BUREAU OF MINES INSTRUCTION GUIDE 19

MINE EMERGENCY TRAINING

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MINE EMERGENCY TRAINING

by

Division of Education and Training Services

U.S. Department of the Interior

Bureau of Mines

Health and Safety Activity

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PREFACE

This text is one of a series of instruction guides developed to help health and safety instructors in the presentation of mine rescue training courses to the people of the mineral industry.

The guide contains three sections: Suggestions to the instructor, an introduction to the course stating its objectives and recommended class time, the text of the course keyed to visuals developed for use in the course.

The visuals shown are available from the Bureau in 35-millimeter slides for use with a standard slide projector.

For complete information on what materials are available and a schedule of current prices, write to--

Division of Education and Training Services
U.S. Bureau of Mines
4800 Forbes Avenue
Pittsburgh, Pa. 15213

For assistance in the presentation, recordkeeping, and certification of this course, contact your local U.S. Bureau of Mines training office.

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SUGGESTIONS FOR THE INSTRUCTOR

This guide was developed to help you, the instructor, in the presentation of the course materials. It is a suggested format for you to follow, and contains all the necessary information for the course. You may wish to add your own materials, or delete portions of the course to meet the specific needs of your teaching situation.

The course is presented as a lecture-demonstration and is amply supported by visual aids. This combination affords a change of pace in the presentation to prevent losing the students' attention. It is suggested that you study the complete text for basic ideas before the class meets, then present them in your own words. In any case, do not read from the text; an instructor who reads from a text might do better by handing out written copies to the students.

It is recommended that you open the course by telling the class why they are there and what they can expect to accomplish. As an instructor, you are responsible for pointing out the importance of the attitudes of employees and operators toward personal safety.

The manner in which you present the course is of vital importance. Experts state that there are three E's in the achievement of safety: Engineering, Education, and Enforcement. This is true, but there is a fourth "E" that is very important in safety--Enthusiasm. Your enthusiasm toward the subject will be infectious to the students; your convictions can become their convictions. Know your subject thoroughly. If you can provoke your men to think about the problem, you have attained an important goal. Thinking leads to ideas, ideas lead to action, and action leads to safer working conditions. This text is not the complete answer. Study available publications on the subject and use firsthand experience to strengthen the presentation.

Before presenting the course, converse with employees and invite them personally to participate in the coming class. Be friendly and courteous! Shake hands with each man and encourage him to talk about his job. Everyone likes to feel important.

In preparing for a class, allow sufficient time to set up the classroom in an orderly fashion and to install all the equipment. Check the classroom ventilation and temperature. If the room is hot and stuffy, your students will go to sleep no matter how good you are. Start on time and quit on time. Watch your class closely. If they become restless or bored, change your pace. Use humor to stress a point, but keep it clean.

Encourage questions--remember that a student retains more by participating than simply by seeing and hearing. Be prepared to give intelligent answers. Never belittle the question to cover your lack of information. Although you have special knowledge of the subject, talk <u>with</u> the group--not down to the crowd.

In the following introduction, you will find an outline of the course, giving its objectives and describing all the necessary preparations. This introduction is intended primarily for your own use, but it may be helpful in defining what you hope to achieve and what you can expect your students to derive from the course.

INTRODUCTION

Purpose

This course is designed to instruct miners in how to handle themselves if an emergency occurs in their particular mine.

Goals and Methods

The overall goals of the course are--

1. To instruct the miner in emergency procedures at his mine.
2. To develop the ability to recognize emergencies when they arise.

Training methods employed will include lecture-discussion and demonstration techniques reinforced with the use of audiovisual materials. Class participation will be encouraged for the motivation of interest and the development of concepts. A map of the specific mine and level in which the miner is employed shall be obtained and used.

Objectives

The objectives of the course are to enable the miner to--

1. Recognize symptoms of an emergency such as--
   - a. Smoke
   - b. Changes in ventilation.
   - c. Sudden air blasts.
   - d. Stench.
2. Know the symptoms and hazards of the following dangerous gases and conditions:
   - a. Carbon monoxide.
   - b. Oxides of nitrogen.
   - c. Hydrogen sulfide.
   - d. Carbon dioxide.
   - e. Oxygen deficiency.
   - f. Sulfur dioxide.
3. Know how and when to use the self-rescuer.
4. Know designated assembly points in his mine.
5. Know the primary and secondary escape routes in his mine.
6. Know barricading positions in his area.
7. Know how to construct a barricade.
8. Know communication and escape procedures.
9. Know what to do until the rescue party arrives.

Time

A minimum of 2 hours will be required to complete the course.

COURSE OUTLINE

1. Individual survival

   a. Recognizing emergencies.

      (1) Interruption of normal operating procedures, etc.

      (2) Smoke and symptoms of CO, NO_2, H_2S, SO_2, and O_2 deficiency.

      (3) Changes in ventilation.

      (4) Airblast.

      (5) Stench.

      (6) Notification. FR 57.11-54.

      (7) Fire alarm system for the individual mine.

      (FR 57.4-40
      (FR 57.4-51

      (8) Methods of communication. FR 57.11-54.

   b. What to do in an emergency.

      (1) Obtain self-rescuer.

      (2) Report emergency.

      (3) Give the location and nature of emergency immediately.

      (4) Seek information. FR 57.4-50.

      (5) Follow instructions received. FR 57.11-53.

      and (FR 57.4-22
      (FR 57.4-23

      (6) Head for designated assembly area if possible (refuge chamber). FR 57.11-51
      FR 57.11-52

      (7) Alternatives, if assembly point cannot be reached.

      (8) Get out according to training or instructions.

      (9) Fire doors. FR 57.11-53.

      (10) Barricade.

2. Escape procedures.

    a. Primary escape procedure. FR 57.11-50.

    b. Secondary escape procedure. FR 57.11-50.

3. Barricading.

    a. Suitable location (previously selected area).

        (1) Pick a place where a minimum number of barricades will be built.

        (2) Inspect to make sure there is no other opening into the barricade area.

        (3) Select large area to accommodate group.

        (4) Stay out of dip places.

        (5) Pick a place that has good back.

        (6) Adequate height.

        (7) Air lines and water lines. FR 57.11-50, 51, and 52.

        (8) Track area if possible (in rail haulage mine only).

    b. Erecting the barricade.

        (1) Temporary barricade.

        (2) Main barricade.

Visual 1

Major Mine Emergency

(page 33)

Visual 2

Recognizing Emergencies

(page 34)

MINE EMERGENCY TRAINING

Training in procedures to follow in event of mine fire, explosion, or other emergency is essential to all personnel in the mining industry. An organized plan for survival should be discussed with all employees. Knowledge of safe procedures and being prepared for an emergency can save, and has saved, many lives (Visual 1).

Being prepared for an emergency provides the miner with a basis for his survival and the survival of his fellow employees.

Recognizing that an emergency exists is a key requisite in training for survival. Every miner must know immediately when a dangerous situation exists. Smoke or clouds of dust indicate that either a fire, a massive rockfall, or an explosion has occurred. Along with the immediate alarm, other symptoms may already be present in the mine atmosphere. Many fatalities and serious accidents have occurred, and continue to occur, in mines throughout the world from the effects of poisonous, suffocating, and explosive gases. Every miner should have a clear understanding of the danger involved, and acquire a thorough knowledge of the subject. This section incorporates pertinent information on the gases most commonly found in mines, their physical characteristics, and their determination and detection (Visual 2).

Visual 3

Oxygen Deficiency

(page 35)

Contaminated Atmospheres

The gases from a fire are much like those from an explosion; that is, carbon dioxide and nitrogen will increase, carbon monoxide will be formed, and oxygen will decrease. Their proportions in the atmosphere of the workings are somewhat similar, and under some conditions in both fires and explosions the carbon monoxide content may be very high and the oxygen content decidedly low. In an explosion, the gases are formed very quickly by rapid burning of combustible material or gas. The gases evolved by a fire usually result from burning of carbonaceous material, and may include hydrogen sulfide or sulfur dioxide.

Oxygen Deficiency

Man breathes easier and works best when the oxygen content of the air is maintained at approximately 21 percent. When the oxygen content drops to 15 percent the person will have symptoms of rapid breathing, rapid heartbeats, dizziness, and buzzing in the ears. A man generally loses consciousness when the oxygen content in the air drops below 12 percent. Any decrease in the normal percentage of oxygen in the atmosphere is called "oxygen deficiency," and it may be produced by the following causes (Visual 3):

1. Removal of oxygen from air by either oxidation of minerals or its consumption by organic matter. Flame and decomposition of timber may also produce oxygen deficiency. Flame consumes oxygen to maintain combustion; so do fungi found in rotting timber and other damp places.

2. Introduction of other gases. This happens in the event of explosions, fires, blasting, or emanations from rock strata, or from an exhaust from internal combustion engine.
3. A combination of both causes.

Carbon Monoxide

Carbon monoxide (CO), frequently but inappropriately called whitedamp, is a product of incomplete combustion of solid, liquid, or gaseous materials that contain carbon. The term "whitedamp" is misleading because the gas is colorless and therefore invisible. It is tasteless and odorless. The specific gravity of carbon monoxide is 0.9672, and its weight per cubic foot at sea level pressure at 70° F is 0.073 pound. The most important characteristic of carbon monoxide is its poisonous, or asphyxiant, action upon man, even in very low concentrations. Because of its widespread occurrence and the fact that it may be formed in burning almost any type of fuel or other carbon-containing substance, carbon monoxide has been a hazard to the human race since man first built fires. Carbon monoxide is produced during mine fires, by explosions of gas, and in blasting or the burning of explosives. Carbon monoxide is combustible, and air that contains 12.5 to 75 percent of carbon monoxide will explode if ignited. Carbon monoxide can be detected with various types of carbon monoxide detectors, but cannot be detected with a flame safety lamp until the concentration becomes so high that persons without respiratory protective equipment would be overcome almost immediately.

Action of Carbon Monoxide on the Body

Carbon monoxide exerts its extremely dangerous action on the body by displacing oxygen from hemoglobin--the red coloring matter of the blood that normally absorbs oxygen from the air in the lungs and delivers the oxygen (as oxyhemoglobin) to the different tissues of the body that require oxygen to do their work and to support life. The affinity of carbon monoxide for hemoglobin is 200 to 300 times that of oxygen. Therefore, if only a small amount of carbon monoxide is present in the air breathed into the lungs, the hemoglobin will absorb the carbon monoxide in preference to the oxygen present. The compound formed by carbon monoxide with blood is known as carbon monoxide-hemoglobin. When carbon monoxide is absorbed by the hemoglobin, it changes the normal oxyhemoglobin to carbon monoxide-hemoglobin and thus reduces the capacity of the blood for carrying oxygen to the tissues. Owing to lack of oxygen, these tissues cannot do their work properly, and ill effects result. The severity of these effects depends on the quantity of carbon monoxide that is absorbed by the blood, or, as it is usually expressed, the "percent saturation" of the blood with carbon monoxide. For example, if half the normal oxyhemoglobin of the blood was displaced by the formation of carbon monoxide-hemoglobin, the blood saturation with carbon monoxide would be 50 percent. The degree of saturation and the rate at which it is attained as the result of exposure to an atmosphere contaminated with carbon monoxide depend on the concentration of carbon monoxide in the air, the duration of exposure, and the extent of physical exertion during exposure.

Symptoms of Carbon Monoxide Poisoning

The symptoms caused by various percentages of carbon monoxide in the blood are given in the following tabulation:

Blood saturation, percent	Symptoms
0 to 10.................	None.
10 to 20.................	Tightness across forehead, possibly headache.
20 to 30.................	Headache, throbbing in temples.

Blood saturation, percent	Symptoms
30 to 40.................	Severe headache, weakness, dizziness, dimness of vision, nausea and vomiting, and collapse.
40 to 50.................	Same as above with more possibility of collapse and unconsciousness, increased pulse and respiration.
50 to 60.................	Unconsciousness, increased respiration and pulse, coma with intermittent convulsions.
60 to 70.................	Coma with intermittent convulsions, depressed heart action and respiration, possibly death.
70 to 80.................	Weak pulse and slowed respiration, respiratory failure, and death.

The symptoms decrease in number with the rate of saturation. A man suddenly exposed to high concentrations may collapse before he experiences any warning symptoms. The rate at which a man is overcome and the sequence in which the symptoms appear depend on several factors--the concentration of gas, the extent to which he is exerting himself, the state of his health and individual susceptibility, and the temperature, humidity, and air movement to which he is exposed. Exercise, and high temperature and humidity, with little or no air movement, tend to increase respiration and heart rate and consequently result in more rapid absorption of carbon monoxide. Under conditions that may be encountered in mine fires and explosions, interest centers mainly on the symptoms of "acute" carbon monoxide poisoning that may develop rather suddenly upon exposure to high concentrations of the gas. However, prolonged exposure to low concentrations of carbon monoxide that do not produce immediate serious effects (sometimes referred to as "chronic" exposure or

Visual 4

Physiological Effects of
Carbon Monoxide
(page 36)

poisoning) may result in a continued feeling of tiredness, headache, nausea, palpitation of the heart, and sometimes mental dullness.

In severe cases of carbon monoxide poisoning that result in prolonged unconsciousness, short of death, with accompanying depletion of the normal supply of oxygen to the body tissues, permanent damage may be suffered. The brain particularly may be affected, to an extent that the victim may sustain an impaired mind, suffering loss of memory and paralysis or sensory defects. Such effects are not caused specifically by the carbon monoxide, but rather by the prolonged lack of oxygen in the tissues. Such asphyxia (unconsciousness caused by lack of oxygen) may result from any cause.

The physiological effects of various concentrations of carbon monoxide and the significance of time of exposure are given in visual 4.

Concentration of carbon monoxide, percent	Physiological effects
0.01....................	Allowable for exposure of several hours.
.04 to 0.05...........	Can be inhaled for 1 hour without appreciable effect.
.06 to .07...........	Just noticeable effects after 1 hour exposure.
.10 to .12...........	Unpleasant, but probably not dangerous after 1 hour exposure.
.15 to .20...........	Dangerous for exposure of 1 hour.
.4 or more............	Death in less than 1 hour.

The generally recognized maximum allowable concentration for an 8-hour exposure to air containing carbon monoxide and with normal oxygen content is 0.005 percent (50 parts of carbon monoxide per million parts of air, by volume). Somewhat higher concentrations may be considered allowable for shorter periods of exposure. For example, in the ventilation of vehicular tunnels, the maximum is generally set at 0.02 percent, as based upon the exposure of traffic officers in alternate 2-hour periods over an 8-hour shift.

The symptoms decrease in number with the rate of saturation. If exposed to high concentrations, the victim may experience few or no symptoms, and will be overcome almost instantly.

Oxides of Nitrogen

Oxides of nitrogen (NO, NO_2, etc.) are formed in mines by burning, by after-burning, and, under certain conditions, by detonation of high explosives. They are also components of the exhaust of diesel and gasoline engines and are formed by the reaction of atmospheric oxygen and nitrogen in the air in close proximity to electric arcs and sparks. Oxides of nitrogen are produced also by burning or decomposition of nitrates and nitrated materials. The most commonly occurring toxic oxides of nitrogen are nitric oxide (NO) and nitrogen dioxide, which occurs in two forms (NO_2 and N_2O_4), depending on the existing temperature. Nitric oxide does not exist in significant amount in the air, because in the presence of moisture and oxygen it is oxidized to the dioxide. Therefore, when air samples are analyzed for oxides of nitrogen the results usually are reported in terms of nitrogen dioxide (NO_2), as such designation gives proper evaluation of the toxic properties of the atmosphere. Nitrogen dioxide is brownish red, but in low concentrations, which nevertheless may be quite toxic, it is not visible, particularly in dimly lighted places. Oxides of nitrogen, in their several forms, are believed to contribute to the powder-fume odor that follows blasting with high explosives. The specific gravity of nitrogen dioxide is 1.5894, and its weight per cubic foot at sea level pressure at 70° F is 0.119 pound.

Visual 5

Physiological Effects of Oxides of Nitrogen
(page 37)

The toxic oxides of nitrogen dissolve in the moisture of the lungs, forming nitrous and nitric acids, which corrode the respiratory passages, and the breathing of relatively small quantities may cause death.

The effect is unlike that of carbon monoxide in that a person may apparently recover from an exposure to oxides of nitrogen and then suddenly die several hours or even days later. Oxides of nitrogen are quite irritating to the throat and upper respiratory tract but do not cause particular pain immediately upon inhalation into the depths of the lungs. However, if exposure has been severe, difficulty in breathing may be noticed in a few hours, and in a few hours more the victim may be dead, literally drowned by the water that has entered his lungs (edema of the lungs) from other parts of his body in an attempt to counteract the corrosive effects of the acids formed by the oxides of nitrogen.

Concentration of oxides of nitrogen		Effects
Parts per million	Percent	
25	0.0025	Maximum allowable for prolonged exposure.
60	.006	Minimum causing immediate throat irritation.
100	.01	Minimum causing coughing.
100 to 150	0.01 to .015	Dangerous for even short exposure.
200 to 700	.02 to .07	Rapidly fatal for short exposure.

When high explosives burn, high concentrations of oxides of nitrogen may be formed; hence areas containing gases from burning high explosives, whether in storage underground or in boreholes, should not be entered except by properly trained personnel with adequate respiratory protection (Visual 5).

When explosives having properly proportioned components are detonated, they usually produce exceedingly small percentages of oxides of nitrogen which are considered harmless. For example, after blasting with 40-percent gelatin dynamite in 36 drift rounds in dry holes, with an occasional wet lifter hole, in an Arizona copper mine, the oxides of nitrogen were found to range only from 0.0000 to 0.003 percent.

Apparently the explosive used in these tests did not produce harmful concentrations of oxides of nitrogen; however, some high explosives, because of the kind and/or proportion of the ingredients may produce oxides of nitrogen in harmful quantities even when apparently properly detonated and no afterburning occurs. Moreover, experiments on gelatin dynamites have shown a ratio as high as 5:1 in oxides of nitrogen between wet holes and dry holes. In wet places, the concentration of these gases decreases rapidly after blasting, even without ventilation.

Monitoring of suspected atmospheres is particularly important since the odor threshold of NO_2 is about the level of the recommended MAC of 5 ppm.

Continued exposures to concentrations much above this value may produce obvious and lasting physical harm. One of the greatest hazards of exposure comes from the fact that effects, except in cases of extremely high concentration, are not felt until several hours after exposure.

Hydrogen Sulfide

This gas, chemical symbol H_2S, specific gravity 1.191, is commonly called "stink damp," due to its distinct odor of rotten eggs. It occurs in many coal and metal mines. It is dissolved into mines through the strata. It is seldom

Visual 6

Effects of Hydrogen Sulfide
(page 38)

found in dangerous quantities. Its common sources in significant quantities are the combustions of black blasting powder, blasting of sulfide ores, and dewatering of flooded areas in mines. Harmful quantities are often found in gypsum mines, in the digging of tunnels, caissons, and shafts, and in natural gas.

It is believed that explosive quantities of hydrogen sulfide have not been found in mines; however, this gas is explosive in any concentration between 4.4 and 44.5 percent in the air.

Hydrogen sulfide is more poisonous than carbon monoxide, but its characteristic odor of rotten eggs makes its presence easy to detect. <u>One-tenth of one percent (0.1 percent) may cause instantaneous death</u>, and unconsciousness may result from exposure to 0.02 percent. This gas is very irritating to the eyes and throat, and as its concentration increases, <u>it also tends to destroy the sense of smell</u>. Thus, a person exposed to H_2S may think the proportion of the gas is decreasing, when it may actually be increasing (Visual 6).

This gas is absorbed by water and is liberated when the water is disturbed; therefore, care must be taken not to disturb pools of water when it is suspected that they may contain hydrogen sulfide. One cubic foot of water can liberate approximately 3 cubic feet of hydrogen sulfide. Water containing this gas should not be allowed to travel along open ditches, and it should be trapped in a sump close to its source, so that it may be pumped through a pipeline in order to prevent the constant liberation of the gas.

Toxic action of hydrogen sulfide for the various concentrations is as follows:

Probable safe concentration for 8 hours exposure...	0.002 percent or 20 ppm.
Dangerous concentration after 1 hour exposure......	.02 percent or 200 ppm.
Extremely dangerous after 30 minutes..............	.04 percent or 400 ppm.
Instantaneous death...............................	.1 percent or 1,000 ppm.

The aftereffects of this intoxication are serious, similar to those of carbon monoxide. They last for long periods of time and may have permanent effects. Should the concentration be high enough, death follows rapidly after the victim has lost consciousness.

Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless, nonflammable, suffocating, irritating gas with a strong, pungent, sulfurous smell. It is sometimes formed in the blasting of certain sulfide ores and may be present when there are gob fires in which iron pyrite is burning. The chemical symbol is SO_2. The specific gravity of sulfur dioxide is 2.2638, and its weight per cubic foot at sea level pressure at 70° F is 0.170 pound.

Sulfur dioxide is strongly irritating to the eyes, nose, and throat, even in low concentrations, and can cause severe damage to the lungs if inhaled in high concentrations, and such concentrations may cause partial or complete respiratory paralysis. Because of the extremely irritating effects of sulfur dioxide, men are not likely to enter voluntarily into atmospheres containing enough of the gas to be immediately dangerous. High concentrations of the

Visual 7

Effects of Sulfur Dioxide
(page 39)

gas (1 percent or more) are irritating to moist areas of the skin. The physiological effects of various concentrations of sulfur dioxide in air are given below (Visual 7).

Concentration of sulfur dioxide, parts per million parts of air	Effects
0.3 to 1	Detectable by most persons by sense of taste rather than by odor.
3 to 5	Detectable odor.
10	Maximum concentration allowable for prolonged exposure.
20	Minimum concentration causing coughing and immediate irritation of the eyes.
50	Pronounced irritation of eyes, throat, and lungs, but possible to breathe several minutes.
50 to 100	Maximum concentration allowable for short exposure (1/2 to 1 hour).
150	Extremely disagreeable but may be endured for several minutes.
400 to 500 (0.04 to 0.05 percent by volume)	Dangerous for even short exposure; may be impossible to breathe.

Because of the strong and characteristic odor and irritating effects of sulfur dioxide, personal observations of the intensity of odor or irritation often may be used to make rough estimates of the concentration present in contaminated atmospheres.

Sulfur dioxide usually can be recognized by its characteristic odor--that of burning sulfur. In low concentrations it is faintly detectable by smell or taste and produces slight throat irritation and tendency to cough. In high concentrations it is increasingly irritating to the eyes, throat, and lungs, and produces an intolerable sense of suffocation. Some estimate of the concentration present can be made from the severity of these effects.

Methane

Methane (CH_4), also known as marsh gas, and sometimes called firedamp, is colorless, odorless, tasteless, nonpoisonous, and flammable. Although methane is odorless, it may be accompanied by other gases that have distinct odors. The specific gravity of methane is 0.5545, and its weight per cubic foot at sea level pressure at 70° F is 0.042 pound. Methane is found occasionally in metal and other types of mines and in tunneling operations. It may issue from "blowers" or "feeders" or from overlying or underlying strata. Methane is frequently found when mining through or near carbonaceous shales.

The liberation of methane from the strata in mines may be a steady flow or a sudden outburst. It is usually found near the mine roof or in high places; after becoming thoroughly mixed with air, it will be found uniformly distributed and will not separate or stratify. Methane has no specific physiological effect upon man, but enough may accumulate in mine workings to dilute the oxygen vaulting in atmospheres deficient in oxygen. Death from asphyxiation has resulted to men who unknowingly entered high concentrations of methane.

Air that contains 5 to 15 percent methane and 12.1 percent or more oxygen will explode if ignited. Adequate ventilation is necessary to dilute the methane content and render it harmless. Two hundred cubic feet of an explosive methane-air mixture can precipitate a general explosion. The concentration of methane, therefore, should be kept as low as possible by proper ventilation.

Recognizing Emergencies

Sudden changes in mine ventilation can serve as a warning to the experienced miner. Knowing when the air is not traveling in its usual course and volume will alert personnel that something is wrong. Blasts of air and stench contaminants in the mine air immediately notify the worker of potential danger.

A fire alarm system shall be installed in a mine that will clearly indicate that a dangerous situation exists. This fire alarm system shall provide an accurate basis for recognizing an emergency.

Interruption of normal operating procedures is often an early indication that something is wrong. A power interruption or an interrupted loading cycle or trip schedule should be investigated promptly. An operating location with no one present should arouse suspicion. Remember that any unusual circumstance should be investigated, because quite often an individual can recognize that an emergency exists from small changes in routine operation and procedures.

Immediately after determining that an emergency exists, the alarm must be spread. Notify everyone in the vicinity. Make sure that someone goes to the telephone to inform mine officials. It is important to describe, as accurately as possible, the situation as it currently exists.

Visual 8

In An Emergency...
(page 40)

Escape Procedures

When a miner learns that an explosion has occurred or a fire has started in the mine, he faces a difficult problem. Generally, he realizes that he must act promptly to save himself and his coworkers. His first impulse is to try to get out of the mine, and usually he picks up his lunch or dinner bucket and begins following the route he has been accustomed to travel to and from his work. If he has noticed the direction in which the air moved under regular working conditions, he now will note whether the air current has stopped or has been reversed.

If the miner has felt the shock of the explosion, he may not be able to determine in what part of the mine the explosion occurred. If he is trying to get out, he should attempt to find a way free of afterdamp (the toxic mixture of gases that follows an explosion) and smoke. If he is not overcome at once, he should not become confused and panic-stricken and waste his strength.

The miner's best chance of getting out alive, if he encounters highly heated or gassy air in his first attempt to escape, is to use a self-rescue device. A self-rescuer will provide protection from carbon monoxide gas while escaping through contaminated mine atmosphere after a fire or explosion. Do not hesitate to put on a self-rescuer immediately after a fire or explosion, because deadly carbon monoxide may be present in advance of the smoke or fire. Many lives have been saved by proper use of the self-rescuer (Visual 8).

A flame safety lamp or other devices for measuring oxygen deficiency should be carried. Self-rescuers will convert harmful carbon monoxide to relatively harmless carbon dioxide, but sufficient oxygen must be present to sustain life.

The flame safety lamp will indicate whether sufficient oxygen is present. It will burn if sufficient oxygen is present, and extinguish in an area of oxygen deficiency. Carry the lamp carefully and observe the action of the flame closely when traveling.

Try to get more information concerning the situation. Go to the predesignated assembly area, or to a refuge chamber. Take your lunch bucket with you; it may save your life. If your self-rescuer is getting warm or even uncomfortable from heat, do not remove it. This is a good indication that you are in an atmosphere containing carbon monoxide. To remove it may mean instant death.

Do not panic; be cautious in your movements. Knowing where you came from can be valuable in an alternate plan for survival if the situation develops adversely. Joining other men or a group of men can provide valuable information and assistance. One man in a group is usually coolheaded enough to assume planning and leadership responsibilities.

Telephone to the outside if this has not already been done. Report the situation as clearly as possible in your surrounding area. Include as many details as you can that are pertinent in describing the emergency.

Listen carefully to information being related over the telephone. Evaluate the communication carefully and ask questions if there is any doubt concerning the procedure. It is a good practice to repeat the instructions out loud so that others may also understand directives being relayed over the telephone.

Follow directions explicitly. Formulate a primary escape route and a secondary one to follow if the initial one is not workable. Use good common

Visual 9

Primary Escape Route
(page 41)

Note: Use map of local mine.

sense in evaluating changing conditions. A knowledge of the location and function of fire doors is essential in planning an escape route.

After mine explosions and during mine fires, deadly gases spread through the workings and imperil the men who survive the violence or heat. At such time many miners have saved their lives by building barricades to protect themselves. Any miner who may be trapped in a mine may escape death if he knows how others have saved their lives by sealing themselves promptly behind well-located and well-constructed barricades, bulkheads, or stoppings.

Primary Escape Route

When a fire or an explosion occurs in a mine, the first impulse of the survivors is to rush toward the nearest exit, either to the surface or to the shaft station, to be hoisted to the top. But if the men encounter smoke and gases, especially if advancing upon them, they must retreat and attempt to try some other possible means of escape.

Usually in times of emergency, people become terror-stricken. A competent person must take charge of the situation at this time.

The "man in charge" must be coolheaded and intelligent, and he must possess leadership qualities. He must have a knowledge of the mine workings, the emergency escapeways, and the designated procedures to follow in case of a mine fire or explosion. He must be able to give instructions to the men and see that these orders are followed.

In case of a recognized emergency, the leader must gather his men together and explain to them the problem they face. He should explain to the men the different alternatives they have for escape, the procedure they will use for escape, and what is expected from them (Visual 9).

Visual 10

Secondary Escape Route
(page 42)

Note: Use map of local mine.

After the men have received their instructions, they should start their escape.

If a rope, line, or suitable material is available, the men should be attached to prevent separation. Evacuation should start with the lead men out front, and the second man within seeing distance of him, and the main body following. Traveling cautiously and every man wearing his self-rescuer, the lead man should explore his primary escape route first. Using the gas-testing devices available, he should test for poisonous gases and oxygen deficiency. He must be on the alert for hazardous conditions such as fires and smoke. He must keep his men under control at all times for their own safety and safety of others.

When escape has been cut off because of gas or smoke or inaccessibility of the primary route, the leader must retreat his men and attempt to escape by way of the secondary route.

Secondary Escape Route

In many instances following an underground mine emergency, the miners are faced with hazards prohibiting the use of primary escape routes.

In this situation an alternative option or a predetermined secondary escape route should be provided and all workmen familiarized with its location and availability. If it is necessary to use the alternate route, proceed to its nearest entrance and follow the same procedure as prescribed for the primary escape route (Visual 10).

Barricading

When escape from the mine is not possible by the primary or the secondary escape routes or when the risk is considered to be too high, barricading is the alternative. Miners should be well trained (and periodically retrained) to isolate themselves from toxic gases and smoke by erecting barricades of any available materials suitable for substantial airtight construction.

In pursuing a means of escape from the mine, either by the primary or secondary route, the entrapped miners should be especially observant of the location of available materials necessary for barricading purposes should the necessity arise. The miners should collect, or store for future use, tools, timber boards, canvas, brattice cloth, water, lunch buckets, and anything else that might be useful in the construction of a barricade.

Many companies provide barricading kits in strategic locations. All miners should be instructed that these materials are not to be used for any other purpose. As a minimum for underground protection, each section should be provided with barricading kits that include spare emergency breathing devices, chemical oxygen generators and carbon dioxide removal agents, food, water, gas detectors, and emergency communication equipment. This material can be mounted on a cart and easily moved to new locations as the section advances or retreats.

In choosing a suitable location for a barricade, the basic purpose of the barricade must be kept in mind. The purpose of a barricaded area is to form a refuge chamber. The size of the enclosed space determines the number of men the barricade will shelter and the length of time they can remain there safely.

Visual 11

Barricades
(page 43)

One of the first considerations is to keep the air in the selected area respirable. An important first step is to short-circuit the ventilation as soon as possible to keep noxious gases from entering the area. It may be necessary to open doors, destroy doors or stoppings.

Temporary barricades may be erected by hanging brattice cloth, moving doors to a new place; doing whatever is necessary to change that ventilation in order to keep the air in the selected area respirable. Since time is of prime importance, it is necessary that a minimum number of barricades be built. In some instances, the drift may be shut off for a considerable distance with one or two barricades. It is necessary to keep in mind that as much area as possible containing respirable air should be sealed off. Assuming that a single miner consumes a cubic yard of air an hour, an enclosed space 10 feet wide by 10 feet high by 10 feet deep contains 1,000 cubic feet or 37 cubic yards of air, and will thus support a single miner for 37 hours. This does not provide for absorption (Visual 11).

In order for this refuge chamber to be effective, it is necessary that all openings into the barricaded area be sealed. You should inspect thoroughly to be certain there are no other openings into the barricaded area. Back-filled ground should not be used, as gases are likely to pass through such areas.

It should be remembered that in many instances, there will be a general power failure, consequently water pumps, ventilating fans, etc., will be inactive; therefore do not barricade in areas where water might accumulate or where certain gases might settle.

Visual 12 Temporary Barricade (page 44)

Visual 13 Permanent Barricade (page 45)

Since the area might be utilized for some time, it should be as safe as possible. Choose a place that has good back. Any place that fits the other criteria and that might also have water or air lines would be desirable. If there is a rail haulage area, and this area meets the other requirements, rescue and recovery procedures would be expedited.

Temporary Barricade

The purpose of the temporary barricade is to establish an immediate barrier against irrespirable air and to provide sufficient time for the erection of a permanent barricade. Once this temporary barricade has been constructed, this also provides an airlock for the rescue team (Visual 12).

Temporary barricades may be erected with any materials available which may be used to form a sealing over the opening. There are documented cases of men using wood, clothing, canvas piping, chute lagging, canvas mat, belting, spilling, etc., to erect temporary barricades. To make this temporary barricade as airtight as possible it may be necessary to use mud, clothing, or anything available to cover or plug those spaces where air might be able to pass.

In order to assist in rescue operations, the men that build the barricade should write on the outside of the temporary barricade the date, time, and number of men that are behind the barricade. This will enable the rescue team to have the necessary materials on hand when the barricade is opened.

Permanent Barricade (Visual 13)

Now that the mine ventilation has been short-circuited and the temporary barricade has been erected, more time is available for building the permanent barricade.

If cement blocks are available, they should be used. When these blocks are used, it may be necessary to backfill along the bottom. The debris taken from the back or along the bottom may be used for backfilling. It will be necessary to plaster with mud all crevices or openings between blocks, back, walls, etc.

In many instances, it will be necessary to use wood or timbers. Timbers should be set against barricades utilizing boards to make them as strong as possible. In some cases waste may be used as ballast between two board barricades. In any case, if boards are used to build the barricade, care should be exercised to make certain the barricade is airtight. If there are air or water lines passing through the barricade, care should be taken to make the area around these lines airtight.

Once the permanent barricade has been built, the air lines should be opened and monitored. The individual in charge should space men throughout the area. The men should rest in order to conserve oxygen. Preferably all lights except one should be turned off.

Air within the enclosed area tends to become dormant, so it is necessary for a man to walk through the area occasionally in order to stir up the atmosphere. This individual should also check the condition of the men.

Since the men may be in the barricaded area for an undetermined time, the man in charge should collect all lunch pails and ration the food and water. The man in charge should periodically check the barricade for leaks and should detail a man to tap on the water or air lines at intervals as outlined in

Visual 14 Duties of the Man in Charge (page 46)

Visual 15 Never Open Barricades (page 47)

emergency rescue procedure in an attempt to establish communications with the mine rescue team (Visual 14).

When communication with the mine rescue team has been established, it must be remembered that the next few minutes, or possibly hours, are of ultimate importance to a successful rescue. Remember, only the mine rescue party is to dismantle a barricade (Visual 15).

The mine rescue team may have come through irrespirable atmosphere. They must, in some instances, obtain extra materials and equipment to take care of the men behind the barricade. They must enter the airlock, rebuild the stopping, and perform many other duties prior to the safe rescue of the men. It is essential that the barricaded personnel remain within the confined area until rescued. Communication between the two groups will include all of the necessary precautions for a safe rescue.

Please fill out the instructor's evaluation form and send it to--

Division of Education and Training Services
U.S. Bureau of Mines
4800 Forbes Avenue
Pittsburgh, Pa. 15213

This is to assist in evaluating the course and to help in planning for future courses and revisions.

INSTRUCTOR'S COURSE EVALUATION FORM

Mine Emergency Training

1. The course was--

   ___ Excellent ___ Adequate

   ___ Better than average ___ Poor

2. Check all visuals that were used:

   ___ Posters ___ Flip charts

   ___ Slides ___ Transparencies

   ___ Pocket cards

3. The visuals were--

   ___ Excellent ___ Adequate

   ___ Better than average ___ Poor

4. Were training models used during the course?

   ___ Yes ___ No

5. The instruction guide was--

   ___ Excellent ___ Adequate

   ___ Better than average ___ Poor

6. The strong points of the program were ______________________________
   ____
   ____.

7. The weak points of the program were ______________________________
   ____
   ____.

8. Briefly state suggestions for improvement or any other comments you wish to make. ______________________________
   ____
   ____
   ____
   ____.

USE THE BACK OF THIS SHEET FOR ANY FURTHER COMMENTS

APPENDIX A.--FEDERAL METAL AND NONMETALLIC MINE SAFETY ACT OF 1966

Part 57.--Health and Safety Standards--Metal and Nonmetallic Underground Mines

57.4 Fire prevention and control.

57.4-32 All employees should be instructed on current escape and evacuation plans, fire alarm signals, and applicable procedures to be followed in case of fire.

57.4-22 Mandatory. Each mine shall have available or be provided with suitable firefighting equipment adequate for the size of the mine.

57.4-23 Mandatory. Firefighting equipment which is provided on the mine property shall be strategically located, readily accessible, plainly marked, properly maintained, and inspected periodically. Records shall be kept of such inspections.

57.4-40 Mandatory. Fire alarm systems shall be provided and maintained in operating condition or adequate fire alarm procedures shall be established to warn promptly all persons endangered by a fire.

Underground Only

57.4-50 Mandatory. Specific escape and evacuation plans shall be established and kept current. Escape routes shall be marked plainly.

Underground Only

57.4-51 Mandatory. Fire alarm systems adequate to warn all employees shall be provided and maintained in operating condition.

Escapeways

Underground Only

57.11-50 Mandatory. Every mine shall have two separate properly maintained escapeways to the surface which are so positioned that damage to one shall not lessen the effectiveness of the other, or a method of refuge shall be provided when only one opening to the surface is possible.

57.11-51 Mandatory. Escape routes shall be:

(a) Inspected at regular intervals and maintained in safe, travelable condition.

(b) Marked with conspicuous and easily read direction signs that clearly indicate the ways of escape.

57.11-52 Mandatory. Refuge areas shall be:

(a) Of fire-resistant construction, preferably in untimbered areas of the mine.

(b) Large enough to accommodate readily the normal number of men in the particular area of the mine.

(c) Constructed so they can be made gastight.

(d) Provided with compressed air lines, water lines, suitable handtools, and stopping materials.

57.11-53 Mandatory. Mine maps shall be posted and available showing escape routes, directions of principal airflow, locations of telephones, fire doors, ventilation doors, and brought up to date as necessary.

57.11-54 Mandatory. Telephone or other voice communication shall be provided between the surface and refuge chambers and such systems shall be independent of the mine power supply.

APPENDIX B.--VISUALS 1-15

The visual material used in the course can be obtained from the Bureau of Mines as transparencies for overhead projection, 35-millimeter slides, and flip charts. For information on ordering this material and a schedule of current prices, write to--

Division of Education and Training Services
U.S. Bureau of Mines
4800 Forbes Avenue
Pittsburgh, Pa. 15213

Alternatively, the visuals printed in this guide can be converted into visual aids, as follows:

Overhead projector transparencies.--Most infrared, dry photo, ozalid, and electrostatic copy machines will produce transparencies by using a variety of colored films and coloring techniques that are readily available.

Slides (35-mm) or film strips.--These can be produced from the visual originals by photographing them using a suitable 35-millimeter camera. Color can be added by using camera filters or by precoloring the visual originals (felt-tip pens, watercolors, etc.) and using colored film.

Flip charts.--Flip charts can be prepared from the visual originals by "blowing up" a photostat of the original visual.

VISUAL 1

MAJOR MINE EMERGENCY

1. Get Out.
2. Barricade.

VISUAL 2

RECOGNIZING EMERGENCIES

1. Sudden changes in ventilation.

2. Blasts of air.

3. Fire alarm systems:

    a. Stench warning system.

    b. Visual or audible warning.

4. Smell of contaminants.

5. Interruption of normal procedures.

VISUAL 3

OXYGEN DEFICIENCY

Oxygen present	Effect
21%	Breathing easiest
17%	Breathing faster and deeper
15%	Dizziness, buzzing noise, rapid pulse, headache, blurred vision
9%	May faint or become unconscious
6%	Movement convulsive, breathing stops, shortly after heart stops

VISUAL 4

Physiological Effects of Carbon Monoxide

Concentration of CO, Percent	Allowable Length of Exposure
0.01	Allowable for exposure of several hours
0.04 to 0.05	Can be inhaled for 1 hour without appreciable effect
0.06 to 0.07	Just noticeable effects after 1 hour exposure
0.10 to 0.12	Unpleasant, but probably not dangerous after 1 hour exposure
0.15 to 0.20	Dangerous for exposure of 1 hour
0.4 or more	Death in less than 1 hour

VISUAL 5

Physiological Effects of Oxides of Nitrogen

Concentration of oxides of nitrogen		Effects
Parts per million	Percent	
25	.0025	Maximum allowable for prolonged exposure
60	.006	Minimum causing immediate throat irritation
100	.01	Minimum causing coughing
100-150	.01-.015	Dangerous for even short exposure
200-700	.02-.07	Rapidly fatal for short exposure

*Divide by 5 for nitrogen dioxide

VISUAL 6

EFFECTS OF HYDROGEN SULFIDE

PERCENT		
0.005 - 0.010	SUBACUTE POISONING 1. MILD EYE IRRITATION 2. MILD RESPIRATORY IRRITATION	1 HOUR
.02 - .03	SUBACUTE POISONING 1. MARKED EYE IRRITATION 2. MARKED RESPIRATORY IRRITATION	1 HOUR
.05 - .07	SUBACUTE TO ACUTE POISONING 1. UNCONSCIOUSNESS 2. DEATH	½ - 1 HOUR
.10 - .20 OR MORE	ACUTE POISONING 1. UNCONSCIOUSNESS 2. DEATH	MINUTES

VISUAL 7

EFFECTS OF SULFUR DIOXIDE

CONCENTRATION		EFFECT
PARTS PER MILLION	PERCENT	
20	0.002	Coughing, irritation to eyes, nose and throat
150	.015	May be endured for several minutes
400	.04	Impossible to breathe

VISUAL 8

IN AN EMERGENCY...

Use Self Rescuer.

Verify and report the kind
and location of emergency.

Go to assembly area
if possible.

Follow instructions as to primary
and secondary escape routes,
barricades, etc.

VISUAL 9

PRIMARY ESCAPE ROUTE

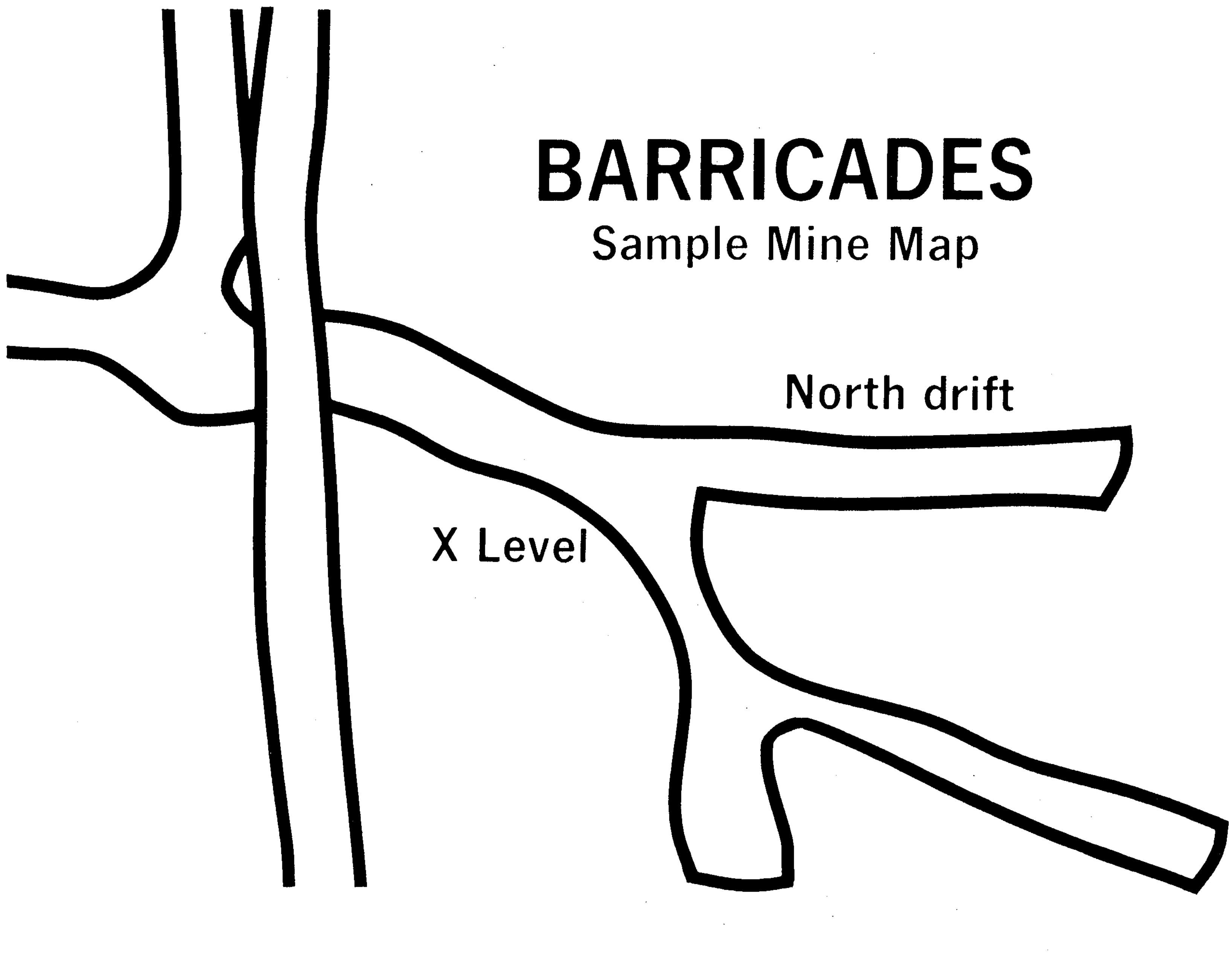
VISUAL 10

SECONDARY ESCAPE ROUTE

VISUAL 11

BARRICADES

Sample Mine Map



VISUAL 12

A temporary barricade is built to provide an <u>IMMEDIATE</u> barrier.

Build it immediately.
Use materials at hand.
Make it as airtight as possible.

VISUAL 13

PERMANENT BARRICADE

Materials --

Substantial.

Available.

Construction --

Rigid.

Tightly sealed on all sides.

Airtight.

VISUAL 14

DUTIES OF THE MAN IN CHARGE

1. Space men throughout area.

2. Turn off all lights except one.

3. Walk around to stir atmosphere
   and check on men.

4. Collect lunch pails and ration food and water.

5. Check barricades for leaks.

6. Try to establish communication.

VISUAL 15

NEVER

OPEN

BARRICADES

INT.-BU.OF MINES,PGH.,PA. 17859