ISSUE DATE: February 8, 2007

PROGRAM INFORMATION BULLETIN NO. P07-03

FROM: KEVIN G. STRICKLIN
Acting Administrator for Coal Mine Safety and Health

SUBJECT: Implementation of Section 2 of the Mine Improvement and New Emergency Response (MINER) Act of 2006: Options for Providing Post-Accident Breathable Air to Underground Coal Miners. This Program Information Bulletin should be used in conjunction with Program Policy Letter No. P06-V-10

Who needs this information?

Underground coal mine operators, miners and miners' representatives, independent contractors, Mine Safety and Health Administration (MSHA) enforcement and technical support personnel, and other interested parties need this information. This Program Information Bulletin (PIB) is issued to provide additional guidance to mine operators and MSHA district managers. This information should be used in conjunction with Program Policy Letter (PPL) No. P06-V-10 (October 24, 2006), concerning implementation of emergency response plans.

What is the purpose of this PIB?

Section 2 of the MINER Act requires that each underground coal mine operator adopt a written accident response plan ("emergency response plan" or ERP) that, among other things, "provide[s] for … emergency supplies of breathable air for individuals trapped underground sufficient to maintain such individuals for a sustained period of time." In this PIB, MSHA reiterates that, in the event of a mine emergency, the first line of defense is to evacuate the mine.

PIBs are temporary directives used to disseminate information or announcements of immediate interest to MSHA employees, mine operators, and other parties. This PIB is intended to be advisory in nature and informational in content. While Section 2 of the MINER Act imposes breathable air requirements on operators, this PIB does not impose additional requirements independent of the MINER Act. It does, however, represent the Secretary's interpretation of the quantity of breathable air that would be sufficient to maintain miners for a sustained period of time. This PIB discusses options for operators that may be of assistance in developing ERPs and for MSHA district managers who must exercise their discretion in approving ERPs. This PIB focuses on the quantity of breathable air needed, addresses the means for providing that air to trapped miners, and informs mine operators that they should train miners on the breathable air provisions of the ERP. In accordance with the MINER Act, post-accident breathable air is intended to maintain trapped miners until rescue teams reach them.

Information

I. Quantity of Breathable Air. In determining the quantity of breathable air necessary to sustain trapped miners, operators should consider specific mine conditions. The ERPs should identify all relevant variables that may impact the time required, under a variety of adverse conditions, to provide breathable air to

trapped miners.

Below are some options that may satisfy the breathable air requirement:

1) An established borehole capable of providing fresh air to a location within 2,000 feet of the working section or a hardened room in accordance with the Emergency Mine Evacuation final rule (71 FR 71037, 71430, December 8, 2006), located within 2,000 feet of the working section.

2) Each miner should be provided a 48-hour supply of breathable air, if advance contingency arrangements have been made to reliably assure that miners who cannot be rescued within 48 hours will receive additional supplies of breathable air sufficient to sustain them until rescue. These contingency arrangements should be based on the following (other arrangements offering similar levels of protection also may suffice):

a) A pre-arranged, pre-surveyed area for barricading or other location that would isolate the miners from contaminated environments, located within 2,000 feet of the working section.
b) The capacity to promptly transport a drill rig to a pre-surveyed location such that a drilled hole would intersect the area designated for barricading (or other alternatives that would isolate the miners from contaminated environments).

3) Each miner should be provided a 96-hour supply of breathable air located within 2,000 feet of the working section.

4) The operator may use other methods to provide breathable air sufficient to sustain miners trapped underground for a period of time that reasonably would be expected to establish a fresh air source for trapped miners, as long as these methods provide equivalent safety protection.

II. Location and Method of Providing Breathable Air. The ERPs should describe the operator's method for providing breathable air to trapped miners and establish the locations in which breathable air will be maintained. PPL 06-V-10 described some options through which miners could isolate themselves from contaminated/hazardous environments. ERPs should provide for breathable air within areas designated for barricading (or other alternatives that will isolate the miners from contaminated environments) and should establish the location of these areas. The locations of these areas should be shown on the escape map.

Within these areas, the supply of breathable air could be provided through various methods, including the following:

A. Boreholes with fresh air blowing fans capable of providing fresh air to trapped miners;

B. Buried or otherwise protected air lines supplied by surface positive pressure blowers and routed to locations that will isolate miners from contaminated environments;

C. Compressed air cylinders, oxygen cylinders, or chemical oxygen generators located at a designated area for barricading or other alternatives that would isolate miners from contaminated environments. When supplying breathable air through one of these methods, carbon dioxide scrubbing capability is necessary to prevent contamination of the isolated

environment.

MSHA has issued further information in Hazard Awareness for Compressed Air and Compressed Oxygen, which is available at www.msha.gov. MSHA has also developed additional information concerning methods for providing breathable air. This additional information addresses calculations for developing quantity of breathable air, and includes scrubbing capability, where applicable. This information is also available on MSHA's website (See Attachments).

III. Training in the Use of Breathable Air. ERPs should specify that all persons going underground will be trained on the breathable air provisions in the ERP.

IV. Timetable for Submission and Implementation of Breathable Air Portion of ERP.

A. Submission of the portion of ERP addressing breathable air. Mine operators must submit this portion of the ERP not more 30 days after the date of this PIB.

B. Implementation of the portion of ERP addressing breathable air. Mine operators must implement the breathable air provisions of the ERP not more than 60 days after the plan is approved.

What is the background for this PIB?

On June 15, 2006, the MINER Act became effective. Section 2 of the MINER Act amends Section 316 of the Federal Mine Safety and Health Act of 1977 and requires underground coal mine operators to develop and adopt, within 60 days of enactment, a written emergency response plan which is to be approved by MSHA. This section further requires that the ERP provide for the evacuation of all individuals endangered by an emergency and the maintenance of individuals trapped underground in the event that miners are not able to evacuate the mine. This Act requires that all emergency response plans shall provide for emergency supplies of breathable air for individuals trapped underground sufficient to maintain such individuals for a sustained period of time.

What is MSHA's authority for this PIB?

The Federal Mine Safety and Health Act of 1977, as amended by the MINER Act, June 15, 2006.

Where is this PIB on the Internet?

This information may be viewed on MSHA's home page (http://www.msha.gov), choosing "Compliance Info" and "Program Information Bulletins."

Who are the MSHA contact persons for this PIB?

Coal Mine Safety and Health Terry
Bentley, (202) 693-9500 E-mail:
Bentley.Terry@dol.gov

Who will receive this PIB?

MSHA PPM Holders
Underground Coal Operators
Miners' Representatives
Independent Contractors Special
Interest Groups

Attachments

Hazard Awareness:
Using Compressed Air and Compressed Oxygen
To Provide Breathable Air Underground

There are hazards inherent in using compressed air systems (positive pressure blowing systems or compressed air cylinders) and oxygen cylinder systems to provide breathable air in underground mining environments. This document discusses each of these systems and associated hazard awareness considerations.

I. Compressed air systems may consist of either of the following:

A. Positive pressure compressed air being induced into the isolation area via a compressor outside the mine
B. Compressed air cylinders stored in designated areas

II. Oxygen cylinder systems consist of compressed oxygen cylinders stored in designated areas

Each of these systems require training on handling, usage, and storage. Proper inspection and maintenance are critical in ensuring the viability of these systems.

I. Compressed Air Systems

A. Outside Positive Pressure Compressed Air

Storage, Handling and Use

Mines should ensure compressors have the capacity to deliver the required volume of air at the point(s) of expected usage. Additional considerations should also include the type of respirator / mask used and the number of miners expected to use them.

Air lines, taps, valves, and breathing devices should be buried and/or protected from fire and explosion forces.

Compressor air intakes should be installed to ensure that only clean, uncontaminated air enters the compressors. Care should be exercised when using compressors in the vicinity of other equipment having gas or diesel engines. Gas engines emit carbon monoxide (toxic fumes) and diesel engines emit sulfur dioxide (noxious fumes) and nitrogen oxides. Compressors requiring oil can generate carbon monoxide (CO) internally which can be supplied inadvertently to miners. Oil-type compressors could be used; however, the air quality must be sampled and/or controlled using CO filtration. Oil-less compressors do not generate carbon monoxide; thus, no CO filtering is required.

Listed below are the recommended standards for breathable air as identified by American National Standards Institute /Compressed Gas Association Commodity Specifications for Grade D breathable compressed air as defined below:

- Oxygen 19.5% - 23.5%
- Carbon Monoxide maximum 10 parts per million (ppm)
- Oil / Hydrocarbon maximum 5 milligrams per cubic meter (mg/m^3)
- Carbon Dioxide maximum 1,000 parts per million (ppm)
- Lack of noticeable odor

A redundant compressor and power source should be installed to ensure continuous operation.

Piping, couplings, and regulators should be installed in a manner that prevents contamination into the system.

Mines should provide means of removing and preventing water buildup in the air supply line.

Piping should be of a quality to allow for a long-life system to remain free of corrosion, rust and other contaminants.

Designs using a respirator/breathing apparatus should employ only NIOSH-approved units with means of flow and pressure regulation.

Respirators/breathing apparatus should be able to connect only to the breathable compressed air line. Tool compressed airlines are not recommended for providing breathable air and should not have means of allowing respirators / masks to connect to them.

B. Compressed Air Cylinders

Storage, Handling, and Use

Use a suitable hand truck for moving cylinders. Do not drag, roll, or slide cylinders.

Valve protection caps should remain in place unless container is secured with valve outlet piped to use point.

Cylinders should be stored upright and firmly secured to prevent falling or being knocked over.

Do not store cylinders in areas where temperatures exceed 125°F (52°C).

Designs using a respirator/breathing apparatus should employ only NIOSH-approved units with means of flow and pressure regulation.

Never ground a compressed air cylinder or allow it to become part of an electrical circuit.

II. Compressed Oxygen Cylinders

Storage and Handling

The cleanliness of oxygen systems is critical for their safe operation. Small combustible particles and oils could provide a fuel source for a fire and explosion if they enter a compressed oxygen system.

Always wear gloves when working on oxygen hardware. Gloves keep the oil from human hands away from the parts.

Ensure that oxygen filling stations and maintenance areas are in a locked, air-conditioned room that is clean and free of dirt, oils, and grease and that signs are posted stating "OXYGEN, NO SMOKING, NO OPEN FLAMES." Filling operations should never be conducted alone. A second person and a portable fire extinguisher should be present during the filling process.

Fire extinguisher equipment should be readily available near oxygen bottles due to the highly flammable characteristics of oxygen.

All components and materials used in the system should be suitable for oxygen service. Aluminum components should be avoided. Replace any oxygen regulators containing aluminum exposed to high-pressure oxygen with regulators made of brass.

Check for loose connections, leaking gas sounds, damage to hoses along their lengths or at their fittings, and broken gauges. Also ensure that tanks are secured and pressure regulators are properly set. Ensure wrenches and pliers are in proper working order.

Do not rely on the color of the cylinder to indicate the contents. Some manufacturers use different color cylinders for the same gas.

Use a suitable hand truck for moving cylinders. Do not drag, roll, or slide cylinders.

Valve protection caps should remain in place unless container is secured with valve outlet piped to use point.

Cylinders should be stored upright when possible and firmly secured to prevent falling or being knocked over.

Do not store cylinders in areas where temperatures exceed 125°F (52°C).

Store cylinders at least 20 feet away from flammable materials.

Never ground a compressed oxygen cylinder or allow it to become part of an electrical circuit.

Use

Compressed oxygen components must not be used with previously used compressed air system components due to the fire and explosion hazards resulting from pure oxygen coming into contact with oil and grease that is inherent with compressed air systems.

All oxygen valves should be opened slowly to prevent the oxygen from heating. Valves should be positioned away from the operator. This will (1) prevent flames from blowing on the miner in the event of an ignition and prevent oxygen saturation of clothing and (2) prevent spontaneous combustion from occurring if clothing is covered in grease and oil.

Due to the risk of spontaneous combustion, oxygen should not be used for cleaning or blowing out dirt and dust particles.

Regulating the release of oxygen and monitoring the safe haven environment to ambient oxygen content (19.5% - 23.5%) is essential. Breathing air that contains more than 80% oxygen at one atmosphere of pressure (sea level) for more than a few hours may cause nasal stuffiness, cough, sore throat, chest pain and breathing difficulty.

Designs using a respirator/breathing apparatus should employ only NIOSH-approved units with means of flow and pressure regulation.

Check valves should be used on oxygen cylinders to prevent cylinder contamination and flashbacks from going back into the tank and causing an explosion.

Methods for Providing Breathable Air

Survival considerations, assumptions, and calculations:

Some mines produce high amounts of methane, hydrogen sulfide, and hydrocarbons. This document provides some guidance on various methods which can be used to provide breathable air to miners awaiting rescue in a safe haven. Not all mines will be able to successfully adopt all of these recommendations due to their inherent mining conditions.

Safe Haven Assumptions

- No Methane (CH_4) liberation into safe haven atmosphere
- CO_2 scrubbing does not account for strata oxidation rates
- Miners die from the effects of CO_2 rather than O_2 deficiency
- Carbon monoxide (CO) purging utilizing compressed air cylinders anticipated as necessary to reduce safe haven concentration to less than 25 parts per million (PPM) for safe havens with a captive volume (not utilizing positive pressure forced air from either a compressed air line or borehole from the surface)
- Body heat and moisture generation is assumed to be dissipated by contact with the safe haven mine roof, ribs, and floor.
- The maximum acceptable temperature in the safe haven is 95^0 F.
- Miners shall monitor air quality through approved multiple gas detector which includes oxygen, carbon monoxide, carbon dioxide, and methane.
- Compressed air and oxygen cylinders are controlled through the usage of a regulator.
- Pressure relief valves are required when supplying fresh air (ie, 750 cubic feet per hour per person).

Breathing Rates & Calculations

- Respiratory Quotient, which is the ratio of CO_2 expelled to O_2 consumed = 0.8 (Technical resources cite respiratory quotients range from 0.7 – 1.0)
- Breathable air is the quantity, quality and methods to supply air necessary to sustain trapped miners
- Assumed Breathing Rate consists of activity levels of 4/5 at rest and 1/5 moderate activity
- Breathing rate at rest = 0.010 cubic feet per minute (CFM) O_2 per person = 0.60 cubic feet per hour (CFH) O_2 per person
- Breathing rate at moderate activity = 0.070 CFM O_2 per person = 4.2 CFH O_2 per person
- Oxygen (O_2) consumption (at Assumed Breathing Rate) = 4/5 x 0.010 +1/5 x 0.070 = 0.022 CFM per person = 1.32 CFH per person
- Carbon Dioxide (CO_2) generation (at Assumed Breathing Rate) = O_2 consumption x Respiratory Quotient = .022 x 0.8 = 0.018 CFM per person = 1.08 CFH per person

Supplied Air Specifications

- Lithium hydroxide (for CO_2 scrubbing) is provided in woven curtains

- Lithium hydroxide required in woven curtain form = .244 lbs. per person per hour; shelf life for LiOH is 5 years
- "K" size compressed air cylinders (9.25 inches diameter x 60 inches height) ref. U.S.DOT specification gas cylinders used for specialty gases spec. 3AA2400 (Grade D) each containing 282 ft^3 @ 2200 psi and weigh 170 lbs each

note: "K" size air cylinders gas volume can vary according to fill pressure. At 2400 psi, the volume would increase to 310 ft^3. This fill pressure range can affect the number of cylinders mine operators need to provide for the maintenance of miners.

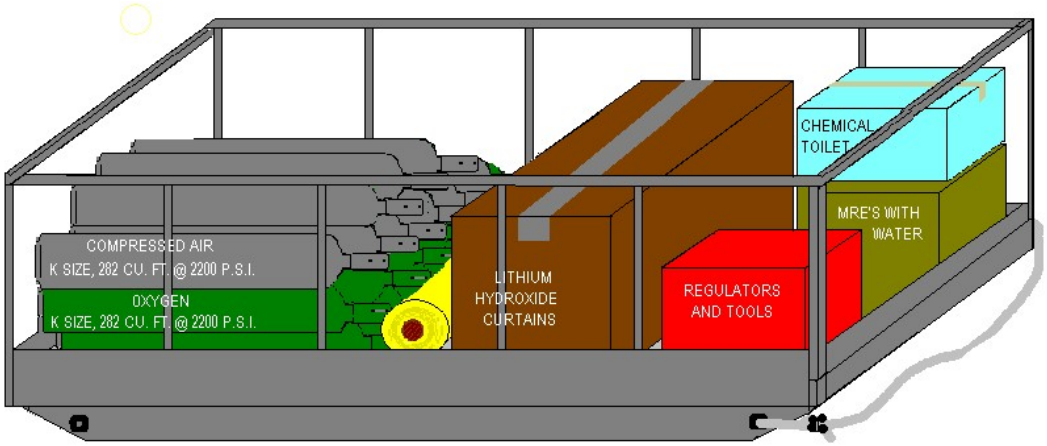
- Grade D air specifications:
  - O_2 = 19.5 to 23.5 %
  - CO = 10 PPM max
  - CO_2 = 1000 PPM max
  - Oil = 5 mg/m^3 max
  - Odor = lack of noticeable odor
- "K" size standard O_2 cylinders (non-USP with greater than 99% O_2) (9.25 inches diameter x 60 inches height) each containing 282 ft^3 @ 2200 psi and weigh 170 lbs each. Welding oxygen cylinders which are greater than 99% oxygen will suffice.

note: "K" size O_2 cylinders gas volume can vary according to fill pressure. At 2400 psi, the volume would increase to 310 ft^3. This fill pressure range can affect the number of cylinders mine operators need to provide for the maintenance of miners.

- Chemically generated oxygen provided by thermal decomposition of chlorate compounds (self-contained oxygen generators SCOGs). Other methods of chemically generated oxygen can be inorganic super oxides or per chlorates
- Safe haven purging "efficiency" estimated to require compressed air cylinders providing at least 3 times the amount of safe haven volume. Miners are to be inside of safe haven volume wearing an SCSR while purging is accomplished.
- Air source and quality provided for compressors and blowing fans is considered to be uncontaminated ambient air

<u>Emergency Supplies</u>

Compressed air and or compressed oxygen cylinders, lithium hydroxide curtains, chemical toilet, brattice cloth, tools, ready to eat meals, and valve regulators can be stored on a portable skid as seen in the example below.



CO_2 Exposure Example with Calculations

The following example demonstrates the rate at which a person would over expose from CO_2 if CO_2 were not removed from the environment (this example does not contain safe haven construction or population density requirements): A hypothetical sealed mine barricade has a volume of 1800 cubic feet (20 feet long, 18 feet wide and 5 feet high) and contains one person. Assuming the initial air quality was 19.5% O_2, and 0 .03% CO_2, below is shown the method used to calculate the period of time per cubic feet of barricade space per person before carbon dioxide reaches unacceptable levels. (Note: unacceptable level would be 3% based on Peele Mining Engineers' Handbook and current MSHA Short Term Exposure Limits for CO_2)

Breathing rate (4/5 at rest and 1/5 moderate activity) for oxygen inhaled is 0.022 cubic feet per minute per person. With respiratory quotient (ratio of CO_2 expelled to O_2 consumed) of 0.8 for persons at rest the rate of CO_2 produced would be 0.018 CFM per person.

0.03% X 1800 ft^3 = 0.54 Cubic Feet (Ambient air containing 0.03% CO_2)

3.0% X 1800 ft^3 = 54 Cubic Feet (Limit - unacceptable air containing 3% CO_2)

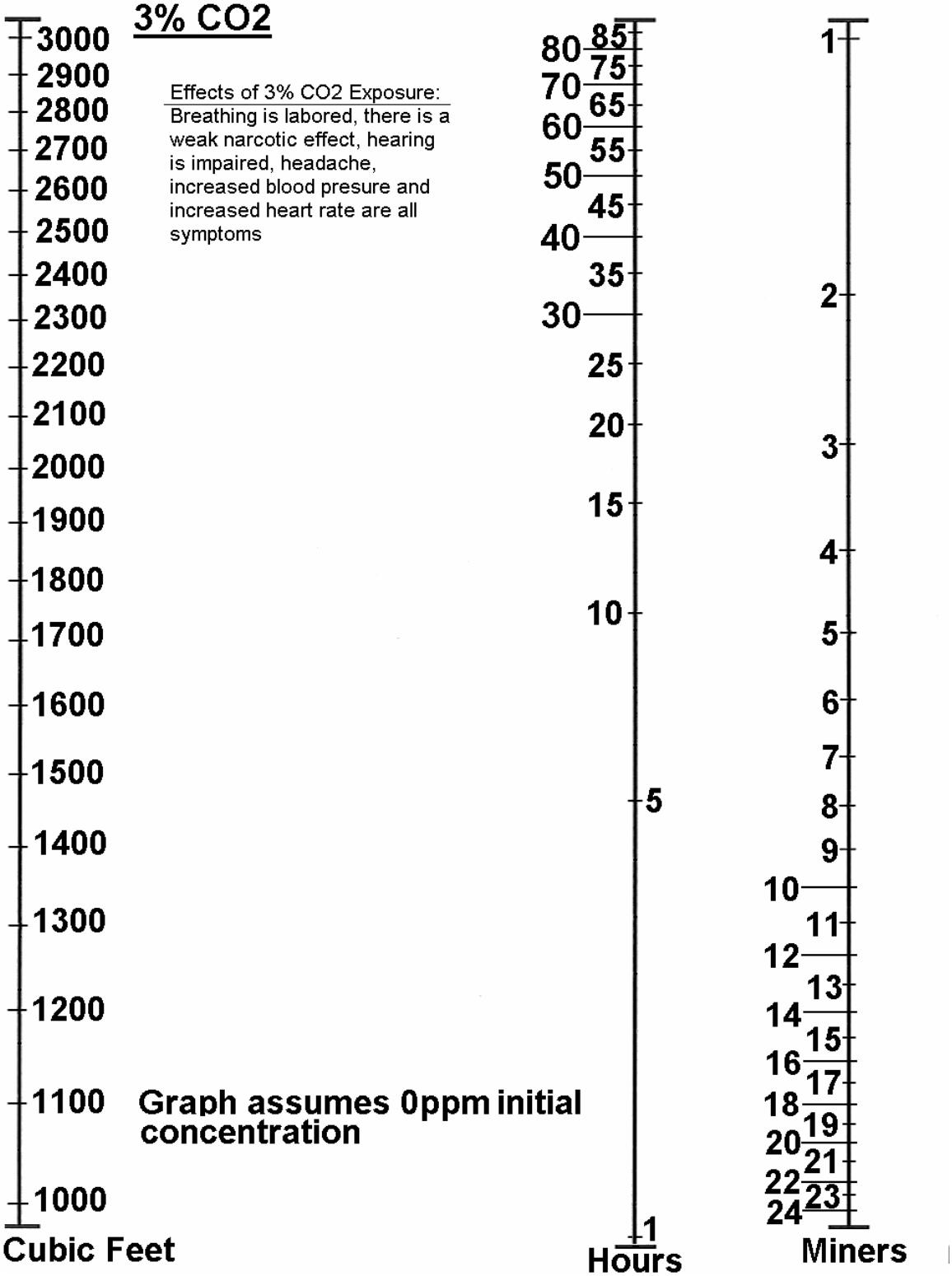
54 ft^3 - 0.54 ft^3 = 53.46 Cubic Feet of Air available before reaching unacceptable level

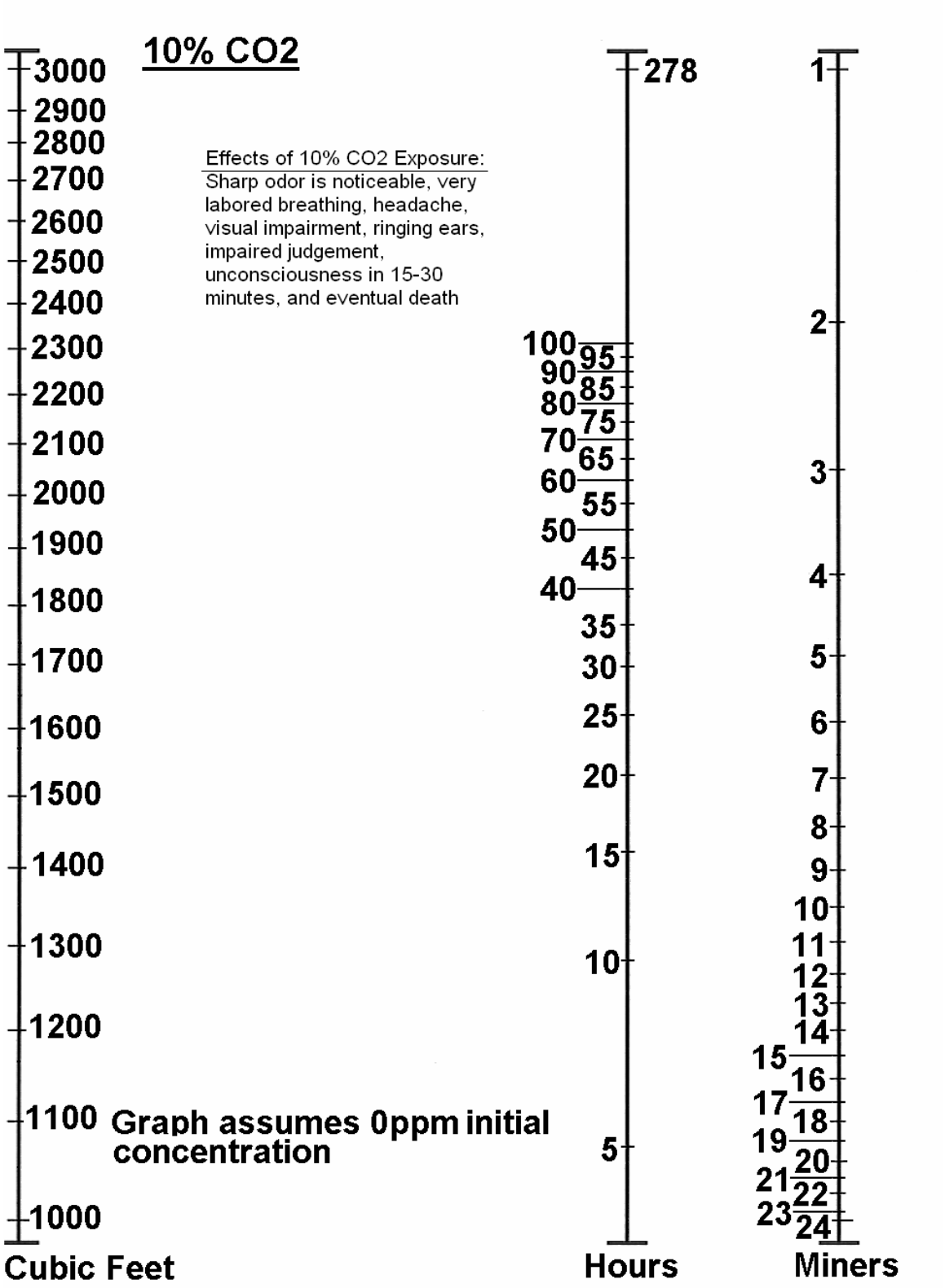
53.46 ft^3 / 0.018 (CFM exhalation rate per person of CO_2) = 2970 minutes or 49.5 hours

Therefore one miner could be maintained 49.5 hours in a barricade with the aforementioned dimensions and initial air quality or 1.65 minutes per cubic foot of barricade space (volume). Correspondingly, 10 miners could be maintained in an 1800 cubic foot space for 4.95 hours before the CO_2 concentration reached the defined unacceptable level.

Additionally, 10 miners in the above defined 1800 ft^3 volume would reach 10 % CO_2 and resulting unconsciousness in approximately 16.6 hours.
The maintenance time for multiple miners in the 1800 cubic feet space is inversely proportional to the number of miners in the barricaded area.

Carbon Dioxide Nomograph
Shown below are two nomographs, one for 3% exposure and one for 10% CO_2 exposure. To use these charts: Connect cubic feet volume behind barricade to the number of miners in barricade with a straight edge and read the result on the center line. The result is the amount of time it takes for the atmosphere to reach 3% or 10% CO_2 in the safe haven volume with the corresponding number of miners. Safe haven volume is the volume behind the barricade.


3% CO2
Effects of 3% CO2 Exposure:
Breathing is labored, there is a weak narcotic effect, hearing is impaired, headache, increased blood presure and increased heart rate are all symptoms
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Cubic Feet
Graph assumes 0ppm initial concentration
80
85
70
75
65
60
55
50
45
40
35
30
25
20
15
10
5
1
Hours
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Miners


10% CO2
Effects of 10% CO2 Exposure:
Sharp odor is noticeable, very labored breathing, headache, visual impairment, ringing ears, impaired judgement, unconsciousness in 15-30 minutes, and eventual death
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Graph assumes 0ppm initial concentration
Cubic Feet
278
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Hours
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Miners

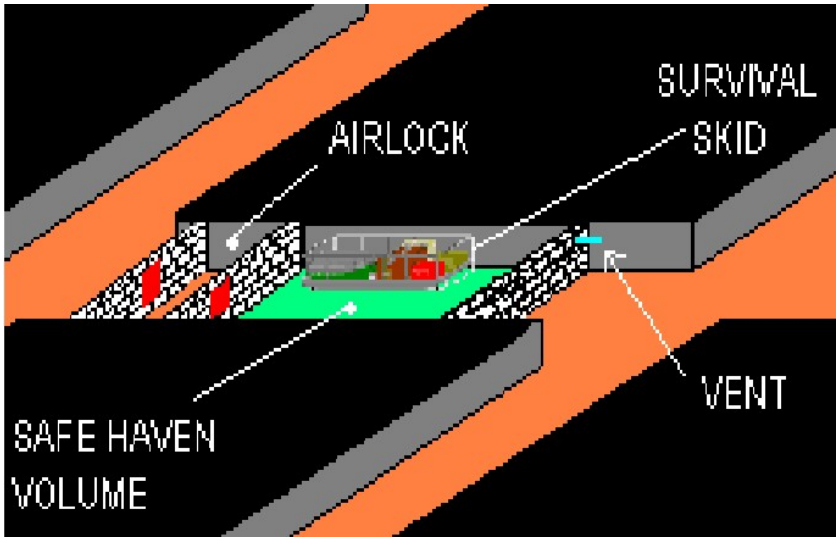
Examples of Methods/Systems for Providing Breathable Air

There are concerns with using the supplied air from compressed cylinders and outside positive pressure blowing systems. For more information on these concerns, please see MSHA's Safety Awareness Information discussing Hazard Awareness for Compressed Air and Compressed Oxygen systems. (SEE LINK)

O_2 Cylinders

- 1.32 cubic feet per hour (CFH) per person = .022 CFM
- CO_2 scrubbing required for miners in the safe haven
- Lithium hydroxide required in woven curtain form = .244 lbs. per person per hour (or equivalent CO_2 scrubbing agent)

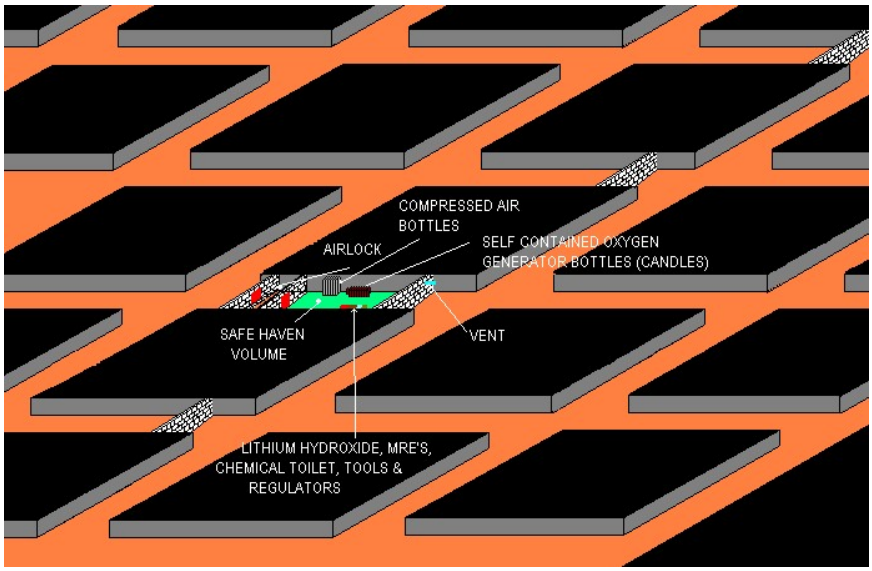
Visual depiction of safe haven scenario using compressed oxygen and compressed air cylinders.



Chemically Generated O2

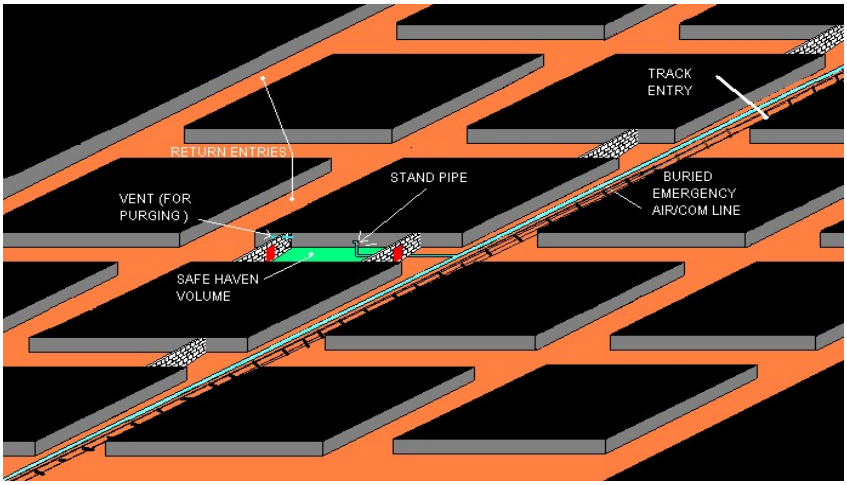
- Chemically generated oxygen provided by thermal decomposition of chlorate compounds (self-contained oxygen generators SCOGs). Other methods of chemically generated oxygen can be inorganic super oxides or per chlorates
- 1.32 CFH per person = .022 CFM per person
- CO_2 scrubbing required for miners in the safe haven
- Lithium hydroxide required in woven curtain form = .244 lbs. per person per hour (or equivalent CO_2 scrubbing agent)

Visual depiction of safe haven scenario using chemically generated oxygen and compressed air cylinders (used for purging initial air environment)



Compressed Air Lines (buried from portal or from vertical borehole to safe haven)

- 750 CFH per person = 12.5 CFM per person
- Breathable air provided by oil compressor with CO filtering capability, or oilless compressor
- No CO_2 scrubbing required

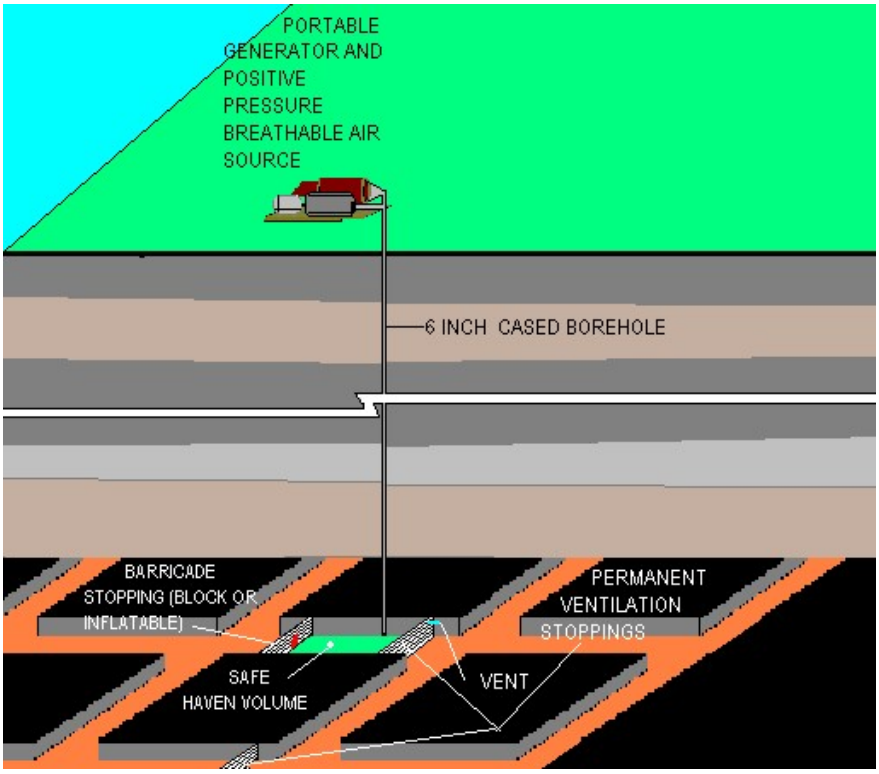


- An option for mines using track haulage in order to secure compressed air lines against explosive forces could be to lay out a properly sized and rated air line and ballast over it.

Vertical Boreholes

- 750 CFH per person =12.5 CFM per person
- Breathable air provided by positive pressure blowing fan
- No CO_2 scrubbing required (CO_2 exits through the vent)

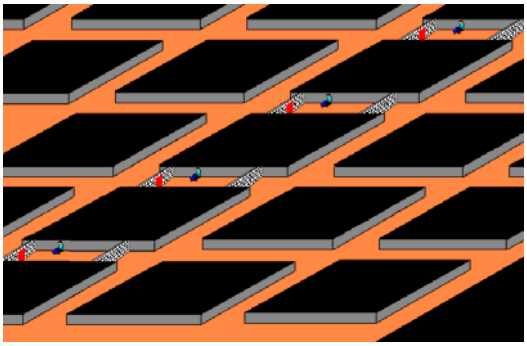
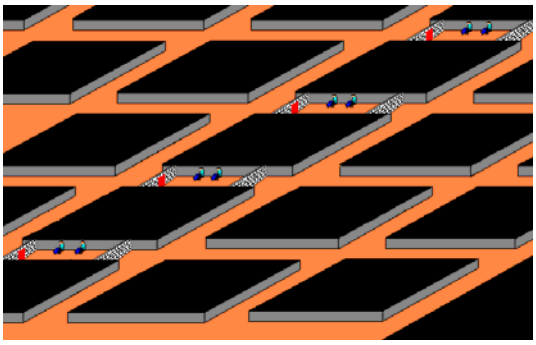
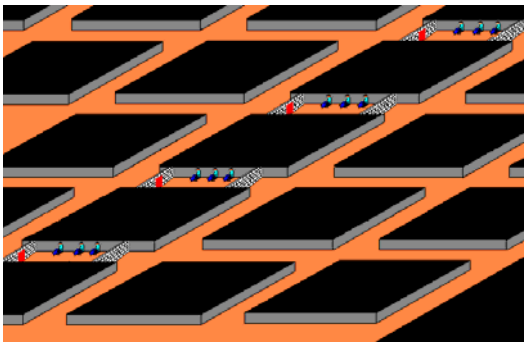
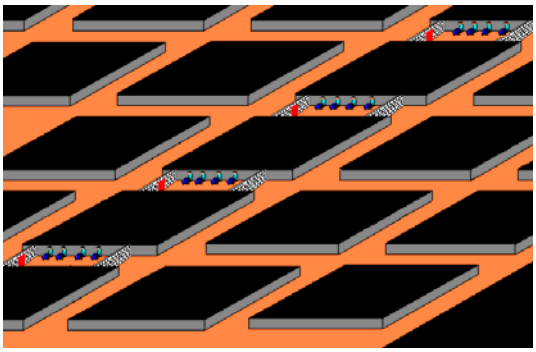
Visual depiction of safe haven scenario using supplied air via a vertical borehole from the surface.



Multiple Safe Havens with Purge Air Provided

- This option is essentially placing miners in small groups within multiple safe havens.
- The theory is that the smaller number of people over a larger volume of safe haven space are less likely to perish from exhaled Carbon Dioxide (CO_2).
- Purge air using Grade D, K sized compressed air cylinders
- No additional compressed air or oxygen cylinders needed
- No CO_2 scrubbing agents needed

Assuming 1800 ft^3 volume per safe haven, each purged with compressed air cylinders.
1 miner will take 49.5 hours to reach 3% CO_2 and 166 hours to reach 10% CO_2
2 miners will take 25 hours to reach 3% CO_2 and 83 hours to reach 10% CO_2
3 miners will take 16.5 hours to reach 3% CO_2 and 55 hours to reach 10% CO_2
4 miners will take 12 hours to reach 3% CO_2 and 41 hours to reach 10% CO_2

Compressed Air Cylinders

- MSHA considers the use of compressed air cylinders as the sole means of providing breathable air to be an impractical solution and encourages mine operators to consider other options.
- The number of K size Grade D compressed air cylinders required to sustain 24 miners for 48 hours is 3,142. Each Grade D breathable compressed air cylinder can provide 22.5 minutes of breathing air per person.
- 750 CFH per person = 12.5 CFM per person if used for providing breathable air

  Note: 750 CFH was derived from the amount of air needed for respiration and dilution of CO_2. By adding excess volume of compressed air (12.5 CFM) to the safe haven beyond what is needed to breathe eliminates the need for lithium hydroxide as a means for removing CO_2. A pressure is created as contaminated air is moved out of the haven through a pressure relief vent. CO_2 scrubbing not required if breathable air is provided solely by compressed air cylinders at the volume specified above. The number of compressed air cylinders should provide air volume at least 3 times the safe haven volume when used for purging.