# PROP the TOP!

U. S. Department of Labor
Mine Safety and Health Administration
National Mine Health and Safety Academy

Other Training Material
OT 44

August 2004

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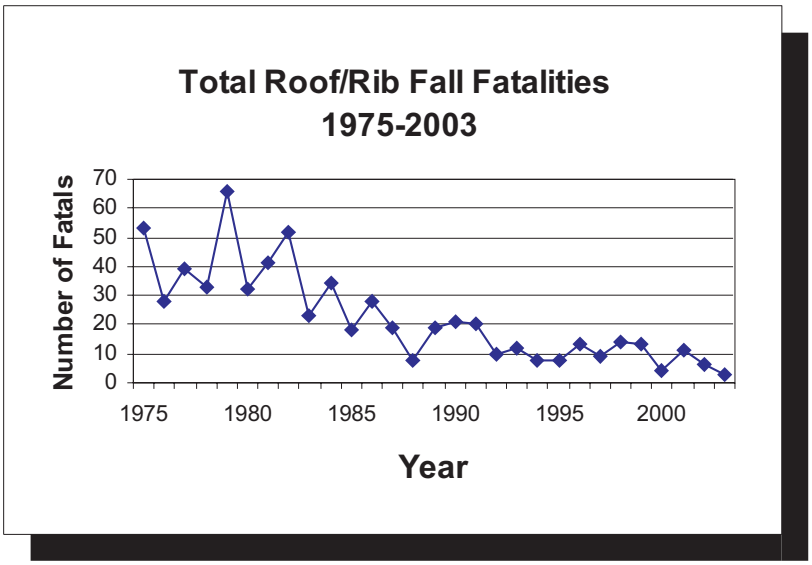
# INTRODUCTION

Over the past thirty years, improvements in roof control technology such as new bolting systems, automated temporary roof support systems (ATRS), widespread use of cabs and canopies, and mobile roof supports led to a significant reduction in roof/rib fall fatalities.




In spite of these advances there is a need for continued emphasis on roof/rib control. MSHA's Preventive Roof/Rib Outreach Program (PROP) is intended to increase awareness among coal mine operators and miners of the hazards that can lead to roof/rib fall accidents, and the precautions necessary to prevent these accidents. This booklet is part of the PROP initiative.

## Persistence of Roof/Rib Hazards

Historically, falls of roof and rib have been the single greatest cause of fatalities in underground coal mines. Roof-rib control hazards are still the single greatest safety problem in underground coal mining. Why is this so?

✔ Roof and rib conditions vary from mine to mine (and in some instances from section to section within a mine). The type of sedimentary rock (such as shale, sandstone, and limestone) overlying the coal seam dictates the strength of the mine roof. Combine this variable roof rock with other geologic factors, such as faults, ancient stream channels, slips, joints, and fossils, and you can see why roof control is the most challenging safety problem in underground coal mines.

Mining personnel have to cope with constantly changing geologic conditions every day. A cut of coal taken from the mining face opens up new territory and potentially new hazards. It's important, then, to understand that every coal mine has a unique set of conditions; what works to control roof and rib conditions in one mine may not work at another operation.

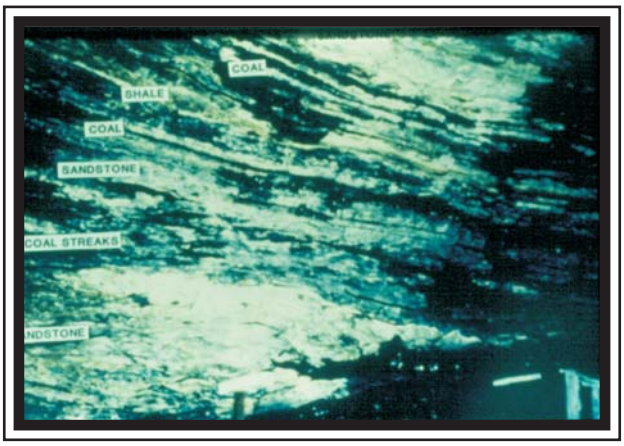
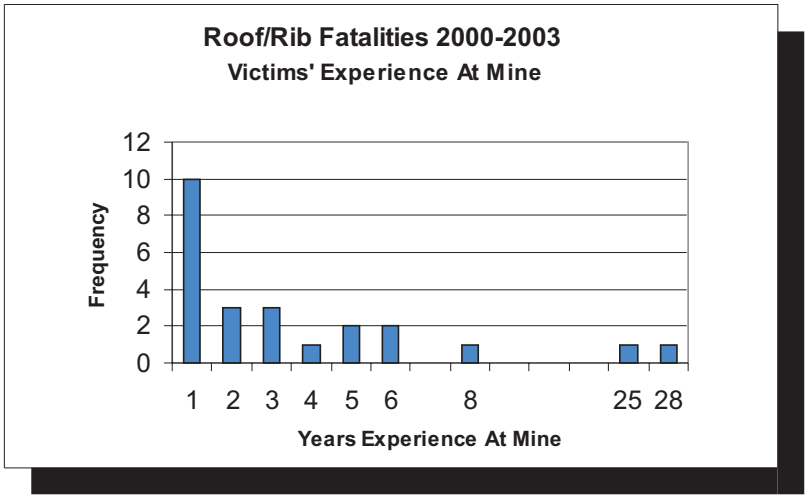



**Figure 1. Variable Roof Rock**

✔ Today's miners often move from mine to mine which exposes them to new geologic conditions and new roof and rib hazards. Combine this with different equipment and/or mining methods and you can see how even experienced miners might be at greater risk when they move from one property to another. The chart below shows that a large number of fatalities involve miners who had very little time at the mine where the accident occurred; forty-two percent of victims had less than two years' experience at the mine.




✔ Coal has been mined in this country for more than 200 years. Most of today's mines are in coal reserves that had previously been avoided because of poor roof conditions. These mines are frequently deeper and may have abandoned mines above and/or below them which often exert additional stress on the roof and ribs.

This means that the roof and rib conditions encountered in many of today's mines require the use of the latest, high-strength roof support systems to help reduce hazards and prevent accidents.

✔ Miners tend to put in a longer work day/week than in the past, a situation that may lead to fatigue or inattention at the end of the shift/week. Simply stated, it's harder to concentrate on what you're doing when you are tired.

By recognizing and understanding these reasons and conditions that continue to make coal mine roof and ribs so hazardous, we can begin to make progress in finding better ways to prevent injuries due to roof and rib falls.

## Tips for Avoiding Injuries

### Be Alert and Share Information

Miners need to be constantly aware of the potential dangers posed by movement of roof and rib. Right now, coal is being produced at a record-breaking pace in our Nation's mines. Due to the ever increasing rate of advance and retreat mining, it's your responsibility to be alert to changing roof/rib conditions. Although the mine operator is responsible for providing you with tools, supplies, equipment, and training to perform your daily tasks, you must ask yourself, "What can I do to ensure my safety and the safety of my co-workers?"

**"When you actually see someone you know and see the life go out of their body in a place like that – it leaves something with you."**

Make frequent and thorough roof/rib evaluations. Take corrective action immediately if you observe an unsafe condition. Get help if you need it and take the time to get the proper tools and materials. Discuss any roof control concerns with your supervisor. Remember, conditions change and your supervisor may not be aware of the change; don't take for granted that he or she knows. Share information about changes in roof/rib conditions with fellow miners.

## Know Your Roof Control Plan

Why is it important for you to know and understand the roof control plan at your mine?

Someone evaluated your mine's roof conditions long before you installed the first roof bolt, set the first timber, or built the first crib. This evaluation revealed the type of rock strata that makes up your immediate and main roof, the maximum and minimum cover over mining projections, and any other nearby active or abandoned mines. A roof control plan for your mine was developed based on an analysis of this data and a review of the proposed mining method(s).

**"The plan was followed, but it pulled 3-foot resin bolts out of the top."**

Your mine's roof control plan specifies the minimum requirements under normal conditions necessary to support the roof. It's imperative that you know what the minimum requirements are in your plan. If you fail to install the proper supports required by your plan, then the roof is inadequately supported and you jeopardize the safety of yourself and your co-workers at the mine. Shortcuts and lack of knowledge put EVERYONE at risk. Remember, the roof control plan specifies the minimum roof support required under normal roof conditions. Minimum support requirements no longer apply when you encounter adverse conditions. Additional supports have to be installed to maintain the degree of safety needed for your protection and the safety of other miners.

Speak to mine management if you and your fellow miners have any concerns regarding the adequacy of your roof control plan. The plan should be revised when prevailing conditions indicate that the plan is not suitable to control the roof and ribs. A roof control plan should also be revised when accident and injury history indicates that the plan is inadequate.

## Don't Go Inby

During the last four years, over one-fourth of all roof fall fatalities have been attributed to travel inby permanent roof supports.

> **"We were only 2 to 3 feet inby the bolts when it fell. I lay there looking at the bolts hoping they would hold."**

Stated another way, 7 out of 24 fatal roof/rib fall accidents occurred when the victim traveled or was positioned inby roof support. In some cases, miners travel inby to mark bolt holes, scale the roof, get a better view of the face when turning a crosscut, or just to take a straight-line shortcut instead of "going around." In other instances, we can only guess why the victims went inby supports. What was going through their mind? Why were they so sure nothing would happen to them?

Too many times we test the laws of probability. We rationalize going inby by telling ourselves, "I'm only going to be out there for just a minute" or "It's only a foot or two inby," or by asking ourselves, "What are the chances that a rock is going to fall while I'm there?" You take the chance but did you ask yourself the important questions – "What's going to happen to my family? Who is going to raise my children?" Is it worth the risk?


**Figure 2. Warning Sign**

## "I'll Be Waiting"

I'll be waiting for you
To make that last big mistake...

Just walk underneath me
Is all it will take...

I'm fair to all and exclude no one
Sister, brother, father, or son...

So get careless and foolish
And come make my day...

And with your blood and tears
I'll make you pay...

So come out and see me
If you need proof...

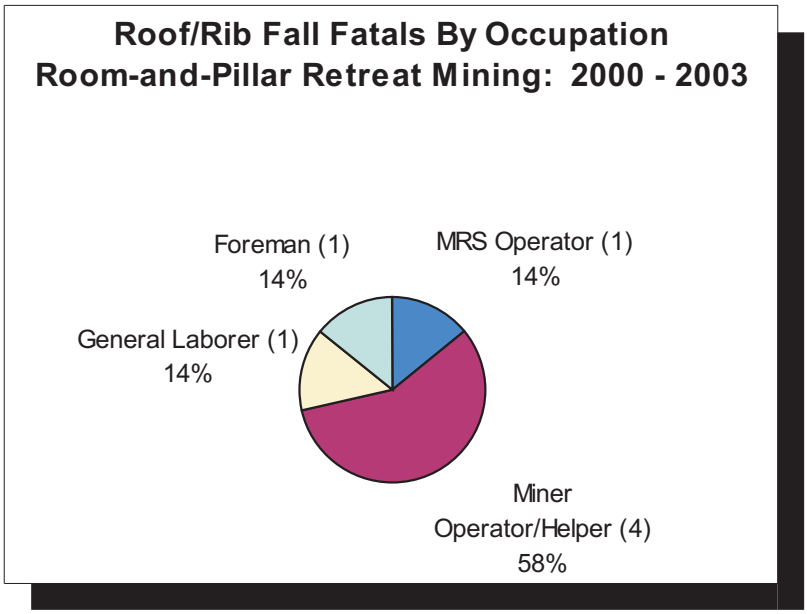
And I'll sign your gravestone
"Unsupported Roof."

***Clint Fabry***
***Coal Mine Safety and Health Inspector***
***District 3***

# Retreat Mining

## Room and Pillar Mining

From 2000 to 2003, roof/rib falls accounted for 24 fatalities in underground coal mines. Seven (29 percent) of these 24 fatalities occurred during room-and-pillar retreat mining operations. The number of fatal accidents occurring on room-and-pillar retreat sections appears high when you consider that mines which use this mining method employ only around 19 percent of underground coal miners and account for about 18 percent of the underground coal production.These statistics indicate that more precautions must be taken when doing this type of mining.




The miner operator/helper occupation is the most hazardous. This fact probably does not come as a surprise since the continuous miner operator and the helper are frequently the closest miners to the pillar line, working in an area that is most prone to roof/rib falls. The additional stress caused by second mining is typically placed on the roof and ribs in the immediate area that

coal is being removed. However, other miners with different occupations, working on retreat sections, are not exempt from the hazards of roof/rib falls. The chart shows that three miners, other than miner operators/helpers, were fatally injured by roof/rib falls on retreat sections. The occupations of these miners included mobile roof support (MRS) operator, general laborer, and a foreman.

The past 15 years have seen a significant increase in the use of mobile roof support (MRS) units during pillaring operations. MRS units limit a miner's exposure on the pillar line by reducing or eliminating the need for roadway timbers and radius turn posts. MRS operators should not, however, be lulled into complacency or a false sense of security. To realize the safety advantages afforded by MRS units, the operating procedures and safety precautions must be followed.

**Figure 3. Retreat Mining Using Mobile Roof Support Beside a Continuous Miner**

Here are some work practices that can help reduce the risk of a roof/rib fall accident when second mining is being conducted:

- **CONSTANTLY MONITOR** roof and rib conditions. Watch breaker and radius post condition, pressure gauges on Mobile Roof Support units, geologic anomalies, floor heaving, and rib sloughing. All miners on the section should monitor these conditions. If a hazardous condition is found, immediately inform the other miners in the area and the section foreman so that a prudent course of action can be taken. This is particularly important when mining the last lift or final push.

- **ALWAYS** work in a safe position. Make sure there's no loose roof or rib near your work position. Continuous miner operators who work on remote controlled machines must make sure they're under safe roof and ribs before mining as they aren't protected by a canopy.

**"It happened so fast I didn't see it fall – all at once I couldn't see for the dust."**

- **ALWAYS** follow the roof/rib control plan. There are many safety precautions in the plan regarding such things as breaker and radius turn post locations, mining sequences, depth of cut, and operator location. These safety precautions are specifically tailored to your mine and to your mining conditions.

- **USE** a test hole to evaluate the competency of the outby intersection of the pillar being extracted before and during mining of the pillar. This can be accomplished with the use of a test hole. Separations in the test hole indicate that the roof is failing.

## Longwall Mining

In general, longwall mining is the safest underground mining method. This is probably because of the protection from roof falls provided by longwall shield canopies during normal mining operations. Even so, there are instances when miners have to work near the shield canopy tips or between the tips and the longwall face. This activity generally occurs when performing maintenance on the shearer or the face conveyor and during longwall recovery operations. Use extra caution when performing these tasks.

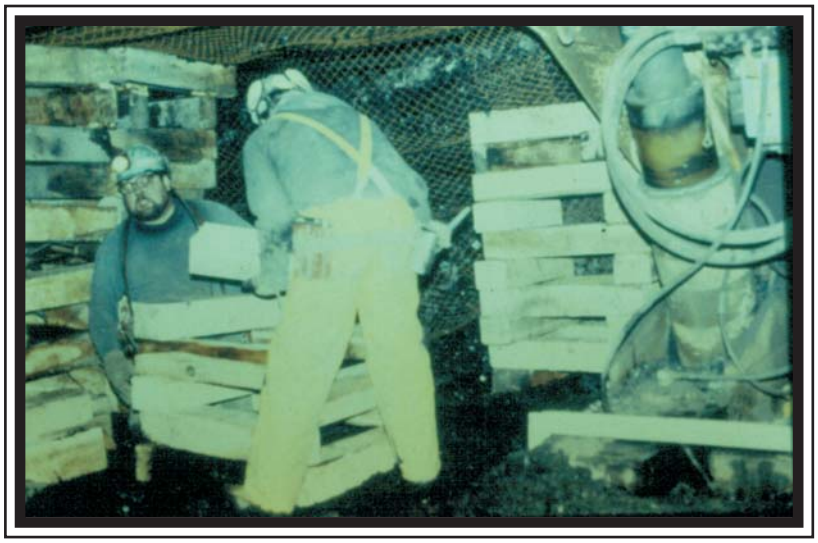


**Figure 4. Longwall Recovery**

# Sources of Roof/Rib Hazards in Underground Coal Mines

There are two broad categories of roof/rib hazards: natural and mining-related.

## Natural Sources of Roof/Rib Hazards

Natural sources of roof/rib hazards are caused by the local geology and the local stress field. For the most part, these natural sources are pre-existing conditions that can't be changed. Natural sources of roof/rib hazards, of course, vary from mine to mine. You need to take the time to learn what types of geological hazards are common in your mine. Once you recognize the hazards normally encountered in your mine, it's much easier to identify and properly support them.

> **"In my 30 years I have never seen a rock shaped that large in one piece. It had a slickened surface – came to a point – shaped like a battleship."**

Geological hazards include: faults, slips, joints, kettlebottoms, horsebacks, thinly-laminated rock, and weak or brittle rock. The overburden (vertical stress) and horizontal stress also can be the source of roof/rib hazards.

Since the natural sources of roof/rib hazards cannot be changed, it is imperative that we identify them through frequent and thorough roof/rib examinations, so that we can take appropriate action. This appropriate action is to take down the hazard or install additional support.

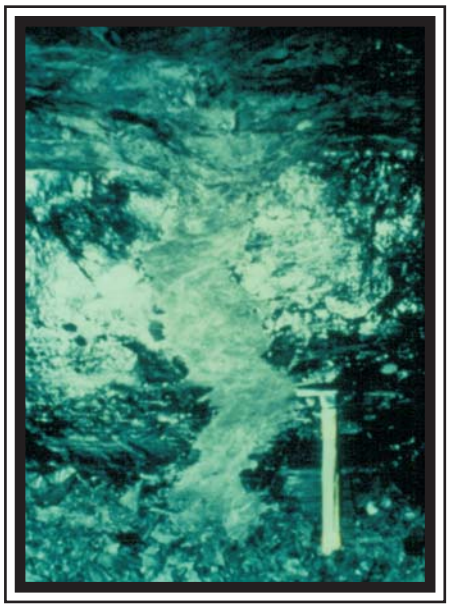


**Figure 5. Geologic Anomaly**

## Mining-Related Sources of Roof/Rib Hazards

Mining-related sources of roof/rib hazards are often under our direct control.

Examples of mining-related sources of roof/rib hazards include: excessive entry width, excessive cut depth, excessive mining height, inadequate temporary support, excessive intersection spans, poor roof bolt installation procedures, inadequately installed roof support (not following the bolting plan), lack of test holes, installing bolts out of sequence, and improper pillar dimensions. Your mine's roof control plan covers most (if not all) of these items.

**"I saw some chips fall, I turned to tell someone to watch the top, but the fall came fast – before I could crank up my shuttle car."**

Other mining-related sources of roof/rib hazards come under the heading of mine design. These include: number of entries, panel length and width, direction of mining, undersized or oversized pillars, crosscut spacing and orientation, roof support type and installed spacing, and overmining or undermining.

Most of the decisions involving the mine design issues (pillar size, direction of mining, etc.) are usually made by mine management. However, there are several critical areas in which you as individual miners can make a difference. Let's take a look at these now.

- **Entry/Crosscut Width.** The mined width is one of the most important factors influencing the stability of an entry or crosscut. The maximum entry and crosscut widths listed in your roof control plan have been selected based on conditions at your mine. It is essential that continuous miner operators adhere to these maximum widths.

  Mining an entry or crosscut just a foot or two wider can create a substantial increase in the stress in the immediate roof and increase the chance of a roof fall.

  Pay special attention to entry and crosscut widths for initial development in drift mines. These openings need to be held to a minimum because of the roof strata conditions associated with the coal outcrop. History tells us that the roof rock near an outcrop is usually weathered and weakened by the presence of mountain breaks, mud seams, surface cracks, and other geologic anomalies. As a result, additional roof support will have to be installed to effectively support the mine roof.

  The approved roof control plan should address how the roof will be supported when these conditions are encountered. If an entry or crosscut is inadvertently developed wider than the maximum listed in the plan, then additional roof supports will have to be installed in conjunction with the primary roof support so miners won't be exposed to unsupported roof.

When larger than normal entry and crosscut widths are planned for such areas as a belt/track entry or longwall set-up entry, additional supports will have to be installed due to the added width. The spacing and type of supports used in these instances will be addressed in the approved roof control plan.

- **Intersections.** During the last four years, 9 miners have died in roof falls and rib rolls in intersections. This figure represents 38 percent of the fatalities caused by roof falls and rib rolls during this time period. This is significant because intersections account for only 10 to 20 percent of the developed area in a coal mine.

  Miners should pay special attention to their surroundings while creating, supporting, or examining an intersection. It's critical that openings that create an intersection should be mined to the minimum possible widths that will allow the safe operation of extraction and haulage equipment. A maximum width should be specified in the roof control plan. Supplemental support must be installed if these maximum widths are exceeded.

  **"[It] came so fast I couldn't jump."**

  The type of intersection created can influence roof/rib conditions. Some mines experience much poorer roof/rib conditions in four-way intersections when compared to three-way intersections. This is due to the larger roof spans created by four-way intersections. In this case, eliminating four-way intersections by staggering crosscuts can result in a reduction in the number of roof falls.

  Mines that have a history of subnormal roof/rib conditions in intersections should systematically install additional roof support in these areas. This additional intersection support should be incorporated into the roof control plan. In addition,

openings leading to an intersection should have timbers installed across them when they are no longer needed for haulage equipment or supplies.

Mine examiners must pay particular attention to roof/rib conditions at intersections as roof stresses will be greatest in these areas because of the larger spans. This situation increases the chance of roof/rib failure. Take corrective actions at the first sign of deteriorating condition.

**Figure 6. Intersection With Supplemental Support**

- **Cut Depth.** Another critical factor that influences the stability of an entry or crosscut is the cut depth.

  The maximum allowable cut depth is listed in your roof control plan and is based on conditions and the type of mining equipment at your mine. You should always remember that the maximum cut depth is based on "normal" roof conditions at your mine and the type of mining equipment used at your operation.

In today's underground coal mines with remote control continuous miners, it's quite common to have a "deep-cut" or "extended-cut" approval.

The roof control plan for mines with deep-cut approval lists some general roof conditions where cut depth should be reduced. The roof control plan can't anticipate and doesn't list every condition or instance where the depth of cut should be limited. Since cut depth plays such an important role in the stability of a mine opening, extra safety precautions are included in roof control plans containing deep-cut approval. These safety precautions include the installation of extra roof support and place additional restrictions on worker location with regard to the last row of bolts. Following these additional safety precautions will help ensure that the level of safety is not diminished when deep-cut mining is being conducted.

Discuss with your supervisor any concerns you might have regarding cut depth. Since roof conditions can change quickly, you should keep your supervisor informed of any abnormal roof conditions as you encounter them.

- **Installation of Roof Supports.** Roof bolter operators often have to install a wide variety of high quality roof support systems. Gone are the days when the only types of bolts available were mechanically anchored bolts and fully-grouted resin bolts. The use of resin-anchored combination bolts, tensioned rebar, mechanically-anchored resin-assisted systems, cable bolts, and other specialty bolts has dramatically increased.

  The big advantage of such a variety is that a mine can customize its roof support system to specific roof conditions. A drawback is that each bolting system used may have its own unique installation procedure, placing an additional burden on roof bolter operators.

Since proper installation procedure is essential to good roof bolt performance, it is imperative that roof bolter operators know and follow manufacturers' recommendations. With all the bolting systems currently available it can become confusing. Immediately contact your supervisor if you have any questions or concerns regarding the roof bolts that you are installing.

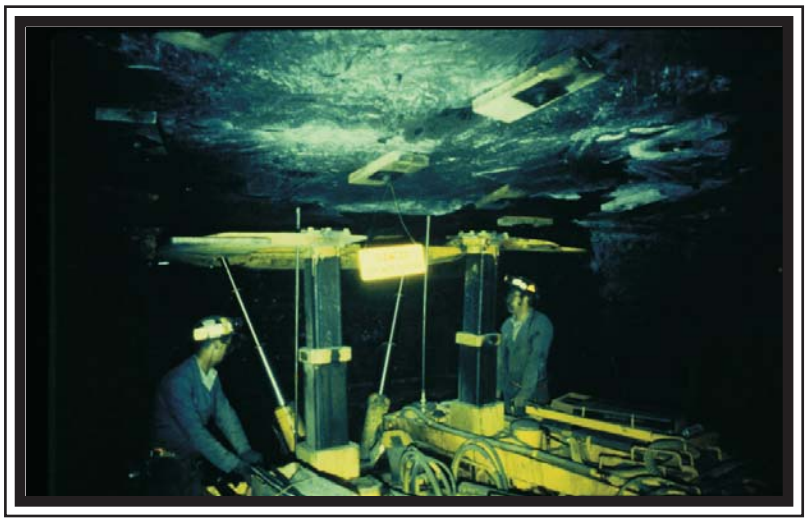


**Figure 7. Installing a Roof Bolt**

In addition to knowing the various installation procedures, roof bolter operators must be very familiar with the approved roof control plan, especially the section on roof bolt installation sequence and spacing. Again, as with most items in the roof control plan, the maximum bolt spacing listed is for normal roof conditions. The bolt spacing should be reduced by installing additional support when you encounter adverse conditions or geologic anomalies.

Roof bolter operators are not the only miners who have been impacted by advancements in roof support systems. Any

miner who installs roof-to-floor standing support, such as posts or cribs, has probably seen dramatic changes to this type of support as well. Wood posts and cribs are being replaced in many mines by a wide variety of alternatives. These new products include: "engineered" wood posts and cribs, cementatious foam cribs, metal containers filled with pumice, and steel-fiber-reinforced concrete cribs. Each support system usually has a unique installation procedure that varies from the traditional wood post and crib installations. As with bolting systems, the actual performance of these new supports is dictated by the quality of the installation, and you should discuss any questions or concerns with your supervisor.

**Figure 8. Installing a Crib**

- **Automated Temporary Roof Support (ATRS).** Automated Temporary Roof Support systems were first introduced to the mining industry in the early 1970s. The use of ATRS systems with roof bolting machines and continuous miners equipped with integral bolters has all but eliminated

fatal roof accidents associated with manually setting temporary support.

ATRS systems are required on all bolting machines operated in mining heights of 30 inches or more. The use of ATRS systems in mining heights below 30 inches is addressed in the roof control plan. MSHA District Managers routinely require the use of ATRS systems in mining heights below 30 inches.

When mining conditions or circumstances prevent the use of an ATRS system, alternative means such as manually set posts or jacks can be used. Bolting a roof fall cavity where the height is above the operating range of the ATRS system is one such circumstance where manually set temporary support can be used.

*Photo courtesy of Grubb Photo Service, Inc.*

**Figure 9. An ATRS System**

Here are some guidelines for roof bolter operators to follow to maximize the protection that an ATRS system can provide:

- **REPORT** any mechanical or hydraulic problems with the ATRS system to your supervisor.
- **FOLLOW** the bolt installation sequence listed in your roof control plan. Failure to follow the approved sequence can result in roof bolter operators being exposed to unsupported roof. Following the approved bolting sequence is extremely critical when operating a single boom (squirmer) roof bolting machine.
- **OBSERVE** the maximum distance that an ATRS system can be set beyond the last row of bolts. This distance can vary and is listed in the roof control plan. Setting an ATRS system beyond this maximum distance greatly reduces its effectiveness.
- **USE** extra caution when bolting a wider-than-normal entry, such as a belt/track entry. A bar-type ATRS system may need to be repositioned in order to complete a full row of bolts in a wider-than-normal entry.
- **PAY** special attention to the bolting sequence when installing five bolts per row with a bar-type ATRS system. Often a five-bolt pattern requires that a bar-type ATRS system be positioned closer to one rib to start the bolt row and then be repositioned to complete the row.

## Available Technical Assistance on Roof Control

MSHA conducts inspections and accident investigations, and provides technical assistance to the mining industry on issues or concerns relating to roof control. Our Technical Support personnel can assist you with a variety of specialized laboratory and field services. Geologists can conduct remote-sensing linear analyses to help identify areas of potentially poor roof conditions. Technical Support staff perform laboratory and in-mine testing to evaluate roof support systems. They do in-mine evaluations of ATRS systems and canopies on mining equipment. Contact your MSHA District Office to request technical assistance.

**"If it hadn't been for the canopy, I wouldn't have been here today."**

## Training

MSHA has determined that injuries from falls of roof, face, and rib are more than eight times as likely to be fatal as underground injuries from other causes. Miners need to know about the specific roof and rib hazards they are potentially exposed to at their mine. This can be done through a combination of formal and informal training, written materials, and through posting of safety bulletins, MSHA Alerts, and fact sheets. Everyone covered by a roof control plan should be instructed on the interpretation and significance of the plan. Regulations specify that any changes in a roof control plan shall be discussed with all miners before implementation.

## Miners' Rights

Miners have the right to:

- Refuse to work in areas of unsafe roof or ribs.
- Notify MSHA of any suspected roof/rib violations or imminent dangers.
- Expect that all necessary roof control related equipment is in place, used, and properly maintained.
- Review the provisions of the roof control plan.
- Receive training in provisions of the roof control plan, including any revisions, prior to implementation.
- Contact the local MSHA office with questions or concerns.

## Operators' Responsibilities

Operators must:

- Provide a safe workplace by supporting or controlling the roof, face, and ribs in areas where persons work or travel.
- Develop and follow an MSHA-approved roof control plan suitable to the prevailing geological conditions and the mining systems used at the mine.
- Install additional roof/rib support when needed.
- Propose revisions to the roof control plan when:
  - ➤ prevailing conditions indicate that the current plan is not suitable; and
  - ➤ accident or injury experience at the mine indicates the plan is inadequate.
- Provide miners with adequate training covering the provisions of the roof control plan.
- Provide an alternative means of temporary support when mining conditions or circumstances prevent the use of an ATRS system.
- Provide adequate machines, tools, and materials to safely install roof support.
- Report to MSHA:
  - ➤ unplanned roof falls at or above the anchorage zone in active workings where roof bolts are in use;
  - ➤ a roof or rib fall on active workings that impairs ventilation or impedes passage; and
  - ➤ a coal outburst that causes withdrawal of miners or which disrupts regular mining activities for more than one hour.
- Conduct frequent and thorough examinations of roof, face, and ribs.

## SUMMARY

Now that you've read this booklet, you might be wondering about your role in the roof control program at your mine. What can you do?

### Take Five and Stay Alive!

1. **Never go under unsupported roof!**
2. Make frequent and thorough roof/rib evaluations.
3. Know and follow the roof control plan.
4. Be alert to changing conditions.
5. Discuss any roof control concerns with your supervisor.

## Questions? Want to Find Out More?

Here are some MSHA offices and services you can use to find out more about mine safety and health concerns.

**MSHA**
**Coal Mine Safety and Health**

**Telephone:** (202) 693-9521

**MSHA**
**Technical Support**
Pittsburgh Safety and Health Technology Center

**Telephone:** (412) 386-6902

**MSHA**
**Technical Information Center and Library**

**Telephone:** (304) 256-3531
**FAX:** (304) 256-3372
**E-mail:** MSHALibrary@dol.gov

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