NIOSH

“I Can’t Get Enough Air!”

Proper Self-contained Self-rescuer Usage

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

I Can't Get Enough Air!

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Instructor's Copy

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Public Health Service
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Contents

Introduction

This document contains most of the materials needed to use the exercise. The main part of the document is the instructor's copy. It tells how to use the exercise, presents the objectives, the master answer sheet, the scoring key, and discussion notes to be used following the exercise. The next section summarizes results from field tests of the exercise, and reports the miners' evaluation of the activity. The last part of this document is three appendices. Appendix A is the exercise problem booklet. This booklet can be duplicated locally. The booklets are reusable. One is needed for every person in the classroom. Appendix B is the answer sheet. Copies of this answer sheet must have the invisible ink answers that appear in Appendix C printed on them.[2] Answer sheets are consumable. One is needed for each person or each small group of persons who work the exercise.

Exercise Summary

Read this section first. It determines if the exercise is appropriate for your classes. If you choose to use the exercise, examine the table of contents and review the remainder of this document.

Type: Invisible ink

Audience: Underground coal miners

Length: 9 questions (30 minutes for administration and 30 minutes for discussion)

Skills: Mine fire escape strategies/procedures
Use of emergency breathing apparatus
Knowledge of sensations experienced when wearing breathing apparatus
Communication

Location: Underground coal mine section, average 60 inch seam height

Problem: You are the section foreman on the 17 Left longwall development section at the Paula Ann No. 3 mine. The section has been driven about 4,000 feet from 4 West Mains. One of the shuttle car operators took a call from the fireboss saying that there was smoke from an unknown source coming into your section. You attempt to contact someone to find out where the smoke is coming from but get no response. You assemble the crew and start riding out of the section on the mantrip when you encounter heavy smoke. At this point, you decide to take your crew and travel on foot in the belt entry that is on a neutral split of air. After traveling about 6 crosscuts in the belt entry, you encounter heavy smoke at which time you and your crew don your person-wearable SCSRs (PWSCSR). After donning the apparatus, you and your crew continue traveling outby in the belt entry. Near the mouth of the section, one miner in the group starts to have trouble breathing from his SCSR. Because breathing resistance is increasing with the length of time the apparatus is worn, the miner is "outbreathing" the device since his oxygen requirements are greater that what the PWSCSR can supply. Although you slow down the pace of your escape, soon more

[2]You can do this yourself if you have the proper equipment, or you may obtain copies of preprinted answer sheets from NIOSH, Pittsburgh Research Laboratory, Pittsburgh, PA (412-386-5901) or email to minetraining@cdc.gov .

miners, including yourself, are having trouble breathing. You must decide when to switch to another PWSCSR that you obtain from a cache along the escape route. At one point, a miner's PWSCSR is completely used up and the group must then stop and change devices.

How to Use This Exercise

1. Look at the performance objectives. Decide of the exercise is relevant for your annual refresher class.

2. Work through the exercise with the developing pen and score your responses.

3. Read the master answer sheet for the exercise. Look at all the answers.

4. Read the "Instructor's Discussion Notes" for the exercise.

5. Become thoroughly familiar with the problem so you can present it to your class without reading it. Put the figures on an overhead projector so you can use these to help explain the problem.

6. When you present the exercise to the class:

   - Give each person an exercise booklet, an answer sheet, and a pen.

   - Demonstrate how to select and mark answers using the developing pen.

   - Go over the instructions for working the exercise with the whole group.

   - Explain the problem making sure everyone understands the problem situation.

   - Have the class members work the exercise.

   - When the class members finish, have them figure up their score using the instructions at the end of the exercise.

   - When everyone has finished, discuss the exercise. Let class members discuss the merits of each answer. Add your own ideas.

Performance Objectives for the I Can't Get Enough Air Exercise

Objective number	Capability verb(s)	Description of required performance and conditions under which it is to occur
1 EE/MG[3]	Recall Apply	Basic information and facts about the toxic effects of carbon monoxide, oxygen deficiency, and the capabilities and limitations of person-wearable self-contained self-rescuers (PWSCSR) when planning and executing escapes from a mine section through heavy smoke
2. EE/SR	Recall Apply	Sequence of steps for properly donning the PWSCSR to ensure the device is put on correctly and fully secured
3. EE/SR	Recall Comprehend	Factual knowledge about the operation of a PWSCSR
4. EE/SR	Recognize	Breathing resistance when it occurs and its cause
5. EE/SR	Anticipate Predict	The probable time when PWSCSRs will be used up and miners will need to don a second apparatus
6. EE/SR	Ordering	Priorities and decisions when faced with a hostile environment and insufficient time to escape using only one PWSCSR

[3]Skill and knowledge domain abbreviations:
EE = evaluation and escape
SR = self-rescue
MG = mine gases

Master Answer Sheet for the I Can't Get Enough Air Exercise

Use this answer sheet to mark your selections. Rub the special pen gently and smoothly between the brackets. Don't scrub the pen or the message may blur. Be sure to color in the entire message once you have made a selection. Otherwise you may not get the information you need. The last part of the message will tell you what to do next.

Question A (Select as MANY as you think are correct.)

1. [This can be dangerous. You need to act now.]

2. [Correct! You need to get your SCSR on now.]

3. [Although you find light smoke in the belt entry, you don't know what toxic]
   [gasses are in the air. You need to use your SCSR now.]

4. [You have already come 15 crosscuts outby the faces. Going back to the]
   [section to get into the return escapeway will waste time.]

5. [Correct! Since you will be in smoke, you will need to have some time]
   [reference.]

Question B (Choose only ONE unless told to "Try Again!")

6. [There is probably a mechanical reason the bags are not inflated. You need]
   [to do something else first. Try again!]

7. [Correct! Be sure that everyone has activated the oxygen. Once the oxygen]
   [is activated, the breathing bag will begin to fill. Do the next question.]

8. [You don't know what toxic gasses are in the air. Everyone needs to get]
   [under apparatus as soon as possible. Try again!]

9. [While there is a cache of SCSRs, the mechanic would have to travel almost]
   [2000 feet to retrieve them. This is dangerous and wastes time. Besides,]
   [as you already know, there are more caches outby. Try again!]

Question C (Select as MANY as you think are correct.)

10. [Correct! Miners should have the mouthpiece fully inserted with their lips]
[sealed over the flange and teeth biting on the lugs.]

11. [Correct! The nose clips must securely pinch the nostrils and not be placed]
[too high on the nose.]

12. [Correct! The goggles will prevent smoke from irritating the eyes. Make sure]
[that the miners have the goggles on with the nose bridge positioned properly]
[and the straps positioned above the ears for a better fit.]

13. [The neck strap must be properly looped over the head and adjusted to]
[prevent the mouthpiece from being pulled out by the weight of the device.]

14. [Correct! People sometimes insert the mouthpiece with the hose twisted.]
[This should be corrected to reduce the chance of breathing difficulty later]

15 [The waist strap must be securely fastened around the waist to prevent the]
[unit from dangling if the miner must crawl or go through a mandoor.]

Question D (Select as MANY as you think are correct.)

16. [This is dangerous as you and the miner could be overcome by CO.]
[ ]

17. [Correct! Miners tend to believe that the SCSR's are easy to breathe from,]
[and think their apparatus isn't working when they encounter breathing]
[resistance or when they are really outbreathing the unit.]

18. [This is dangerous as both of the miners could be overcome by CO.]
[ ]

19. [This is dangerous as you and the miner could be overcome by CO.]
[ ]

20. [Correct! The miner operator most likely is outbreathing the apparatus.]
[Stopping for a few minutes gives your crew a chance to rest.]

Question E (Choose only ONE unless told to "Try Again!")

21. [Correct! Do the next question.]

22. [This is dangerous. Even though the smoke is not as thick in the return]
[escapeway, high concentrations of CO may be present. Try again!]

23. [Even though you still don't know where the fire is, you may have trouble]
[finding a pager phone in the smoke. You could also easily become]
[separated from your crew. Try again!]

24. [Your SCSRs are still working. While there is a cache of SCSRs at the mouth]
[of the section, there are more caches located outby. You need to continue]
[your escape. Try again!]

Question F (Choose only ONE unless told to "Try Again!")

25. [Since you've only been wearing the SCSR for about 30 minutes, it is doubtful]
[that the device is used up. Try again!]

26. [Correct! The longer an apparatus is worn, the harder it is to breathe from it.]
[Slowing your pace should help you to breathe better. Do the next question.]

27. [Blowing into the breathing bag will cause you to inhale bad air and put it into]
[the breathing circuit. This could cause breathing difficulty later. Try again!]

28. [This is dangerous since CO may be present. Try again!]

Question G (Select as MANY as you think are correct.)

29. [Correct! The miners need to rest a few minutes while keeping their]
[mouthpieces in and breathing from their SCSR.]

30. [You still don't know where the fire is and how far you will have to go to reach]
[fresh air.]

31. [Since the smoke is heavy in the intake escapeway, it would be dangerous to]
[take your crew to the SCSR cache and have them don a new apparatus.]

32. [Correct! Because you've been under apparatus for more than thirty minutes,]
[you need to stop and get units from this cache before continuing on.]

Question H (Select as MANY as you think are correct.)

33. [Correct! While it has been difficult to breathe from the SCSR, miners need to keep their lungs isolated to prevent being overcome by CO.]

34. [While it is becoming harder to breathe from the SCSR, it is not time to change the apparatus since it is still working.]

35. [Correct! The first SCSRs you and your crew donned are still working. There is a risk in changing units in heavy smoke. You need to continue your escape and go as far as possible before switching units.]

36. [While it is becoming harder to breathe from the SCSR, it is not time to change the apparatus since it is still working. In addition, it may be some time before help arrives.]

Question I (Choose only ONE unless told to "Try Again!")

37. [Correct! Most likely, the miner's SCSR is depleted. Soon other miners will experience the same problem. Everyone should stop and switch units.]

38. [This will separate you from your crew. Besides, other miners may begin to have similar problems. Try again!]

39. [Once the device is on, you should NOT take it off until you must switch to another unit or until you get into good air. Try again!]

40. [This miner's comment that his breathing has been pinched off, combined with the amount of time that has elapsed should tell you that he really has used up his SCSR. Try again!]

Finding Your Score

Number of "Correct" answers you colored in = (1)_____

24 minus number of incorrect answers you colored in = (2)_____

Add lines one and two to get your total score = (3)_____

Highest possible score = 40

Lowest possible score = 0

Instructor's Discussion Notes for the I Can't Get Enough Air Exercise

Use the information presented here and on the master answer sheet, your own ideas and experience, and those of the miners in your class, to discuss the exercise after it is completed. Group discussion can strengthen knowledge and skills, correct errors, and relate the exercise content to the experiences of the miners. After they have worked the exercise, miners enjoy discussing the problem. They also frequently think of better ways to respond to a problem than those listed among the answers. The purpose of the exercise is to help miners think about and remember basic knowledge and skills they may someday need to deal with an emergency. The discussion following the exercise can contribute to this goal and tailor the exercise content to the needs of the group you are training.

It is helpful to show overhead transparencies of the master answer sheet during the discussion while the miners look at their problem booklets. This allows you to lead the group through the exercise and to disclose and discuss all the answers to each question. Most of the information about why particular answers are correct or incorrect is given on the master answer sheet.

The following notes provide additional information for you to discuss with your class. Read through and think about the notes before the class. Don't read the notes to the class members. This would be boring and ineffective. Rather, incorporate the ideas you find here with your own ideas and make these points at the appropriate place in the discussion of the exercise.

Question A - The correct answers are 2 and 5. Everyone should don their SCSR and check the time. About 2/3 of the miners interviewed who had escaped underground mine fires, reported that they delayed donning their SCSR because they didn't know where the fire was located or how far they may have to travel to reach fresh air. Consequently, they traveled through heavy smoke bare-faced before donning the unit. Although the smoke is light in the belt entry, miners need to don their SCSR as soon as possible. Even in light smoke, the CO level could be high enough to cause danger. It is also important to note the time (5). SCSRs are designed to provide 60 minutes of oxygen to the user. Without a time reference, it will be difficult to estimate how long a miner has been under apparatus. Watching the smoke to see if it subsides (1) is dangerous and wastes valuable time. Having miners open their SCSRs and loop the neck strap without isolating their lungs (3) is dangerous since CO may be present. Leading your crew back to the section to go out the return escapeway (4) will waste time. Besides, there will still be smoke in the return escapeway.

Question B - The correct answer is 7. Everyone needs to be reminded to be sure to activate the oxygen on their unit. The miners in this exercise were using Person-Wearable SCSRs that have a chemical bed that produces O_2 when exposed to moisture from the breath. Activation of the starter oxygen on an SCSR provides several minutes of O_2 until the chemical bed begins to produce oxygen. Not activating the starter oxygen will reduce the amount of time that the unit can provide O_2. Also, until the chemical bed begins

generating oxygen, miners while be rebreathing air that is not being supplemented with O_2. This is dangerous as miners could faint without warning due to lack of oxygen.

Telling miners to exhale several breaths into the apparatus to inflate the breathing bag (6) should only be done if you are certain their starter oxygen has failed. The reason is that a cold start takes some time. Telling miners who are having trouble with their SCSR to take the device off and escape bare-faced (8) is not advised since you don't know how much CO is present. While the mechanic could go back to the cache of SCSRs in the primary escapeway (9), he would have to travel almost 2,000 feet to and from the cache. This would waste time and could be dangerous.

Question C - The correct answers are 10, 11, 12, and 14. You should look for: the mouthpiece in with lips over the flange and the miner biting on the lugs; nose clips on securely; goggles on with the nose bridge properly seated and strap located above the ears; and no kinks or twists in the breathing hose. Carrying the apparatus under the arm in such a way to reduce tension on the breathing hose (13) is not correct because the neck strap should be properly looped and adjusted to prevent tension on the breathing hose. The waist strap should not be tucked in the bottom of the unit (15) but should be securely fastened around the waist. Failure to secure the waist strap will cause the unit to dangle in front of the miner when crawling or passing through mandoors and the breathing hose could get caught and tear .

Question D - Correct answers for this question are 17 and 20. You should motion for the miner to put his mouthpiece back in and stop so that the crew can rest. Of the 46 miners interviewed who wore SCSRs to escape a mine fire, 63% reported having difficulty breathing from the device. It appears that a majority of the miners were unaware that there is breathing resistance when SCSRs are used and that this resistance increases with the length of time the unit is worn and with increased levels of physical exertion. When resistance is encountered, miners think that the apparatus is not working. In some cases, miners' oxygen demands are greater than the SCSR can provide, in which case the miner "out breathes" the device. When miners experience breathing resistance, they should slow their pace and, if necessary, stop and rest for several minutes. Removing the mouthpiece should not be done (16, 18, and 19).

Question E - The correct answer for this question is 21. You need to continue your escape by leading the crew down the return escapeway. Miners should not take out the mouthpiece and "save" their SCSRs (22). Although you don't know where the fire is located, you know that there are caches of SCSRs along the escape route. Traveling through smoke without the protection of an SCSR, even though the smoke is lighter in the return, is dangerous since miners could be overcome at anytime with CO. Making your way to a mine phone to find out where the fire is located (23) could be dangerous. You may not be able to locate the phone in the smoke and you could easily become separated from your crew. While you could send a miner to locate the cache of SCSRs near the mouth of the section where you are stopped (24), this would waste time. Your SCSRs are still working and you know that there are additional caches of SCSRs outby your location. You and your crew need to continue your escape.

Question F - The correct answer is 26. You should slow down your pace and motion for others to do the same. Miners will experience breathing resistance when SCSRs are used. This resistance increases with the length of time the unit is worn and with increased levels of physical exertion. Since you've only been under apparatus for about 30 minutes, it is doubtful your SCSR is depleted and needs to be removed (25). Taking breaths of outside air to inflate the breathing bag (27) will not make breathing easier since resistance is not related to the amount of air in the breathing bag. This practice is also dangerous since there may be CO present. Taking the mouthpiece out or breathing around it to get more air (28) is also dangerous due to the possible presence of CO.

Question G - The correct answers are 29 and 32. Since you and other miners are having trouble breathing from your SCSRs, you need to stop and rest and pick up spare units. Because you don't know how far you have to travel to reach fresh air, you should not continue traveling down the return escapeway (30) without stopping at the cache. There is no need to take the entire crew to the cache of SCSRs and don the apparatus immediately (31). Taking all of the crew could be dangerous as miners may become separated from the group if the smoke is dense. Since your SCSRs are still working, there is no need to don new apparatus at this time.

Question H - The correct answers to this question are 33 and 35. You need to motion miners to put their mouthpieces back in and signal for everyone to take another SCSR and follow you down the return escapeway. Even though it is becoming harder to breathe, as long as you can breathe from the SCSR, the apparatus is still working. There is no need to have miners don a fresh apparatus from the cache (34). While you could change apparatus and then wait by the mandoor for help to arrive (36), it is not time to change SCSRs since the first device is still working. Waiting at the mandoor while wearing a fresh SCSR can help extend the time the device can be worn, but it may be some time before help arrives. This is a dangerous practice since you could become trapped inby the fire.

Question I - The correct answer to this question is 37. Stop with your crew and have everyone take off their SCSR and don the spare that they are carrying. Having others continue on while you stay back with the miner experiencing difficulty to help him don a fresh SCSR (38) could separate you from the rest of the crew. Most likely, other miners will begin experiencing similar breathing problems. Having the miner travel without an SCSR through the return, even though the smoke is not as heavy (39), is dangerous since CO and other toxic gases can be present. Motioning for the miner to put his mouthpiece back in (40) will not help since the miner has completely used up his SCSR.

Discussion

Since 1988, three major mine fires have occurred in which miners had to escape under apparatus. As part of a project investigating worker responses to these events, Bureau researchers have interviewed 46 miners about their escape experiences. Testimonies from these workers have been analyzed regarding personal experiences with SCSRs during their escape.

The accounts given by miners tend to reflect previous Bureau of Mines research findings, especially regarding miners' abilities to don SCSRs. As one miner said:

> *...When we was getting them things on, I really got nervous then, putting that thing on. That's when I started to panic and didn't really know what to do-- because we hardly ever-- never, had one of them things in my mouth or noseclips on or nothing before. And, I didn't know if I was doing anything right.*

In general, workers reported several problems that indicate they were not adept in donning the device. The problems included difficulty locating the oxygen lever on compressed oxygen SCSRs and leaving the mouthpiece plug in place when donning the apparatus. About 42% of the miners who donned compressed oxygen devices said that they blew into the SCSR (to inflate the breathing bag) on the first breath. This is not only an incorrect action, but also potentially dangerous. Many workers reported difficulty adjusting the neck and waist straps. In all, slightly more than 41% of the miners interviewed reported trouble of one sort or another when they donned the SCSR. Of these, about one half indicated that they needed help from a buddy to get the apparatus on. Without a doubt, it is important that miners check each other out when donning the device to ensure that each person has their apparatus on correctly.

Interviews with miners who escaped underground mine fires reveal that a number of them delayed donning their SCSR. Many said that they "saved" their SCSRs because: 1) they new that the devices were designed to provide 60 minutes worth of oxygen; and 2) they often did not know where the fire was located and how far they would have to travel to get outby the fire. As a result, about 67% of the workers reported that they donned their SCSR in smoke, and traveled bare-faced through smoke 10 minutes before donning their SCSR. It is interesting to note that none of the workers who escaped any of the three fires had a CO monitor available. Be sure miners understand that any delay donning the devices is dangerous because carbon monoxide can be present even in what appears to be clear air.

Testimony from miners who have escaped underground mine fires revealed that some may not really understand the dangers that CO can pose. When asked if he thought he might be getting some CO, even though there was light smoke in the entry he was traveling, one miner stated:

> *...Well, the way I was thinking, we was on the intake side-- and we was just starting to get smoke. When we went in the return, it wasn't even heavy as that, so why worry-- you know what I mean-- as long as you couldn't see the smoke.*

When asked directly if they had thought about the presence of CO when removing the mouthpiece to breathe or talk when the smoke was heavy, about 39% of the miners said that they had not. At least one miner did think about CO but felt he had no choice:

> *...I know there's a lot of CO but I don't know how much is there, but I can't breathe. If I can't breathe in this thing (SCSR), I'm just going to collapse anywa* y.

You may wish to share some of the following information on CO with members of your class. These facts may help miners understand the importance of rapid protection of one's body from CO intoxication by the use of SCSRs.

CO is a colorless gas with no odor or taste. Yet CO has its great affinity for hemoglobin - about 240 times that of oxygen. This means that even small concentrations of CO in the mine atmosphere are rapidly concentrated to dangerous levels in the red blood cells. CO attaches tightly to hemoglobin and remains in place for a long time. It impairs the transport of O_2 and interferes with the release of oxygen from the hemoglobin molecule, thus stopping oxygen from entering the red blood cells and body tissues.

Recovery from CO intoxication can take several hours, even when the victim has been moved to fresh air. CO intoxication can result in decreased manual dexterity, unconsciousness, permanent brain damage, and death depending on the concentration and exposure time. Research conducted, in which test subjects were exposed to a concentration of 0.01 percent CO (100 PPM) for 2.5 hours, resulted in decreased visual perception, manual agility, and the ability to learn and perform certain intellectual tasks. Exposure to a concentration of 0.10 percent (1,000 PPM) can produce headache, weakness, mental incapacitation, and nausea within 30 to 45 minutes.

Mine atmospheres with CO concentrations of from 1 to 2 percent (10,000 to 20,000 PPM) or even higher levels are likely after a methane or dust explosion and in certain types of fires. One breath of such an atmosphere can incapacitate a person and the second or third breath can render him unconscious with death following within a few minutes. During a mine fire, CO levels in the mine air can change drastically as the ventilation system distributes the contaminated air throughout the mine. Delaying donning SCSRs or removing the mouthpiece and taking breaths of outside air can prove fatal.

Based on information obtained from the interviews, it appears that a majority of the miners were unaware that there is breathing resistance when SCSRs are used and that this resistance increases with the length of time the unit is worn and with increased levels of physical exertion. Quoting one miner:

> *…You know, I was under the opinion you should have no problems at all, but the faster you walked, it seemed like it was getting harder to breathe, so you'd slow your pace and then it seemed like you'd have no problem at all.*

None of the miners interviewed had ever worn an SCSR either in an actual emergency or in a training class. When breathing resistance was encountered, miners tended to think that

their apparatus is not working properly. In some cases, miners' oxygen demands were greater than what the SCSR could provide, in which case the miner "out breathed" the device. Of the miners interviewed, 63% reported that, for one reason or another, they had trouble breathing from the device. Subsequently about 59% of the workers indicated that they either took the mouthpiece out to breathe or that they "breathed around" the mouthpiece while in smoke. When miners experience breathing resistance, they should slow their pace and, if necessary, stop and rest for several minutes. As long as they can still breathe from the SCSR, the device is still working.

Based on accounts from individuals who have worn SCSRs during laboratory human subject testing, breathing resistance will continue to increase the longer the unit is worn. Wearers have indicated that, when the SCSR is completely used up, one will experience a sensation similar to breathing through a straw and then pinching off the end. In other words, the wearer will not get **any** air from the device once it is completely used.

This exercise is designed to emphasize important points related to donning and wearing an SCSR to escape a mine fire. As mentioned earlier, interviews with the miners who escaped these fires indicated that many of them delayed donning their SCSR. Delaying the donning of SCSRs is dangerous because carbon monoxide can be present even in apparently clear air. Miners' testimonies also suggested that many had trouble donning their SCSR. Finally, numerous miners recounted that their experience breathing from an SCSR was different from what they expected. Discuss what can be done to assist miners to safely evacuate mines during a fire and encourage the proper use of emergency breathing apparatus. Compare your ideas and those generated by class members to the following list developed by safety researchers.

1) Conducting more training that tells miners to "don their SCSRs at the first sign of smoke" would probably not be effective. All of the miners interviewed knew that they were supposed to do this. Yet they did not comply with this procedure for the reasons discussed earlier.

2) SCSR training should be hands-on, coupled with evaluation and feedback to the trainee. This would provide miners the opportunity to don an SCSR. Evaluation of each worker's performance will aid in identifying errors made in donning the SCSR and feedback can be provided to the trainee to aid in correcting these errors.

3) The entire donning procedure should be taught including insertion of the mouthpiece. Unless miners actually practice insertion of the mouthpiece, a trainer cannot say for certain that a worker can perform this particular step correctly. Having miners insert the mouthpiece and breathe from the device would also afford trainees the opportunity to feel the sensation of breathing through an SCSR and experience, first-hand, what breathing resistance is like. If miners are exposed to the sensations felt when breathing through an apparatus, they may be less likely to take out the mouthpiece or breathe around it in smoke when breathing resistance is encountered.

4) Periodic, hands-on practice is necessary if miners are to be proficient in donning an SCSR. This practice can be given on the job, perhaps built into fire drills and other emergency preparedness routines.

5) Placing extra SCSRs in caches at well-marked locations along escape routes is a good way to encourage miners to don their SCSRs early at the first sign of smoke. Many mines currently follow this practice. Potential problems are that miners may have to use escape routes that do not take them by caches of SCSRs. Under these circumstances, they may have difficulty locating caches of units in heavy smoke. Encourage miners to take extra SCSRs with them if additional units are available.

6) Deciding when to change from one SCSR to another is difficult. Some individuals believe that one should wait until the device is completely used up before changing apparatus. In a group of escaping miners, this may require the group to stop many times as each person changes out his or her SCSR. Other individuals feel that this decision should be based on the time the apparatus has been worn. If this rule is followed, all miners in an escape group would be stopping at the same time to switch apparatus.

7) With carbon monoxide detectors, mine crews can determine if CO is absent or below dangerous levels. If CO is absent, or is present at extremely low levels, and if O_2 levels are adequate, miners can continue traveling out of the mine in apparently clear air or in smoke without donning their SCSR. This tactic would make it easier for miners to travel and also help "save" the SCSR for when it was needed should CO or O_2 deficient air be encountered during the escape.

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Scoring Key for the I Can't Get Enough Air Exercise

The correct answers are marked with an asterisk.[4]

Question	Answer Number					
A	1	2*	3	4	5*	
B	6	7*	8	9		
C	10*	11*	12*	13	14*	15
D	16	17*	18	19	20*	
E	21*	22	23	24		
F	25	26*	27	28		
G	29*	30	31	32*		
H	33*	34	35*	36		
I	37*	38	39	40		

[4]This page may be duplicated and used as an overhead transparency.

Appendix A: Problem Booklet

Duplicate this copy of the problem booklet for use in your classes. **Booklets should be printed on only one side of the paper.** Each person in your class should have a problem booklet while they are working the exercise. The problem booklets are reusable. To save effort and money, ask the trainees to avoid marking in the booklets and collect all the booklets after the class.

You may obtain a copy of the problem booklet from NIOSH, Pittsburgh Research Laboratory. The telephone number for this agency is listed in the footnote on page three of this document.

I Can't Get Enough Air

Problem Booklet

NIOSH
Pittsburgh Research Laboratory
Pittsburgh, Pennsylvania

Instructions

Read the problem described on the next page. Then answer the 9 questions. Do them one at a time. Don't jump ahead, but you may look back to earlier questions, earlier figures, and your answers. Some questions tell you to select as many answers as you think are correct. Other questions ask you to select only one answer unless you are told to "Try Again!" Follow the directions for each question.

After you have selected your choice to a question, look up the number for that choice on the answer sheet. Rub the special pen between the brackets for that choice. A hidden message will appear that tells you if the choice is correct and provides you with additional information. When you finish you will learn how to score your performance.

I Can't Get Enough Air

Background

You are the section foreman on the 17 Left longwall development section at the Paula Ann No. 3 mine. You are also a member of the mine rescue team.

You and eight other miners are working on the section today.

The coal seam height varies between 58 and 62 inches. Entries and crosscuts are 20 feet wide, and are on 100' centers.

This section has 3 entries and has been driven 4,000 feet from the 4 West mains.

The crew travels to and from the section in the #2 entry in a rail-mounted battery powered mantrip.

The mine uses belt haulage and there is a 48 inch belt located in #3 entry. The belt entries are on a separate split of intake air that moves inby from the dumping point to the section. There is a pager phone at the belt feeder.

The primary escapeway is the #2 intake air course, while the secondary escapeway is in the #1 return airway. At 4 West Main, the primary continues to follow the track and the secondary escapeway follows the left side return.

Everyone is wearing a 60-minute person-wearable self-contained self-rescuer (SCSR) on their belt. You also have 10 person-wearable SCSRs cached at intervals of about 1,500 feet in the primary escapeway in crosscuts between the primary and secondary escapeways.

You and your crew had hands-on SCSR training 6 months ago.

You <u>do not</u> have a hand-held CO detector.

Problem

One of your shuttle car operators took a call from the fireboss saying that there is smoke from an unknown source coming into your section. You attempted to contact someone on the pager phone to find out where the smoke was coming from, but got no response. You and your crew then tried to evacuate down the intake escapeway riding the mantrip, but encountered heavy smoke at #30 crosscut. You therefore decided to go through the mandoor at #31 crosscut and travel on foot down the belt entry that is on a neutral split of air. Turn the page and study Figure 1, then turn to question A.

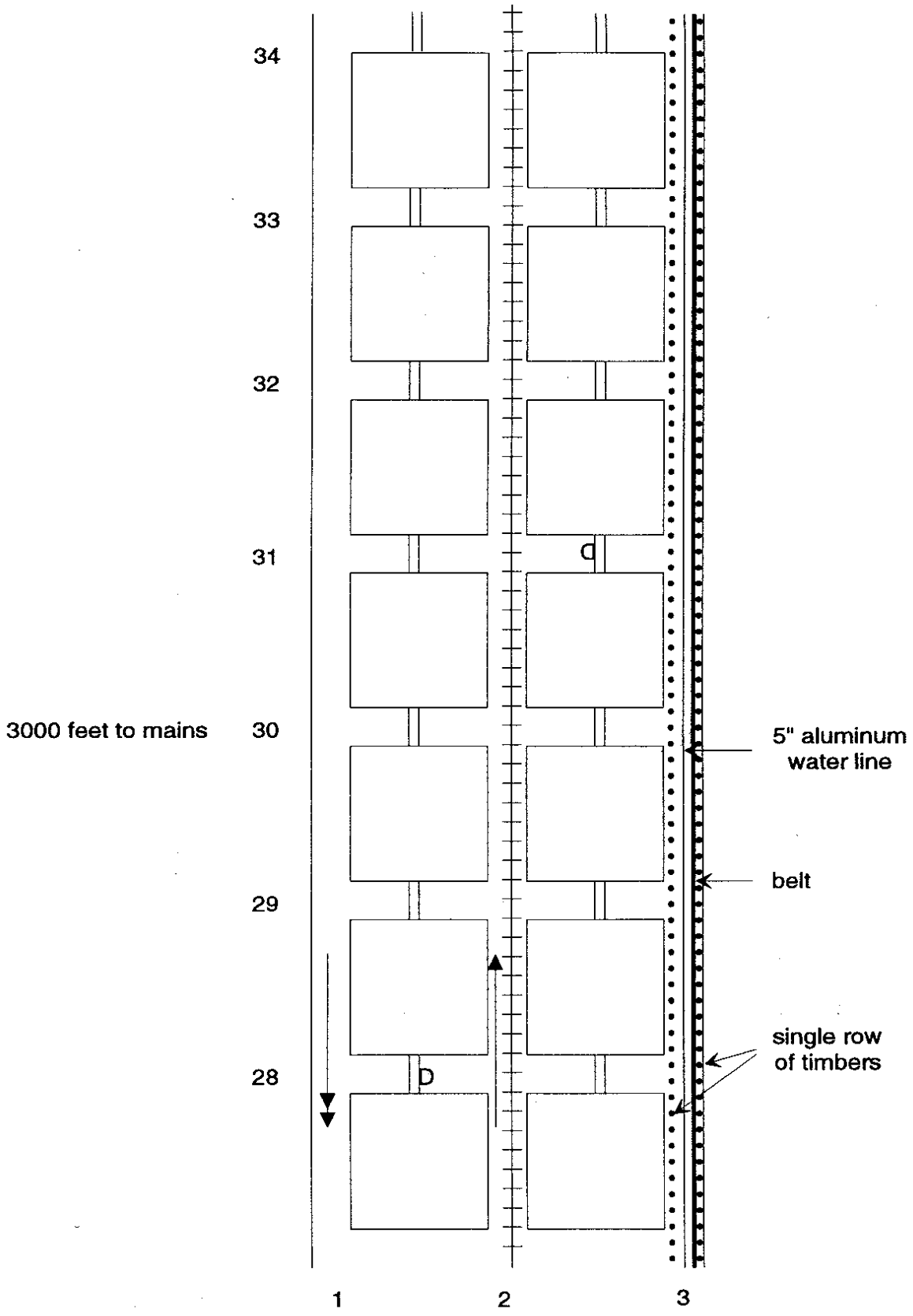

Figure 1: Section map for 17 Left (not to scale)

Question A

You and your crew go through the mandoor at #31 crosscut into the belt entry. The air is clear and you travel about 6 crosscuts, at which point you find light smoke. What should you do now? (Select as MANY as you think are correct.)

1. Watch the smoke for a while to see if it subsides.

2. Tell everyone to don their SCSR now.

3. Tell everyone to open their SCSR and loop it around their neck, but not to activate the apparatus.

4. Take your crew, lead them back to the section, and go out the return escapeway.

5. Check the time.

When you have made your selection(s) do the next question.

Question B

You decide to tell the crew to put on their SCSRs now. You check the time. It's 11:10 A.M. As you and your crew start to don the SCSRs you notice that several miners are having trouble. You observe that the breathing bags on their apparatus are not inflated. What should you do now? (Choose only ONE unless told to "Try Again!")

6. Tell the miners to exhale several breaths into the apparatus to inflate the breathing bag.

7. Remind everyone that they must activate the oxygen on the SCSR.

8. Tell the miners having trouble that the devices are not working, and to take them off. Tell them that they will probably be able to escape barefaced.

9. Tell the mechanic, who has his SCSR on, to go back to the SCSR cache in the primary escapeway and bring back more units.

Question C

The miners who had trouble had forgotten to activate the starter oxygen on their SCSRs. You realize that before continuing you need to check everyone to be sure that they have their SCSR on properly. You look for the following: (Select as MANY as you think are correct.)

10. Mouthpiece in, with lips over the flange and the miner biting on the lugs.

11. Nose clips on securely and positioned properly.

12. Goggles on, with nose bridge seated properly and the strap above the ears.

13. The apparatus carried securely under the miner's arm in such a way that there is no tension on the breathing hose.

14. No kinks and twists in the breathing hose that might restrict breathing.

15. The waist strap is tucked out of the way in the bottom of the unit.

When you have made your selection(s) do the next question.

Question D

When everyone gets their SCSR on successfully, you move out. The smoke is heavier now and the visibility is less than 40 feet. The SCSR mouthpiece is gagging you, your throat is dry, you're sweating under your goggles, and the noseclips are hurting your nose. You have traveled about 25 crosscuts when the miner operator in your crew pulls the SCSR mouthpiece out and yells, "I don't think this SCSR is working. I can't get enough air!" What do you do? (Select as MANY as you think are correct.)

16. Take your mouthpiece out and tell the miner that you are only a few breaks from another air split. Tell him to take the unit off and continue barefaced.

17. Motion for the miner operator to put the mouthpiece back in and not to talk.

18. Since you are close to another air split, signal for one of the other miners to share his SCSR with the miner operator.

19. Take the miner operator's SCSR and breathe through it to be sure that it is working.

20. Stop with your crew so that they can rest for a moment.

When you have made your selection(s) do the next question.

Question E

You stop the crew to take a rest. (See Figure 2.) After a couple of minutes, you see that the miner operator is no longer outbreathing the unit. While you are stopped, the mechanic decides to go outby and check the 4 West return and intake escapeways. He comes back and signals you and the crew to follow. When you go through a door, you come into the return escapeway and find that the smoke is not as thick. What should you do now? (Choose only ONE unless told to "Try Again!")

21. Continue your escape by leading your crew down the return escapeway instead of the belt line since the smoke is not as thick.

22. Tell your crew to take their mouthpieces out and save their SCSRs since the smoke is not as thick in the return and there is not as much CO.

23. Have the crew wait in the return escapeway while you go to a mine phone to find out where the fire is.

24. Send a miner into the primary escapeway to locate a cache of SCSRs and bring extras back for the crew.

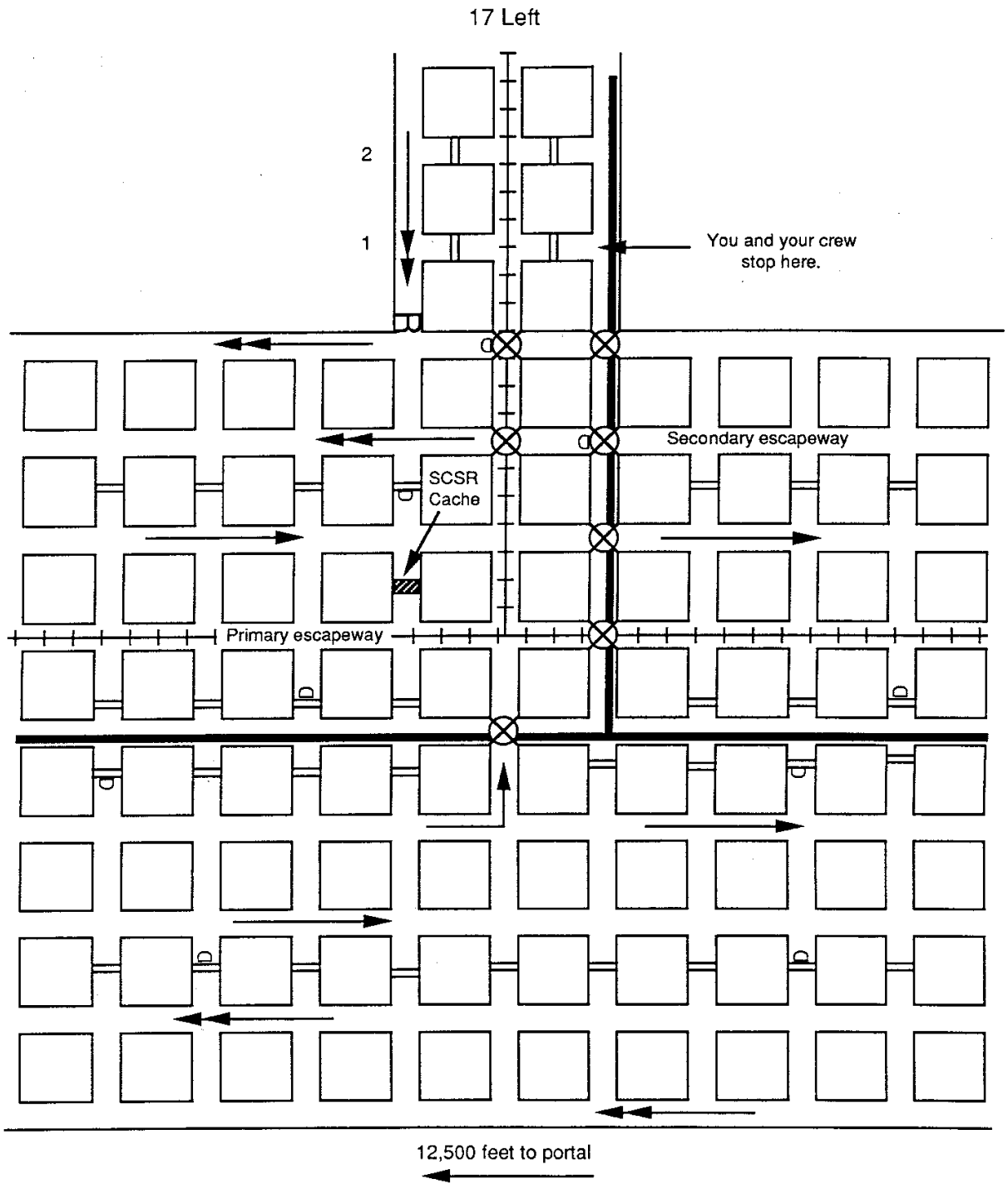

Figure 2: Map of 17 Left and 4 West Mains intersection

Question F

You and your crew continue down the 4 West return escapeway at a moderate pace, checking into the primary escapeway periodically. The smoke continues to be lighter in the return and the visibility is about 100 feet. After you travel 10 more crosscuts in the return, you begin to have trouble breathing from your SCSR. It feels like you are not getting enough oxygen from the apparatus. You check your watch and realize that you have been wearing the device for about 30 minutes. What should you do now? (Choose only ONE unless told to "Try Again!")

25. Take the apparatus off since it's probably depleted and you will smother if you don't.

26. Slow down your pace and motion to everyone to do the same.

27. Take several breaths of outside air and blow the bag back up to make breathing easier.

28. Pull the mouthpiece out slightly and breathe around it to get more air.

Question G

You and your crew slow your pace and travel another 4 crosscuts. The primary escapeway still has heavy smoke and you are still having trouble breathing from your SCSR. Some of the other miners are also having trouble breathing. You've been under apparatus for about 35 minutes. You can barely see a sign up ahead indicating there is a cache of SCSRs in the primary escapeway. What should you do now? (Select as MANY as you think are correct.)

29. Stop with your crew where the SCSR cache sign is located so that they can rest for a moment.

30. Continue traveling down the return escapeway. You need to get to good air as quickly as possible.

31. Take your crew into the primary escapeway, lead them to the SCSR cache, and signal them to don a new SCSR immediately.

32. Take two other miners with you to the cache in the primary escapeway, motion for them to a take enough SCSRs for everyone to have a spare, and to get back into the return escapeway.

When you have made your selection(s) do the next question.

Question H

You stop with your crew near the mandoor leading to the SCSR cache. While your crew rests, you take two other miners with you to the cache and get enough units for everyone. When you come back to your crew with additional SCSRs, you notice that one of the remaining six miners has taken his mouthpiece out completely and two others are cheating by breathing around it to get air. What should you do now? (Select as MANY as you think are correct.)

33. Motion for the miners to put their mouthpieces back in and try to breathe through them.

34. Motion for everyone to take off their SCSR and don one of the units you brought from the cache.

35. Signal for everyone to take another SCSR and to follow you down the return escapeway.

36. Since you and your crew are having trouble breathing from the SCSR, have everyone don a unit from the cache and then wait with you by the mandoor until help arrives.

When you have made your selection(s) do the next question.

Question I

The miners put their mouthpieces back in and you continue to lead your crew down the escapeway. You check the time and find that you and your crew have now been under apparatus about 45 minutes. You travel another 5 crosscuts (visibility is still poor) when a miner takes his mouthpiece out and says "I can't get anything from this SCSR. It's like breathing through a straw with the end pinched shut!" What should you do now? (Choose only ONE unless told to "Try Again!".)

37. Stop with your crew and motion for everyone to take off their SCSR and don the one they are carrying.

38. While the others in your crew continue on, stay back with this miner and help him don his new SCSR.

39. Since the smoke is still not as thick in the return, allow this miner to go without an SCSR so that he can save the one he is carrying in case you get into heavier smoke.

40. Motion for this miner to put his mouthpiece back in and not talk.

The miner who reported that his SCSR felt like trying to breath through a straw with the end pinched shut has probably exhausted his unit. At this time, you and your crew have been under apparatus for over 50 minutes. Since one person needs to change devices, everyone on the crew should do the same at this time since the hour is just about over, and so that the group can stay together. After donning the second SCSR and checking each other to make sure everyone has the unit on properly, you and your crew continue your evacuation.

End of Problem

Scoring your performance

1. Count the total number of responses you colored in that were marked "correct". Write this number on the first line on the answer sheet.

2. Count the total number of incorrect responses you colored in. Subtract this number from 24. Write the difference on the second line on the answer sheet.

3. The best score is 40. The worst score is 0.

Appendix B: Answer Sheet Blanks

These are the answer sheet blanks. Copies of these blank answer sheets may be duplicated in the normal fashion. However, the answers that are found within the brackets must be printed on these blank answer sheets in invisible ink. These answers are found in Appendix C. If you have the capability to print invisible ink, make copies of the blank answer sheets. Then make a mimeograph master of the answers that appear in Appendix C. Then print the invisible ink on the blank answer sheets, being careful to make sure all pages print and that the appropriate answers line up with the appropriate blanks. The Master Answer Sheet shows all the answers in their proper place.

Most companies and trainers prefer to purchase preprinted answer sheets. You may obtain copies of preprinted answer sheets from NIOSH, Pittsburgh Research Laboratory. The telephone number for this agency is listed in the footnote on page three of this document.

The exercise may be administered in small groups or individually. Used individually, you will need one answer sheet for each person in your class. If you use the exercise in small groups, you will need one answer sheet for each 3 to 5 persons in your class. The answer sheets are consumable. You will need a new set for each class.

Special developing pens are also needed by each person who marks an answer sheet. These are "PENIB" and may be obtained from SICPA Customer Service, 8000 Research Way, Springfield, VA 22153, phone 1-888-742-7287.

Answer Sheet for I Can't Get Enough Air

Use this answer sheet to mark your selections. Rub the special pen gently and smoothly between the brackets. Don't scrub the pen or the message may blur. Be sure to color in the entire message once you have made a selection. Otherwise you may not get the information you need. The last part of the message will tell you what to do next.

Question A (Select as MANY as you think are correct.)

1. [ ]

2. [ ]

3. [ ]
   [ ]

4. [ ]
   [ ]

5. [ ]
   [ ]

Question B (Choose only ONE unless told to "Try Again!")

6. [ ]
   [ ]

7. [ ]
   [ ]

8. [ ]
   [ ]

9. [ ]
   [ ]
   [ ]

Question C (Select as MANY as you think are correct.)

10. [ ]
    [ ]

11. [ ]
    [ ]

12. [ ]
    [ ]
    [ ]

13. [ ]
    [ ]

14. [ ]
    [ ]

15. [ ]
    [ ]

Question D (Select as MANY as you think are correct.)

16. [ ]
    [ ]

17. [ ]
    [ ]
    [ ]

18. [ ]
    [ ]

19. [ ]
    [ ]

20. [ ]
    [ ]

Question E (Choose only ONE unless told to "Try Again!")

21. [ ]

22. [ ]
    [ ]

23. [ ]
    [ ]
    [ ]

24. [ ]
    [ ]
    [ ]

Question F (Choose only ONE unless told to "Try Again!")

25. [ ]
    [ ]

26. [ ]
    [ ]

27. [ ]
    [ ]

28. [ ]

Question G (Select as MANY as you think are correct.)

29. [ ]
    [ ]

30. [ ]
    [ ]

31. [ ]
    [ ]

32. [ ]
    [ ]

Question H (Select as MANY as you think are correct.)

33. [ ]
    [ ]

34. [ ]
    [ ]

35. [ ]
    [ ]
    [ ]

36. [ ]
    [ ]
    [ ]

Question I (Choose only ONE unless told to "Try Again!")

37. [ ]
    [ ]

38. [ ]
    [ ]

39. [ ]
    [ ]

40. [ ]
    [ ]
    [ ]

Finding Your Score

Number of "Correct" answers you colored in = (1)_____

24 minus number of incorrect answers you colored in = (2)_____

Add blanks one and two to get your total score = (3)_____

Highest possible score = 40

Lowest possible score = 0

Appendix C: Invisible Ink Answers

These pages contain the answers that must be printed in the blanks of the answer sheet in Appendix B. These answers are spaced and sequenced correctly so that they exactly match up with the appropriate blanks on the answer sheet blank.

Once the answers have been printed in the answer sheet blanks, the developing pen reveals the formerly invisible printed message.

You may purchase preprinted answer sheets or you may prepare your own copies. To learn more about this option, and to determine how many answer sheets and developing pens you will need, see the introductory section of the Instructor's Copy.

This can be dangerous. You need to act now.

Correct! You need to get your SCSR on now.

Although you find light smoke in the belt entry, you don't know what toxic gasses are in the air. You need to use your SCSR now.

You have already come 15 crosscuts outby the faces. Going back to the section to get into the return escapeway will waste time.

Correct! Since you will be in smoke, you will need to have some time reference.

There is probably a mechanical reason the bags are not inflated. You need to do something else first. Try again!

Correct! Be sure that everyone has activated the oxygen. Once the oxygen is activated, the breathing bag will begin to fill. Do the next question.

You don't know what toxic gasses are in the air. Everyone needs to get under apparatus as soon as possible. Try again!

While there is a cache of SCSRs, the mechanic would have to travel almost 2000 feet to retrieve them. This is dangerous and wastes time. Besides, as you already know, there are more caches outby. Try again!

Correct! Miners should have the mouthpiece fully inserted with their lips sealed over the flange and teeth biting on the lugs.

Correct! The nose clips must securely pinch the nose and not be placed too high on the nose.

Correct! The goggles will prevent smoke from irritating the eyes. Make sure that the miners have the goggles on with the nose bridge positioned properly and the straps positioned above the ears for a better fit.

The neck strap must be properly looped over the head and adjusted to prevent the mouthpiece from being pulled out by the weight of the device.

Correct! People sometimes insert the mouthpiece with the hose twisted. This should be corrected to reduce the chance of breathing difficulty later.

The waist strap must be securely fastened around the waist to prevent the unit from dangling if the miner must crawl or go through a mandoor.

This is dangerous as you and the miner could be overcome by CO.

Correct! Miners tend to believe that the SCSR's are easy to breathe from, and think their apparatus isn't working when they encounter breathing resistance or when they are really outbreathing the unit.

This is dangerous as both of the miners could be overcome by CO.

This is dangerous as you and the miner could be overcome by CO.

Correct! The miner operator most likely is outbreathing the apparatus. Stopping for a few minutes gives your crew a chance to rest.

Correct! Do the next question.

This is dangerous. Even though the smoke is not as thick in the return escapeway, high concentrations of CO may be present. Try again!

Even though you still don't know where the fire is, you may have trouble finding a pager phone in the smoke. You could also easily become separated from your crew. Try again!

Your SCSRs are still working. While there is a cache of SCSRs at the mouth of the section, there are more caches located outby. You need to continue your escape. Try again!

Since you've only been wearing the SCSR for about 30 minutes, it is doubtful that the device is used up. Try again!

Correct! The longer an apparatus is worn, the harder it is to breathe from it. Slowing your pace should help you to breathe better. Do the next question.

Blowing into the breathing bag will cause you to inhale bad air and put it into the breathing circuit. This could cause breathing difficulty later. Try again!

This is dangerous since CO may be present. Try again!

Correct! The miners need to rest a few minutes while keeping their mouthpieces in and breathing from their SCSR.

You still don't know where the fire is and how far you will have to go to reach fresh air.

Since the smoke is heavy in the intake escapeway, it would be dangerous to take your crew to the SCSR cache and have them don a new apparatus.

Correct! Because you've been under apparatus for more than thirty minutes, you need to stop and get units from this cache before continuing on.

Correct! While it has been difficult to breathe from the SCSR, miners need to keep their lungs isolated to prevent being overcome by CO.

While it is becoming harder to breathe from the SCSR, it is not time to change the apparatus since it is still working.

Correct! The first SCSRs you and your crew donned are still working. There is a risk in changing units in heavy smoke. You need to continue your escape and go as far as possible before switching units.

While it is becoming harder to breathe from the SCSR, it is not time to change the apparatus since it is still working. In addition, it may be some time before help arrives.

Correct! Most likely, the miner's SCSR is depleted. Soon other miners will experience the same problem. Everyone should stop and switch units.

This will separate you from your crew. Besides, other miners may begin to have similar problems. Try again!

Once the device is on, you should NOT take it off until you must switch to another unit or until you get into good air. Try again!

This miner's comment that his breathing has been pinched off, combined with the amount of time that has elapsed should tell you that he really has used up his SCSR. Try again!

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Email: pubstaft@cdc.gov

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