

Vulcan Mine Recovery

Instructor's Copy

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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 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 them². Answer sheets are consumable. One is needed for each small group of 3 to 5 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

Length: Twelve questions (35 minutes for administration plus time for discussion)

Skills: Gathering information useful for predicting conditions on the section after a face ignition
Selecting procedures to make sure everyone is out of the mine, and that the ignition is properly and promptly reported
Developing plans and procedures for safely entering the mine to recover the section

Location: Underground

Problem: You are the mine foreman. When you return from an errand, you learn there has been a large face ignition in the Vulcan Mine. The 001 section crew has come out of the mine with three injured miners. The three injured miners have been sent to a hospital by ambulance. You must decide what to do right away to prevent any further damage or injuries, to report the ignition, and to learn about conditions in the mine on the section, and to safely restore the section and the mine to operation.

² You can do this yourself if you have the proper equipment, or you may obtain copies of preprinted answer sheets from MSHA, National Mine Health & Safety Academy, Dept. of Instructional Materials, 1301 Airport Road, Beaver, WV 25813-9426 phone 304-256-3257, fax 304-256-3368 or email to lord-mary@msha.gov.

How to Use This Exercise

1. Look at the performance objectives. Decide if the exercise is relevant for your mine training 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 that you can present it to your class without reading it. Put the maps on an overhead projector so you can use these to help explain the problem.
6. When you present the exercise to the class:
 - Arrange class members into small groups of from 3 to 5 persons.
 - Give each person an exercise booklet, and each small group of 3 to 5 one answer sheet and a developing pen.
 - Demonstrate how to select and mark answers using the developing pen.
 - Go over the instructions for doing 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.
 - When everyone has finished, discuss the exercise. Let class members discuss the merits of each answer. Add your own ideas.

Performance Objectives for Vulcan Mine Recovery

Objective number	Capability verbs)	Description of required performance and conditions under which it is to occur
1. MG/EE ³	Recognize Discriminate Select	Relevant information needed to assess the conditions of a mine section and atmosphere after a methane ignition and miner evacuation but before reentry
2. MG/EE	Identify Select	Correct, efficient, legal, and safe ways to gather relevant information about conditions on the mine section and in the mine, while remaining on the surface
3. MG/EE	Choose Order	A sequence of actions that can be carried out from the surface that minimize risk of further damage to the mine or injury to miners
4. MG/EE	Recognize Construct Select	Reasonable inferences about mine conditions and the mine atmosphere, given information about mine layout, ventilation and concentrations, proportions, and changes in levels of mine gases
5. MG/EE	Select Identify Gather	Equipment required for safely entering and inspecting a mine following a methane ignition
6. MG/EE	Choose Select Plan	Correct, efficient, legal, and safe procedures for entering a mine following an ignition for purposes of inspection and restoring ventilation following an ignition
7. MG/EE	Select Assign	Qualified personnel for critical tasks, including monitoring mine gases, carrying out communications, exploration and mine examination, and restoring ventilation
8. MG/EE	Assess Evaluate	Meanings of changing proportions and levels of mine gas concentrations over time, given information on mine ventilation conditions and changes
9 MG/EE	Plan Select Evaluate	Safe and efficient routes into and out of the mine for purposes of inspection and restoring ventilation
10 MG/EE	Plan	Safe and efficient methods for restoring ventilation to a face following a methane ignition on a mine section

³ Skill and knowledge domain abbreviations:

MG = mine gases

EE = emergency evacuation and escape

Master Answer Sheet for Vulcan Mine Recovery

Use this answer sheet to mark your selections. Rub the developing 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. [Correct. A head count and the checkout board confirm all miners are out. The assistant mine foreman says the 10 miners on the 002 section, second panel right inby the ignition were warned immediately. They came out about the same time as the 001 section crew.]
2. [Two hours.]
3. [Correct. The assistant mine foreman called all three. He reports that the MSHA and state inspectors were nearby at another mine and will be there in a few minutes. The superintendent has not been reached.]
4. [Correct. The shuttle car operator shows you the section map in Figure 1. (See page 5 of the exercise booklet.) The ventilation is O.K. except for the line curtain in the #4 entry, which is completely down and partially burned. The miners knocked the power to the section at the power box. The location of the equipment is shown in Figure 1.]
5. [Hatcher Memorial Hospital in Oakwood.]
6. [Correct. According to the miners, about 45 minutes ago.]
7. [Correct. The shuttle car operator says the clothing of two miners in #4 entry at the face caught on fire. The miner operator put these clothing fires out using the wash down hose. There was no other fire. The ignition lasted only a few seconds. The fireball filled about half of the #4 entry inby the last crosscut.]
8. [Correct. The assistant foreman tells you the main power is still on.]
9. [Correct. You hear the fan running. When you check the water gauge, you find it is pulling 2.5 inches. A check of the intake air shows a flow of approximately 36,000 cfm.]
10. [No one present knows for sure.]
11. [Correct. No detectable smoke is present. Gas checks show 0.87% methane, 0.00% carbon monoxide, 20.60% oxygen, and 0.03% carbon dioxide. Normal methane readings in the returns at the exhaust range from 0.50% to 0.80%. The preshift reading was 0.80%.]
12. [The crew estimates about 350 tons.]
13. [Seven years as foreman, two years at this mine.]

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

- 14. [The assistant foreman and the other miners refuse to do so.]
- 15. [Correct. Main power is off. Fan is still running. Foreman from 002 section]
[reminds you the sumps may soon fill up and flood the sections.]
- 16. [Correct. The miner goes to another phone nearby and tries to contact the]
[mine superintendent.]
- 17. [When you order this, the assistant mine foreman and the 002 section]
[foreman remind you that the MSHA and state inspectors will be there any]
[minute and that the MSHA office asked you to wait for them.]
- 18. [Correct. The first readings he gets are 0.87% methane, 0.00% carbon]
[monoxide, 20.60% oxygen, and 0.03% carbon dioxide. He reports no smoke.]
- 19. [He goes to look for the records.]
- 20. [Correct. He says what little is left is near the dinner hole.]

Question C (Choose only ONE unless you are told to "Try again!")

- 21. [There is no carbon monoxide or smoke in the return air. Try again!]
- 22. [There is no evidence for this. Try again!]
- 23. [The carbon dioxide reading in the return air is normal. Try again!]
- 24. [Correct. The methane in the return air at the portal is elevated to 0.87% from]
[the preshift level of 0.80%.]
- 25. [There is no evidence for this. Try again!]

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

- 26. [Correct.]
- 27. [Correct. Only one is available.]
- 28 [Correct.]
- 29. [Correct.]
- 30. [Correct.]
- 31. [Done.]
- 32. [Done.]
- 33. [Done.]
- 34. [Correct.]
- 35. [Done.]
- 36. [Done.]
- 37. [Correct.]
- 38. [Correct.]
- 39. [None are available at this site at this time.]
- 40. [Correct.]
- 41. [Done.]

Question E (Choose only ONE unless you are told to "Try again!")

42. [He is being treated at the hospital and is not available. Try again!]
43. [Correct. This is the 002 section foreman. He wants to go. Do the next question.]
44. [He says he is willing to go in. Try again!]
45. [He says he is willing to go in, but he doesn't know the overall mine ventilation]
[that well. Try again!]
46. [When you call you learn it will take them two hours to get to the mine.]
[Try again!]

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

47. [The others say this would take too long and make it impossible to take all]
[the equipment you need.]
48. [Correct. You load all of your supplies and equipment and the four of you go]
[in by scoop.]
49. [Correct. As you prepare to go in, the readings are the same as earlier, that is,]
[no smoke, CH₄ = 0.87%, O₂ = 20.60%, CO = 0.00%, and CO₂ = 0.03%.]
50. [Correct.]
51. [Correct. You find the intake air to be free of methane at every point along]
[the way in. There is no carbon monoxide and the oxygen level is normal.]
52. [Correct. All the stoppings look normal.]
53. [Correct. You stop at each mandoor. Everything is normal. There is no smoke,]
[no methane, and no carbon monoxide.]
54. [Correct. You call out and report everything is normal. You learn that the gas]
[readings in the return airway are unchanged.]
55. [When you suggest this, the other three persons look shocked. The MSHA]
[inspector says this is no time to be joking around.]
56. [Correct. The others think this is a good idea.]
57. [When you suggest this, the others say it is not necessary since the gases are]
[being constantly monitored on the surface. Also, because the mine ventilation]
[system is exhausting, fresh air is moving inby along the belt.]

Question G (Choose only ONE unless you are told to "Try again!")

58. [Correct. The others agree this is a good place because it will not block ventilation, is not too close to the face, but is near the pager. Do next question.]
59. [The section foreman says this will disturb the section ventilation. Try again!]
60. [The others yell at you to stop before you tram the scoop through the check curtain. Try again!]
61. [The state inspector says this is a poor place to park. Try again!]
62. [The others yell at you to stop the scoop before you get there. Try again!]

Question H (Choose only ONE unless you are told to "Try again!")

63. [This would disturb ventilation and place you in possible danger. Try again!]
64. [Correct. This would not disturb ventilation, and would keep you in good air. Do the next question.]
65. [This would disturb ventilation and place you in possible danger. Try again!]
66. [This would disturb ventilation and place you in danger. Try again!]

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

67. [The inspectors forbid you to do so.]
68. [Correct. You see no signs of fire or embers, but the miner blocks your view.]
69. [Correct. You see nothing. The air is clear. There is no sign of smoke.]
70. [Correct. No methane or carbon monoxide is detected, and the oxygen is found to be over 20%.]
71. [The inspectors tell you not to do this.]
72. [Correct. In five minutes you have the curtain all the way up to the continuous miner, as far as the roof is bolted. There is no sign of fire. You calculate the air flow in the entry to be 5,000 cfm. A gas reading near the face shows 2.5% methane Readings across the last open crosscut all the way to the #1 and #2 entries show 1.80% methane.]

Question J (Choose only ONE unless you are told to "Try again!")

73. [The inspectors say this is dangerous and forbid you to do so. Try Again!]
74. [Correct. The superintendent has been located. The chief engineer and coal geologist are present. A mine rescue team is standing by. It is suggested you come out so further strategy can be planned. Do the next question.]
75. [He refuses and the two inspectors tell you the fan should not be reversed. Try again!]

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

76. [The two inspectors forbid you to do this.]
77. [Correct. Surface personnel tell you to leave at once.]
78. [Correct. No methane is present in the intake air.]
79. [The inspectors and the foreman tell you it is best to take the scoop because it is faster.]
80. [Correct. No methane is found until you get about half way to the portal. There a value 0.14% is observed. The level drops to zero as you near the surface.]
81. [Correct. The foreman says this is a good idea in case the stoppings between the returns, the neutral, and the intake airways leak.]

Question L (Choose only ONE unless you are told to "Try again!")

82. [There is still no carbon monoxide present in the returns. Try again!]
83. [Correct. This explains the higher and persistent levels of methane after the initial ignition in #4 entry. It also explains the sudden increase in methane content and the increased outward flow of 1800 cfm in the returns.]
84. [Such an explosion would have been heard. There is no evidence of a fire or explosion in the return air, e.g., no carbon monoxide or smoke. Try again!]

Finding your score

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

81 minus number of incorrect answers you colored in = (2) _____
Do not count answers 2, 31 and 32.

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

Highest possible score = 81

Lowest possible score = 0

Instructor's Discussion Notes for Vulcan Mine Recovery Exercise

Use the information presented here and in the problem book, your own ideas and experiences, 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. The purpose of the exercise is to help miners think about and remember basic knowledge and skills they may someday need to deal with a mine emergency. The discussion following the exercise contributes to this goal and tailors the exercise content to the needs of the group you are training.

It is helpful to show the overhead transparencies of the exercise questions and maps during the discussion. This allows you to lead the group through the exercise and discuss all the answers to each question. Most of the information about why particular answers are correct or incorrect is given in this set of notes. It is important for you to discuss this information with the class as you show the scoring key. Otherwise, class members may not know why an answer is right or wrong.

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

Question A - The correct answers are 1, 3, 4, 6, 7, 8, 9 and 11. The key point is to gather only the information that is needed immediately. It is important to learn: (1) if everyone is out of the mine, (9) if the fan is running, (3) if the mine power has been knocked, (3) if the mine superintendent and authorities have been notified, (4) the details of the ventilation and conditions on the section, (6) how long ago the ignition took place, (7) the extent of the fire, and (11) the condition of the air in the returns at the surface (which can tell you if there is a fire in the mine or not.) This information is needed to make decisions about what to do next.

Gathering information about how long it is until sunset (2) and what hospital the injured miners were taken to (5) is not helpful for making decisions about actions that need to be made right now. It doesn't take long to get this information, but more important things should be attended to first. Thinking about the injured miners at this time may interfere with your paying attention to things that need your immediate attention. You can do nothing to help the burned miners. You can and should do some things to correct the situation in the mine.

Asking questions about when the miners had their last annual refresher training (10), the daily production (12), and the 001 section foreman's experience (13) also waste time. These matters are all relevant, but not right now. Training and experience matters should be routine concerns before an emergency develops, or after the emergency is over.

Question B - The correct answers are 15, 16, 18, and 20. It is important to knock the mine power (15). Equipment in the mine at the face area or elsewhere could ignite the methane (a sump motor, for example). Immediately monitoring the return air (18) for gases and smoke can tell you much about conditions underground. It is also important to contact the mine superintendent (16). Finding out where the brattice material (20) is stored on the section gives you information about what supplies are needed when a group goes into the mine.

Shutting down the mine fan (14) is dangerous and illegal (CFR 75.300-3) and could lead to a dangerous buildup of methane. Immediately entering the mine with a small crew to restore ventilation (17) without notifying an MSHA District or Subdistrict office having jurisdiction over the mine is illegal (CFR 50.10). In this case a federal and state inspector were nearby. It would be wise to wait for them. Anyway, before anyone rushes into the mine, more information about mine conditions is needed, as well as more preparation to enter the mine. In other situations where the inspectors were not nearby, and when there were people in the mine, or danger of further destruction to mine property, you would need to enter the mine and act before the federal and state inspectors arrived. However, even in this event you should gather information and equipment and plan your procedures before rushing into the mine. Sending a miner to look up annual refresher training records (19) wastes time and ties up a miner whose help you may need for more important things.

Question C - The correct answer is 24. You should suspect there is a high rate of methane liberation at the face. If you used the right procedures (monitoring the return air for gases) you know there is no carbon monoxide or carbon dioxide present, and that the methane level is up from the pre-shift value of .80% to .87%. Given the size of the mine and the 36,000 cfm of airflow, the methane liberation at the face must be steady and fairly high.

The increased methane in the returns would not necessarily be associated with a water inundation (22). The high oxygen and low carbon dioxide levels in the return air rule out a black damp inundation (23). If there were a fire anywhere in the mine, the return air should contain carbon monoxide and usually some smoke (25).

Question D - The correct answers are 26, 27, 28, 29, 30, 34, 37, 38 and 40. The experts disagree on the merits of taking the flame safety lamp and the life-line. Most argue that the flame safety lamp should not be taken into the mine (32) because methane is known to be present and that the methane detectors (26) and oxygen detectors (27) are safer and more accurate. Other experts say as long as the lamp is properly assembled and permissible, it is more reliable (32) than the oxygen detector and the methane monitor. Most experts say they would not take a life-line because the crew is going in with good air. At the first sign of bad air, high levels of methane, or heavy smoke, this crew should come out. The SCSRs are carried to be used only for escape (29). There is no need for the life-line since there should be no exploration in conditions of poor visibility. A few other experts say they would take the life-line if it were available, just to play it safe in case a fire or explosion were to occur while they were underground.

The experts agree that instruments for monitoring the mine gases should be taken. These include carbon monoxide, oxygen, carbon dioxide, and methane detectors. The experts also agree that an anemometer is needed (38) to make air velocity readings at the face, and along the way if they suspect poor air movement. Some would take smoke tubes as well. All would also take an SCSR for each person. Many would take a couple of mine rescue apparatuses if these were available but others say this is not necessary. All would take mine and section maps and materials to mark their positions on the maps as they explore and on the mine rib and roof as they advance. All would also take fire fighting materials, a brass hammer, nails, and brattice material.

All the other items are generally viewed as unnecessary (33, 35, 36, 39, 41) since this is not a mine rescue operation, only a bare-faced trip into the mine in intake air to examine the mine and the section and to restore ventilation.

Question E – The correct answer is 43. The most important qualities for your helper are that he or she know both the ventilation and layout of the section, and also have a good knowledge of the whole mine and its ventilation system. The experts agree that, if possible, this person should be a certified mine examiner who has recently examined this mine and this section.

Mine rescue experts who are far away and who have never been in this mine (46), would be a poor choice when other well qualified persons are nearby.

Question F – The correct answers are 48, 49, 50, 51, 52, 53, 54 and 56. The experts would take a well maintained permissible scoop into the mine in the #4 entry intake airway (48). The scoop is needed to carry all the equipment and to move rapidly into and out of the mine. They would walk in if the mine were using a track and trolley wire system. In this case they would not turn the mine power on to run a mantrip for fear of setting off an explosion. They would also walk if a permissible scoop, maintained in permissible condition, were not available.

Before going in, two reliable persons should be selected to monitor the mine phone at the surface (50) and to monitor the air velocity and gases in the return air at the exhaust fan (49). The miners who go underground should check with the person on the surface phone at every underground phone along their route. They should ask for the return air gas and velocity readings at the surface each time they call out. They should report what they have found, where they are, where they are going next, and about how long it should be before they call out again. This is so the surface personnel can keep track of their movements. They should also mark their positions and findings on the mine map and the examiner should make the usual fireboss marks on the mine rib and roof as the group proceeds.

The group should be alert for signs of smoke and monitor for methane on the trip inby in the #4 entry (52). Before entering the belt entry to call out to the surface, the mandoor should be felt (to make sure it is cool and no fire is present on the other side), the door opened slightly, the air visually inspected, and gas checks made (53). If everything is normal, one or two miners should proceed through the door to the phone to call out (54). The others should wait in the intake air entry. There is no need to cross the belt

and go through the mandoor (57) to the return air entries (#1 and #2). This would waste time, could be dangerous, and is unnecessary because the return air is being monitored at the surface.

Donning the SCSRs on the trip (55) in would be foolish. It would waste a precious resource that might be needed later to escape if there were a fire, explosion, or gas inundation. However, it would be wise to have each miner carry their own SCSR on the trip into the mine and while working to recover the section (56).

Question G – The correct answer is 58. The best place to park the scoop is position A. In this spot the scoop will cause the least restriction of the intake air flow to the face. It is important to keep the air flowing to the face to dilute the methane. You should suspect that a lot of methane is still being liberated because the level at the surface is staying at 0.87%, a full 4,700 feet away and after the air from the whole mine has mixed with return air from this section. The increase in the methane level over the pre-shift level of 0.80% could be from somewhere else, but the ignition at the face of #4 entry on the 001 section should make you cautious.

In position A, the pager is also nearby and in direct line of sight. This spot is also far enough away and upstream in the intake air, to be away from methane that might be leaking through a check curtain.

All the other positions would disturb and slow the ventilation or would be too near potential sources of explosive methane and air mixtures. Even though the scoop is permissible, it would be unwise to tram it to such positions.

Question H – The correct answer is 64. Route B is correct because it causes the least disturbance to the section ventilation. It also allows you to check the methane and oxygen levels at critical points near the tailpiece, check curtains, the #5 entry, and at the mouth of the #4 entry where the trouble began. Throughout the route you are in fresh intake air that protects you from oxygen deficiency and mine gases.

Route A is dangerous (63) because it places you in return air that is potentially explosive and oxygen deficient and because it repeatedly disturbs the ventilation as you move through check curtains. Route C, although it takes a different pathway, has the same problems (65). Route D also disturbs check curtains (66) and traveling all the way to the face of the #4 entry would be very dangerous. . You would likely be overcome by oxygen deficient air associated with a high methane concentration.

Question I – the correct answers are 68, 69, 70 and 72. Given the 3.5% methane and 18% oxygen reading, you should not go into the #4 entry. The methane concentration is probably higher further into the entry and the oxygen level lower. You would be overcome quickly if you went up toward the face.

Shutting your cap lamps off (68) to look for glowing coals and shining your lights into the entry (69) to look for smoke are good things to do. Note that if you did see signs of glowing coals or smoke, the situation would be much more serious. If the methane level in the entry is higher than 15% the gas-air mixture would not be explosive. But there

might be enough oxygen present to cause a pair of gloves or a miner's jacket on the continuous miner to continue to burn slowly, as a smoldering fire. Ask the miners in your class, "What would happen if you were to restore ventilation to the face under these conditions?" (The fresh air would dilute the methane, bringing it down into the explosive range. At the same time the inrush of fresh air would fan the smoldering fire. A violent explosion of the methane-air mixture would be almost certain.) You might also ask the members of your class what they would do if they saw evidence of a smoldering fire in the entry and suspected the methane level in the entry was very high. (The face should not be ventilated. It would be best to spray water into the section with a fire hose to put out the smoldering fire. Mine rescue apparatus should be obtained. A miner wearing a mine rescue breathing apparatus should go into the entry and make sure there is no smoldering fire. Only after this is done should ventilation be restored. Can you think of other alternatives?)

Extending a line curtain into the entry along the right rib (72) would be a good thing to do only after you determine there is no ignition source in the entry. Only one miner should extend the curtain up toward the face. The others should stay back and watch so they could rescue the miner hanging the curtain if needed. Hanging the new curtain on the right in a blowing position would protect the miner from oxygen deficient air. The old curtain cannot be used because it is partially burned.

Traveling all the way across the last open crosscut to the #1 entry (71) would be dangerous before restoring the ventilation. The air should be monitored for gas after the curtain is up and before going out from fresh air.

Question J – the correct answer is 74. The best thing to do is to check with the others on the surface. Enough time has passed so that people like the chief engineer, the coal geologist, and others can be reached. Additional information from maps of other old mines in the area may have been gathered. While you are working underground to restore the ventilation, the surface personnel should be working to figure out what is going on and what else may need to be done.

It would be foolish and illegal to activate the power to the mine and the section, and even more foolish to tram the continuous miner (73) out of the face of #4 entry. (CFR 75.308.) Anyway, if the methane monitor on the miner is working, the machine would not operate. (CFR 75.313.) Your instruments show a continual 2.5% methane level, even with the ventilation restored and 5,000 cfm airflow at the face of the entry. This means that there has to be 125 cfm of methane being liberated from the entry. You need to report this and check with the surface people before doing anything else.

Reversing the fan would be foolish (75) and is illegal . (CFR 75.300-3.) It would allow a dangerous accumulation of methane in the face area (perhaps enough to overcome you and certainly enough to be explosive) while the air was being reversed. Later it would distribute a methane-air mixture throughout the whole mine, including the neutral air of the belt (because the fan would be blowing). You would then have to travel out of the mine in this mixture and could easily get into trouble.

Question K –The correct answers are 77, 78, 80 and 81. Given the continual high levels of methane (2.5%) after you restore 5,000 cfm ventilation to the face of #4 entry, you should suspect the worst. The 10% methane reading under the check curtain is very serious. It means the rate of methane liberation has increased suddenly. It also means that a much higher concentration methane is being liberated, perhaps 100%. Otherwise it could not have increased so quickly to 10%, given the 13,000 cfm of fresh air to the section. It is important to report what you have observed to the surface and leave at once. The roof fall may have been at the face of #4 entry or elsewhere. It may have taken down curtains you can see. It may have pushed methane and other gases around the check curtains.

It would be very dangerous to go through the check curtain and into the last open crosscut or into the face area (76) of the #4 entry. You would likely be overcome by oxygen deficient air.

It would be dangerous to start out on the scoop (79) without first taking a methane reading. If the methane reading approached the explosive range (5 - 15%), it would be wise to leave the scoop and walk out. However, if no methane or only a small amount were present at the scoop, it would be faster and safer to take the scoop out.

Question L – The correct answer is 83. The initial methane ignition may have resulted from the miner notching into old works filled with pressurized methane. The subsequent roof fall could have taken down more coal between the new cut and the old works allowing a rapid inflow of methane. Because the coal seam dips away from the face of 001 section, this even more likely. The methane in the old works would rise to the highest point, near the face of the 001 section. Carbon dioxide and water would be further down the slope of the coal seam in the old works. Water flowing into the old works could pressurize the methane in the abandoned mine. A rapid flow of pressurized methane could quickly inundate the 001 section after a roof fall broke out the barrier pillar. After the roof fall, the methane in the return air at the fan rapidly increases to 4.40% and the flow increases by 1,800 cfm. These signs, along with a reduced oxygen level, strongly suggest a pressurized methane inundation has occurred.

There are no signs of carbon monoxide or smoke. Therefore, it is unlikely there is a fire anywhere in the mine (82) or that there has been an explosion (84).

References

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Scoring Key for the Apparent Diving Accident

The correct answers are marked with an asterisk.⁴

Question	Answer Number								
A	1*		3*	4*	5	6*	7*		
	8*	9*	10	11*	12	13			
B	14	15*	16*	17	18*	19	20*		
C	21	22	23	24*	25				
D	26*	27*	28*	29*	30*				33
	34*	35	36	37*	38*	39	40*	41	
E	42	43*	44	45	46				
F	47	48*	49*	50*	51*	52*			
	53*	54*	55	56*	57				
G	58*	59	60	61	62				
H	63	64*	65	66					
I	67	68*	69*	70*	71	72*			
J	73	74*	75						
K	76	77*	78*	79	80*	81*			
L	82	83*	84						

⁴ This page is printed in large type so that it may be copied 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.

You may obtain a copy of the problem booklet from MSHA, National Mine Health & Safety Academy, Dept. of Instructional Materials, 1301 Airport Road, Beaver, WV 25813-9426 phone 304-256-3257, fax 304-256-3368 or email to lord-mary@msha.gov.

Vulcan Mine Recovery Exercise

Problem Booklet

Instructions

Read the problem situation described on the next page. Next, answer each of the 12 questions. Do them one at a time. Don't jump ahead, but you may look back to earlier questions and answers. Some questions ask you to select all of the answers that 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 a choice to a question, look up its number on the answer sheet. Select your answer(s) to each question by rubbing the developing pen between the brackets on the answer sheet. A hidden message will appear and tell you if you are right. When you have finished, you will learn how to score your performance.

Background

The mine is wet and gassy in 52 inch coal with a good sandstone top and entries 18 feet wide.

Ventilation is 36,000 cfm at the exhaust fan.

The face is 4700 feet from the portal.

A three inch water line with 90 psi runs into the section. Fire hoses are present throughout the mine and on the section.

Just before the shift, the 001 section, first panel right off the East mains, was firebossed and the ventilation was good.

The coal seam dips about 6 degrees to the south. The 001 section advances to the south.

Halfway through the second shift, a methane ignition occurred at the face of the #4 entry of the 001 section while coal was being cut. The continuous miner operator, the miner helper, and the section foreman were burned. The four other miners on the section removed the three injured miners from the section, knocked the power at the section power box, provided first aid to the injured, reported the ignition and injuries, and brought the injured out. The burned miners have been sent to a local hospital.

Problem

You are the mine foreman. You have just returned from an errand. When you arrive at the mine office you learn of the ignition from your assistant mine foreman and the four uninjured miners from the section.

Turn the page and answer Question A.

Question A

Questions that you should ask immediately include: (Select as MANY as you think are correct.)

1. Is everyone out of the mine?
2. How long is it until sunset?
3. Has someone notified the mine superintendent, MSHA and state officials?
4. What are the details of the ventilation and conditions on the section?
5. To what hospital were the burned miners taken?
6. How long ago did the ignition occur?
7. Was there any fire on the section after the ignition?
8. Has the main power to the mine been shut off?
9. Is the fan still operating?
10. Have the members of the 001 section had their annual refresher training within the last year?
11. What is the appearance and condition of the air in the returns at the surface?
12. What was today's production for the 001 section before the ignition?
13. How many years has the 001 section foreman worked in this job?

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

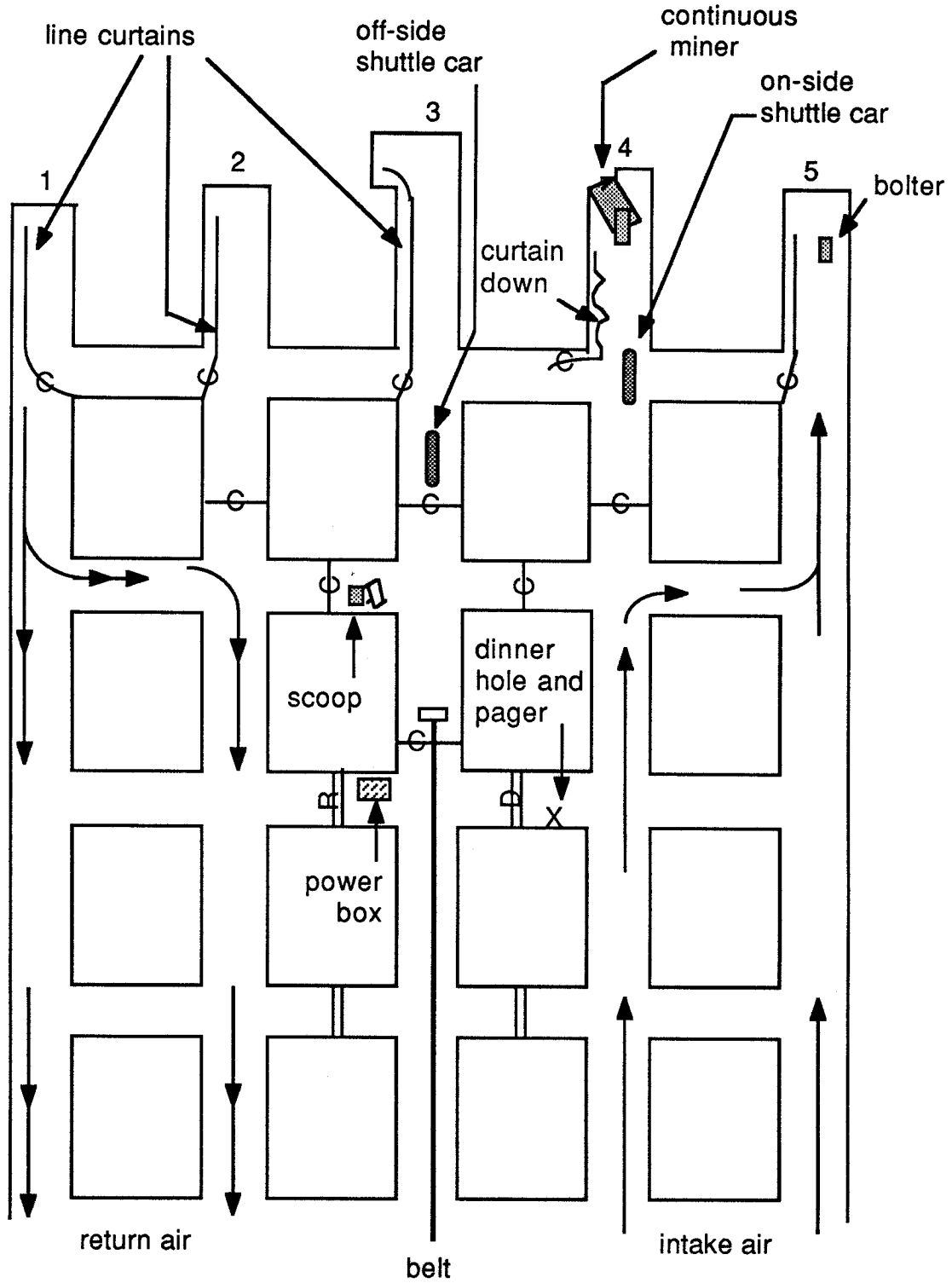


Figure 1: Map showing section ventilation and conditions

Question B

At this point what actions should you take? (Select as MANY as you think are correct.)

14. Order the mine fan shut down.
15. Knock the power to the whole mine, but leave the fan running.
16. Send one of the miners to another phone. Tell him to keep trying to locate the mine superintendent by calling his home, his associates, secretary, etc.
17. Using a battery operated scoop, immediately take the 002 section foreman and the brattice man from the 001 section into the 001 section and restore ventilation in #4 entry.
18. Send one certified miner to monitor the air in the returns at the exhaust fan for gases and smoke and have this person report to you periodically.
19. Send a miner to the company office to check if the 001 section miners have had annual refresher training within the last year.
20. Ask the utility man where brattice material is stored on the 001 section.

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

Question C

Given the information you have collected so far, which of the following conditions do you suspect on the 001 section? (Choose only ONE unless you are told to "Try again!")

21. There is an active mine fire on the section, possibly involving the continuous mining machine and its oil, as well as some coal.
22. There is a water inundation of section 001 at the face in entry #4.
23. There is a blackdamp inundation of section 001 at the face in entry #4.
24. Methane liberation, probably at the face of the #4 entry, is still fairly high.
25. Coal is on fire somewhere on the section. The fire is producing methane and hydrogen.

Question D

You decide to get ready for a trip into the mine to the 001 section. What equipment will you assemble? (Select as MANY as you think are correct.)

26. Two methane detectors
27. Two oxygen detectors
28. A carbon monoxide detector
29. One SCSR for each person entering the mine
30. A current mine map and a map of 001 section
31. Three extra pairs of gloves
32. A flame safety lamp
33. A portable telephone and line on a reel
34. A brass hammer, nails, and brattice material
35. A stretcher and first aid kit
36. A 40 to 50 foot rope to serve as a life line
37. Two dry chemical fire extinguishers and 6 to 8 bags of rock dust
38. An anemometer
39. Four mine rescue breathing units
40. Chalk and pen to mark on the maps and on the roof and rib
41. Extra fuses for the power box on the section

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

Question E

One MSHA and one state inspector arrive. They talk with you. You give them all the information you know at this time. They ask you to lead the group in. Who else will you take with you? (Choose only ONE unless you are told to "Try again!")

42. The foreman from 001 section
43. The available miner who is most familiar with the mine's ventilation, the 001 section, and who is also a certified mine examiner
44. The shuttle car driver from the 001 section who witnessed the ignition, although he is not a certified mine examiner
45. The brattice man from the 001 section, although he is not a certified mine examiner
46. Two mine rescue team members from the company headquarters which is 100 miles away

Question F

You have selected the 002 section foreman to go in with you and the inspectors. What procedures will you establish for entering and traveling in the mine? (Select as MANY as you think are correct.)

47. Walk in the entire way from the portal in the #5 entry intake airway.
48. Take a permissible battery operated rubber-tired scoop in through the #4 entry intake airway.
49. Have the person at the mouth of the exhaust fan continue to monitor the return air for gases and smoke while you are underground.
50. Have someone monitor the mine phone in the mine office and also continue to try to locate the superintendent.
51. Use a hand held spotter to monitor for methane as you travel inby.
52. Travel in the #4 entry so you can inspect the stoppings on the way in.
53. Stop the scoop at each mandoor. Get off. Feel the mandoor to see if it is hot. If it is not, open the door slightly. Inspect the air in the belt entry for smoke. Then take methane, carbon monoxide, and oxygen readings in the belt entry by holding the instruments through the mandoor.
54. After taking gas readings, enter the belt entry and call to the surface at each of the three mine phones as you travel inby. Tell the surface what you have found, where you are going next, and when you should be at the next phone. Ask for the latest information about the gases in the return air at the surface.
55. Tell each person in the scoop to break open their SCSR, put it on, and breathe with it on the way in to the section.
56. Remind each person to carry their SCSR with them at all times while traveling into and working on the section.
57. At each mandoor, stop the scoop. Have someone get off, go into the belt entry and take gas readings. Then, have the person go through the second mandoor into the #2 and #1 return entries to make gas readings.

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

Question G

You are now near the face of section 001. Which position marked on the section map on the following page (Figure 2) is the best place to park the scoop? (Choose only ONE unless you are told to "Try again!")

58. Position A

59. Position B

60. Position C

61. Position D

62. Position E

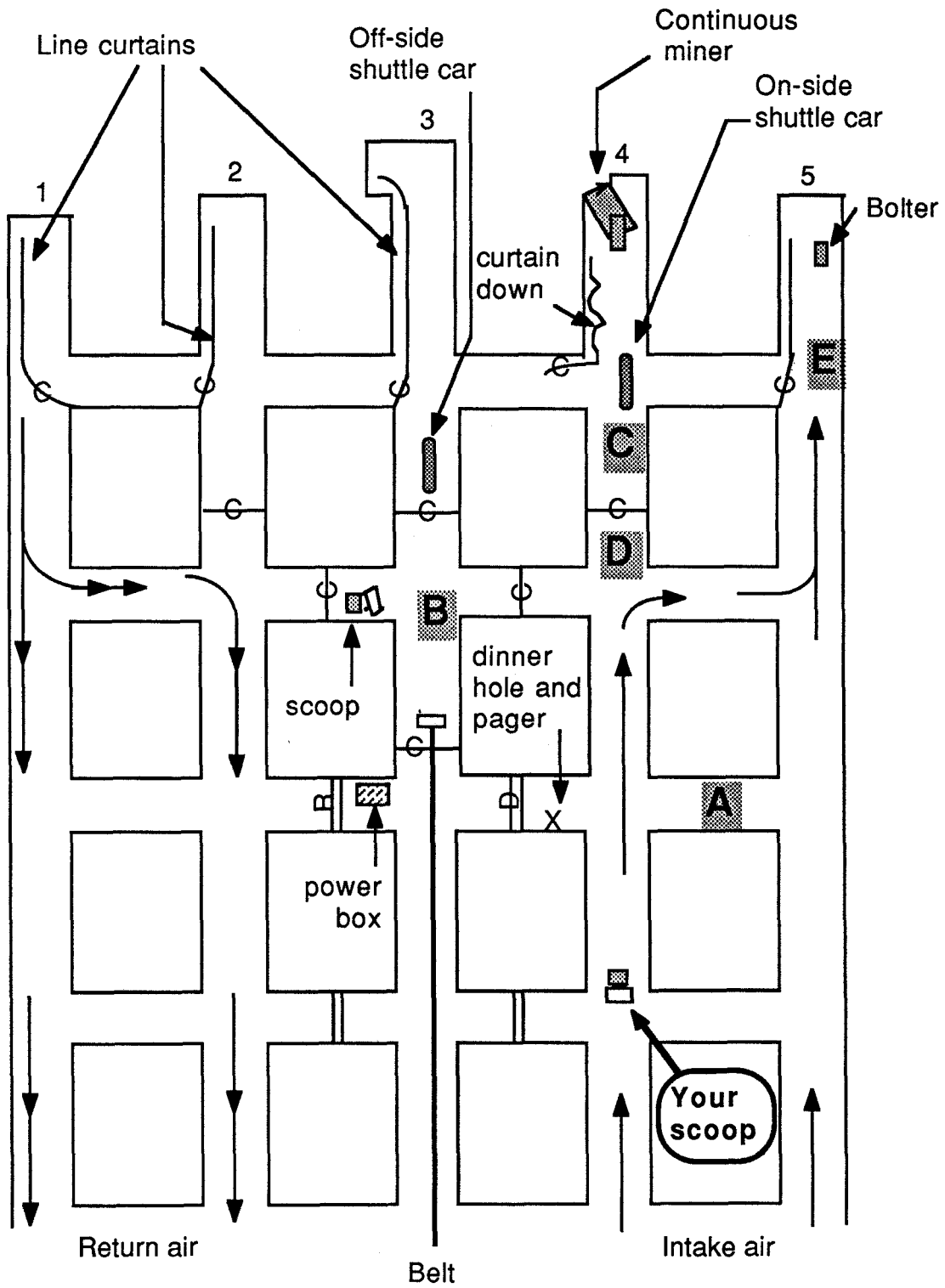


Figure 2: Map showing possible places to park the scoop (positions marked in large bold letters)

Question H

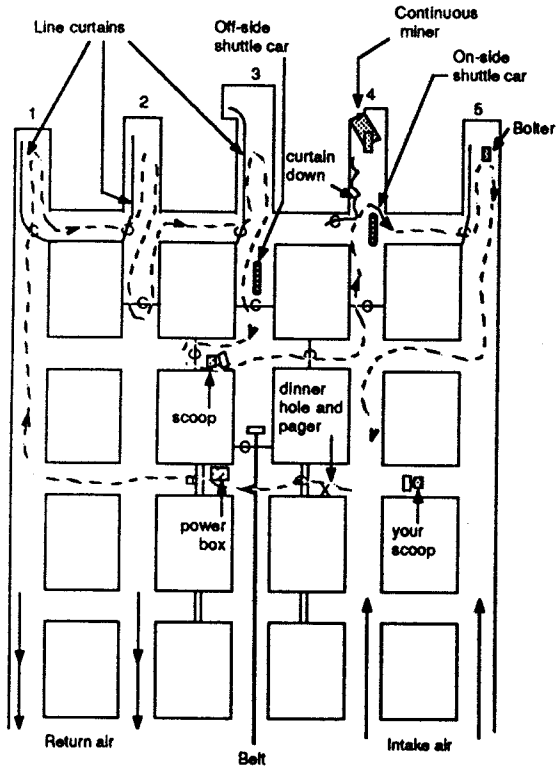
Now you have parked the scoop. Which route will you take to the face to check the ventilation and the condition of the section? See Figure 3 on the next page. (Choose only ONE unless you are told to "Try again!")

63. Route A

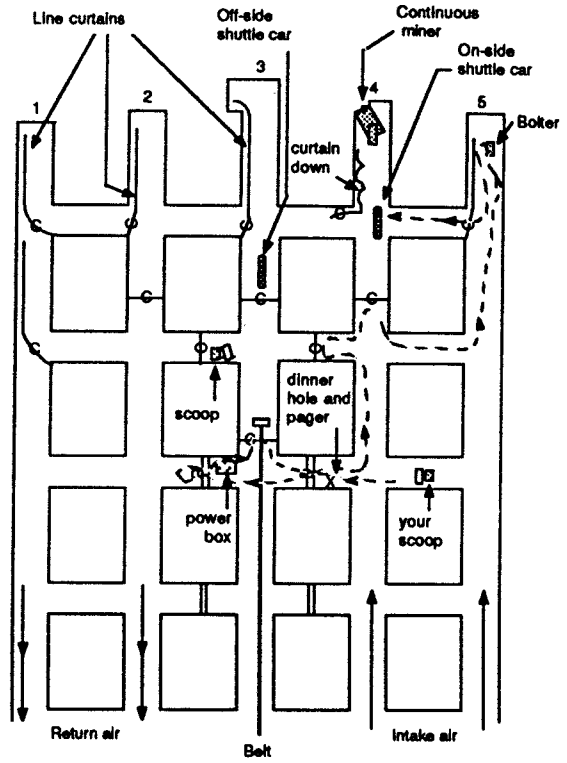
64. Route B

65. Route C

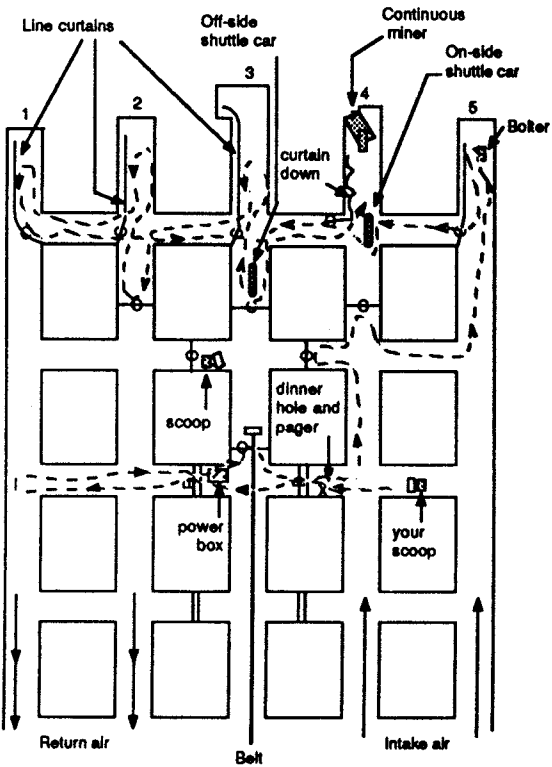
66. Route D



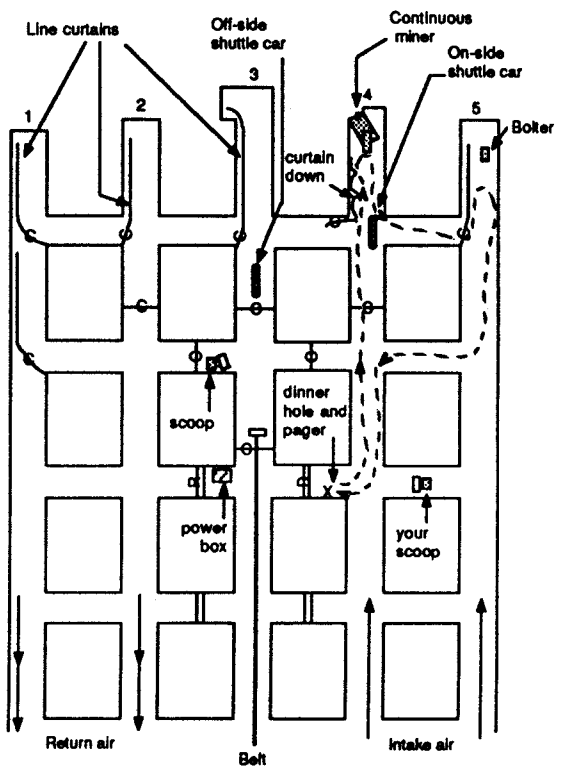
Route A



Route B



Route C



Route D

Question I

You have taken the route to the face shown on the map on the next page (Figure 4). The Xs along the route mark the places where you took gas readings. The A marks the place where you took an anemometer reading. You find no methane, no carbon monoxide, and 20.90% oxygen at points X1 through X7. You calculate 13,000 cfm air flow at point A. At point X8 you find the methane to be 3.5%, the oxygen to be 18%, and 0.00% carbon monoxide. What will you do now? (Select as MANY as you think are correct.)

67. Enter the face of #4 entry and travel toward the continuous miner and keep measuring the gases.
68. Shut off your cap lamps. Look into the #4 entry. Look for any signs of glowing coals or fire.
69. Shine your lights into the face of # 4 entry. Look for signs of smoke.
70. Make a gas check at the outby end of the shuttle car.
71. Travel through the last open crosscut all the way to the #1 entry, measuring the gases as you go.
72. Use the brattice cloth you brought with you. Hang a line curtain from the left corner of the #4 pillar, across the crosscut on the right of the on-side shuttle car, and along the right rib of the #4 entry. Extend the curtain a little at a time toward the face of the #4 entry, keeping fresh air blowing over you.

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

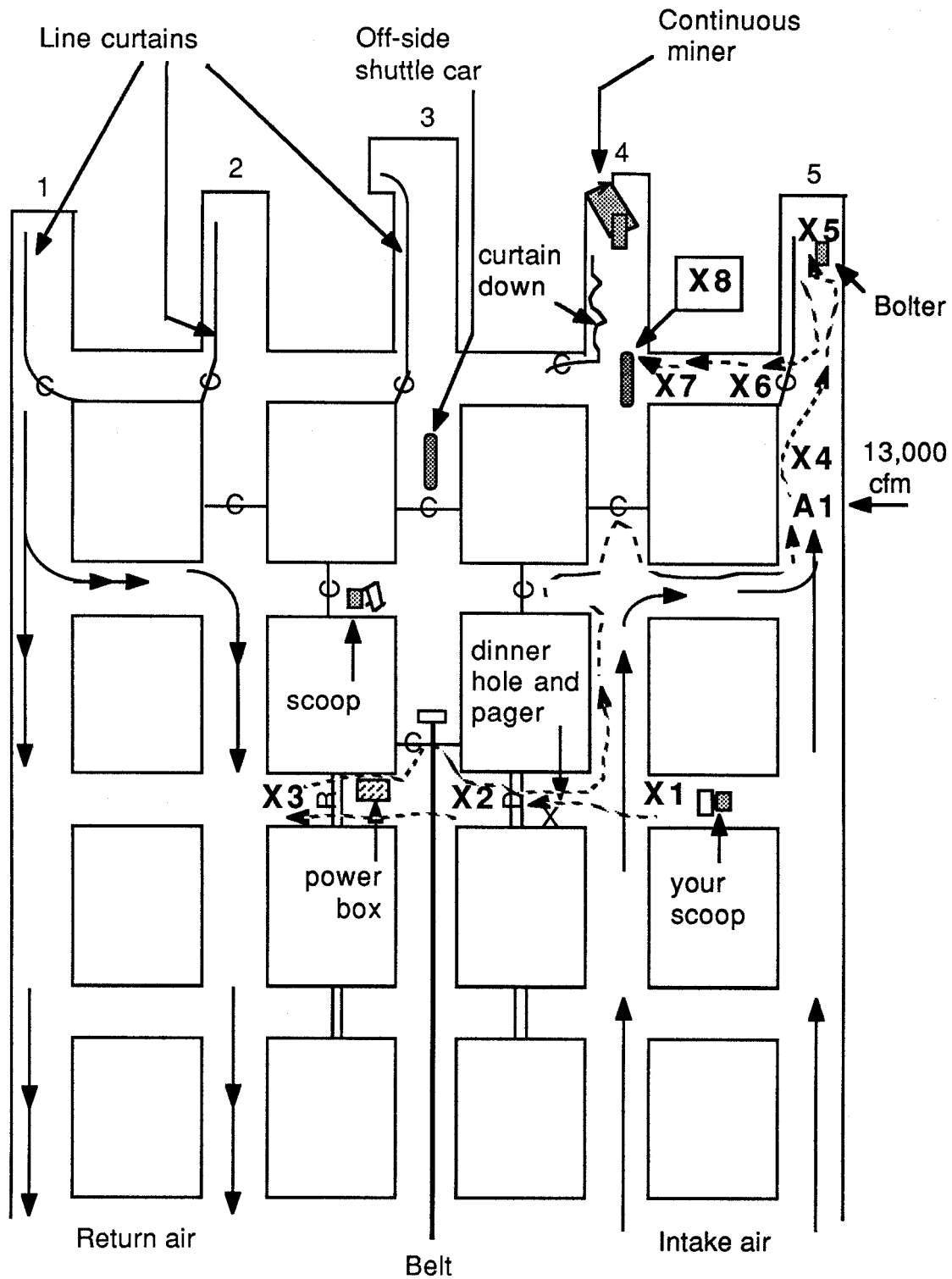


Figure 4: Position of gas and air readings (Xs = gas readings, A = air flow)

Question J

You send the section foreman to call out at the pager and report that you have restored ventilation on the section, but that the methane is still 2.5% at the face of the #4 entry. What action should you take at this time? (Choose only ONE unless you are told to "Try again!")

73. Ask the surface to turn on the power to the mine. You then turn the power on at the power box on the section and tram the continuous miner out of the entry.
74. Ask for advice from the surface where engineering personnel and other specialists may now be available.
75. When he calls out, tell the section foreman to ask the surface personnel to reverse the fan.

Question K

All four of you are near the tailpiece. As you are getting ready to come out of the mine, you hear what sounds like a large roof fall. The check curtain in the #3 entry near the face billows toward you. When you move up the beltway and look under the curtain, you see a lot of dust. When you hold your methane detector under the curtain, it reads 10%. See the map on next page (Figure 5). What will you do now? (Select as MANY as you think are correct.)

76. Go to the #4 entry and up to the face to see if there has been a roof fall so you can make an accurate report to the surface about conditions on the section.
77. Report what you have observed to the surface and immediately leave the face area.
78. Take a methane reading at the scoop before using it to leave the section.
79. Leave the scoop where it is and walk out of the mine.
80. Monitor for methane all the way out as you tram to the surface.
81. Travel out in the scoop in the #5 entry in the intake airway.

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

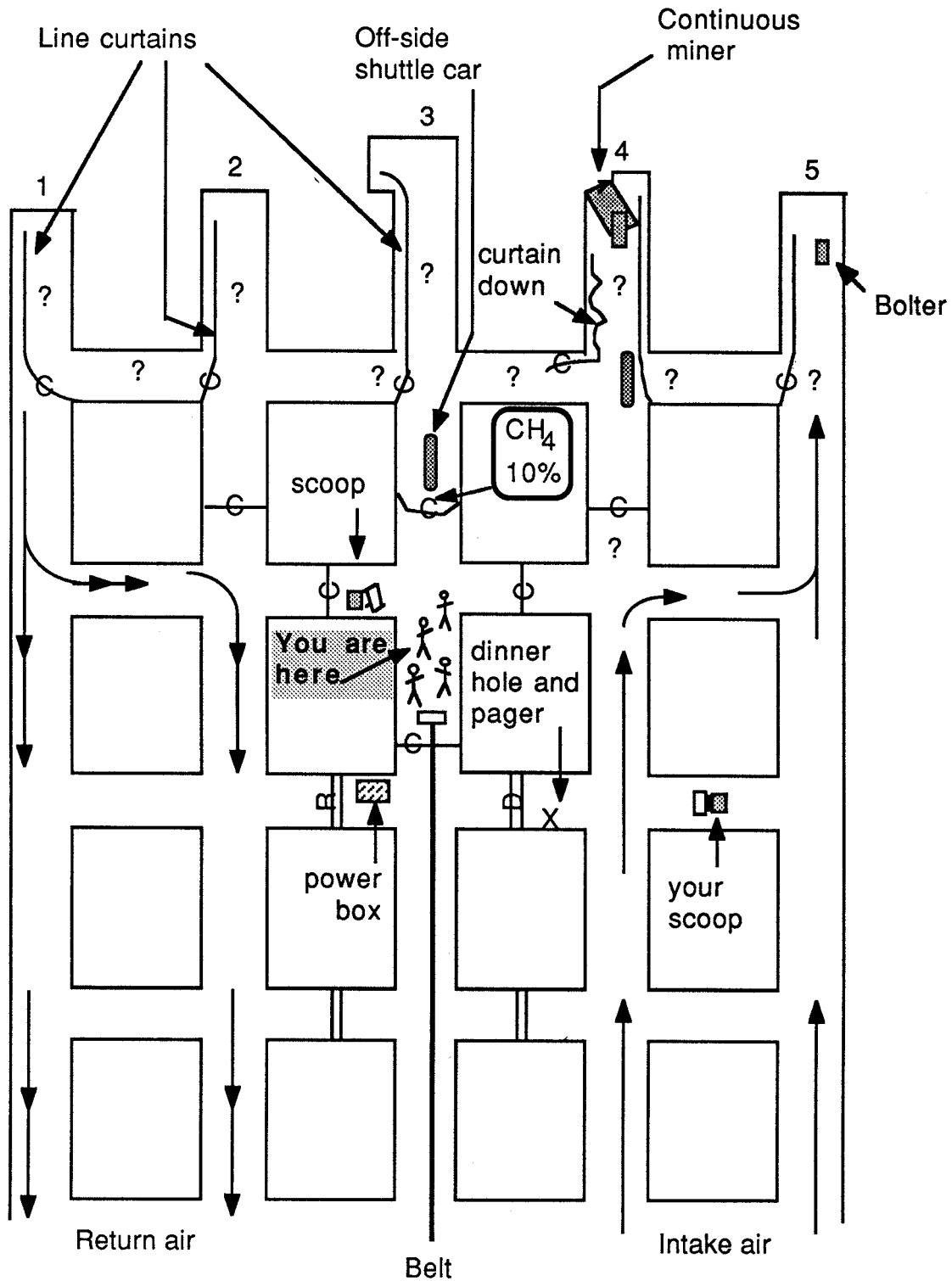


Figure 5: Your position and methane reading behind check curtain after sound of roof fall

Question L

When you arrive at the surface, you learn that the methane in the return air at the exhaust fan has reached 4.40% and the airflow in the returns is approximately 1800 cfm higher than the intake airflow. No carbon monoxide is present and the oxygen content is about 19.0%. At this point what do you suspect is the source of the methane? (Choose only ONE unless you are told to "Try again!")

82. There is a mine fire somewhere on section 001 or near it.
83. The methane is probably pressurized gas from old works that have been exposed by the continuous miner in #4 entry and by a subsequent roof fall in that entry.
84. There has been an explosion in the mine, perhaps in by the 001 section. The increased levels of methane and the increased flow of air in the returns are caused by the expansion of the air from the heat.

End Of Problem

Scoring your performance

1. Compare your completed answer sheet with the scoring key to learn which of your choices are correct, incorrect, or neutral.
2. Count the total number of correct answers you colored in. Write this number on the first blank on the answer sheet.
3. Count up the total number of incorrect answers you colored in. Subtract this number from 38. Write the difference on the second blank on the answer sheet. **Do not count answers 2, 31 and 32.**
4. Add the numbers in the first and second blanks on the answer sheet. This is your score.

The best possible score of 81 results from selecting all 43 of the correct answers, and none of the 38 wrong answers. The 3 neutral answers do not count for or against your score. The worst possible score of zero results from selecting all the wrong answers and no correct answers.

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. Make a 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 places.

Most companies and trainers prefer to obtain copies of the preprinted answer sheets from MSHA, National Mine Health & Safety Academy, Dept. of Instructional Materials, 1301 Airport Road, Beaver, WV 25813-9426 phone 304-256-3257, fax 304-256-3368 or email to lord-mary@msha.gov.

The exercise is designed to be used in small groups. You will need one answer sheet for each group of 3 to 5 persons in your class. The answer sheets are consumable. You will need a new set for each class.

A developing pen is also needed by each person who marks an answer sheet.

Answer Sheet for Vulcan Mine Recovery

Use this answer sheet to mark your selections. Rub the developing 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. []
- 6. []
- 7. []
[]
[]
[]
- 8. []
- 9. []
[]
[]
- 10. []
- 11. []
[]
[]
[]
- 12. []
- 13. []

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

- 14. []
- 15. []
[]
- 16. []
[]
- 17. []
[]
[]
- 18. []
[]
- 19. []
- 20. []

Question C (Choose only ONE unless you are told to "Try again!")

- 21. []
- 22. []
- 23. []
- 24. []
[]
- 25. []

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

- 26. []
- 27. []
- 28. []
- 29. []
- 30. []
- 31. []
- 32. []
- 33. []
- 34. []
- 35. []
- 36. []
- 37. []
- 38. []
- 39. []
- 40. []
- 41. []

Question E (Choose only ONE unless you are told to "Try again!")

- 42. []
- 43. []
- 44. []
- 45. []
[]
- 46. []
[]

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

- 47. []
[]
- 48. []
[]
- 49. []
[]
- 50. []
- 51. []
[]
- 52. []
- 53. []
[]
- 54. []
[]
- 55. []
[]
- 56. []
- 57. []
[]
[]

Question G (Choose only ONE unless you are told to "Try again!")

58. []
[]

59. []

60. []
[]

61. []

62. []

Question H (Choose only ONE unless you are told to "Try again!")

63. []

64. []
[]

65. []

66. []

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

67. []

68. []

69. []

70. []
[]

71. []

72. []
[]
[]
[]
[]

Question J (Choose only ONE unless you are told to "Try again!")

73. []

74. []
[]
[]

75. []
[]

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

76. []

77. []

78. []

79. []
[]

80. []
[]

81. []
[]

Question L (Choose only ONE unless you are told to "Try again!")

82. []

83. []
[]
[]

84. []
[]

Finding your score

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

81 minus number of incorrect answers you colored in = (2) _____
Do not count answers 2, 31 and 32.

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

Highest possible score = 81

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

Correct. A head count and the checkout board confirm all miners are out. The assistant mine foreman says the 10 miners on the 002 section, second panel right in by the ignition were warned immediately. They came out about the same time as the 001 section crew.

Two hours.

Correct. The assistant mine foreman called all three. He reports that the MSHA and state inspectors were nearby at another mine and will be there in a few minutes. The superintendent has not been reached.

Correct. The shuttle car operator shows you the section map in Figure 1. (See page 5 of the exercise booklet.) The ventilation is O.K. except for the line curtain in the #4 entry, which is completely down and partially burned. The miners knocked the power to the section at the power box. The location of the equipment is shown in Figure 1.

Hatcher Memorial Hospital in Oakwood.

Correct. According to the miners, about 45 minutes ago.

Correct. The shuttle car operator says the clothing of two miners in #4 entry at the face caught on fire. The miner operator put these clothing fires out using the wash down hose. There was no other fire. The ignition lasted only a few seconds. The fireball filled about half of the #4 entry in by the last crosscut.

Correct. The assistant foreman tells you the main power is still on.

Correct. You hear the fan running. When you check the water gauge, you find it is pulling 2.5 inches. A check of the intake air shows a flow of approximately 36,000 cfm.

No one present knows for sure.

Correct. No detectable smoke is present. Gas checks show 0.87% methane, 0.00% carbon monoxide, 20.60% oxygen, and 0.03% carbon dioxide. Normal methane readings in the returns at the exhaust range from 0.50% to 0.80%. The preshift reading was 0.80%.

The crew estimates about 350 tons.

Seven years as foreman, two years at this mine.

The assistant foreman and the other miners refuse to do so.

Correct. Main power is off. Fan is still running. Foreman from 002 section reminds you the sumps may soon fill up and flood the sections.

Correct. The miner goes to another phone nearby and tries to contact the mine superintendent.

When you order this, the assistant mine foreman and the 002 section foreman remind you that the MSHA and state inspectors will be there any minute and that the MSHA office asked you to wait for them.

Correct. The first readings he gets are 0.87% methane, 0.00% carbon monoxide, 20.60% oxygen, and 0.03% carbon dioxide. He reports no smoke.

He goes to look for the records.

Correct. He says what little is left is near the dinner hole.

There is no carbon monoxide or smoke in the return air. Try again!

There is no evidence for this. Try again!

The carbon dioxide reading in the return air is normal. Try again!

Correct. The methane in the return air at the portal is elevated to 0.87% from the preshift level of 0.80%.

There is no evidence for this. Try again!

Correct.

Correct. Only one is available.

Correct.

Correct.

Correct.

Done.

Done.

Done.

Correct.

Done.

Done.

Correct.

Correct.

None are available at this site at this time.

Correct.

Done.

He is being treated at the hospital and is not available. Try again!

Correct. This is the 002 section foreman. He wants to go. Do the next question.

He says he is willing to go in. Try again!

He says he is willing to go in, but he doesn't know the overall mine ventilation that well. Try again!

When you call you learn it will take them two hours to get to the mine. Try again!

The others say this would take too long and make it impossible to take all the equipment you need.

Correct. You load all of your supplies and equipment and the four of you go in by scoop.

Correct. As you prepare to go in, the readings are the same as earlier, that is, no smoke, $\text{CH}_4 = 0.87\%$, $\text{O}_2 = 20.60\%$, $\text{CO} = 0.00\%$, and $\text{CO}_2 = 0.03\%$.

Correct.

Correct. You find the intake air to be free of methane at every point along the way in. There is no carbon monoxide and the oxygen level is normal.

Correct. All the stoppings look normal.

Correct. You stop at each mandoor. Everything is normal. There is no smoke, no methane, and no carbon monoxide.

Correct. You call out and report everything is normal. You learn that the gas readings in the return airway are unchanged.

When you suggest this, the other three persons look shocked. The MSHA inspector says this is no time to be joking around.

Correct. The others think this is a good idea.

When you suggest this, the others say it is not necessary since the gases are being constantly monitored on the surface. Also, because the mine ventilation system is exhausting, fresh air is moving in by along the belt.

Correct. The others agree this is a good place because it will not block ventilation, is not too close to the face, but is near the pager. Do next question.

The section foreman says this will disturb the section ventilation. Try again!

The others yell at you to stop before you tram the scoop through the check curtain. Try again!

The state inspector says this is a poor place to park. Try again!

The others yell at you to stop the scoop before you get there. Try again!

This would disturb ventilation and place you in possible danger. Try again!

Correct. This would not disturb ventilation, and would keep you in good air. Do the next question.

This would disturb ventilation and place you in possible danger. Try again!

This would disturb ventilation and place you in danger. Try again!

The inspectors forbid you to do so.

Correct. You see no signs of fire or embers, but the miner blocks your view.

Correct. You see nothing. The air is clear. There is no sign of smoke.

Correct. No methane or carbon monoxide is detected, and the oxygen is found to be over 20%.

The inspectors tell you not to do this.

Correct. In five minutes you have the curtain all the way up to the continuous miner, as far as the roof is bolted. There is no sign of fire. You calculate the air flow in the entry to be 5,000 cfm. A gas reading near the face shows 2.5% methane. Readings across the last open crosscut all the way to the #1 and #2 entries show 1.80% methane.

The inspectors say this is dangerous and forbid you to do so. Try Again!

Correct. The superintendent has been located. The chief engineer and coal geologist are present. A mine rescue team is standing by. It is suggested you come out so further strategy can be planned. Do the next question.

He refuses and the two inspectors tell you the fan should not be reversed. Try again!

The two inspectors forbid you to do this.

Correct. Surface personnel tell you to leave at once.

Correct. No methane is present in the intake air.

The inspectors and the foreman tell you it is best to take the scoop because it is faster.

Correct. No methane is found until you get about half way to the portal. There a value 0.14% is observed. The level drops to zero as you near the surface.

Correct. The foreman says this is a good idea in case the stoppings between the returns, the neutral, and the intake airways leak.

There is still no carbon monoxide present in the returns. Try again!

Correct. This explains the higher and persistent levels of methane after the initial ignition in #4 entry. It also explains the sudden increase in methane content and the increased outward flow of 1800 cfm in the returns.

Such an explosion would have been heard. There is no evidence of a fire or explosion in the return air, e.g., no carbon monoxide or smoke. Try again!