

**Raggs & Curly Guarding Exercise**  
**Instructor's Copy**

Mining Systems and Human Engineering  
U. S. Bureau of Mines  
Pittsburgh, Pennsylvania

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Appendix A: Problem Booklet (duplicate this for use in class) and instructions for exercise completion

Appendix B: Answer sheet blanks (print the answers on these blanks)

Appendix C: Invisible ink answers (print these on the answer sheet blanks)

## 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 booklet is three appendices. Appendix A is the exercise problem booklet. The booklets are reusable and can be duplicated locally. One is needed for every person in the class. Appendix B is the answer sheet. Copies of this answer sheet must have the answers that appear in Appendix C printed on them.<sup>1</sup> Answer sheets are consumable. One is needed for each person or each small group of persons who work the exercise. Also included with this instructor's copy is a 3-D slide reel. A reel of 3-D slides and a View-Master<sup>2</sup> viewer<sup>3</sup> is necessary for each person or group of persons working the exercise.

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<sup>1</sup> 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](mailto:minetraining@cdc.gov).

<sup>2</sup> Reference to specific products does not imply endorsement by the Bureau of Mines.

<sup>3</sup> These may be purchased from your local toy store or purchased directly from Fisher-Price, Inc., View-Master Custom Sales, Customer Service, 636 Girard Avenue, East Aurora, NY 14052, (716) 687-3899.

## 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: 3-D invisible ink

Audience: Surface coal mine/preparation plant

Length: Eight questions (30 minutes for administration plus 30 for discussion)

Skills: Machine and equipment guarding strategies and procedures, including hazard identification, warning and caution sign usage, safe work habits, safe guarding practices and decision making skills.

Location: Surface coal mine mobile conveyor area

Problem: You, Earl E. Raggs, are the chief mechanic at the main complex of the AB Coal Company. You have been called to the Jake's Run Surface Mine. The mine supplies coal directly to rail cars by means of a 48" mobile conveyor. The superintendent explains that during a recent insurance inspection, some potentially dangerous situations concerning improper guarding practices were noted. He instructs you to conduct a survey and document some of the guarding problems you observe around the mobile conveyor. Your recommendations will be part of a planned company wide guarding policy. He assigns Noah "Curly" Hair, who just recently became a mechanic's helper at this operation, to accompany you. The superintendent stresses the fact that Curly is not too familiar with safe guarding practices and asks that you take this opportunity to share your knowledge concerning guarding. You and Curly are to report back to the superintendent with your findings.

Skills: In the context of this problem scenario:

Identify those hazards which exist when machine guards are damaged or missing

Evaluate the potential for injury when working on or near moving parts

Recognize and implement those safeguards which reduce the occurrence of machine guarding related accidents

Implement and comprehend the safe work procedures that assist employees in working safely

Recognize the components of a proactive machine guarding policy

### **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 own 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.
6. When you present the exercise to the class:
  - Give each small group of persons (or person, if working the exercise individually) an answer sheet and a developing pen. Working in small groups tends to get people discussing their views and causes the class members to think about the topic from other points of view.
  - Give each person an exercise booklet, a 3-D slide reel, and a 3-D viewer.
  - Demonstrate how to select and mark answers using the developing pen, and how to use the 3-D viewer.
  - 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.

## Master Answer Sheet for the Raggs and Curly Guarding 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. [ Correct. It is a good idea to clean the illegible sign. A comprehensive guarding policy should include periodic cleaning of warning and caution signs. ]
2. [ Correct. A missing guard exposes a hazard. ]
3. [ In many circumstances it may be necessary to alter existing guards. The addition of straps to this guard strengthens and protects it. ]
4. [ Correct. Coal buildup can be a fire and tripping hazard. The amount of coal may indicate that additional maintenance is necessary here. ]
5. [ The electrical box does not require additional guarding in this situation. ]

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

6. [ The distance between the salamander and the fuel depot is adequate and poses no hazard. ]
7. [ Correct. Holes in guards present a hazard because they make it possible for persons to come into contact with moving parts. ]
8. [ Correct. Even if the guard was in good condition, the rollers would not be completely enclosed by the guard. Contact with moving parts is not prevented here. ]
9. [ Correct. Warning and/or caution signs are a good safety practice. ]
10. [ Correct. Coal build-up is a potential fire and tripping hazard. The amount of coal seen here may indicate that equipment modifications may be necessary to prevent continued spillage. ]
11. [ Correct. Space left between the frames of guards allows openings where fingers could contact moving parts. ]

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

12. [ Correct. If you look closely, you can see a triangular guard on the ]  
[ opposite side of the structure. It may be a possible violation if a similar ]  
[ guard is not in place on this side of the structure. ]
13. [ Correct. It is a good policy to include caution and warning signs as ]  
[ part of the guarding program. ]
14. [ Correct. This problem needs to be addressed. Either the area should ]  
[ be guarded so that the large pieces can be confined or the source of ]  
[ the problem should be remedied. ]

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

15. [ Correct. It is a good policy to include caution and warning signs as ]  
[ part of the guarding program. ]
16. [ Correct. Holes in guards present a hazard because they make it ]  
[ possible for persons to come into contact with moving parts. ]
17. [ Correct. This problem needs to be addressed. ]

**Question E** (Select as MANY as you think are correct.)

18. [ Correct. Materials used include screen, belting, and manufacturer ]  
[ equipped guards. ]
19. [ Correct. Extended grease fittings and cups allow for easy greasing of ]  
[ moving parts, and are required. ]
20. [ Correct. Sometimes we forget that guarding includes handrails to ]  
[ guard against the employee falling from an elevated position. ]
21. [ Correct. There is no problem here. ]
22. [ Correct. Even though they are out of reach, moving parts may break ]  
[ and pieces may fly out and hit someone if not guarded. ]

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

23. [ This is not necessarily true. Manufacturer's specifications do not ]  
[ always meet company, state and federal regulatory agency ]  
[ guarding specifications. ]
24. [ Correct. The existing guard does not adequately stop access to ]  
[ potential hazards. ]
25. [ Correct. This is recommended in order to make guards more obvious. ]
26. [ This is not practical. If guards were there they could restrict movement ]  
[ of the wheels and could be a hazard. ]
27. [ Correct. Warning signs are good guarding practice. The use of ]  
[ reflective materials along the catwalk of the machine and around the ]  
[ other guards can draw attention to potentially hazardous areas, such ]  
[ as the step as a tripping hazard. ]



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

- 28. [ Correct. Handrails provide a means of support and guard against ]  
[ accidental slips and falls. ]
- 29. [ Correct. Combustible materials may be an ignition source and a fire ]  
[ could easily develop. ]
- 30. [ This is not required. The only sign required is a "NO SMOKING/NO ]  
[ OPEN FLAMES" sign. ]
- 31. [ Correct. Batteries may be a source of hydrogen gas, which is highly ]  
[ explosive. Batteries should be kept in a secure location to guard ]  
[ against chemical burns. ]
- 32. [ The safety chains shown are adequate and the door is locked. ]
- 33. [ That is not a problem here. It is not recommended that compressed ]  
[ gas be stored in metal sheds because of the potential heat build up. ]
- 34. [ Correct. Side of stairs is broken and steps are not anchored solidly to ]  
[ the shed. Accumulations of unmarked drums and debris create a ]  
[ potential fire hazard. ]
- 35. [ Correct. Fire extinguishers are required because it is a wooden ]  
[ structure which presents a fire hazard. ]

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

36. [ Correct. Warning signs alert personnel to potential hazards associated ]  
[ with moving parts. ]
37. [ This doesn't make a good guard. Additional hazards may be ]  
[ introduced when trying to remove a heavy guard. ]
38. [ Correct. These procedures clarify safe practices to be followed ]  
[ including guarding issues. ]
39. [ Correct. Through a preventive maintenance schedule and regular ]  
[ inspection, guarding problems can be documented and corrected. ]
40. [ Correct. This is always a good practice. In addition, thought ]  
[ should be given to other forces such as belt tension, pressurized ]  
[ liquids and gases, etc. ]
41. [ Correct. One example is extended grease fittings and cups which ]  
[ eliminate the need to work close to moving parts when lubricating. ]

**Finding Your Score**

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

9 minus number of incorrect answers you colored in = (2) \_\_\_\_\_

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

Highest possible score = 41

Lowest possible score = 0

## **Instructor's Discussion Notes for Raggs & Curly Guarding 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 need to address safety and health issues. 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.

Many accidents result from workers coming in contact with moving parts of machinery. Employees working on or around machinery must be protected. The primary means of prevention is to guard all moving parts.

An effective machine guard should have certain characteristics in design and construction. Such guards should:

1. Be considered a permanent part of the equipment or machine.
2. Afford maximum protection.
3. Prevent access to the danger zone.
4. Be convenient. It must not interfere with efficient operation.
5. Be designed for the specific job and specific machine, with provisions made for oiling, inspecting, adjusting, and repairing machine parts.
6. Be durable and constructed strongly enough to resist normal wear.
7. Not present a hazard in itself.
8. Be constructed to contain those parts that may fail and/or be propelled, possibly striking employees.

Although the main theme of the exercise focuses on proper machine guarding practices, other safety strategies have been addressed. It is also important to note that many of the

scenes contain hazards that are not easily recognizable. The participants are encouraged to take their time and search each scene in an attempt to identify appropriate hazards.

**Question A** - Answers 1,2 and 4 are correct. A comprehensive guarding policy should include periodic cleaning of warning/caution signs (1). If you look closely, you will note that the lettering on the sign is different and this may be a specific warning. The missing guard (2) may have been removed so that coal spillage could be cleaned up or to perform some type of maintenance or repair. However, a guard not in its proper place exposes a hazard. Except when testing the machinery, guards shall be securely in place while machinery is being operated, 30 CFR 77.400(d). The pile of coal (4) is a tripping hazard and is also a potential fire hazard. 30 CFR 77.205(b) states that travelways and platforms or other means of access to areas where persons are required to travel or work, shall be kept clear of all extraneous material and other stumbling or slipping hazards. In addition, the build up of coal is a build up of a combustible material and shall not be allowed to accumulate where it can create a fire hazard, 30 CFR 77.1104. The build up of coal may also indicate that additional maintenance or repair is necessary around the shaft. Warning signs warn employees about specific hazards associated with that piece of equipment or a particular environment. Caution signs alert employees to use additional care and awareness when performing tasks. In many circumstances it may be necessary to alter an existing guard (3). The addition of straps to this guard strengthens and protects the guard. The electrical box (5) does not require additional guarding in this situation because of the low voltage associated with the device.

**Question B** - Answers 7, 8, 9, 10 and 11 are correct. Holes in guards present a hazard (7) because they make it possible for persons to come into contact with moving parts. Employees should be encouraged to report any damaged or missing guards. A guard serves two main purposes; first, it provides a barrier between the moving parts and persons, and second, it contains moving parts that fail and/or have the potential to dislodge and strike a person or equipment. The exposed roller (8) should be enclosed by extending the guard at the tail piece. Warning signs and/or caution signs are a good safety practice (9). Although signs are not required in many situations, signs can warn people of general and specific hazards associated with equipment, tasks and environments. Coal build up is a potential tripping and fire hazard (10) and may be grounds for a citation. When there is space between the frames of guards, the possibility for individuals to contact moving parts exists (11). Framed screen or metal guards should be bolted tightly to other frames so no openings or spaces are present between sections of guards. The distance between the salamander or heat pot (6) and fuel depot is adequate and does not present a hazard.

**Question C** - The correct answers are 12, 13 and 14. Uniformity and consistency are important components of good guarding practices. For example, if on one side of a piece of equipment there is a triangular guard covering a roller bearing, the roller bearing on the opposite side should also be guarded with a triangular guard (12). It is also a good practice to use similar guarding configurations throughout the entire site. It is always a good safety practice to use warning and caution signs, even if there is not a requirement to do so (13). These signs alert employees to hazards and conditions found in the workplace.

Caution signs should advise employees to use extra caution when working in this area. Warning signs should also remind workers that guards should not be removed, and if it becomes necessary, guards must be replaced. The large pieces of coal under the equipment deserve attention (14). Not only may this be a potential fire hazard, but the size of the chunks should alert employees that there may be a more serious problem with the equipment. If you decide to investigate, the machinery must have the power shut off, and be locked and tagged and blocked against motion, 30 CFR 77.404(c). This is also required if someone has the task of cleaning up the spilled coal under the structure.

**Question D** - The correct answers are 15, 16 and 17. Warning and/or caution signs are a sound safety practice (15). Holes in a guard make the guard ineffective and it no longer restricts individuals from contacting moving parts (16). It is suggested that the cause of the large chunks be investigated and addressed (17). At some time or another the area is going to have to be cleaned, so why not take steps now to reduce the amount of spillage.

**Question E** - The correct answers are 18, 19, 20, 21 and 22. Many different types of material can be used for guarding (18). There are, however, some criteria one should consider. The material should be strong and durable. It should be rigid so that it acts as a barrier. The weight of material is an important consideration. For example, there may be times when maintenance personnel will need to remove a guard to repair equipment. Extended grease fittings and cups allow for easy lubrication of moving parts (19). 30 CFR 77.404(d) states that machinery shall not be lubricated while in motion where a hazard exists, unless equipped with extended fittings or cups. Sometimes we forget that guarding includes handrails and toeboards (20). Handrails prevent people from falling when working or walking at elevated positions. Toeboards serve a dual purpose by preventing the fall of tools or materials over the edge and provide a warning to employees that they are near the edge of a work area. Guarding moving parts that are not within reach of employees is a good safety practice (22). If an employee can climb or maneuver himself to be in the close proximity of moving parts, those parts should be guarded. If moving parts are out of reach, but could fly or fall and strike someone in the event of failure, those moving parts should also be guarded. The walkway is cleared and free of tripping hazards and is not a problem here (21).

**Question F** - The correct answers are 24, 25 and 27. It is recommended that the guard around the engine compartment be extended to completely enclose the engine (24). There is at least one instance where a mining company was assessed a fine for failing to completely enclose the engine compartment. The final ruling stated that an employee performing maintenance could stretch his arm and have his hand come in contact with moving parts such as a motor fan. It is a good safety practice to paint machine guards a different color than the main structure or the equipment (25). A different color is more recognizable, obvious and stands out to alert employees that moving parts are close by. Even though the moving parts are guarded, this practice can be a "caution sign" for employees. A warning/caution sign or reflective tape can help to increase employee awareness to potentially hazardous areas such as the steps and obstructions (27). Many people believe that if a piece of equipment comes with guards already affixed they meet

the requirements of federal, state and local standards. In many cases this is not true. Manufacturers specifications may not necessarily meet company, state and federal regulatory agency guarding specifications (23). Special applications of equipment in a mining environment may require that additional guarding be installed or the original guard be altered to meet regulations. A good practice is to identify your guarding needs and include them in your specifications for the equipment you are going to purchase. A good guarding plan will address this by having a section that deals with inspecting new or purchased equipment to ensure the guarding requirements are being met. It would not be practical to extend a guard over the tire; in addition to interfering with steering, a guard here could create a greater hazard (26).

**Question G** - The correct answers are 28, 29, 31, 34 and 35. The hand rail lying off to the side does represent a potential hazard (28). Handrails provide a means of support and guard against accidental slips and falls. Wood, drums and debris are combustible materials and are a fire hazard (29). These materials stored in close proximity to compressed gases increase the potential for a catastrophic incident. Each cylinder should be marked to identify the gas it contains. Batteries may be a source of hydrogen gas, which is highly explosive (31). Batteries should be stored only at secure locations. The steps themselves are not anchored solidly to the shed and could slide down and injure someone. The left top step is broken loose from the frame (34). Another concern here is the unmarked drums and the collection of debris which are potential fire and health hazards. It is a good safety practice, and it is required, to have fire extinguishers at this location because the structure is wooden and presents a fire hazard (35). A sign stating that compressed gasses are stored here is not required, however, it is required to place a "No Smoking/No Open Flame" sign at areas where compressed gases are stored (30). The safety chains securing the compressed gas cylinders are adequate(32), as required by 30 CFR 77.208(d). The door is secured by a lock. Compressed gases should not be stored in a metal shed (33). On hot sunny days the build up of heat in a metal shed could effect the gases and create a potentially hazardous situation. The storage area in the photo provides protection from the elements and provides an open path in the event of an explosion.

**Question H** - The correct answers are 36, 38, 39, 40 and 41. Although warning/caution signs are not a requirement, these signs can alert personnel to potentially hazardous acts and conditions (36). Signs and their use should be one component of any guarding policy. Written work procedures such as Standard Operating Procedures (SOP), Job Safety Analysis (JSA) and documentation that lists specific steps in completing a task help ensure safety (38). Not only can written work procedures guide an employee through the process of doing a task safely, but they also alert the employee to specific hazards associated with that particular job. A thorough maintenance program and inspection plan can dramatically improve general guarding conditions throughout your operation. By identifying and documenting guarding problems, steps can then be taken to correct these situations (39). Except when testing the machinery, guards shall be securely in place while machinery is being operated, 30 CFR 77.400(d). Repairs or maintenance shall not be performed on machinery until the power is off, and the machinery is blocked against motion, except

where motion is necessary to make adjustments 30 CFR 77.404(c). It is required that equipment be de-energized, locked and tagged out by the person doing the repair (40). Always consider other forces such as belt tension, take-up tension, pressurized liquids and gases and all forces that may act on the equipment being worked on. Remember the term, "zero mechanical state". This is a state in which a piece of equipment has **NO** internal or external outside forces acting on it. Ensure any machinery or equipment you are working on is at zero mechanical state. For example, if you intend to work on a belt tail roller, you shut off the belt, lock and tag it out. Even though it has been de-energized, there are still forces acting on the roller. Tension take-up pulley, weight of belt and weight of any material on the belt are all acting on the roller. These forces can cause the roller to move at any time even though it has been de-energized. For the roller to be at zero mechanical state, all forces must be neutralized to prevent an accident. Guards should be designed and modified to protect as well as prevent maintenance employees from contacting moving parts (41). One example, is extended grease fittings and cups to lubricate moving parts. Machinery shall not be lubricated while in motion where a hazard exists, unless equipped with extended fittings or cups, 30 CFR 77.404(d). Substantial does not mean heavy. Sturdy guards that do not give under weight are more appropriate. Heavy guards (37) present a lifting hazard for those employees authorized to remove guards to maintain equipment.

### Scoring Key for Raggs and Curly Guarding Exercise

The correct answers are marked with an asterisk.<sup>4</sup>

<u>Question</u>	<u>Answer Number</u>					
A	1*	2*	3	4*	5	
B	6	7*	8*	9*	10*	11*
C	12*	13*	14*			
D	15*	16*	17*			
E	18*	19*	20*	21*	22*	
F	23	24*	25*	26	27*	
G	28*	29*	30	31*	32	33
	34*	35*				
H	36*	37	38*	39*	40*	41*

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<sup>4</sup> This page may be duplicated and used as an overhead transparency.



## **References**

McHose, Andre (1992). Manufacturing Development Applications. Institute of Industrial Engineers. Chicago: Donnelley & Sons Co.

Guide to Equipment Guarding at Coal Mines. (1990). Mine Safety and Health Administration. Beckley, WV: National Mine Health and Safety Academy.

Accident Prevention Manual for Industrial Operations. (1980). Chicago: National Safety Council.

Office of the Federal Register. (1992). Code of Federal Regulations, Parts 1 to 199. Washington, DC: U. S. Government Printing Office.

## Background

Although the sensible notion of "good guarding practices" is fairly common within general industry, other factors suggest that variability exists in the regulatory interpretation and use of machine guards at the workplace. How can this variability be described? Does it fall within the literature relating to perception and recognition, motivation, judgment and decision making, ergonomic design, or the adherence of workers to safe job procedures? Understanding and describing this variability may offer insight to solutions that embody all these concepts. This knowledge could assist in the design of training, the design of guarding components, or regulatory policy. The evidence of variability is manifested by the information obtained from injury reports, legal controversies and violations/citations associated with machine guarding practices.

One important consequence of variability between regulatory intent and practice is the frequency of serious injuries. A variety of questions might be posed based on any one of these incidents. To illustrate, in 1993, a beltman was fatally injured while cleaning an area around an underground belt drive. The MSHA investigative report notes:

A beltman was fatally injured when he partially removed a guard from the side of a stationary roller and entered the take-up area with the belt in motion. Guarding for the belt and take-up assembly was constructed with four foot wide by eight foot long sheets of expanded metal welded in angle iron frames and bolted onto a main frame. The guarding was then secured to the entire length of the drive and take-up assembly on both sides. Evidence indicated that the victim partially removed the stationary guard in an attempt to gain access to the take-up area. While shoveling loose coal, he became caught in the roller and was fatally injured.

Assuming the guard was "adequate" prior to its removal, here are some questions that might be asked to explore the contributing factors:

- (a) Was there an appropriate machine guarding policy at the mine?
- (b) How was the employee trained? Were there any follow-up observations of his performance?
- (c) Was there a lock-out/tag-out procedure?
- (d) Was the hazard recognizable?
- (e) Was this a safe practice?

Responses to these questions highlight variability. These include perceptions of what constitutes: (a) an appropriate policy, (b) quality training, (c) an adequate procedure, (d) a recognizable hazard, and (e) a safe practice. These perceptions would be expected to vary within and across the inspectorate, the work force and management. This exercise helps to better identify and define these variabilities and offers a more focused approach to reduce variability in the concepts of safe guarding practices.

Outside of mining, the importance of reducing these variabilities is also documented. For example, within the agricultural sector, an estimated 20,000 occupational amputations occur annually. Ninety percent of these serious injuries are traced to machinery and equipment. The magnitude and severity of these injuries amplify the need to better define safe guarding practices. The careful consideration of factors contributing to these incidents might lead to a better understanding of the variability between regulatory intent and everyday practice.

Another indication of variability is perhaps evident in the number of legal controversies surrounding safe or unsafe guarding practices. In more than a few cases, the final determination of "compliance" with guarding regulations is a product of the judicial system. In one case, involving a piece of mobile equipment, it was determined that failure to properly guard "the cooling fan blades and air compressor belts and pulleys" located on the front of the engine was a valid violation. The parts in question were located in the center of the engine compartment in front of the engine. In order for an individual to contact the parts, it would be necessary to reach over the truck frame, which is approximately 2 1/2 feet high, and extend his arm a distance of approximately 2 1/2 to 3 feet. The judge ruled that, "Given the physical accessibility of the engine compartment, the fact that mechanics could check and work on running equipment, and that contact with the cited machine parts could occur, we conclude that a reasonable possibility of contact existed." In litigation, variability is exhibited by the opposing views of those involved in the case.

Violation and citation data may also imply large levels of variability within and across the inspectorate, the general work force and management. In 1991, for general industry, OSHA reports over 4,000 violations issued for unsafe machine guarding practices, with an initial dollar penalty of \$6,642,274. The direct costs resulting from citations of unsafe machine guarding ranked 3rd, behind hazard communication and electrical lockout tag-out procedures.

A review of Mine Safety and Health Administration data indicated that from 1991 through 1993 there were 20,517 significant and substantial (S&S) violations issued for unsafe guarding practices in the mining industry. These numbers may be directly linked to the undefined variability that surrounds safe guarding practices. How one interprets machine guarding regulations, how one determines if a guard is adequate (or, in compliance with the regulations), how one maintains or modifies a guard or how one adheres to safe guarding practices can all contribute to large levels of variability.

Variability within the applied interpretations of rules, regulations and actual work practices may be a major contributing factor in machine guarding injuries, violations and litigation. The training simulation provided here is an attempt to better define and understand differences in the interpretation and application of machine guarding regulations. And also to present safe machine guarding practices to reduce existing variability. The use of the 3-D slides within a realistic problem setting can improve the fidelity of safety training thus aiding in the transfer of safety skills. The benefits of this and similar exercises could bring about a further reduction in the number of injuries related to improper guarding practices,

less reliance on the judicial system to resolve a variety of interpretations of machine guarding regulations and a reduced level of violations.

Field tests conducted have shown that this exercise is an excellent way to involve participants in a situation and teach them sound machine guarding principles. The purpose of this exercise is to generate thinking and discussion and help reinforce common safety practices used in the mining industry, thereby reducing the number of incidents and injuries associated with poorly guarded moving parts of machinery.

## **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, Pittsburgh, PA phone 412-386-5901, fax 412-386-5902 or email to [minetraining@cdc.gov](mailto:minetraining@cdc.gov).

**Raggs & Curly Guarding Exercise**

**Problem Booklet**

## **Instructions**

Read the problem situation described on the next page. Then answer each of the 8 questions. Do them one at a time. Some questions will ask you to look at one or more 3-D slides. Look at the appropriate slide or slides, then continue on with the exercise. Don't jump ahead, but look only at the questions and slides to which you are directed. However, you may look back to earlier questions and answers at any time. 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 slowly and gently rubbing the special 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.

## **The Situation**

You, Earl E. Raggs, are the chief mechanic at the main mine complex of the AB Coal Company. You have been called to the Jake's Run Surface Mine. The mine supplies coal directly to rail cars by means of a 48" mobile conveyor. The superintendent explains that during a recent insurance company inspection, some potentially dangerous situations concerning improper guarding practices were noticed. He instructs you to conduct a survey and document some of the guarding problems you observe around the mobile conveyor, and make recommendations for correcting these problems. Your recommendations will be part of a planned company wide guarding policy. He assigns Noah "Curly" Hair, who was just recently reassigned as a mechanic's helper at this operation, to accompany you. The superintendent stresses the fact that Curly is not too familiar with safe guarding practices and asks that you take this opportunity to share your knowledge concerning guarding. You and Curly are to report back to the superintendent with your findings. Turn to Question A.



**Question A**

You and Curly, take a camera and notebook, and begin to document the status of the guards located at the mobile conveyor area. Look at Slide 1. You are looking for unsafe guarding practices and related problems. What should you point out to Curly? (Select as MANY as you think are correct.)

1. A dirty warning sign.
2. A missing guard.
3. Altered guard.
4. Coal spillage.
5. A missing guard around the electrical box.

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

**Question B**

Continuing your survey, you and Curly go to the rear of the bin. Look at Slide 2. What hazards would you note and point out to Curly at this location? (Select as MANY as you think are correct.)

6. The salamander is located too close to the fuel depot.
7. There are holes in the guards.
8. The guard is not extended far enough to enclose all pinch points.
9. Warning signs are inadequate.
10. Coal has built up here.
11. Guard screens are not aligned .

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

**Question C**

The next place you stop is a conveyor dump point. Look at Slide 3. Other than repairing the holes in the guards and cleaning up obvious spillage, what corrective measures should you recommend to the superintendent for this area? (Select as MANY as you think are correct.)

12. Replace the missing triangular guard on the near side.
13. Display warning signs.
14. Investigate the cause of the large coal chunks underneath the equipment.

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

**Question D**

You walk around the dump point to look at the other side. This is what you see. Look at Slide 4. What corrective measures should you and Curly recommend to the superintendent for this area? (Select as MANY as you think are correct.)

- 15. Display warning signs.
- 16. Repair the holes in the guard.
- 17. Investigate the cause of the large coal chunks underneath the equipment.

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

**Question E**

You and Curly travel to the mobile conveyor. Look at Slide 5. You ask Curly to assess this piece of equipment. What positive guarding practices would you expect Curly to note? (Select as MANY as you think are correct.)

- 18. Effective use of multiple guarding materials.
- 19. Extended grease fittings.
- 20. Handrail and toe boards.
- 21. Walkway is clear of all slip and trip hazards.
- 22. Guarding for machinery parts which are out of reach.

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

**Question F**

Curly mentions to you that he saw another example of guarding on a piece of mobile equipment. Look at Slide 6. This is a refurbished piece of equipment which arrived from the factory not too long ago. After new tires are put on it, what guarding changes, if any, do you think should be made before the equipment is put into use? (Select as MANY as you think are correct.)

- 23. No changes should be made because this is the way it came from the factory.
- 24. Extend the height of the guard around the engine compartment.
- 25. Paint the engine compartment guards a different color than the equipment.
- 26. Extend the guarding down to cover the top of the tire.
- 27. Install warning signs and reflective materials on the step.

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

**Question G**

You decide to conclude this initial phase of the survey by asking Curly to survey his work area near where the compressed gas is stored. Look at Slide #7. You see quite a few potential hazards at this site and decide to have Curly point them out to you. What should Curly point out as potential hazards? (Select as MANY as you think are correct.)

- 28. The handrail is lying off to the side and not attached to the steps.
- 29. Combustible materials are stored too close to the compressed gas.
- 30. There are no signs indicating compressed gas storage.
- 31. Batteries are not stored properly and are placed too near the compressed gas.
- 32. Compressed gases are not secured in place.
- 33. Compressed gases should be stored in metal sheds.
- 34. Housekeeping is poor in this area.
- 35. There are no fire extinguishers here.

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

## **Question H**

You meet with the superintendent to brief him on your findings. Besides the condition of the guards themselves, what are some other safety practices that you might recommend to support safe work procedures around moving parts? (Select as MANY as you think are correct.)

36. Warning signs placed in close proximity to moving parts.
37. Materials used for guarding should be substantial and heavy.
38. Written procedures such as SOP's and JSA's that address specific tasks.
39. A maintenance and inspection program specifically aimed at guarding.
40. Removal of a guard only after a piece of equipment has been de-energized and locked and tagged out.
41. Guards should be designed and modified to protect maintenance personnel as well as making their job easier.

## **End of Problem**

### **Scoring your performance**

1. Count the total number of responses you colored in that were marked "correct". Write this number in the first blank on the answer sheet.
2. Count the total number of incorrect responses you colored in. Subtract this number from 9. Write the difference in the second blank on the answer sheet.
3. The best score is 41. 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. 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 NIOSH, Pittsburgh Research Laboratory, Pittsburgh, PA phone 412-386-5901, fax 412-386-5902 or email to [minetraining@cdc.gov](mailto:minetraining@cdc.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. These may be obtained from the A. B. Dick Company, P.O. Box 1970, Rochester, New York 14692, phone 1-800-225-4835.

### Answer Sheet for the Raggs and Curly Guarding 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. [ ]  
[ ]  
[ ]
- 2. [ ]
- 3. [ ]  
[ ]
- 4. [ ]  
[ ]
- 5. [ ]

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

- 6. [ ]  
[ ]
- 7. [ ]  
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- 8. [ ]  
[ ]  
[ ]
- 9. [ ]  
[ ]
- 10. [ ]  
[ ]  
[ ]
- 11. [ ]  
[ ]

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

12. [ ]  
[ ]  
[ ]

13. [ ]  
[ ]

14. [ ]  
[ ]  
[ ]

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

15. [ ]  
[ ]

16. [ ]  
[ ]

17. [ ]

**Question E** (Select as MANY as you think are correct.)

18. [ ]  
[ ]

19. [ ]  
[ ]

20. [ ]  
[ ]

21. [ ]

22. [ ]  
[ ]

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

- 23. [ ]  
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[ ]
- 24. [ ]  
[ ]
- 25. [ ]
- 26. [ ]  
[ ]
- 27. [ ]  
[ ]  
[ ]  
[ ]

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

- 28. [ ]  
[ ]
- 29. [ ]  
[ ]
- 30. [ ]  
[ ]
- 31. [ ]  
[ ]  
[ ]
- 32. [ ]
- 33. [ ]  
[ ]
- 34. [ ]  
[ ]  
[ ]
- 35. [ ]  
[ ]

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

- 36. [ ]  
[ ]
- 37. [ ]  
[ ]
- 38. [ ]  
[ ]
- 39. [ ]  
[ ]
- 40. [ ]  
[ ]  
[ ]
- 41. [ ]  
[ ]

**Finding Your Score**

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

9 minus number of incorrect answers you colored in = (2) \_\_\_\_\_

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

Highest possible score = 41

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. It is a good idea to clean the illegible sign. A comprehensive guarding policy should include periodic cleaning of warning and caution signs.

Correct. A missing guard exposes a hazard.

In many circumstances it may be necessary to alter existing guards. The addition of straps to this guard strengthens and protects it.

Correct. Coal buildup can be a fire and tripping hazard. The amount of coal may indicate that additional maintenance is necessary here.

The electrical box does not require additional guarding in this situation.

The distance between the salamander and the fuel depot is adequate and poses no hazard.

Correct. Holes in guards present a hazard because they make it possible for persons to come into contact with moving parts.

Correct. Even if the guard was in good condition, the rollers would not be completely enclosed by the guard. Contact with moving parts is not prevented here.

Correct. Warning and/or caution signs are a good safety practice.

Correct. Coal build-up is a potential fire and tripping hazard. The amount of coal seen here may indicate that equipment modifications may be necessary to prevent continued spillage.

Correct. Space left between the frames of guards allows openings where fingers could contact moving parts.



Correct. If you look closely, you can see a triangular guard on the opposite side of the structure. It may be a possible violation if a similar guard is not in place on this side of the structure.

Correct. It is a good policy to include caution and warning signs as part of the guarding program.

Correct. This problem needs to be addressed. Either the area should be guarded so that the large pieces can be confined or the source of the problem should be remedied.

Correct. It is a good policy to include caution and warning signs as part of the guarding program.

Correct. Holes in guards present a hazard because they make it possible for persons to come into contact with moving parts.

Correct. This problem needs to be addressed.

Correct. Materials used include screen, belting, and manufacturer equipped guards.

Correct. Extended grease fittings and cups allow for easy greasing of moving parts, and are required.

Correct. Sometimes we forget that guarding includes handrails to guard against the employee falling from an elevated position.

Correct. There is no problem here.

Correct. Even though they are out of reach, moving parts may break and pieces may fly out and hit someone if not guarded.

This is not necessarily true. Manufacturer's specifications do not always meet company, state and federal regulatory agency guarding specifications.

Correct. The existing guard does not adequately stop access to potential hazards.

Correct. This is recommended in order to make guards more obvious.

This is not practical. If guards were there they could restrict movement of the wheels and could be a hazard.

Correct. Warning signs are good guarding practice. The use of reflective materials along the catwalk of the machine and around the other guards can draw attention to potentially hazardous areas, such as the step as a tripping hazard.

Correct. Handrails provide a means of support and guard against accidental slips and falls.

Correct. Combustible materials may be an ignition source and a fire could easily develop.

This is not required. The only sign required is a "NO SMOKING/NO OPEN FLAMES" sign.

Correct. Batteries may be a source of hydrogen gas, which is highly explosive. Batteries should be kept in a secure location to guard against chemical burns.

The safety chains shown are adequate and the door is locked.

That is not a problem here. It is not recommended that compressed gas be stored in metal sheds because of the potential heat build up.

Correct. Side of stairs is broken and steps are not anchored solidly to the shed. Accumulations of unmarked drums and debris create a potential fire hazard.

Correct. Fire extinguishers are required because it is a wooden structure which presents a fire hazard.

Correct. Warning signs alert personnel to potential hazards associated with moving parts.

This doesn't make a good guard. Additional hazards may be introduced when trying to remove a heavy guard.

Correct. These procedures clarify safe practices to be followed including guarding issues.

Correct. Through a preventive maintenance schedule and regular inspection, guarding problems can be documented and corrected.

Correct. This is always a good practice. In addition, thought should be given to other forces such as belt tension, pressurized liquids and gases, etc.

Correct. One example is extended grease fittings and cups which eliminate the need to work close to moving parts when lubricating.