen.

B. **Type**: Underground work problem

C. **Materials:**

- Apparatus
- Other Team Equipment
- Construction Materials for Building Bulkhead
- Tools for Building Bulkhead

D. **Arrangements**: Arrange for the use of an area underground and for placement of construction materials at building site or nearby (depending on whether an easier or more difficult problem was set up).

E. **Description**: This activity can vary in difficulty depending on the team's experience and how challenging it needs to be. Their assignment is to build a bulkhead in the specified area.

- **Easier Assignment:**
    - Construct a brattice bulkhead.
    - Materials provided at site.
    - Work at a slow pace.
    - Team told exactly where to build bulkhead.
    - Team should prepare site before putting up bulkhead.
- **Harder Assignment:**
    - Construct a brattice or wood bulkhead.
    - Team must transport materials to site from nearby.
    - Work at a faster pace.
    - Team given general area, must pick exact site (for instance, they should choose a spot with good back and even surfaces).
    - Team should prepare site before putting up bulkhead.

- Have team members or the bench person prepare the apparatus. When ready, the team should go under oxygen. Have the captain take the team underground to the prearranged site to build the bulkhead. Accompany them to observe and evaluate their performance.

F. **Evaluation**:

Building Temporary Bulkheads:						
Did the team:	**Yes**			**No**		
1. Complete assignment in a reasonable time?						
2. Transport construction materials to site efficiently (if applicable)?						
3. Choose a good site for building bulkhead *(good back, even surfaces, enough room for a permanent bulkhead to be built, and so on)*						
4. Prepare site properly?						
5. Efficiently work together as a team?						
6. Construct a tight bulkhead?						
Did the team member:	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
1. Work and breathe well with the apparatus on?						
Did the captain:	**Yes**			**No**		
1. Distribute workload among team members?						
2. Stop the team for apparatus checks when appropriate?						

Comments, problems, and recommendations:

Activity 6
Practicing Exploration Duties

Level 1

A. **Purpose**: Team members will practice coordinating their individual duties with the team objective of advancing and exploring a specified distance underground.

   Note: This is not a complete exploration assignment since there is no briefing and no problem involved. The team is simply to practice traveling as a team as well as performing individual duties. The next activity is a complete exploration assignment.

B. **Type**: Underground work problem

C. **Materials**:

   - Apparatus
   - Team Equipment
   - Gas Detectors
   - Map And Mapboard
   - Communication Equipment
   - Scaling Bar
   - Fresh Air Base Equipment
   - Map
   - Communication Equipment

D. **Arrangements**:

   - Arrange for the team to explore a small area of the mine with an easy terrain.
   - Prepare copies of a map of the area to be explored.
   - At the starting point of the exploration, set up a simple FAB with a map and communication equipment.
   - Have someone (perhaps the team alternate) stay at the FAB to handle communications and to mark the map.
   - Have someone stay at the FAB to serve as the communication line or cable attendant.

E. **Description**:

- Have the team or bench person prepare the apparatus.
- When ready, the team should report to the trainer with their apparatus and equipment.
- Give the team's map person a map showing the area to be explored.
- The team's assignment is to explore a designated area for about 400 feet, and report and map the conditions they find.
- The team should advance on intake air (and in single-level mines, tie-in all crosscuts and adjacent entries).
- Tell the team they will be evaluated on how they function as a team, and how they perform their individual duties (such as mapping, gas testing, ground testing, and communications).
- The captain should lead the team to the FAB and have each check their equipment and go under oxygen. When the team is ready, let them begin their assignment. Accompany the team to observe and evaluate their performance. The individuals staying at the fresh air base should stand by ready to perform their duties.

F. **Evaluation**:

Practicing Exploration Duties:		
A. Team and Apparatus Checks	**Yes**	**No**
1. Did the captain check team and apparatus before leaving the FAB?		
2. Did captain make a first check soon after leaving the FAB?		
3. Did captain provide a reasonable number of rest stops for the team?		
4. Were team and apparatus checks made at each rest stop?		
5. Was the oxygen supply or timer of each apparatus checked at each rest stop?		

Practicing Exploration Duties:		
B. Traveling Procedures	**Yes**	**No**
1. Did the team travel in proper order?		
2. Did any team member advance into an area ahead of the team captain?		
3. Did the captain provide a reasonable number of rest stops for the team?		
4. Was the oxygen supply or timer of each apparatus checked at each rest stop?		
C. Testing Procedures	**Yes**	**No**
1. Was routine ground testing done by the captain?		
2. Were routine gas tests indicated at proper places?		
3. Were tested areas properly marked?		
D. Communications	**Yes**	**No**
1. Did the captain and co-captain communicate clearly?		
2. Did team members properly respond to all signals and directions?		
3. Was talking among team members kept to a minimum?		
4. Were all significant findings reported to the FAB?		
5. Were communications with the FAB clear and understandable?		
6. Did team communicate to the FAB frequently enough?		

Practicing Exploration Duties:		
E. Mappings	**Yes**	**No**
1. Did team map person note all important findings correctly on the map?		
2. Do the team map and the FAB map correlate with each other?		
F. Overall Team Performance	**Yes**	**No**
1. Did team explore full extent of area?		
2. Did team function smoothly under the direction of the captain?		

Comments, problems, and recommendations:

Activity 7
Carrying Out an Exploration Assignment

Level 2

A. **Purpose**: To practice carrying out all duties they are expected to perform starting at the briefing, then performing underground exploration, and providing the debriefing in an environment as realistic as possible.

B. **Type**: Underground work problem

C. **Materials**:

- Apparatus:
- Team equipment:
  - Gas Detectors
  - Map and Mapboard
  - Communication Equipment
  - Scaling Bar
- Fresh Air Base Equipment
  - Map
  - Communication Equipment
- Placards (placed underground to indicate various conditions)

D. **Arrangements**:

- Arrange for them to explore an area that they can cover in two hours.
- Prepare copies of a map of the area to be explored.
- At the starting point of the exploration, set up a simple FAB with a map and communication equipment.
- Arrange for someone (perhaps the team alternate) to stay at the FAB to handle communications and to mark the map.
- Arrange for someone to stay at the FAB to serve as the communication line, or cable, attendant.
- Prepare an exploration briefing. (Samples are provided as a guide.)
- Place three or four placards in the area to be explored indicating various conditions, such as smoke, water, a piece of equipment burning, damage to a ventilation control, a fall area, and so on. Choose conditions that will coordinate with the situation given to the team in the briefing.

E. **Description**:

- Have the team or bench person prepare the apparatus.
- When ready, the team should report to the trainer with their apparatus and equipment.
- Give the team a map of the area to be explored and brief the team on their assignment.
- Give them a time limit.
- The captain should lead the team to the FAB, have the members check their equipment, and go under oxygen. When the team is ready, let them begin their assignment. Accompany the team to observe and evaluate their performance. The individuals staying at the FAB should stand by ready to perform their duties. Debrief the team when they return.
- If training two teams, alter this to utilize both teams. Have the second team run the FAB while the first team is exploring. When the first team returns to the FAB, have them brief the second team. Then, have the second team explore while the first team runs the FAB.

F. **Sample Briefing for Multi-Level Mines**

- At 4:00 p.m., the dispatcher received a report of a possible rockburst from the underground hoist attendant at the #2 shaft, #9 level. The attendant heard a loud noise and felt a large gush of air in the underground hoist room and there was limited visibility in the area.
- All miners have been evacuated, and a FAB has been set up at the #2 shaft station, #9 level.
- The team's assignment is to explore and determine conditions on the #9 level. Advance as far as possible, but be sure to return to the FAB no later than two hours after starting exploration.
- There will be a backup team at the FAB and a reserve team on the surface. The main fan is operating and the power has been cut to that part of the mine. The CO reading is 600 PPM.
- Are there any questions?

G. **Evaluation**:

Exploration Assignment:		
A. Briefing	**Yes**	**No**
1. Did team members ask appropriate questions for the problem?		
2. Did the team members review the map?		
B. Preparing to Begin Work	**Yes**	**No**
1. Were required checks performed on the apparatus?		
2. Were all members fit to go under oxygen?		
3. Was all team equipment checked?		
C. Team and Apparatus Checks	**Yes**	**No**
1. Did captain check team and apparatus before leaving the FAB?		
2. Did captain make a first check soon after leaving the FAB?		
3. Did captain provide a reasonable number of rest stops for the team?		
4. Were team and apparatus checks made at each rest stop?		
5. Was the oxygen supply or timer of each apparatus checked at each rest stop?		

Exploration Assignment:		
D. Traveling Procedures	**Yes**	**No**
1. Did team travel in proper order?		
2. Did any team member advance into an area ahead of the team captain?		
3. Did any team member travel on bad ground?		
4. (In single-level mines) Did team “tie-in” as they advanced, so they were never forward of an unexplored area?		
5. Did team mark the route of travel?		
E. Testing Procedures	**Yes**	**No**
1. Was necessary ground testing done by captain?		
2. Were appropriate gas tests taken at proper places?		
3. Were tested areas properly marked?		
F. Communications	**Yes**	**No**
1. Did captain and co-captain communicate clearly??		
2. Did team members properly respond to all signals and directions?		
3. Was talking among team members kept to a minimum?		
4. Were all significant findings reported to the FAB?		
5. Were communications with the FAB clear and understandable?		
6. Did team communicate to the FAB frequently enough?		

Exploration Assignment:		
G. Mapping	**Yes**	**No**
1. Did team map person note all important findings correctly on the map?		
2. Do the team map and FAB map correlate with each other?		
H. Overall Team Performance	**Yes**	**No**
1. Did team function smoothly under the direction of the captain?		
2. Did team respond properly to each of the placards?		
I. Debriefing	**Yes**	**No**
1. Did team make a thorough report on their findings?		
2. Did team go over the map during the debriefing?		

Comments, problems, and recommendations:

Activity 8
Using Hand-Held Dry Chemical Extinguishers

Level 1

A. **Purpose**: To develop skills in extinguishing small fires using a hand-held dry chemical extinguisher.

B. **Type**: Outdoor work problem

C. **Materials**:

- Dry chemical extinguishers (At least one for each team member plus one as a backup. Additional ones are suggested so that team members can work individually and then with a partner.)
- Metal trough for containing the fire (If using a 5-pound multi-purpose extinguisher, use a trough 5 feet by 2 feet and about 10 or 12 inches deep. If using a 10-pound multi-purpose extinguisher, the trough could be 6 feet by 5 feet and about 10 or 12 inches deep.)
- Fuel for the fire (Fuel oil is frequently used for training fires because it produces heavy smoke. A small amount of kerosene is often added. It will float on the top and is more easily ignited than the fuel oil. In extremely cold weather, some prefer to substitute gasoline, which has a lower ignition point, for the kerosene.) See the *Arrangements* section for further details on fuel and lighting the fire.
- A safe means of igniting the fire. (Use a 4 or 5-foot long pole or rod and wrap cloth around one end for a torch. Wire, even a metal hanger, can be used to hold the cloth in place.)
- Matches

D. **Arrangements**: Ensure it is a safe and controlled fire.

- If training six team members, fill the trough about six inches high with fuel oil (one inch per trainee). This should be enough to last for all six people and should eliminate the need to refuel the trough.
- If training more than six or having them work individually and then in pairs, refueling the trough is needed; refueling is safer than overfilling (more than six inches of fuel). Do not allow the fuel too close to the top causing it to possibly boil over. To safely refuel, let the trough cool down before pouring more fuel into it.
- Once six inches of fuel oil is in the trough, pour in about a half-gallon of kerosene (in cold temperatures use gasoline) To ignite, light the torch, approach it holding the torch low, and light the fuel. As long as the fuel supply lasts, simply relight with torch after each trainee

extinguishes the fire.

- Clear the fire area of flammables. Keep oil drums and fuel containers an adequate distance away to eliminate the chance of them heating up and rupturing.

E. **Description**:

- Have each team member extinguish the fire.
- As a safety measure, each firefighter should be backed up by another team member with an extinguisher.
- After each person has had a turn, have the team members pair up and practice putting out the fire with a partner.

When describing this activity, emphasize the following:

- Proper approach to the fire.
- Proper handling of the extinguisher.
- Proper technique with the extinguisher.

F. **Evaluation**:

Hand-Held Dry Chemical Extinguishers:						
Did the team member:	#1	#2	#3	#4	#5	#6
1. Approach fire from the proper direction?						
2. Follow correct procedures for operating the extinguisher?						
3. Use proper firefighting techniques?						
• Advance slowly?						
• Aim ahead of the flame?						
• Use side-to-side motion						
4. Extinguish the fire efficiently?						
5. Back away from fire after it was extinguished?						
6. Work efficiently and safely together?						

Comments, problems, and recommendations:

Activity 9
Firefighting Practice Session

Level 2

A. **Purpose**: Team members will gain experience in fighting a fire with water while wearing apparatus and under realistic conditions (heat, smoke).

B. **Type**: Work problem held at a firefighters' training center under the direction (or with the assistance) of an experienced fire trainer.

C. **Materials**:

- Apparatus
- Firefighting equipment (available from training center)

D. **Arrangements**:

- Team members will be better prepared to deal effectively with a mine fire if they have experience in fighting a fire in heat and smoke conditions. This type of training requires special facilities and is best directed by an experienced fire trainer. It is suggested to make arrangements for the team to participate in a fire training session at a firefighters' training center.
- When making these plans, specify that the team needs to practice fighting a fire with their apparatus on and working in heat and smoke conditions. (The team should already have some experience in wearing apparatus in smoke.) If the proper facilities are available, ask to have the team fight a fire in a confined area to approximate conditions they would encounter in a mine fire.

E. **Description**:

Explain to the team that this is an opportunity to gain realistic firefighting experience. In describing the activity, emphasize the following:

- Proper approach to the fire.
- Proper technique with the equipment being used.

F. **Evaluation**:

Firefighting:						
Did the team member:	#1	#2	#3	#4	#5	#6
1. Approach fire from the proper direction?						
2. Use proper technique with the equipment?						
3. Extinguish the fire efficiently?						
4. Back away from fire after it was extinguished in case of a flashback re-ignition?						
5. Work and breathe well with apparatus on?						
Did the team:	Yes			No		
1. Work together well as a group?						
Did the captain:	Yes			No		
1. Stop the team for apparatus checks when appropriate?						

Comments, problems, and recommendations:

Activity 10
Assessing Fire and Post-Explosion Situations

Level 1

A. **Purpose**: Practice assessing fire and post-explosion situations to determine the hazards present and the procedures that should be followed.

B. **Type**: Classroom discussion

C. **Description**: Describe possible mine rescue situations to the team and have them discuss what hazards they might expect to find and what procedures and precautions should be followed. Use the situations provided below or create other ones.

D. **Sample Situation 1** (for multi-level mines):

   An ore train derailed at an intersection near the 200-level shaft station, and the motor caught fire. The motor crew attempted to fight the fire, but soon realized it was out of control. What are the hazards of this situation and what procedures should be followed before rescue crews go in?

   - ***Hazards**:*

     The fire can spread and trap miners working on the 200 level or on levels above and below.

   - ***Procedures**:*

     - *Evacuate mine completely, if possible*
     - *Put notification plan into action*
     - *Cut power from area, if feasible*
     - *Post guard to monitor continued operation of main fan and to alert command center of any problems with the fan*
     - *Take gas readings at main exhausts*
     - *Make plans to send in rescue crews to assess the conditions*

E. **Sample Situation 2:** A fire has been burning in a timbered drift for about two hours. The mine has been evacuated, all miners are accounted for, and mine rescue work has begun. The first teams have established the fire location and performed the exploration work, including ground testing and gas testing. The command center is sending the team in to fight the fire directly with water. What are the hazards of the situation and what procedures need to be followed?

- ***Hazards***:
  - *The team will be involved in direct firefighting.*
  - *Team members will wear apparatus for protection against possible CO and oxygen-deficiency in the fire area.*
  - *They will deal with heat and smoke problems, the possibility of bad ground conditions, and the presence of explosive gases.*
- ***Procedures***:
  - *Approach the fire on the intake air side. Even though the last team checked the back and sides and did gas testing, our team would realize the conditions can change quickly, so we would remain alert to these conditions. Because the team is fighting the fire with water, there is the potential for hydrogen buildup, so intermittent gas tests would be made.*
  - *The team will want to be sure adequate ventilation continues moving over the fire. This will help dissipate any gases and push the smoke away from the team. If smoke backs up into the flow of intake air, the team can use a transverse brattice to push the smoke back.*
  - *Report all changes in ventilation to the FAB.*

F. **Sample Situation 3:** There are indications that a methane explosion occurred in a working area. What hazards should a team going in be concerned about?

- ***Hazards:***

  After an explosion, there is the possibility of further explosions and fires. The team should be concerned about the stability of ground conditions, gas conditions, ignition sources, and how adequately the ventilation system is functioning to dilute and carry off the toxic and explosive gases.
- ***Procedures***:
  - *Ask if the main fan is running and if the power has been disconnected from the affected area.*

- *During the exploration, we would pay particular attention to gas testing and ground testing.*
- *Assess the condition of the ventilation system.*
- *Recognize and note any ignition sources that could cause fires or further explosions.*

G. **Evaluation**: Make copies of the checklist for each sample situation used.

Assessing Fire and Post Explosion Situations:		
Did the team:	**Yes**	**No**
1. Correctly identify the hazards of the situation?		
2. Correctly describe the procedures that should be followed?		
3. Correctly identify the precautions to be taken?		

Comments, problems, and recommendations:

Activity 11
Using a Foam Generator Underground

Level 2

A. **Purpose**: The team will practice carrying out a mock firefighting assignment using a foam generator.

B. **Type**: Underground work problem

C. **Materials**:

- Foam Generator
- Apparatus
- Team Equipment
    - Gas Detectors
    - Map and Map Board
    - Communication Equipment
    - Scaling Bar
- Fresh Air Base Equipment
    - Communication Equipment
    - Map
- Placards For Indicating Fire and Smoke Conditions

D. **Arrangements**:

- Arrange to use a development drift underground. This will be the fire area. Choose a spot that has access to water and, if necessary, air lines so that the team can hook up the foam generator.
- Place fire and heavy smoke placards at the furthest point in the fire area, placards indicating less smoke at the beginning of the fire area.
- Prepare copies of a map of the fire area.
- Set up a simple FAB 1,000 feet from the fire area on intake side.
- Arrange for someone to stay at the FAB, handle communications, and mark the map.
- Assign a communication line or cable attendant at the FAB.
- Arrange to have the foam generator situated near the fire area.
- If planning to have them build a bulkhead and set up the generator in a bulkhead opening, have the construction materials at the site.

E. **Description**:

- Have the team or bench person prepare the apparatus.
- When ready, the team should report with their apparatus and equipment.
- Give the team's map person a map showing the fire area and their route to the fire area.
- Explain that the route to the fire area has already been explored.
- The team's assignment is to advance to the fire area, check current conditions, move the foam generator into position (not too close to the fire) and begin applying foam to the fire.
- The team should return to the FAB no later than two hours after starting their assignment.
- The captain should lead the team to the FAB, have members check their equipment, and go under oxygen. When the team is ready, let them begin their assignment. Accompany them to observe and evaluate their performance. The individuals staying at the FAB should stand by ready to perform their duties. Debrief the team when they return.

F. **Evaluation**:

Using Foam Generator Underground:		
A. Briefing	**Yes**	**No**
1. Did team members ask appropriate questions for the problem?		
2. Did the team members review the map?		
B. Preparing to Begin Work	**Yes**	**No**
1. Were required checks performed on the apparatus?		
2. Were all members fit to go under oxygen?		
3. Was all the team equipment checked?		

Using Foam Generator Underground:		
C. Team and Apparatus Checks	**Yes**	**No**
1. Did captain check team and apparatus before leaving the FAB?		
2. Did captain make a first check soon after leaving the FAB?		
3. Did the captain provide a reasonable number of rest stops for the team?		
4. Were team and apparatus checks made at each rest stop?		
5. Was the oxygen supply or timer of each apparatus checked at each rest stop?		
D. Traveling Procedures	**Yes**	**No**
1. Did team travel in proper order?		
2. Did any team member travel on bad ground?		
E. Testing Procedures	**Yes**	**No**
1. Was necessary ground testing done before putting the foam generator in place?		
2. Were appropriate gas tests taken in the fire area?		
3. Were tested areas properly marked?		
F. Firefighting Procedures	**Yes**	**No**
1. Did the team move the generator into place efficiently?		
2. Was the generator placed in a reasonable spot (not too close to the fire or too far from it?)		

Using Foam Generator Underground:		
G. Communications	**Yes**	**No**
1. Did the captain and co-captain communicate clearly?		
2. Did team members properly respond to all signals and directions?		
3. Were all significant findings reported to the FAB?		
4. Were communications with the FAB clear and understandable?		
5. Did the team communicate to the fresh air base frequently enough?		
H. Mapping	**Yes**	**No**
1. Did team map person note the necessary information on the map (current conditions, placement of generator)?		
2. Do the team map and FAB map correlate with each other?		
I. Debriefing	**Yes**	**No**
1. Did team make a thorough report on their findings?		
2. Did team go over the map during the debriefing?		

Comments, problems, and recommendations:

Activity 12
Using an Air Lock to Rescue a Survivor

Level 2

A. **Purpose**: Practice a rescue assignment that requires using an air lock.

B. **Type**: Underground work problem

C. **Materials**:

- Apparatus
- Team Equipment
    - Gas Detectors
    - Map and Mapboard
    - Stretcher and Blanket
    - First Aid Equipment
    - Communication Equipment
    - Scaling Bar
    - Extra Approved Apparatus
- Fresh Air Base Equipment
    - Map
    - Communication Equipment
- Construction Materials for Brattice Cloth Bulkhead
- Tools for Building Bulkhead

D. **Arrangements**:

- Arrange to use a refuge chamber as the barricaded area. (If not available, a bulkhead with a man door could be used as the barricade instead. Otherwise, a barricade needs built in preparation for this activity.)
- Arrange for someone to play the role of an uninjured survivor.
- Set up a simple FAB a distance from the barricaded area.
- Have someone stay at the fresh air base to handle team communications.
- Have someone at the FAB serve as the communication line, or cable, attendant.
- Prepare copies of a map of the barricade area.

E. **Description**:

- Have the team or bench person prepare the apparatus.
- When ready, the team should report with their apparatus and equipment.
- Give them a map showing the barricade and the route of travel to it.
- Tell the team the area has been explored and that the adequate fresh air cannot be advanced to the barricade quickly enough.
- The team's job, therefore, is to go in, put up an air lock, and bring out any survivors found behind the barricade.
- The captain should lead the team to the FAB, have them check their equipment, and go under oxygen. When ready, let them begin. Accompany them to observe and evaluate. Those staying at the FAB should stand by ready to perform their duties. Debrief the team when they return.
- **Note**: In future activities dealing with survivors, add first aid or have the team faced with a survivor who panics and behaves irrationally. Another possible situation is to have the team find three injured survivors behind the barricade. (The team will need to deal with multiple injuries and will need to call the FAB for further instructions about transporting the survivors.)

F. **Evaluation**:

Using an Air Lock to Rescue a Survivor:		
A. Briefing	**Yes**	**No**
1. Did members ask questions for the problem?		
2. Did the team members review the map?		
B. Preparing to Begin Work	**Yes**	**No**
1. Were required checks performed on the apparatus?		
2. Were all members fit to go under oxygen?		
3. Was all the team equipment checked?		
C. Team and Apparatus Checks	**Yes**	**No**
1. Did captain check team and apparatus before leaving the FAB?		

Using an Air Lock to Rescue a Survivor:		
2. Did captain make a first check soon after leaving FAB?		
3. Did the captain provide a reasonable number of rest stops for the team?		
4. Were team and apparatus checks made at each rest stop?		
5. Was the oxygen supply or timer of each apparatus checked at each rest stop?		
D. Traveling Procedures	**Yes**	**No**
1. Did the team travel in proper order?		
2. Did any team member travel on bad ground?		
E. Constructing the Air Lock	**Yes**	**No**
1. Was necessary ground testing done before putting up the air lock?		
2. Was the site prepared properly?		
3. Were the building materials transported efficiently?		
4. Did the team construct a satisfactory air lock? (If not, what was wrong with it?)		
F. Dealing with Survivors	**Yes**	**No**
1. Did the team attempt to establish verbal contact with survivor quickly?		
2. Did they keep one opening of the air lock closed at all times?		
3. Did team properly respond to survivor the needs of survivor? (If not, what should they have done?)		
4. Did team transport survivor safely and efficiently?		

Using an Air Lock to Rescue a Survivor:		
G. Communications	**Yes**	**No**
1. Did the captain and co-captain communicate clearly?		
2. Did the team members properly respond to all signals and directions?		
3. Were all significant findings reported to the FAB?		
4. Were communications with the FAB clear and understandable?		
5. Did the team communicate with the FAB frequently enough?		
H. Mapping	**Yes**	**No**
1. Did the team note the necessary information on the map (air lock, position of survivor, other findings)?		
2. Do team and FAB maps correlate?		
I. Debriefing	**Yes**	**No**
1. Did the team make a thorough report on their findings?		
2. Did the team go over the map during the debriefing?		

Comments, problems, and recommendations:

Activity 13
Determining Recovery Operation Hazards and Procedures

Level 1

A. **Purpose**: Practice assessing post disaster conditions to determine the hazards present and the procedures they should follow during recovery work.

B. **Type**: Classroom discussion

C. **Materials**:

- Level or section map showing post disaster conditions (Use the one provided or develop a unique one.)
- Laptop computer
- Pencils

D. **Arrangements**: Give the team a copy of a level or section map showing post disaster conditions and, if possible, show the map as a PowerPoint.

E. **Description**:

- Describe a recovery situation to the team. (Sample provided as a guide.)
- Give the team a map depicting the situation.
- Have team discuss the hazards of the situation and what procedures they would follow in carrying out their assignment. Include all team members in the discussion.

F. **Sample Recovery Situation** (single-level mine)

An area has been sealed due to failed direct firefighting efforts. The plan is to reopen the sealed area using progressive ventilation. Recent air samples indicate no traces of CO in the sealed area, but has a low oxygen level.

Look at the map; another team has put up an air lock in the No. 4 entry. Your team's assignment is to explore and assess conditions. Check all entries and crosscuts; tie-in as you go. Do not advance past two breakthroughs.

1. What hazards might be encountered while exploring the area?
    - *Toxic or explosive gases*
    - *Weakened ground conditions (heat from the fire)*
    - *Hot spots or smoldering material.*

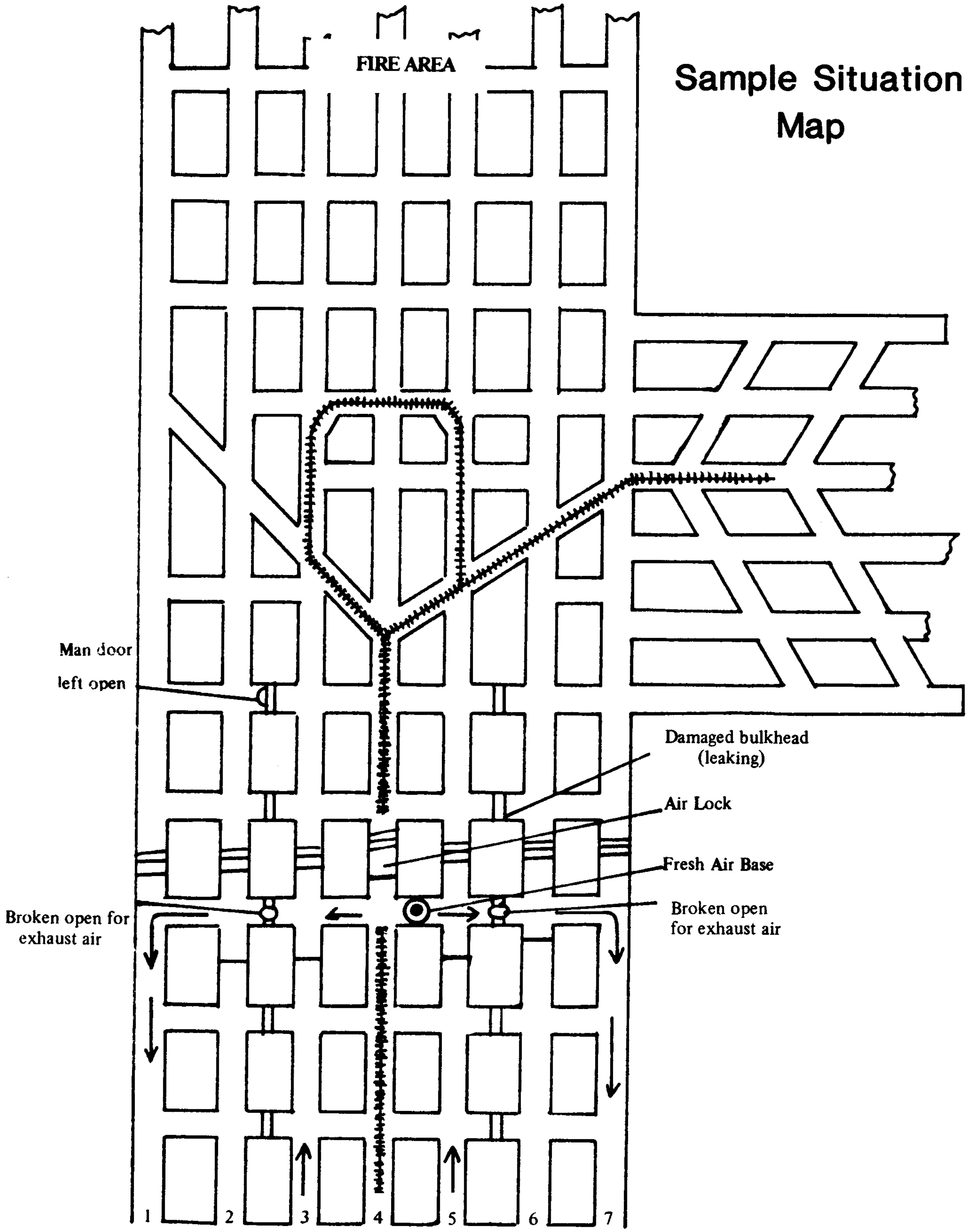
2. How would you advance and what tests should you make as you advance? Have them describe the order they would explore the entries and crosscuts.
    - *Tie-in all entries and crosscuts*
    - *Take temperature readings*
    - *Test the back and sides*
    - *Test for gases as they advance.*
3. What conditions should you be reporting?
    - *Gas conditions*
    - *Ground conditions*
    - *Condition of all ventilation controls*
    - *Condition of any power lines, communication lines, or air or water lines in the area*
4. How many bulkheads are needed to reseal the unexplored area and where should the bulkheads be placed?
    - *Eight bulkheads are needed to reseal the unexplored area. (See map on the following page for placement of bulkheads.)*

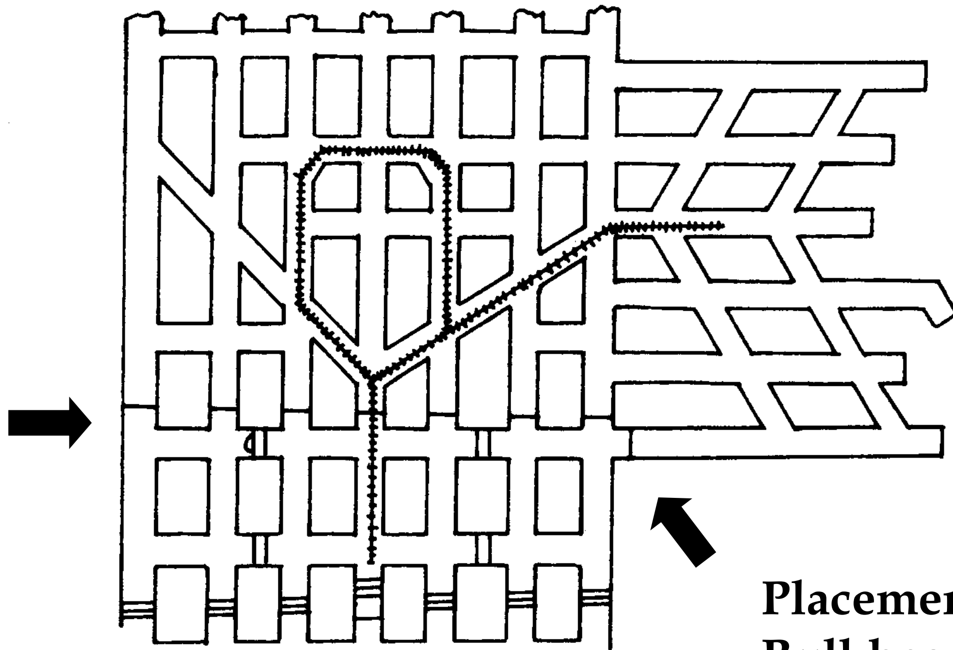
G. **Evaluation**: Use the following checklist while evaluating the team's performance. List and discuss any problems encountered.

Recovery Operation:		
A. Did the team:	**Yes**	**No**
1. Did team identify all possible hazards?		
2. Indicate all tests they should make?		
3. Describe the procedures they would follow to carry out their assignment?		
4. Did team transport survivor safely and efficiently?		

Comments, problems, and recommendations:

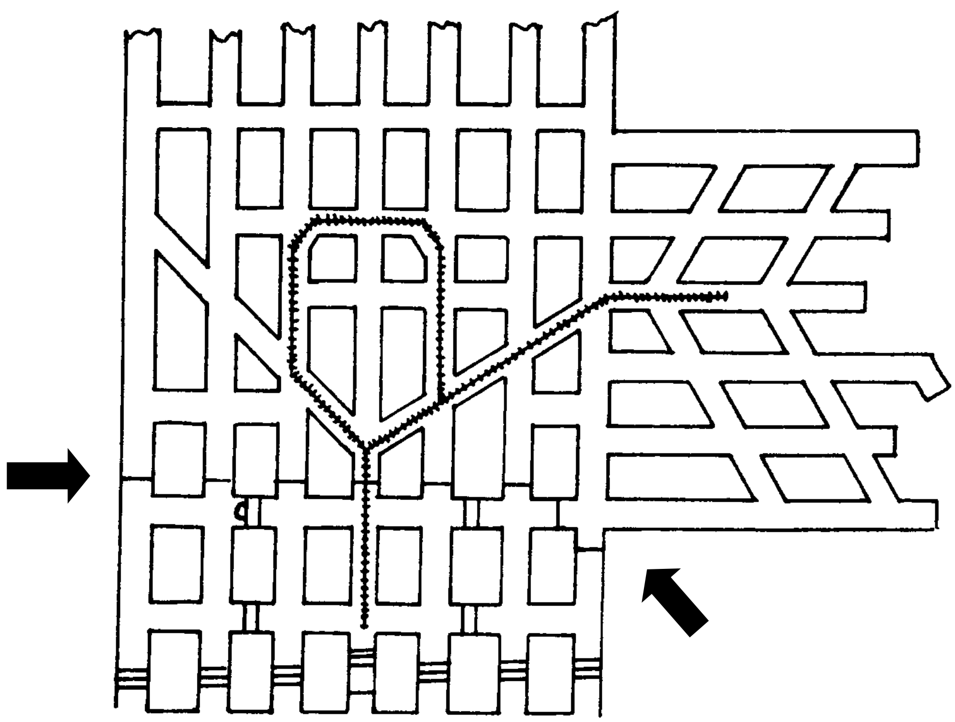
Sample Situation Map





Placement of Bulkheads

or



Activity 14
Mock Disaster Training Session

Level 2

A. **Purpose**: To provide realistic mine rescue training not only for the teams but for other mine personnel who would be involved in an actual mine rescue situation.

B. **Description**: A mock disaster is a simulation of an actual mine rescue operation.

C. **Arrangements**: A mock disaster training session requires setting up a command center, establishing a FAB, and deploying teams on a rotation schedule.

- Prepare areas for a command center and a FAB (both with necessary communications) and an underground area in which the team will be working (placards can be used to indicate various conditions).
- Have maps of the underground area, a briefing and team assignments, and a team rotation schedule.
- Set aside an area for teams to prepare and clean their apparatus.
- Personnel needed to carry out the mock disaster include:
    - Rescue teams (at least three although four is the optimum number for a single day's training session) and
    - The appropriate safety and management personnel to man the command center and FAB.
    - Other surface personnel who could be called on in a real rescue situation. For instance, guards needed for checking people as they come onto the property, a supply clerk, lamp person, mine electrician, mechanical foreman, etc. (Refer to the *Surface Organization* module for a complete list of personnel and duties.)
- Invite MSHA and state officials to observe or participate in the mock disaster. (optional)
- Have equipment and food available for all participants.

A mock disaster training session requires the participation of quite a few people, particularly, management-level people. While it can cost a significant amount of time and money, this training can be an extremely valuable experience. It's realistic training for the teams and for those in charge (to practice coordinating and directing rescue work).

D. **Evaluation**:

Mock Disaster		
A. Organization Problems	**Yes**	**No**
1. Did people know where to go upon arrival?		
B. Information Flow	**Yes**	**No**
1. Was necessary information transmitted smoothly between the command center, the FAB, and the teams?		
2. Were all communications recorded at the FAB and the command center?		
C. Command Center Decision Making	**Yes**	**No**
1. Were the necessary people available to provide needed information and assist in decision making at the command center?		
2. Were the command center decisions made efficiently?		
3. Were briefings and debriefings effective?		
4. Did the team rotation changes go smoothly?		
5. Did the teams perform adequately?		
6. Were conditions at the FAB and command center appropriate (too much noise, too many people, too few)?		
7. Did people stationed on the surface outside the command center (i.e., guards, supply clerk, etc.) have any problems carrying out their jobs?		
8. Have access to the information they needed?		

Comments, problems, and recommendations: