

MSHA Handbook Series



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ROOF CONTROL PLAN APPROVAL AND REVIEW PROCEDURES

PREFACE

This handbook establishes guidelines and procedures for CMS&H personnel to follow when evaluating and processing roof control plans and/or roof control plan revisions. The guidelines and instructions in this handbook address procedural, administrative, and technical aspects of plan reviews, and are intended to serve as organizational and technical aids for roof control Plan Reviewers. Guidance for conducting inspection activity can be found in the CMS&H General Inspection Procedures Handbook.

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Date

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Chapter 1
INTRODUCTION

A. Purpose and General Requirements of Roof Control Plans

A sound roof control plan is essential for controlling the roof, face and ribs, including coal or rock bursts in underground coal mines. Each mine operator is required by 30 CFR 75.220 (a) (1) to develop and follow a roof control plan, approved by the Mine Safety and Health Administration (MSHA) District Manager, that is suitable to the prevailing geological conditions, and the mining system to be used at the mine. Additional measures must be taken to protect persons if unusual hazards exist. Section 75.220 (a) (2) requires that an operator must submit a proposed plan and any revisions to the District Manager in writing. Under section 75.220 (c), no proposed roof control plan or revision to a roof control plan shall be implemented before it is approved by the District Manager.

A good roof control plan includes information and criteria that supervisors and miners need to be aware of to maintain effective roof control in their working environment. Section 75.221 specifies information that must be included in each roof control plan. Section 75.222 sets forth the criteria that must be considered on a mine-by-mine basis in the formulation and approval of plans and revisions. Additional measures may be required by the District Manager to suit the particular conditions at the mine.

B. Authority

Title 30 CFR 75.220 – 75.223.

C. Responsibility

Only the District Manager or those designated as acting in the District Manager's absence have the authority to approve or disapprove roof control plans.

D. Directives Affected

This handbook incorporates and supersedes the following MSHA Directives:

1. Program Information Bulletin No. P10-23 Precautions for the Use of the Analysis of Retreat Mining Pillar Stability (ARMPS) Computer Program, Dated 12/27/2010
2. Program Information Bulletin No. P09-03 General Guidelines for the Use of Numerical Modeling to Evaluate Ground Control Aspects of Proposed Coal Mining Plans, Dated 3/16/2009
3. Procedure Instruction Letter No. I12-V-02 Pillar Recovery Design, Technologies, and Procedures in Roof Control Plan Reviews, Dated 2/16/2012
4. Procedure Instruction Letter I12-V-15 Tensioned Cable Bolts, Dated 5/7/2012
5. Program Information Bulletin No. P11-33 Best Practices for Turning Crosscuts with Remote Controlled Continuous Mining Machines, Dated 5/6/2011

6. Program Information Bulletin No. P11-30 Use of Mobile Roof Support (MRS) Units for Retreat Mining, Dated 4/27/2011
7. Program Information Bulletin No. P11-29 Protecting Miners from Hazards Related to Rib Falls, Dated 4/21/2011

Chapter 2
MANAGEMENT SYSTEM CONTROLS

A proposed roof control plan, and any revisions to the plan, must be submitted in writing to the District Manager. All requests for approval of roof control plans and/or revisions should be submitted to the District Office. A District Manager that desires an arrangement for mine operators to submit plans to other locations, e.g., a Coal Mine Safety and Health Field Office, should obtain approval for these other locations from the Administrator of Coal Mine Safety and Health.

A Mine Plan Approval System (MPAS) is in place in each MSHA District Office. This system is a database application that tracks plan approvals and reviews. Each District Office should log all plan submittals into the MPAS and assign a tracking number to the plan. Other data that must be entered into the system include the date a plan was received and the mine identification number.

Each MSHA District Office should use the MPAS to track an operator's response to a District Manager's request for plan revisions, and to identify overdue responses.

A plan request should be handled efficiently with an effort to complete the process in a time period of 45 calendar days. If more than 45 days is required, then the reasons for the extra time should be documented in the comments section on the plan transmittal sheet.

When MSHA formally requests additional information from a mine operator in order to make a decision, the request date for the additional information should be recorded in the MPAS. If the operator fails to respond to this request, MSHA should ask the operator to withdraw the plan via letter, e-mail or fax and the withdrawal action should be documented in the MPAS. If the operator refuses or does not respond in a timely manner, the plan should be disapproved and a letter sent to the mine operator explaining the rationale for the decision. If the mine operator withdraws its plan and submits a new plan, the new plan should be documented in the MPAS.

Only those persons designated by the Roof Control Supervisor, Assistant District Manager (ADM) or District Manager may contact the operator for additional information.

The progress of the plan and/or revision through the approval process should be coordinated by the ADM following the district's Standard Operating Procedure (SOP) and Plan Transmittal Sheet. A sample SOP, together with the Plan Transmittal Sheet, is provided in Appendix A. The content of the District Roof Control SOPs must conform to the elements provided in the sample SOP and should not contain any policies or procedures. After the submittal has been entered into the MPAS and a tracking number has been assigned, the following sequence of events should occur. It is recognized that many changes or revisions are proposed that address specific portions of the approved plan. Therefore, all the following steps may not be necessary in all situations. The ADM may expedite the review process where the nature of the revision warrants in that case.

1. The original submittal and Plan Transmittal Sheet should be given to the Roof Control Supervisor. He/she assigns the plan to the Plan Reviewer.
2. After receiving the plan and/or revision from the Roof Control Supervisor, the Reviewer conducts a thorough review in accordance with the Chapters 3-6 of the MSHA Roof Control Plan Approval and Review Handbook.
3. The Reviewer uses the Plan Transmittal Sheet to document the plan coordination and review, together with his or her recommendations and any relevant comments. The Reviewer then returns the review to the Roof Control Supervisor.
4. The Roof Control Supervisor documents his or her recommendations, along with any relevant comments, on the Plan Transmittal Sheet, and then forwards the plan to the ADM.
5. The ADM documents his or her recommendations, along with any relevant comments, on the Plan Transmittal Sheet, and forwards the plan to the District Manager.

The District Manager must notify the operator in writing whether the proposed plan is approved or denied.

1. If the District Manager approves the proposed plan or revision, written notification is sent to the operator stating that the roof control plan is approved.
2. If the District Manager determines that the proposed plan or revision is not suitable to the prevailing geological conditions or the system of mining to be used at the mine, written notification is sent to the operator that (1) addresses the deficiencies of the proposed plan or revision for which approval is denied; (2) provides the operator an opportunity to discuss with the District Manager the problems identified and potential solutions; and (3) sets a reasonable time for the operator to submit any revised plan provisions, if needed. If the deficiencies are corrected, approval correspondence is prepared. If provision(s) cannot be approved, MSHA procedures established in the Program Policy Manual, Volume V, V.G-4 apply.

Once the District Manager signs the approval or denial letter, the complete plan (submittal), and the approval or denial letter, are mailed to the mine operator.

The date the review was completed and the date the District Manager signed the letter of approval or denial is entered into the MPAS.

One copy of the completed approved plan and/or revision (with approval letter) is sent to the MSHA Coal Mine Safety and Health Field Office and placed in the Uniform Mine File. This copy should be sent at the same time that the approval letter is sent to the operator. If appropriate, copies of the approved plan (with approval letter) should also be sent to the appropriate state agency and the miners' representative. Copies of denied or withdrawn plans are not required to be sent to the field office. If a plan is withdrawn by the operator, that fact should be documented in the MPAS.

One copy of the completed approved plan with the approval letter should be retained at the District Office. This file should also include all documentation of the plan reviews and

evaluations (including MSHA Form 2000-204 (if applicable), checklists, drawings, sketches, correspondence between the operators and Plan Reviewers, etc.) that support the decision to approve the plan. This file should be retained by the District for at least as long as the plan is in effect. Documentation for plans for which approval is denied or for plans that are withdrawn by the operator is not required to be retained.

In accordance with Section 75.223 (d), MSHA must review all roof control plans every six months. The date on which the initial plan is approved becomes the date of record for that plan. The first six month review must be completed within six months of the date of record for the plan. All subsequent six month reviews are completed within six months of the date of the last completed review. If the operator revises and resubmits a previously approved plan, and the resubmittal is approved, then the new approval date becomes the date of record for the plan.

Chapter 3
PLAN REVIEWS

While responding promptly to each request for a roof control plan approval is important, review quality and thoroughness are essential. MSHA has established explicit criteria and guidance for assessing the quality of, and potential safety risk associated with, proposed plans. Districts are required to document the basis for their conclusion that approved plans will provide effective roof control.

The Roof Control Supervisor or Specialist will review the plan as follows:

1. In considering whether to approve a proposed plan, the Reviewer must determine whether the plan is consistent with all relevant, mandatory provisions of the Mine Act and MSHA's standards and regulations.
2. If the operator is resubmitting a previously approved plan, then the Reviewer should ensure that it maintains at least the same level of protection for the miners as the previously approved plan. Any significant additions, deletions, or changes must be noted.
3. The Reviewer determines that all required information has been submitted.
4. The Reviewer contacts the assigned CMI and/or Field Office Supervisor to solicit comments on the appropriateness of the plan. The Reviewer documents any comments by the CMI and Field Office Supervisor on the Plan Transmittal Sheet.
5. The Reviewer considers written comments from the representatives of miners and documents whether comments were received on the Plan Transmittal Sheet.
6. If the mine operator submits written correspondence (including e-mail), it should be printed and retained with the official file. Significant interactions, such as meetings with the operators, should also be documented.
7. If the plan under review is for an existing mine, the Reviewer checks the mine files for information relating to plan adequacy including roof fall history, injury experience, accident reports, , citations, and plan review (MSHA Form 2000-204) forms from the mine. Appendix I contains guidance for evaluating a mine's historical record.
8. Based on the type of plan submittal and the complexity of the mine, the Reviewer determines whether MSHA's Directorate of Technical Support (Technical Support) Roof Control Division's assistance with the review of the plan is warranted. Appendix C, "Approval of Complex and/or Non-Typical Roof Control Plans and Addendums," is used to assist in determining which plans should be forwarded to Technical Support.

When a plan submittal, or any portion thereof, is forwarded by the District Office to Technical Support for assistance with the review, the District Office records the transmittal in the comments section of the MPAS district level data entry screen. This record should include the date and pertinent information regarding the plan that was sent to Technical Support as well as the date and summary of the Technical Support recommendations.

9. If Technical Support's assistance is not requested with a plan, then the Reviewer uses Analysis of Retreat Mining Pillar Stability (ARMPS), Analysis of Longwall Pillar Stability (ALPS), Analysis of Multiple Seam Stability (AMSS) or other applicable software for development and/or retreat pillar stability analysis. Critical input parameters and calculations sent by an operator are verified by the Roof Control Specialist (or Reviewer) as part of the review. The necessary input parameters (depth of cover, projected pillar centers, mining heights, interburden thicknesses, etc.) may be obtained from the 30 CFR 75.372 ventilation map, the 30 CFR 75.1200 mine map, or other documented sources. If necessary, the District Manager should exercise his authority under 30 CFR 75.1203 to require an operator to furnish a current 30 CFR 75.1200 mine map with depth of cover contours (or surface topography and seam elevation contours). Appendix D contains guidance for conducting pillar stability analyses. If MSHA's evaluation shows that the stability factors calculated do not meet or exceed the design criteria in the appropriate NIOSH software program listed in Appendix E, "Precautions for the Use of the National Institute for Occupational Safety and Health (NIOSH) Pillar Analysis Computer Programs," or do not meet or exceed minimum safety criteria for other computer models used, see Appendix F, "General Guidelines for the Use of Numerical Modeling to Evaluate Ground Control Aspects of Proposed Coal Mining Plans" then the proposed roof control plan is forwarded to Technical Support for assistance in accordance with Appendix C.
10. The Reviewer communicates with other plan approval groups concerning common issues in a plan. The Reviewer consults with the Ventilation Group and reviews overlay and underlay maps of coal mine workings above and below projected mining. The Reviewer should pay particular attention to evaluating the possible presence of impounded water above projected mining. If the Reviewer determines that such impoundments may exist, a permit may be required in accordance with 30 CFR 1716-2.
11. MSHA has created roof control plan checklists to assist the Reviewer in reviewing plans, and to document the rationale supporting plan approvals. MSHA's mandatory standards, interpretive guidance, safety precautions and best practices are included in the checklists. The checklists are not intended to be a "one size fits all" approach because roof control plans are developed and revised on a mine-by-mine basis considering the prevailing geological conditions and the mining system to be used at the mine. Consequently, not all items on the checklists are always applicable for each and every mine. If an item on any of the checklists is not applicable during a review, the Reviewer should mark the item "N/A." The checklists are contained in Appendix B. Other Appendices provide additional information that can aid the Reviewer in determining which checklist items may be appropriate on a mine-by-mine basis. Specifically, retreat mining is addressed in

Appendices G and H, mobile roof supports are addressed in Appendix M, rib control is addressed in Appendix O, turning crosscuts is addressed in Appendix L, and tensioned cable bolts are addressed in Appendix K.

12. If applicable, the Specialist, Roof Control Supervisor, Field Office Supervisor, Coal Mine Inspector (CMI) or Technical Support conducts a limited inspection of the mine and evaluates the suitability of the plan to the roof and rib conditions. The results of the evaluation should be discussed with the operator and any miners' representatives. Guidance for conducting underground inspections for a roof control plan approval or review is contained in Appendix J.
13. The Roof Control Group determines whether an on-site evaluation should be conducted at a new highwall and/or pre-existing highwall that is developed as a portal area for new underground mine openings.
14. The Reviewer should evaluate all plan requests for making extended cuts with remote controlled continuous mining machines in accordance with MSHA PIL "Procedures for Evaluation of Requests to Make Extended Cuts With Remote Controlled Continuous Mining Machines," available at <http://www.msha.gov/regs/complian/PILS/2012/PIL12-V-11.asp>.

Upon completion of the review, the Reviewer makes a recommendation as to whether the plan should be approved, and marks the appropriate box on the Plan Transmittal Sheet. Following his or her review, the Roof Control Supervisor and the ADM review the Plan Reviewer's recommendation, and note their own recommendations on the Transmittal Sheet.

Chapter 4
REVIEWS OF PLAN REVISIONS

The procedures for reviewing plan revisions (addendums) are similar to those for reviewing plans. The key difference is that most proposed plan revisions only address specific portions of the approved plan. Therefore, some steps in Chapter 3 may be unnecessary in some situations. In particular, depending on the nature of the revision only some of the checklists may be appropriate (Chapter 3, section 11). The Roof Control Supervisor should make the determination as to which checklists should be used for each revision.

A revision of the roof control plan is not necessarily required each time that equipment is added. However, a revision is necessary when there is a significant change to the mining system. Significant changes include the addition of a roof bolter with a different roof bolt installation pattern or a different type of Automated Temporary Roof Support (ATRS) system, new mining equipment that would require a change to the depth of an extended cut or pillar lift depth (e.g., center drive shuttle car or continuous mining machine (CM) with deck), a change from shuttle cars to continuous haulage, or adding a roof bolter with rib bolting capability.

In accordance with 30 CFR 75.220 (a) (2), when revisions are proposed, only the revised pages need to be submitted unless otherwise specified by the District Manager. When the number of revisions to an approved plan makes it difficult to determine the operative provisions of the plan, the District Manager should notify the operator in writing to submit a revised plan that clearly sets forth all previously approved revisions and any proposed revisions, and deletes those provisions that are no longer applicable.

Chapter 5
QUARTERLY REVIEWS

Reviews of the roof control plans should be completed every quarter by a CMI to ensure that the plans are suitable to current geological conditions and mining systems in the mine. The CMI should use the MSHA Form 2000-204 to document the results of these reviews. If the CMI indicates a deficiency on the MSHA Form 2000-204, then the form should be sent to the District Roof Control Supervisor for evaluation.

After receiving the MSHA Form 2000-204, the District Roof Control Supervisor should determine if a roof control plan deficiency exists. If a deficiency is determined, the District Roof Control Supervisor should require the plan to be revised to address the deficiency.

The Roof Control Group should prepare correspondence for the District Manager's signature that (1) identifies the deficiencies of the plan; (2) provides the operator an opportunity to discuss with the District Manager the problems identified and potential solutions; and (3) sets a reasonable time for the operator to submit any revised plan provisions, if needed. If the deficiencies are corrected, approval correspondence must be prepared. If provision(s) cannot be approved, MSHA procedures established in the Program Policy Manual, Volume V, V.G-4 apply.

The District Roof Control Supervisor should notify the CMI who identified the deficiency and the Field Office Supervisor of the corrective action taken and of the applicable plan changes, by either memo or e-mail. If the District Roof Control supervisor determines that no deficiency exists, he or she should notify CMI and Field Office Supervisor by memo or by e-mail. In either case, a copy of the memo or e-mail should be attached to the MSHA Form 2000-204 and included in the Uniform Mine File.

Chapter 6
SIX MONTH REVIEWS

In accordance with 30 CFR 75.223, the roof control plan must be reviewed every six months by an Authorized Representative of the Secretary (AR). This requirement ensures that approved plans are still appropriate for the mine and continue to provide an adequate system of roof control and are revised as conditions warrant.

When the number of revisions (addendums) to the plan makes it difficult to determine the operative provisions of the plan, the District Manager should notify the operator in writing to submit a revised plan that incorporates all revisions in an orderly manner, and deletes those provisions that are no longer applicable.

The regular CMI may conduct the six month reviews of the less complex or typical plans in the District with assistance provided by the Roof Control Specialist as needed. A Roof Control Specialist should conduct the six month reviews of the more complex or non-typical plans in the District. Refer to Appendix C for additional guidance on complex or non-typical plans and addendums. The following are the basic steps in the six month review:

Prior to the underground inspection, the following items should be reviewed by either the CMI or the Roof Control Specialist:

- Detailed historical record of safety conditions at the mine including roof fall accident data, roof control citations, roof and rib fall injuries, roof falls, and coal or rock outbursts for at least the prior six months (see Appendix I).
- Previous MSHA Form 2000-204 comments.

The Reviewer communicates with other plan approval groups concerning common issues in a plan. The Reviewer consults with the ventilation group reviewing overlay and underlay maps of coal mine workings above and below projected mining. The Reviewer should ensure that the possible presence of impounded water above projected mining are evaluated. If the Reviewer determines that such impoundments may exist, a permit may be required in accordance with 30 CFR 75.1716-2.

The Reviewer should also evaluate mining projections using ARMPS, ALPS, AMSS, or other applicable software for development and/or retreat pillar stability analysis. Appendix D contains guidance on conducting pillar stability analyses. Critical input parameters and calculations sent by an operator should be verified by the Reviewer. The necessary input parameters (depth of cover, projected pillar centers, mining heights, interburden thicknesses, etc.) may be obtained from the 30 CFR 75.372 ventilation map, the 30 CFR 75.1200 mine map, or other documented sources. If necessary, the District Manager should exercise his or her authority under 30 CFR 75.1203 to require operators to furnish a current 30 CFR 75.1200 mine map with depth of cover contours (or surface topography and seam elevation contours).

If MSHA's evaluation shows that the stability factors calculated do not meet or exceed the design criteria listed in the appropriate NIOSH software program listed in Appendix E, "Precautions for the Use of the NIOSH Pillar Analysis Computer Programs", or do not meet or exceed minimum safety criteria for other computer models used, then the proposed mining should be considered as "complex or non-typical" and the process described in Appendix C, "Approval of Complex and/or Non-Typical Roof Control Plans and Addendums" should be followed. If MSHA conducted a pillar stability analysis concurrently with the review of the ventilation plan at any time during the six months prior to the roof control plan review, then the Plan Reviewer may make the determination that it is not necessary to conduct another analysis, but in every case the results of the pillar stability analysis should be documented.

If necessary, the Specialist, Roof Control Supervisor, Field Office Supervisor, CMI, or Technical Support conducts a limited inspection of the mine and evaluates the roof and rib conditions. The results of the evaluation should be discussed with the operator and any miners' representatives. Guidance for conducting underground inspections for a roof control plan approval or review is contained in Appendix J. The Roof Control Group should contact the assigned CMI and/or Field Office Supervisor to solicit comments on the appropriateness of the plan.

Following the inspection, a Plan Review form (MSHA Form 2000-204) should be completed by the Authorized Representative of the Secretary or Roof Control Specialist who is conducting the six month review. A brief narrative describing the adequacy or any deficiencies of the plan should be included on the MSHA Form 2000-204. If the MSHA Form 2000-204 indicates a deficiency or needed change, the form should be sent to the District Roof Control Supervisor for evaluation.

For mines in a non-producing status, the CMI's review, as recorded on MSHA Form 2000-204 may be used for computer input and review in the MPAS.

After completion of the six month review, if deficiencies in the plan are identified, the Roof Control Supervisor or Specialist must prepare correspondence for the District Manager's signature that (1) informs the operator of the findings of the review and the need for revisions to the approved plan; (2) provides an opportunity to discuss with the District Manager the problems identified and potential solutions; and (3) sets a reasonable time for the operator to submit any revised plan provisions, if needed. If the corrections will result in significant changes to the plan, then the procedures in Chapter 4 on plan revisions apply. If the deficiencies are corrected, approval correspondence must be prepared. If provision(s) cannot be approved, MSHA procedures established in the Program Policy Manual, Volume V, V.G-4 apply. A copy of the deficiency letter and subsequent approval letter must be sent to the appropriate field office and be included in the uniform mine file.

APPENDIX A

ROOF CONTROL SAMPLE STANDARD OPERATING PROCEDURES
WITH PLAN TRANSMITTAL SHEET

When any roof control plan and/or revision (addendum) of a roof control plan is received in the District Office, (List title of person in the district who will complete this task) will log it into the Mine Plan Approval System (MPAS) and assign a tracking number to the plan.

(List title of person in the district who will complete this task) will attach a Plan Transmittal Sheet to the plan and complete all applicable sections.

(List title of person in the district who will complete this task) forwards the original plan and Plan Transmittal Sheet to the Roof Control Supervisor.

Roof Control Supervisor assigns the plan and/or revision to the Plan Reviewer.

The Reviewer conducts a thorough review of plan in accordance with the Chapters 3-6 of the MSHA Roof Control Plan Approval and Review Handbook.

The Reviewer uses the Plan Transmittal Sheet to document the plan coordination and review, together with his or her recommendations and any relevant comments and then returns the review to the Roof Control Supervisor.

The Roof Control Supervisor documents his or her recommendations, along with any relevant comments, on the Plan Transmittal Sheet, and then forwards the plan to the Assistant District Manager for Technical Services (ADM).

The ADM documents his or her recommendations, along with any relevant comments, on the Plan Transmittal Sheet, and forwards the plan to the District Manager.

The District Manager must notify the operator in writing whether the proposed plan is approved or denied. The notification will be conducted in accordance with the MSHA Roof Control Plan Approval and Review Handbook.

Once the District Manager has signed the approval or denial letter, the complete plan (submittal), and the approval or denial letter, are mailed to the mine operator by (List title of person in the district who will complete this task).

The date the review was completed and the date the District Manager signed the letter of approval or denial is entered into the MPAS by (List title of person in the district who will complete this task).

One copy of the completed approved plan (with approval letter) is sent to the MSHA Coal Mine Safety and Health Field Office at the same time that the plan is sent to the mine operator by (List title of person in the district who will complete this task) and placed in the Uniform Mine File by

(List title of person in the district who will complete this task). If appropriate, copies of the approved plan (with approval letter) should also be sent to the appropriate state agency and the miners' representative by (List title of person in the district who will complete this task). Copies of denied or withdrawn plans are not required to be sent to the Field Office. If a plan is withdrawn by the operator, that fact should be documented in the MPAS.

One copy of the completed approved plan and/or revision with the approval letter should be retained at the District Office. This file should also include all documentation of the plan reviews and evaluations (including MSHA Form 2000-204 (if applicable)), checklists, drawings, sketches, correspondence between the coal operators and Plan Reviewers, etc.) that support the decision to approve the plan. This file should be retained by the District for at least as long as the plan is in effect. Documentation for plans for which approval is denied or for plans that are withdrawn by the operator is not required to be retained.

Note: It is recognized that many changes or revisions are proposed that address specific portions of the approved plan. Therefore, not all the above steps may be necessary in all situations. The ADM may expedite the review process as necessary.

ROOF CONTROL PLAN APPROVAL
AND REVIEW PROCEDURES

APPENDIX A

DISTRICT X PLAN TRANSMITTAL SHEET

SECTION A: GENERAL INFORMATION

DATE RECEIVED FROM: OPERATOR MAIL OTHER _____ / ____ / _____ RECEIVED BY: _____

MSIS Plan Tracking No. _____

PLAN TYPE: _____

COMPANY NAME: _____

MINE NAME: _____ I.D. NO. _____

FIELD OFFICE: XX XX XX XX XX XX

PLAN SUMMARY / COMMENTS: _____

SECTION B: ON-SITE REVIEW (IF APPLICABLE) AND MINER'S REPRESENTATIVE'S COMMENTS

ON-SITE REVIEW CONDUCTED: YES, NO DATE OF REVIEW: _____

COMMENTS: _____

• COMMENTS RECEIVED FROM MINER'S REPRESENTATIVE? YES NO NO REPRESENTATIVE (See reverse)

SECTION C: PLAN COORDINATION and REVIEW

PLAN COORDINATED WITH (WHEN APPLICABLE): Please date and initial

ADM FOR ENF _____ FO SUPV _____ CMI ASSIGNED TO MINE _____

HEALTH _____ VENT _____ ROOF _____ TRAINING _____

STATE _____ Technical SUPPORT _____ OTHER _____

COMMENTS: _____

SECTION D: DISTRICT REVIEW

ROOF CONTROL SPECIALIST: DATE REVIEWED: _____ INITIALS: _____

RECOMMENDATION: APPROVAL DISAPPROVAL ACKNOWLEDGEMENT FWD TO TS CONCUR WITH STATE OTHER _____

ROOF CONTROL SUPERVISOR: DATE REVIEWED: _____ INITIALS: _____

RECOMMENDATION: APPROVAL DISAPPROVAL ACKNOWLEDGMENT FWD TO TS CONCUR WITH STATE OTHER _____

ASSISTANT DM (TECHNICAL): DATE REVIEWED: _____ INITIALS: _____

RECOMMENDATION: APPROVAL DISAPPROVAL ACKNOWLEDGMENT FWD TO TS CONCUR WITH STATE OTHER _____

DISTRICT MANAGER: DATE: _____ INITIALS: _____

APPROVED DISAPPROVED ACKNOWLEDGED FWD TO TS CONCUR WITH STATE OTHER _____

SECTION E: DISTRIBUTION OF APPROVED PLANS

NOTE: FIELD OFFICE - RETURN ORIGINAL TRANSMITTAL SHEET TO ENGINEERING SERVICES

TRACKING DATES (IF APPLICABLE): MSIS _____ / _____ SCANNED _____ UMF _____

(In --- out)

PROVIDED TO OPERATOR & DISTRICT FILE: DATE: _____ INITIALS: _____

NOTIFICATION OF APPROVAL:

ASSISTANT DM (ENFORCEMENT) NOTIFIED BY - INITIALS: _____ DATE: _____ PHONE EMAIL IN PERSON

FIELD OFFICE SUPERVISOR NOTIFIED BY - INITIALS: _____ DATE: _____ PHONE EMAIL IN PERSON

INSPECTOR NOTIFIED BY - INITIALS: _____ DATE: _____ PHONE EMAIL IN PERSON

APPENDIX B

CHECKLISTS FOR USE IN PLAN REVIEWS

- Roof Control Plan Review Preliminary Items (For six-month reviews and reviews of resubmittals of previously approved plans)
- New Mine Openings
- General Plan Information
- Mine Layout
- General Roof Support
- Tensioned Roof Bolts
- Resin Grouted Roof Bolts
- Supplemental Support
- Mining Equipment
- Extended Cuts
- Pillar Retreat Mining
- Mine-Specific Mobile Roof Support Units
- Longwall Mining

ROOF CONTROL PLAN REVIEW PRELIMINARY ITEMS
(For six-month reviews and reviews of resubmittals of previously approved plans):

Review the detailed historical record of safety conditions at the mine for at least the prior six months, including:

- Accident data,
- Roof control citations,
- Roof and rib injuries, and
- Non-injury roof falls and bursts.

Review comments made on previous MSHA Forms 2000-204.

Review comments from field personnel.

(If comments/recommendations from the field personnel will not be incorporated, notify that person(s) of your reasoning for not incorporating the comments/recommendations.)

NEW MINE OPENINGS AND PUNCHOUTS

Mandatory Standards

30 CFR 75.221 (a) states that the following information shall be in each roof control plan.

(11) The roof control plan shall include a description of the method of protecting persons-

(i) From falling material at drift openings; and

(ii) When mining approaches within 150 feet of an outcrop.

The following items should be addressed in the roof control plan on a mine-by-mine basis:

An on-site evaluation should be conducted at a new drift or slope mine by a roof control specialist to evaluate the highwall and determine a minimum roof control plan for development.

Prior to a punchout, an on-site evaluation should be conducted by a CMI or Roof Control Specialist to evaluate the highwall.

The initial development plan should apply to at least the first 150 feet of development from the highwall, and any subsequent time that mining approaches within 150 ft of the outcrop. It should consist of the following at a minimum:

Roof bolt type and minimum length

Maximum roof bolt spacing

Maximum crosscut and entry widths

Minimum crosscut and entry centers

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

All unstable material shall be removed from the highwall above intended mine openings and areas between openings where miners travel or are required to perform work.

A substantially constructed canopy shall be installed at all intended drift or slope openings before penetrating the coal seam from a highwall. Canopies shall also be installed at any other drift or slope openings in highwalls prior to being used by workers to enter or exit the mine. The canopy shall be substantially constructed and extend from the highwall for a distance which will provide for adequate protection from falling highwall material.

GENERAL INFORMATION FOR PLAN REVIEW

Mandatory Standards

30 CFR 75.221 (a) states that the following information shall be in each roof control plan.

- (1) The name and address of the company.
- (2) The name, address, mine identification number and location of the mine.
- (3) The name and title of the company official responsible for the plan.
- (4) A typical columnar section of the mine strata which shall—
 - (i) Show the name and the thickness of the coalbed to be mined and any persistent partings;
 - (ii) Identify the type and show the thickness of each stratum up to and including the main roof above the coalbed and for distance of at least 10 feet below the coalbed;
 - (iii) Indicate the maximum cover over the area to be mined.

30 CFR 75.221 (b) Each drawing submitted with a roof control plan shall contain a legend explaining all symbols used and shall specify the scale of the drawing which shall not be less than 5 feet to the inch or more than 20 feet to the inch.

30 CFR 75.221 (c) All roof control plan information, including drawings, shall be submitted on 8½ by 11 inch paper, or paper folded to this size.

Note: Keep the plan as concise and simple as possible by eliminating all unnecessary material - especially material that restates the regulations.

Note: The pages in the plan must be numbered sequentially.

(Note: Regarding Section 75.221(a) (4) (ii) where possible, a geologic log from an exploration borehole located near the active mining area should be provided)

MINE LAYOUT

Mandatory Standards

30 CFR 75.203 (a) provides that “[p]illar dimensions shall be compatible with effective control of the roof, face and ribs and coal or rock bursts.”

30 CFR 75.221 (a) (8) provides that the plan shall contain “[d]rawings indicating the planned width of openings, [and] size of pillars....”

30 CFR 75.222 (b) (3) and (4) (i) and (ii) state that “[a]ny opening that is more than 20 feet wide should be supported by a combination of roof bolts and conventional supports” and that “[p]osts should be installed to limit each roadway to 16 feet wide where straight and 18 feet wide where curved; and a row of posts should be set for each 5 feet of space between the roadway posts and the ribs.”

30 CFR 75.222 (b) (5) states that “[o]penings should never be more than 30 feet wide.”

(Section 75.221(a)(8) which requires drawings indicating the method of pillar recovery and the sequence of mining pillars is discussed in another checklist included in this Appendix.)

The following items should be addressed in the roof control plan on a mine by-mine basis:

Pillar dimensions should be specific dimensions instead of ranges. For example, specify "Pillar dimensions in mains and submains will be 80 feet wide by 120 feet long" instead of "Pillar width = 50 to 120 feet and pillar length = 80 to 140 feet." Mines that do use a range of pillar sizes should incorporate a pillar stability factor. For example, “pillar dimensions will be such that the calculated ARMPS stability factors will meet NIOSH criteria at all times.”

A brief description of the pillar design analysis method used, including design software version (release number).

The listing or identification of pillar stability factors or safety factors for the analysis method used.

(Note: The pillar dimensions should either (1) meet or exceed the generally accepted or recommended design criteria for the analysis method used, or (2) meet mine-specific design criteria that are supported by sufficient documentation and mining history.)

A brief description of the barrier design analysis used, and the barrier pillar stability factor or safety factor for the analysis method used.

Request Technical Support assistance when applicable. See Appendix C, “Approval of Complex and/or Non-Typical Roof Control Plans and Addendums” for guidance.

Compare the material pertaining to mine layout and mining methods with the material in the ventilation plan. For example, compare depth of cut, typical box cut mining sequence, mining projections, etc.

The plan should specify the maximum depth of cut.

The plan should specify the typical mining height.

Check the projected mining in relation to overlying and underlying workings. If a multiple seam interaction is possible, then an analysis should be provided.

Check the projected mining in relation to overlying bodies of water. If the body of water is sufficiently large to constitute a hazard to miners, notify the operator that a permit is required in accordance with 30 CFR 75.1716-2. The application for a permit must be filed with the District Manager and must contain the information specified in 30 CFR 75.1716-3.

Borehole drilling plans may be required if mining will approach workings in the same seam in accordance with 30 CFR 75.388, or within 50 feet of overlying or underlying seams.

ROOF SUPPORT

Mandatory Standards

75.221 (a) provides that the following information shall be included in each roof control plan.

(5) A description and drawings of the sequence of installation and spacing of supports for each method of mining used

(9) A list of all support materials required to be used in the roof, face and rib control system, including, if roof bolts are to be installed

(i) The length, diameter, grade and type of anchorage unit to be used;

(ii) The drill hole size to be used.

30 CFR 75.222 (e) states that” [o]penings that create an intersection should be permanently supported or at least one row of temporary supports should be installed on not more than 5-foot centers across the opening before any other work or travel in the intersection.”

30 CFR 75.222 (c), regarding installation of roof support using mining machines with integral roof bolters, states that:

(1) Before an intersection or pillar split is started, roof bolts should be installed on at least 5-foot centers where the work is performed, and

(2) Where the roof is supported by only two roof bolts crosswise, openings should not be more than 16 feet wide.

(Note: The roof support material must be compatible with the roof strata. Remember that 30 CFR 75.204 (f) (1) requires that tensioned roof bolts that provide support by creating a beam of laminated strata shall be at least 30 inches long, and tensioned roof bolts that provide support by suspending the roof from the overlying stronger strata shall be long enough to anchor at least 12 inches into the stronger strata.)

The following items should be addressed in the roof control plan on a mine by-mine basis:

The bolting sequence should not place roof bolter operators under unsupported roof or with their backs turned to unsupported roof.

Areas should be bolted within 24 hours after mining - especially if the roof is laminated, unconsolidated material.

Places should not remain unbolted over weekends or over any other periods of 2 days or more, regardless of the roof strata.

In accordance with 30 CFR 75.203 (c), specify the amount of support necessary in an entry before a crosscut can be mined. (Full support is preferred.)

Rib support should be specified in the plan when necessary to protect persons from falls of rib resulting from the prevailing geologic conditions at the mine. For example, when the mining height exceeds 7 ft. and the depth of cover exceeds 700 ft rib support should be considered.

Rib support should be specified in the plan when the accident and injury experience at the mine indicates that it is necessary.

TENSIONED ROOF BOLTS

Mandatory Standards

30 CFR 75.221 (a) (9) (iii) provides that the roof control plan shall include “[t]he installed torque or tension range for tensioned roof bolts.”

(30 CFR 75.204 (f) (3)) requires that the specified torque or tension range “shall maintain the integrity of the support system and shall not exceed the yield point of the roof bolt nor anchorage capacity of the strata.”

(30 CFR 75.222 (b) (2)) states that “[w]hen tensioned roof bolts are used as a means of roof support, the torque or tension range should be capable of supporting roof bolt loads of at least 50 percent of either the yield point of the bolt or anchorage capacity of the strata, whichever is less.”

(Note: Machine-mounted pressure gages may be used to verify installed bolt tension where the use of torque wrenches is not feasible (such as for mechanically anchored, resin-assisted bolts) or where the use of a torque wrench exposes the worker to hazards (such as extremely high places). However, because the use of pressure gages introduces another variable in monitoring bolt tension, where a manual torque reading can be safely obtained, the use of a torque wrench is encouraged.)

(Note: If a pressure gage is used, the relationship between installed torque and bolter hydraulic pressure should be verified on a weekly basis and a record of this calibration maintained.)

(Note: For mechanically anchored, resin-assisted bolts, at the beginning of each shift, each bolter operator should install a bolt without resin (out of pattern) and verify the torque with a torque wrench.)

30 CFR 75.221 (a) (10) provides that “[w]hen mechanically anchored tensioned roof bolts are used, the roof control plan shall include the intervals at which test holes will be drilled.”

(Note: The intervals should be evaluated based on depth of cut and roof strata.)

(Note: The depth of the test holes does not have to be specified. However, if it is, then 30 CFR 75.204 (f) (2) requires that the depth be “at least 12 inches above the anchorage horizon of the mechanically anchored tensioned bolts being used.”)

(Note: The requirement for test holes for mechanically anchored tensioned bolts also applies to mechanically-anchored, resin-assisted bolts. Since the mechanical anchor is the primary anchorage device (and the resin is just assisting or preventing system bleed-off), the information obtained from the test hole is necessary to ensure proper performance of these bolts.)

RESIN GROUTED ROOF BOLTS

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

Resin-grouted rods shall be installed in accordance with the manufacturer's recommendations. Such recommendations shall not be in conflict with the following requirements:

- (1) All resin bolts shall be installed with approved bearing plates installed and maintained firmly against the mine roof and roof bolting machine operators shall wear adequate eye protection while installing the bolts.
- (2) Resin packages shall be stored in accordance with the manufacturer's recommendations and shall not be used if the manufacturer's recommended shelf life is exceeded. Broken or deteriorated cartridges shall not be permitted to accumulate in the mine.
- (3) The different types or makes of resin shall only be used in accordance with the manufacturer's recommendations.
- (4) All fully grouted non-tensioned roof bolts shall be fully grouted. If a return of resin grout cannot be observed by the roof bolting crew, one roof bolt without a plate shall be installed to allow the passage of a device that can touch the resin grout in the drilled hole to determine the amount the resin bolt has been grouted. For the bolt to be considered fully grouted, resin must be encountered within a distance no greater than 1 inch for each foot of bolt length (i.e., for an 8-ft bolt, then the resin should be encountered within 8 inches of the roof line). If the bolt is not considered fully grouted, then additional resin shall be added during the normal bolting cycle to accomplish a fully grouted installation. This test need only be conducted in each working place where a visible resin grout return cannot be observed and corrective measures apply only to the working places where the condition exists.

SUPPLEMENTAL SUPPORTS

Mandatory Standards

Mandatory Standard 30 CFR 75.221 (a) (7) provides that the roof control plan shall include that “[w]hen tunnel liners or arches are to be used for roof support, the roof control plan shall include specifications and installation procedures for the liners or arches.”

Mandatory Standard 30 CFR 75.221 (a) (12) requires that the roof control plan shall include “[a] description of the roof and rib support necessary for the refuge alternatives.”

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

Where loose material is being taken down in previously supported areas, a minimum of two temporary supports shall be installed between the person and the loose material not to exceed 5 feet between the person and the loose material unless such work can be accomplished from an area supported adequately by permanent supports.

All posts (except breaker posts), shall be installed with a wooden cap block, plank or crossbar between the post and the mine roof.

When adverse roof conditions are encountered such as horsebacks, slickensided slip formations, clay veins, kettle bottoms, surface cracks, mud seams or a similar type of adverse roof condition is found to exist in the mine roof, supplemental roof supports shall be installed in addition to the primary support, as appropriate in the affected area, to adequately support the roof.

Where damaged roof bolts are being replaced or additional support is being installed in isolated instances without the use of an ATRS system, a minimum of two temporary supports shall be installed in a manner that will best protect the miners replacing the supports.

Where overhead crossbars, beams, or similar roof supports, are installed along haulage roadways they shall be provided with a means to prevent the support from falling in the event the supporting legs become dislodged.

In the event of a continuous mining machine malfunction or breakdown that requires anyone to go inby permanent roof support to correct the condition, the unsupported area, where practical, shall be supported with roof bolts and the remaining unsupported roof in the working place shall be supported with temporary supports set on 4-foot maximum centers lengthwise and crosswise where miners are present. If cribs are necessary, temporary supports shall be installed before constructing the cribs. Any work shall be performed under the direct supervision of a certified foreman. Temporary roof support shall be removed by remote means.

If polyurethane grout will be used, appropriate safety and health precautions should be included in the roof control plan.

MINING EQUIPMENT

Mandatory Standards

30 CFR 75.221 (a) (6) requires that “[w]hen an ATRS system is used, the maximum distance that an ATRS system is to be set beyond the last row of permanent support.”

(Note that in accordance with PIL No. I12-V-11 pertaining to Procedures for Evaluation of Requests to Make Extended Cuts With Remote Controlled Continuous Mining Machines, this measurement is made from the last fully completed row of undisturbed roof bolts.)

In addition, the following items should be addressed in the roof control plan on a mine by-mine basis:

The ATRS system, maintained in proper working condition, is acceptable roof support during roof-bolting operations provided such supports are placed firmly against the mine roof, and provided the controls are operated from permanently supported roof before the roof bolter operator(s) proceed in by permanently supported roof. This does not apply to roof bolters that meet the provisions of 30 CFR 75.209 (e) (2) (ii).

When the ATRS system will not provide adequate support due to excessive height, an original equipment manufactured extension may be used. When temporary supports are used, the maximum cut depth shall be limited so as to effectively control the roof and no more than 20-foot deep cuts shall be taken for a total distance not to exceed 40 feet in any entry, room or crosscut before corrective action is taken to provide an acceptable ATRS system to accommodate this condition.

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

When the CM is being trammed anywhere in the mine, other than when cutting or loading coal, no person shall be allowed along either side of the CM.

At any time the CM is being operated using a remote control unit, the unit shall be equipped with an emergency stop (E-Stop) switch or panic bar that will de-energize the CM quickly in the event of an emergency. The emergency stop switch or panic bar shall be prominent and readily accessible.

The pump motor of the CM shall be de-energized during loading or unloading of the trailing cable that supplies electrical power to the CM.

When remote systems are being transported or stored in the mine, they shall be secured or de-energized. No two remote control systems may use the same frequency on the same section at any one time.

EXTENDED CUT SAFETY PRECAUTIONS

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

For mines with a history of unplanned roof falls or accidents and injuries from roof falls, the plan shall include a limit of two unsupported extended cuts per Mechanized Mining Unit (MMU).

The extended cut provisions are a part of the approved Roof Control Plan. The extended cut provisions should be covered in annual refresher training, and this training should include all affected miners before beginning extended cuts.

In addition, the following items should be addressed in the roof control plan on a mine-by-mine basis:

The emergency stop (E-Stop) switch or panic bar, located on the remote control box of the CM, shall be maintained in working order at all times.

During place changing, all persons involved in the move shall be positioned in an area away from any part of the CM at all times while the CM is being trammed. If an operator's compartment is provided and a cab or canopy is required due to the mining height, then the CM shall be trammed from the compartment.

The CM operator (remote control station) and other persons in the area shall not be allowed to expose any portion of their bodies inby the second full row of undisturbed permanent supports during mining.

No person shall be inby the CM operator's work position while the CM is operating, except for the haulage operator when necessary to load.

In the event of a breakdown of face equipment in an unsupported area, permanent roof support shall be installed as close to the work area as possible. In addition, temporary roof support, as defined below, shall be installed for a minimum of two rows inby the deepest point to be accessed. Any work shall be performed under the direct supervision of a certified foreman. If cribs are necessary, temporary roof support shall be installed in the area first. Temporary roof support will be removed by remote means.

Extended cuts will not be allowed to stand un-supported for a period in excess of 24 hours.

A conspicuous reference mark on the CM or some other visual means shall be provided for the miner to determine when the maximum depth of cut is attained.

An extended cut shall not be taken when mining within 150 feet of the outcrop.

When the ATRS system is inoperative, roof bolting operations in the working place shall not begin until the ATRS system is operative.

All openings that create an intersection (20-foot cuts or greater), including headings, shall be fully supported or have at least two rows of permanent supports (roof bolts) installed in the opening prior to any work or travel into the intersection. This shall include starting an additional opening or holing through into an intersection. This does not prevent passing by the opening to conduct the required preshift and on-shift examinations.

Before a crosscut is started, the area shall be permanently supported to within 4 feet of the face or at least two rows of bolts shall be installed in by the proposed crosscut rib line. The first cut when turning a crosscut shall be limited to a maximum of 24 feet in depth from the last full row of installed roof bolts.

When subnormal or adverse roof conditions are encountered, the depth of cut shall be limited to 20 feet or less until roof conditions have improved to a point where extended cuts may be safely resumed.

A device to actuate the fire suppression system shall be installed on the remote control panel. In addition, a device shall be installed on the CM that can be used to manually actuate the fire suppression system from a point outby, under supported roof, or the system can be actuated remotely from a permanently supported location, with the actuation device operated by its own power source, independent of the electrical power provided by the trailing cable.

RETREAT MINING PRECAUTIONS

Mandatory Standards

30 CFR 75.203 (a) states that "[t]he method of mining shall not expose any person to hazards caused by ... faulty pillar recovery methods."

30 CFR 75.221 (a) (8) requires that the roof control plan shall contain "[d]rawings indicating the planned width of openings, size of pillars, method of pillar recovery and the sequence of mining pillars."

30 CFR 75.222 (d) provides the following criteria on pillar recovery that shall be considered on a mine-by-mine basis in the formulation and approval of a roof control plan:

- (1) During development, any dimension of a pillar should be at least 20 feet.
- (2) Pillar splits and lifts should not be more than 20 feet wide.
- (3) Breaker posts should be installed on not more than 4-foot centers.
- (4) Roadside-radius (turn) posts, or equivalent support, should be installed on not more than 4-foot centers leading into each pillar split or lift.
- (5) Before full pillar recovery is started in areas where roof bolts are used as the only means of roof support and openings are more than 16 feet wide, at least one row of posts should be installed to limit the roadway width to 16 feet. These posts should be:
 - (i) Extended from the entrance to the split through the intersection outby the pillar in which the split or lift is being made; and
 - (ii) Spaced on not more than 5-foot centers.

In addition, the following items should be addressed in the roof control plan on a mine by-mine basis:

Whether supplemental roof bolts that are longer and stronger than the plan's primary support are to be installed in each intersection prior to pillar extraction. If so, the plan should specify the number of bolts to be installed, their length, and their type and other characteristics. These supports may be installed during development.

The cut-by-cut pillar extraction sequence should be illustrated in a drawing included in the roof control plan. The lift sequence should be indicated by numbers which correspond to individual pillar lifts.

The plan should specify the maximum width of the lifts.

The location of mobile roof supports, timbers, or other roof supports that will be installed immediately after each lift should be illustrated on a cut-by-cut basis in a drawing included in the roof control plan.

Whether the mine site ground conditions warrant limiting access to just one roadway into the intersection when the last lifts for a pillar are taken.

Whether the mine site ground conditions warrant having supplemental support installed in the entry and/or crosscut in addition to supplemental support that may be installed in the intersections.

Pillar recovery at depths exceeding 2,000 ft. may not be appropriate due to the heightened risk of bursts at such unusual depths. (Additional guidance can be found in Appendix G.)

At depths exceeding 1,000 ft., pillar splitting may be problematic due to the heightened risk of bursting. (Additional guidance can be found in Appendix G.)

Where retreat mining is proposed and the depth of cover exceeds 1,000 feet, mine operators should assess areas of high burst likelihood in advance of mining. The assessments should identify those areas of high burst likelihood based on the depth of cover, the geological conditions, the potential for multiple seam interactions, and recent ground control experience. The assessments should be guided by an experienced ground control professional and should be conducted as mining conditions/experience warrant, but at least on an annual basis.

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

A visible mark shall be placed on the CM to indicate the depth of cut.

The coal ribs shall be marked clearly to indicate the minimum size of the stump not to be mined. A drawing shall be included showing maximum fender width and minimum size final stump where applicable.

Prior to retreat mining, a mandatory test hole shall be drilled in each intersection to determine any separation in the strata. The depth of the hole shall be specified -- i.e., 2 ft. longer than the primary support installed. If the test holes are drilled during development they must be left open for examination. Such test holes shall be examined by a certified foreman prior to beginning retreat mining in the pillar(s) immediately inby. If any separations are detected, additional support such as longer bolts anchored above the separation, timbers, cribs, or crossbars shall be installed prior to retreat mining.

During retreat mining, a certified person knowledgeable in the retreat mining method being used shall be present on the working section during coal extraction.

During pillar recovery, no person except haulage equipment operators shall be inby the continuous mining machine operator while coal is being mined. In addition, all work or travel in the intersection immediately outby the pillar being mined shall be limited to those employees necessary to mine the coal and/or install supports. All personnel shall be positioned outby the active intersection during the last lift.

Under no circumstances shall anyone travel inby installed breaker posts.

A copy of the current approved roof control plan, including the retreat mining provisions of the plan, and any supplements shall be maintained on the section.

Prior to any retreat mining, all persons engaged in retreat mining (including new crew members) shall be trained in the provisions of the approved roof control plan relative to retreat mining. Training shall be conducted before retreating of a new panel begins. The operator shall notify the MSHA District Manager 24 hours prior to retreat mining a new panel.

Preshift and on-shift examinations should include a thorough assessment of geologic conditions, deteriorating conditions and additional stress resulting from abutment loading. Any hazards should be reported and either dangered off, or appropriately supported. Examinations should include at least the 1st and the 2nd rows of pillars outby the line of pillars being mined.

A roof/rib assessment should be conducted prior to retreat mining, to include underground mapping of geologic features, existing ground conditions, roof support installed, and unusual mining dimensions. The assessment should result in a hazard map that identifies actions to be taken prior to and during retreat mining, such as monitoring more closely, installing extra support, or skipping pillars. Such an assessment is particularly important if the proposed pillaring will be conducted in a previously mined section that was not developed with the intent to perform retreat mining.

The retreat mining provisions of the roof control plan are only valid for mining pillars in the sequence shown on the drawings that are included in the roof control plan. If panel configurations differ, such that the sequence in the drawings are no longer applicable, then an addendum shall be submitted and approved prior to mining that panel. This is especially important when the panel has a change of direction.

Mine-Specific Mobile Roof Support Units

The roof control plan should address the following items on a mine-by-mine basis. An evaluation should consist of determining whether the criteria is needed at a specific mine.

All section personnel shall be trained in the pillar recovery method using mobile roof support (MRS) units. Only persons who have received the proper task training are permitted to operate an MRS.

All personnel shall be positioned clear of all pinch points when an MRS unit is being trammed. Under no circumstances shall anyone be permitted beside or within the turning radius of the MRS when the unit is being moved.

Onboard manually operated controls or manual overrides shall be "locked out" or under a bolted-down cover plate to restrict their usage. These controls are for maintenance and troubleshooting purposes only.

Maintenance should be performed in areas where permanent roof supports are maintained outby the active pillaring area. If it is necessary to perform maintenance on a disabled MRS unit in an active pillar area, temporary supports shall be installed to adequately support the roof in the work area. In outby areas, temporary roof supports shall be set before pressurizing or depressurizing an MRS unit manually.

MRS units used in lieu of breaker or radius turn posts during mining of pillars shall be positioned for each cut as indicated on page _____ of the roof control plan. The position of each MRS unit shall be sequenced with the pillar lift as the lifts are mined. Some variations in the location of the MRS units may exist due to roof conditions present during pillar recovery. However, an MRS unit shall be kept as close as practical to the continuous mining machine during each lift.

While in the active pillaring area, the MRS units shall be operated in pairs, using the radio remote control. When moving from pillar lift to pillar lift, each MRS shall be advanced sequentially so that one unit will never be offset more than one-half the length of its companion unit. At least one unit of each pair shall be pressurized against the roof at all times. Umbilical remote controls shall not be used in the active pillaring area.

When setting and lowering an MRS unit, the unit operator shall be positioned in a safe location, at least 25 feet away from the unit. All other personnel shall be located outby the MRS operator during these processes and any time the units are moved between lifts. Miners shall not be allowed to congregate in the area when an MRS unit is being raised, set, lowered, or cycled.

While pillaring, MRS pressure gages or colored area lights shall be used to monitor roof loading.

Gages or lights shall be continually observed to determine if pillaring operations need to be stopped in a specific lift. Pillaring operations shall cease when the MRS yield pressure is reached (mining shall cease in that lift and the mobile roof supports will be moved and set-up for the next lift). The mobile roof supports have a yield pressure of ___ psi. If either the gages or the colored warning lights are not operational, then pillaring shall cease immediately until repairs are made.

Upon completion of mining in a given pillar, the MRS units should be moved sequentially, as set forth in safety precaution No. __ and as a group if four MRS units are in use until all the MRS units are between solid coal pillars. The MRS operator shall be positioned at a remote location outby the active pillaring area intersection during this move. Once the units are between solid coal pillars, the umbilical remote may be used for tramping to the next set-up location.

Immediately upon the completion of mining a block, the approaches to the gob will be supported according to the approved roof control plan.

When using four MRS units, if one of the units positioned inby the CM becomes inoperative, then one of the two MRS units positioned on the outby end of the pillar shall be moved inby the CM to provide two MRS units between the CM and the gob area. The remaining MRS unit on the outby side of the pillar shall be repositioned to act as a breaker at a location adjacent to the intersection as indicated on page _____. At this location, a minimum of eight posts or two cribs shall be used in place of the removed outby unit. The block of coal being mined may be completed in this manner, after which all four units must be operational before mining the next pillar.

When using two MRS units, if one becomes inoperative, mining shall be discontinued until the unit is operational or support procedures are used in accordance with provisions in the approved roof control plan for retreat mining using timber supports.

MRS cables shall be hung on break away hangers inby the last open crosscut. No hangers shall be retrieved from the blocks being mined.

Breaker posts may be pushed out with the MRS units to allow positioning when mining is started on a block. However, before dislodging posts with one MRS unit, its companion unit must be pressurized against the roof.

When parking an MRS unit for an extended period of time, it shall be positioned between solid coal pillars outby the active pillaring area. Each unit should remain in contact with the roof to prevent dynamic loading in the event of a roof fall. However, just enough set force to contact the roof should be used. The radio remote control units should be stored in a safe area away from the machines.

Mined heights in excess of the working range of the MRS units must be anticipated and shall be addressed using Original Equipment Manufacturer (OEM) extensions.

However, in isolated (unanticipated) cases, when an MRS unit cannot be set firmly against the roof, extensions meeting the following criteria shall be used to increase the reach of the MRS units:

- The extensions shall not exceed 18 inches in height, and shall be constructed from a single layer of wood blocks, placed skin-to-skin.
- The wood blocks shall be adequately restrained by channel or angle iron tack-welded to three sides of the MRS roof contact plate and held in place by chains, straps, or other equivalent means.
- Wood extensions as a means of extending the reach of the MRS unit shall only be used for a maximum of three rows of pillars.

LONGWALL MINING

Mandatory Standards

30 CFR 75.215 (a) and (b) requires that the roof control plan specify “[t]he methods that will be used to maintain a safe travelway out of the section through the tailgate side of the longwall,” and “[t]he procedures that will be followed if a ground failure prevents travel out of the section through the tailgate side of the longwall.”

30 CFR 75.222 (g) provides the following criteria on longwall mining systems that shall be considered on a mine-by-mine basis in the formulation and approval of a roof control plan:

- (1) Systematic supplemental support should be installed throughout –
 - (i) The tailgate entry of the first longwall panel prior to any mining; and
 - (ii) In the proposed tailgate entry of each subsequent panel in advance of the frontal abutment stresses of the panel being mined.

- (2) When a ground failure prevents travel out of the section through the tailgate side of the longwall section, the roof control plan should address—
 - (i) Notification of miners that the travelway is blocked;
 - (ii) Re-instruction of miners regarding escapeways and escape procedures in the event of an emergency;
 - (iii) Re-instruction of miners on the availability and use of self-containing self-rescue devices;
 - (iv) Monitoring and evaluation of the air entering the longwall section;
 - (v) Location and effectiveness of the two-way communication systems; and
 - (vi) A means of transportation from the section to the main line.

- (3) The plan provisions addressed by paragraph (g) (2) should remain in effect until a travelway is reestablished on the tailgate side of a longwall section.

In addition, the following items should be addressed in the roof control plan on a mine by-mine basis:

Specify the maximum widths of the setup and recovery rooms.

Specify the support installation sequences and the supplemental supports to be used in the:

- setup room,
- recovery room,
- adjoining crosscuts, and
- notches mined for conveyor drives and other equipment.

Specify the procedures that will be used during longwall face recovery, including:

- Meshing prior to the recovery point
- Shield recovery
- Safety precautions for wire ropes, slings, chains, fastenings, fittings, and attachments

Specify procedures to be used when a shield cannot be pressurized against the mine roof due to cavities. It should also specify procedures to be used when a shield cannot be pressurized against the mine roof due to hydraulic or other problems.

Specify safety precautions for using internal controls to advance and reposition shields.

A geological assessment of the headgate and tailgate entries should be conducted prior to longwall mining, to include (a) a review of past experience and geological data, and (b) underground mapping of geologic features, existing ground conditions, roof support installed, and unusual mining dimensions. The assessment should result in a hazard map that identifies actions to be taken prior to during longwall mining, such as monitoring more closely or installing extra support.

APPENDIX C

APPROVAL OF COMPLEX AND/OR NON-TYPICAL ROOF CONTROL PLANS AND
REVISIONS (ADDENDUMS)

All new roof control plans and revisions that are complex and/or non-typical should be evaluated to assure that plans provide for adequately designed support systems and pillar dimensions.

Roof control plans or revisions are considered complex or non-typical meet one or more of the following criteria:

- a) Room and pillar retreat mining at overburden depths of 1,000 feet or greater.
- b) Design criteria that do not meet or exceed the stability factors calculated using one of the three NIOSH software programs listed in Appendix E, Precautions for the Use of the NIOSH Pillar Analysis Computer Programs, or do not meet or exceed minimum safety criteria for other computer models used.
- c) Mines with a history of bounces or bumps, regardless of the amount of overburden cover.
- d) Other criteria considered unusual by the District Manager.

For complex and/or non-typical plans or revisions, the mine operator should provide the data and engineering evaluations conducted to support their determination that systems provide safe work environments for miners, and that pillar dimensions are compatible with effective control of the roof, face, and ribs and coal or rock bursts.

The mine operator should submit with any complex and/ or non-typical plan or revision the following:

- a) A risk assessment specific to the particular mining operation that includes depth of overburden, coal strength, pillar recovery method and development and retreat stability factors. The risk assessment should contain a statement detailing the basis on which the operator has determined that the plan is appropriate and suitable to the mining conditions.
- b) Where recommendations are made by consulting engineers, the operator should provide the reports upon which the assertion of adequacy depends and direct the consultants to cooperate fully with the MSHA Plan Reviewers in verifying their conclusions.
- c) Data from currently available tools such as ARMPS, ALPS, AMSS, LaModel, RocScience, or other applicable software. MSHA may compare the proposed plan evaluation method against a different evaluation system developed by third parties.
- d) Where plans are based in any part on empirical information, the operator should provide information sufficient to permit field evaluations of the installed systems and verification of the similarity in mining conditions. Such plans are those using a support system or pillar dimensions proven to work under similar mining conditions, e.g., similar mining depth and roof conditions. This information can be included with the operator's statement in (a) above that the plan is appropriate and suitable to the mining conditions.
- e) A detailed and comprehensive review of technical and engineering data submitted in support of the proposed plan, and an analysis of potential hazards and other relevant factors.

The MSHA Plan Reviewer should first establish that the submitted supporting information is adequate, given the complexity and severity of the mining environment, and request additional information if needed. The evaluation should also include previous plan submittals and approvals, citation history, and roof fall accidents (injury and non-injury). A site visit shall also be made by District personnel where applicable.

The assistance of MSHA's Technical Support Roof Control Division should be sought and their recommendations considered in all complex or non-typical plan approvals and revisions.

The District Manager should not approve the proposed plan or revision until the operator has provided the data and evaluation supporting the proposal and MSHA has completed a confirming evaluation. MSHA should keep all plan review information as long as the plan is in effect that explains the rationale behind the approval of plan or revision, including the completed appropriate checklist evidencing the review with signatures, dates and comments.

When and where site- or mine-specific pillar size and pillar stress loading design tools have generated reliable design parameters and reliable minimum safety factors, those validated parameters may be used as a basis for plan approvals for mining under the same or less severe conditions.

APPENDIX D

GUIDELINES FOR CONDUCTING PILLAR STABILITY ANALYSES

MSHA's standard at **30 CFR 75.203 (a)** states that "[p]illar dimensions shall be compatible with effective control of the roof, face and ribs and coal or rock bursts." To comply with this standard, the retreat mining portion of the roof control plan submittal should include an engineering design and supporting analysis. The analysis method is at the discretion of the mine operator. The pillar recovery sections of roof control plans submitted to MSHA for approval should include:

- A brief description of the pillar design analysis method used including design software version (release number).
- The listing or identification of pillar stability factors or safety factors for the analysis method used.
- A pillar design that meets or exceeds the generally accepted, or recommended design criteria, for the analysis method used or meets mine-specific design criteria that is supported by sufficient documentation and mining history.

Pillars whose calculated stability factors do not meet or exceed the design criteria listed in one of the NIOSH software programs listed in Appendix E, "Precautions for the Use of the NIOSH Pillar Analysis Computer Programs," or that do not meet or exceed minimum safety criteria for other computer models used, should be considered complex or non-typical. See Appendix C, "Approval of Complex or Non-Typical Roof Control Plans and Addendums."

Pillar stability analyses for plan reviews can be either:

- *Generic*, using the maximum depth of cover, typical mining height, and other input parameters contained within the roof control plan, or
- *Site-specific*, using actual input parameters obtained from mine maps, mining projections, and/or underground measurements.

Generic analyses are most appropriate for new mines submitting their first roof control plans. Site-specific analyses should be conducted for base plans submitted for operating mines, six-month reviews, and addendums involving proposed mining. The discussion below applies primarily to site specific analyses.

The first step is normally to review the results of analyses submitted by the operator or conducted by MSHA as part of previous reviews. These analyses can help in the selection of the most appropriate software and input parameters. Also, when and where previous site specific pillar stability analyses have generated reliable design parameters and minimum stability factors; those validated features may be used as a basis for plan approvals for mining under the same or less severe conditions. For example, if a previous analysis shows that a satisfactory stability factor was obtained where the depth of cover was greater than it is now, and no other parameters have changed significantly, then it may not be necessary to conduct a new analysis.

The next step is to determine which pillar analysis software will be employed. ARMPS is used most often, because it is applicable to development mining, room and pillar retreat mining, and many bleeder pillar analyses. The Analysis of Longwall Pillar Stability (ALPS) program is most appropriate for evaluating the tailgate corner of longwall panels. The Analysis of Multiple Seam Stability (AMSS) program is suitable for situations involving potential multiple seam interactions, and it incorporates ARMPS and ALPS evaluations. Detailed instructions for using these NIOSH programs can be found in the programs' Help files. If a plan was developed using other pillar analysis programs, such as LaModel or RocScience, Technical Support's assistance should normally be requested.

In determining which mine layouts are to be analyzed, the Reviewer typically looks for the "most severe" conditions, defined as the conditions that will generate the lowest pillar stability factors. Often, these will be found under the deepest cover. However, they may also occur where the mining height is greatest, where smaller pillars are used, or where abutment loads are the greatest. In the case of multiple seam interactions, the most severe conditions can occur where the interburden is thinnest, where isolated remnant pillars are present in previously mined seams, and/or where the active seam has been undermined. Often, the Reviewer should select several sites to analyze because it may not be immediately evident which condition is the "most severe."

A critical step is the collection of the input data. The depth of cover is often the most important parameter. It is normally obtained from a mine map that includes depth of cover contours. Alternatively, it can be obtained by subtracting the coal seam elevation from the surface elevation. The Help files included with the NIOSH programs contain further guidance on determining the depth of cover. Mine maps are also essential for evaluating the ARMPS loading condition, barrier pillar widths, the type of remnant pillar, gob dimensions, and other such parameters.

The mining height is also extremely important. Inspectors' notes can be a very valuable source of data, since the "total mining height" should be measured at the site of each air reading. Also, some mine maps contain "coal sections" that provide information on the thicknesses of the coal and rock layers mined underground. The ARMPS Help file provides guidance determining the input mining height when rock is mined with the coal. Also, it is normally appropriate to input the *average* mining height over the area to be analyzed.

Nominal dimensions for entry centers, crosscut centers, and entry widths are normally used in the analyses. The nominal entry and crosscut centers are the projected planned mining dimensions with slight variation expected from the actual mining procedures. The nominal entry width is the typical initial mining width before rib spall. Nominal dimensions are used so that the results can be directly compared with the NIOSH case history data bases that were used to calibrate the programs. In very exceptional cases, it may be appropriate to make adjustments for excessive rib sloughage or off-center mining. When using NIOSH programs, the default values for parameters such as the in situ coal strength and the abutment angle should also be employed.

Pillar stability analysis with NIOSH software should be conducted using guidance contained in the program Help files, the professional literature published by NIOSH and MSHA authors, and MSHA guidance documents such as Appendix E. In house resources, such as Technical Support

experts, are also good sources of information. To check that an analysis submitted by an operator was conducted properly, it may only be necessary to ensure that the proper input data was employed.

If a pillar stability analysis of mining projections indicates that the calculated stability factors do not meet or exceed the NIOSH design criteria listed in Appendix E, or do not meet or exceed minimum safety criteria for other computer models used, then the results of the analysis should be discussed with the operator. If the operator subsequently proposes changed mining projections, then those new projections should be analyzed using the procedures just described. If changes to the mining projections are not subsequently proposed by the operator, then the procedures described in Appendix C on “Approval of Complex and/or Non-Typical Roof Control Plans and Addendums,” should be followed.

Documentation of pillar stability analyses should be maintained. This may be accomplished by printing the output file and including it in the mine file, saving the input file to a network drive, entering the information into a spreadsheet, or some other method.

APPENDIX E

PRECAUTIONS FOR THE USE OF THE NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH (NIOSH) PILLAR ANALYSIS COMPUTER PROGRAMS

The National Institute for Occupational Safety and Health (NIOSH) has developed software to aid in the analysis and design of coal pillars and underground mine layouts. The three NIOSH software programs discussed here, and the links to obtain them, are:

1. Analysis of Retreat Mining Pillar Stability (ARMPS)
www.cdc.gov/niosh/mining/works/coversheet1813.html
2. Analysis of Longwall Pillar Stability (ALPS)
<http://www.cdc.gov/niosh/mining/works/coversheet1807.html>
3. Analysis of Multiple Seam Stability (AMSS)
www.cdc.gov/niosh/mining/works/coversheet1808.html

ARMPS, ALPS, and AMSS are easy to use because they require minimal user inputs beyond the panel geometry and depth of cover. The programs calculate “stability factors” (SF) that can be compared to NIOSH recommendations or other criteria. The NIOSH SF recommendations were derived from real world mining experience, using statistical analysis of large databases of successful and unsuccessful mining case histories. The programs are accompanied by extensive “help” files that provide guidance for their use. The programs also include other resources, including technical papers that describe research that resulted in their development. Users of the programs should periodically check the NIOSH website to ensure that they are using latest versions.

In many cases, the NIOSH programs are the simplest and most reliable engineering techniques available for sizing coal pillars. MSHA strongly encourages mine operators to use these programs to help ensure that pillar dimensions are compatible with effective control of roof, face, and ribs and coal or rock bursts.

Information for users of all ALPS, ARMPS, and AMSS

Coal Strength Input. NIOSH recommends that 900 psi be used for coal strength if comparisons are to be made with the case history databases and NIOSH recommended stability factors. For example, the current version of ARMPS will display the following warning if the user selects a coal strength value other than 900 psi:

The ARMPS case history data base was analyzed with an in situ coal strength of 900 psi. Stability factors (SF) obtained with a different in situ coal strength may not be comparable to the suggested stability factor values obtained from NIOSH’s analysis of the data base. Also, NIOSH research has shown that the reliability of the ARMPS design method decreases substantially when laboratory coal strengths were used in place of the default value. For more information, see Help/Resources/In situ strength of coal [Available in the ARMPS Help file].

Unit Weight Input. Typical unit weights for coal measure rocks range from about 150 to 170 pounds per cubic foot. An unreasonably low value, e.g. entering coal density rather than rock density or a typographical error, could result in an underestimate of applied load and, consequently, inappropriately high stability factors.

The current version of ARMPS will display the following warning if the user selects an overburden unit weight other than 162 pounds per cubic foot:

The ARMPS case history database was analyzed with an overburden unit weight of 162 pounds per cubic foot. Stability factors obtained with a different overburden unit weight may not be comparable to the suggested stability factor values obtained from NIOSH's analysis of the database.

Entry Height Input. ARMPS users should note that the value entered for entry height is the mined height of the pillars, which is not necessarily equal to the seam thickness. Some engineering judgment may be exercised when the mined height contains a significant amount of rock. If the strength of the mined rock is approximately the same as the coal, then the full mined height should be entered. Where the rock is significantly stronger than coal, some reduction in the mined height may be justified. Further details can be found in the ARMPS help file.

Depth of Cover Input. The appropriate depth of cover may be difficult to determine in mountainous terrain. The most recent NIOSH guidance for calculating the depth of cover is in the ARMPS help file.

Information for users of ARMPS

Breadth of Active Mining Zone (AMZ) Input. Users should be aware that stability factors determined using breadth of Active Mining Zone (AMZ) values other than the ARMPS default, i.e., five times the square root of the overburden, are inconsistent with those in the ARMPS database. Stability factors determined using a consistent AMZ value other than the default could be compared to one another to assess relative stability but they should not be compared directly with those in the ARMPS case history database. Older versions of ARMPS provide no warning if a breadth of AMZ value other than five times the square root of the overburden is input to the program.

The current version of ARMPS will display the following warning if the user de-selects the box titled "Set AMZ automatically":

The ARMPS case history data base was analyzed with the breadth of the Active Mining Zone (AMZ) calculated automatically (AMZ = five times the square root of the depth of cover). Stability factors obtained with a different AMZ may not be comparable to the suggested stability factor values obtained from NIOSH's analysis of the data base. For more information, see Help/Project Input Parameters [Available in the ARMPS Help file].

Pressure Arch Factor Input. Users should be aware that stability factors determined using Pressure Arch Factor (Fpa) values other than the ARMPS default, i.e., 0.28 times the natural log of the depth-to-panel-width ratio, are inconsistent with those in the ARMPS database. Stability factors determined using an Fpa value other than the default could be compared to one another using a consistent Fpa to assess relative stability but they should not be compared directly with those in the ARMPS case history database. Older versions, prior to version 6, of ARMPS do not include the pressure arch function.

The current version of ARMPS will display the following warning if the user de-selects the box titled “Set arch factor automatically”:

The ARMPS case history data base was analyzed with the Pressure Arch Factor (Fpa) calculated automatically (Fpa=0.28 times the natural log of the depth-to-panel-width ratio). Stability Factors (SF) obtained with a different Fpa may not be comparable to the suggested SF values obtained from NIOSH’s analysis of the data base. For more information, see Help/Project Input Parameters [available in the ARMPS Help file].

Mining with one active section and two side gobs. Mine operators are discouraged from employing mine layouts in which pillars will be extracted between two previously worked-out gob areas. The current version of ARMPS will display the following warning if the user selects the loading condition “one active section and two side gobs”:

In the ARMPS data base, of the 19 case histories of Active Retreat and Two Side Gobs under deep cover, only 7 were successful. This extraction sequence should be avoided if possible.

None of the 12 unsuccessful cases in the NIOSH data base employed adequate barrier pillars. If a retreat section is located between two side gobs, it is essential that adequate barrier pillars be in place to protect it from both side gob loadings.

Unusual Mining Situations. Many real-world retreat mining scenarios entail mining configurations that ARMPS does not directly address. Some examples include pillars that are left at the mouth of a retreat panel that function as a “composite barrier pillar,” floor being extracted on retreat which increases the mining height, and more than one row of bleeder pillars is left in an adjacent, previously mined panel. Some solutions to these and other situations have been developed by MSHA Technical Support, Roof Control Division, and can be downloaded from <http://icgcm.conferenceacademy.com/papers/detail.aspx?iid=933>.

ARMPS Design Criteria. The most recent version of ARMPS includes the design criteria that are summarized in the tables below. NIOSH recommends a universal minimum ARMPS production pillar stability factor of 1.5 for all depths, and minimum barrier pillar stability factors of 1.5 are recommended when the depth exceeds 650 feet. For narrow panels with stronger barrier pillars, NIOSH suggests that the ARMPS production pillar SF may be somewhat reduced.

Table 1.—Standard ARMPS Design Criteria

Depth of Cover (ft)	Panel Width (ft)	ARMPS SF	Barrier Pillar SF
<650	Any	1.5	No Recommendation
>650	Any	1.5	1.5

Table 2.—Alternate ARMPS Design Criteria

Depth of Cover (ft)	Panel Width (ft)	ARMPS SF	Barrier Pillar SF
650-1,000	<425	$1.5 - (0.20 \times (H - 650/350))$	2.0
>1,000	<425	1.3	2.0

Site-specific criteria used in lieu of NIOSH's recommendations should be developed cautiously using multiple case histories with known conditions at a given mine. Back analysis is most appropriate for mines that have a proven track record of retreat mining. In these cases, proper examination of individual mine data may demonstrate that stability factors above or below NIOSH's recommended values are warranted. Proper examination would entail an analysis of the broad experience at a mine site rather than a focus on isolated case(s) that represent a limited extreme. Also, it is imperative that back analyses consider barrier pillar stability factors as well as pillar stability factors, especially at depths greater than 650 ft.

ARMPS criteria should be reevaluated if difficult ground conditions are experienced or if changes in mining conditions, e.g., geology or roof support type or density, are anticipated. Back-calculated stability criteria should be used only in conditions that are consistent with the mine-specific case histories. For example, an ARMPS stability factor developed from retreat mining experience in routinely developed panels of pillars may be inappropriate for recovery in older workings, e.g., mains or submains. Often these older workings contain irregularly shaped pillars that complicate the recovery process and may not be modeled effectively in ARMPS. Furthermore, the pillars, floor, roof, and roof supports may have suffered deterioration over time, making older workings unsuitable for pillar recovery. Site-specific stability factors that are less than the NIOSH recommendations should not be used unless they are determined to be appropriate for the area to be mined.

Designs using Pressure Arch Factor. Users should be aware that in the deeper mining cases ARMPS uses a pressure arch algorithm to estimate the design loadings carried by the pillars in the AMZ. The algorithm was derived from statistical analysis of the ARMPS data base.

Most of the 645 case histories in the data base were obtained from mines located in UT, CO, VA, eastern KY, and southern WV. The pressure arch behavior of the overburden in these locations may differ from that in other mining regions. Users should exercise caution, make conservative assumptions, and use prudent engineering judgment when applying the pressure arch algorithm in other mining regions.

The current version of ARMPS will display the following warning if the stability factors are calculated using a Pressure Arch Factor that is less than 1.0:

The Pressure Arch loading model used in ARMPS v6 was derived from analysis of case history data from the Western and Central Appalachian coalfields in the US. The overburden rock in these two coalfields is relatively strong. No research has been conducted to test the applicability of the pressure arch loading model in other coalfields.

Complicated Panel Geometries. The ARMPS program was developed to accommodate geometries commonly used in room and pillar retreat mining operations. However, some complicated geometries cannot be modeled directly. The latest version of ARMPS, version 6, can account for a row of pillars left to establish a bleeder system adjacent to mined-out panels, opposite mined-out panels, and in adjacent mined-out panels. Older versions of the software cannot. Users should exercise caution, make conservative assumptions, and use prudent engineering judgment in applying ARMPS to geometries that are not standard in the program.

Information for users of ALPS

Coal Mine Roof Rating Input. NIOSH developed the Coal Mine Roof Rating (CMRR) to measure the structural competence of mine roof on a rating scale from 0 to 100. The CMRR may be calculated from either underground exposures, such as in roof falls, or from logging and testing exploratory drill core. Details on the CMRR can be found in the CMRR computer program, available at <http://www.cdc.gov/niosh/mining/works/cover sheet1812.html>. The ALPS SF values recommended by NIOSH are dependent upon the CMRR input. The ALPS program shows the recommended ALPS SF for a default CMRR=35. Any changes to the default CMRR value should be thoroughly justified with geologic and/or engineering data.

Loading Condition. The ALPS output includes calculated SF values for five loading conditions—development, headgate, bleeder, tailgate, and isolated. However, ALPS was developed primarily to help prevent blockages of tailgates. The ALPS data base only contains case histories of successful and unsuccessful tailgates, and so the NIOSH SF recommendations only apply to the tailgate loading values. Those values are marked with three asterisks in the ALPS output.

ARMPS, rather than ALPS, should be used to analyze most other situations involving development, bleeder, and isolated loadings. ARMPS models of these situations are more accurate because ARMPS now includes a pressure arch factor in its loading model and ALPS does not.

ALPS Design Criteria. The ALPS output presents two sets of SF, labeled “Classic ALPS” and “ALPS(R).” The Classic ALPS analysis modeled the pillars with the original Bieniawski pillar

strength formula, which assumes that the pillar strength is constant regardless of the pillar's length-to-width ratio. The ALPS (R) model used the Mark-Bieniawski formula, which does consider the effect of pillar length. NIOSH developed recommended values for both from statistical analyses of ALPS data base. The formulas for calculating the NIOSH recommended SF values are:

- Recommended Classic ALPS SF = 1.76 - 0.014 CMRR
- Recommended ALPS SF(R) = 2.00 - 0.016 CMRR

Because the ALPS(R) model is more accurate, in most cases, it is the preferred one to use. However, mines that have experienced long-term success with square pillars sized according to the Classic ALPS recommendations may continue to use that formula. In the ALPS program, the recommended SF values are shown on the Input/Parameters page on the CMRR/Sizing tab.

Supplemental Support Installed in the Tailgate. NIOSH did not provide any explicit guidance regarding supplemental support with ALPS program. However, most of the successful tailgate case histories included in the ALPS data base employed a level of supplemental support equivalent to two rows of wood cribs. Consequently, to be comparable with the ALPS data base, longwall tailgates should: (1) employ pillars that meet the NIOSH ALPS SF recommendations, and (2) also install appropriate supplemental support for their mining conditions.

Information for users of AMSS

Type of Multiple Seam Interaction. NIOSH developed AMSS to help identify the location and likely severity of the two most common types of interactions, namely (1) *undermining*, where stress concentrations caused by previous full extraction in an overlying seam is the primary concern, and (2) *overmining*, where previous full extraction in an underlying seam can result in stress concentrations and rock damage from subsidence. AMSS should not be used to analyze two other types of multiple seam interaction, namely (3) *dynamic* interactions that occur whenever active mining occurs above or beneath open entries that are in use, or (4) *ultra-close* interactions that occur when two seams are mined very close together, but no full extraction has taken place.

Coal Mine Roof Rating (CMRR). In an AMSS evaluation, the roof quality for the active seam, the seam being mined, is an important input parameter. The default value in the AMSS program is CMRR=45. Higher values of the CMRR should not be employed unless they can be thoroughly justified with geologic and/or engineering data.

NIOSH selected the default value of the CMRR because the NIOSH multiple seam data base contains few cases where the CMRR is less than 45. However, if the actual roof rock is weaker than CMRR=45, then it is essential that an appropriate lower value of the CMRR be entered into AMSS to prevent a misleading and non-conservative result.

Identification of Remnant Structures. The multiple seam interactions that AMSS can evaluate only occur above or below remnant structures in the previously mined seam. A remnant structure is normally a coal pillar or solid coal that was left adjacent to a worked out gob area.

Details on identifying remnant structures, and classifying them as either gob-solid boundaries or isolated remnant pillars, is contained in the AMSS Help file.

Users of AMSS should also be aware that, under some circumstances, remnant structures can be present without adjacent full extraction. For example, if an area contains a number of developed pillars that have yielded, they may have shed load in the same manner as a worked out gob area. If the map of the previously mined seam shows that such an area may exist, the pillars within it should be evaluated with ARMPS. If low ARMPS SF is calculated, then yielding should be presumed and the region treated as a gob for the analysis.

AMSS Design Criteria. An AMSS evaluation of a potential multiple seam interaction has two components. The first is pillar stability. After first adjusting the pillar loads to account for the multiple seam interaction, AMSS uses either ALPS or ARMPS to determine multiple seam pillar SF. That SF is then evaluated using the standard NIOSH design criteria for ALPS and ARMPS. The second component is labeled “Predicted Stability” on the AMSS output page. It is a color-coded condition that has three levels:

- GREEN: A major interaction is unlikely.
- YELLOW: A major interaction should be considered likely unless a pattern of supplemental roof support (cable bolts or equivalent) is installed.
- RED: A major interaction should be considered likely even if a pattern of supplemental roof support is installed.

Users should be aware that the two components are calculated independently of each other, and both should be considered when evaluating the likelihood of a multiple seam interaction.

APPENDIX F

GENERAL GUIDELINES FOR THE USE OF NUMERICAL MODELING TO EVALUATE
GROUND CONTROL ASPECTS OF PROPOSED COAL MINING PLANS

Effective mine design has long been recognized as an essential element in establishing safe and productive mining operations. Over the years, numerous empirical and analytical techniques (e.g. Analysis of Retreat Mining Pillar Stability (ARMPS) and Analysis of Longwall Pillar Stability (ALPS) computer programs) have been developed to analyze pillar stability. These methods can provide a reasonable estimate of pillar strength and stability under specific conditions and relatively simple mining geometries. In practice, however, situations often arise where areas of concern contain pillar configurations with varying entry and crosscut orientations and widths in addition to differing pillar dimensions. Additional factors such as non-uniform pillar lines, remnant stumps scattered throughout irregularly shaped gobs and multiple seam mining can further complicate an analysis. In such instances, application of empirical and analytical methods to evaluate ground stability is difficult. To evaluate mining configurations and sequences not easily treated by simplified empirical or analytical methods, numerical modeling methods (i.e., boundary element, finite element) can be employed.

Simulation Process

The following is an eight-step process developed by MSHA, Technical Support, Roof Control Division for the simulation of underground mining systems.¹ While it is specifically directed to numerical modeling applications, it can also be used in conjunction with empirical or other analytical methods.

1. **Observe Underground Areas** - This is an essential first step in solving ground control problems regardless of the methodology employed. Mine conditions should be categorized in a number of areas where differing pillar sizes, panel configurations and overburden levels are found. A deterioration index rating system, discussed below, can aid in the description of in-mine ground conditions.
2. **Estimate Model Parameters** - Coal, rock and gob properties must be established consistent with the requirements of a particular numerical method. Ideally, those properties will be based on coal and rock tests of the specific mine site. In the absence of that data, published properties of adjacent or same seam mines can be used. It should be noted that laboratory values tend to overstate the actual in-situ properties. Consequently, it is appropriate to apply a reduction factor, based upon specimen size, to the laboratory values. As an example: strength reduction factors of 1/5 for 2-inch cubes and 1/4 for 3-inch cubes have been used to estimate in situ coal strength from test data. When no site-

¹ Karabin, G.J., and M. A. Evanto. Experience with the Boundary Element method of Numerical Modeling as a Tool to Resolve Complex Ground Control Problems. Proceedings of the 13th International Conference on Ground Control in Mining, WV Univ., August 1994, pp. 201-213.

related data is available, general coal and mine roof rock properties can be used, or the default values offered in the software, can be employed. Regardless of the source of data, it cannot be overemphasized that they represent only a first estimate of mine roof and rock properties that must be validated.

3. **Model Observed Areas** - The third step of the process involves modeling each of the areas observed underground. The properties estimated above are tested under various geometric and overburden conditions to determine their suitability to accurately model observed areas. Successfully modeling many areas under a variety of different conditions increases confidence in the properties used.
4. **Verify Model Accuracy** - This is the most critical step in the entire simulation process. Each of the areas modeled must be closely examined to ensure that the results correlate with observed conditions. If reasonable correlations cannot be made, the model must be recalibrated (material properties adjusted) and the process repeated. It should be noted that relating the output of numerical models (stress, convergence, etc.) to observed conditions (pillar sloughing and roof or floor deterioration) is often difficult given the complexities of the underground environment. The use of a deterioration index rating system, discussed below, can simplify the task of verifying model accuracy.
5. **Establish Threshold Limits** - Once the accuracy of the model is verified, threshold limits delineating acceptable and unacceptable mining conditions must be established to evaluate the effectiveness of proposed design alternatives. Pillar safety factors, stress, or convergence levels corresponding to deteriorating ground conditions can be identified. Other factors such as the extent of pillar yielding or predicted pillar, roof and floor conditions can also be used.
6. **Model New Configurations** - Having established an effective model and a means of evaluating the results of analyses, new mining techniques can be simulated. Generally, several alternatives are modeled under the conditions expected at the mine location where the design will be implemented.
7. **Evaluate New Configurations** - The various alternatives can be evaluated relative to the threshold limits established. For instance, if specific pillar safety factors, stress, and convergence values were found to correspond to deteriorating ground conditions, an alternative that produces levels lower than those values would be desired. However, if none of the configurations evaluated meet the threshold requirement for stable conditions, then new alternatives must be developed and analyzed.
8. **Implement Best Alternative** - Once the best alternative is identified (either meeting the threshold criteria or providing the most favorable conditions), it can be cautiously implemented. The level of confidence in achieving a successful design is directly proportional to the breadth of the evaluation and the degree of correlation noted in the

model verification process. In any event, conditions should be closely monitored as the design is implemented, and any deviations from the expected behavior would warrant reassessing the mining plan and recalibration of the model.

Deterioration Indices

As mentioned previously, the most critical phase of the simulation process is verifying the accuracy of a model through correlation with actual underground conditions. To aid in the evaluation of in-mine ground conditions and verification of model accuracy, a set of deterioration indices should be established to quantify pillar, roof and floor behavior. For example, observed in-mine locations could be assigned a numerical rating on a scale of 0 - 5 (0 being the best condition and 5 the most severe) in each of the three categories: pillar, roof and floor. The deterioration index levels should be reasonably well defined to minimize subjectivity of observations and promote consistency in ratings from site to site and from observer to observer.

Guidelines for the Boundary Element Method

While the above simulation process and deterioration indices can be applied to numerical modeling in general, the following topics specifically address the boundary element method (BEM) of numerical modeling for coal mining applications.

Mining Geometry

An essential step when using the boundary element method is creating a model grid that duplicates the in-mine geometry. The seam must be broken into elements of a size that allows the entry, crosscut and pillar dimensions to be accurately reproduced. Seam elements must be small enough to model details of the mine geometry and produce discernible differences in performance, yet large enough to allow broad areas of the mine to be included in the simulation.

As a general rule, setting the element size at one-half the entry width has provided acceptable results in most coal mining applications. A 10-ft. element width (for a 20-ft.-wide entry/crosscut configuration) should enable a large area to be modeled and yet provides the stress and convergence detail needed to effectively evaluate conditions. Both larger (1-entry width) and smaller (1/4-entry width) element sizes can be used for specific applications, but are limited in application to scenarios where detail (small elements) or influence area (large elements) are considered critical for the analysis.

A number of other geometric guidelines have been identified that can aid in creating an effective boundary element model:

- To the extent possible, locate model boundaries over solid coal or known stable areas to reduce the likelihood of erroneous loading conditions (transferred stress from adjacent yielded areas not propagating into the zone of interest).

- Orient the model such that the primary areas of interest are positioned away from the model boundaries to minimize end effects.
- Known or potential yielding pillars should not contain linear-elastic elements which could erroneously affect the stress transfer to adjacent areas.
- Known or potential yielding pillars should contain an odd number of elements across the minimum dimension to ensure accurate pillar strength and peak core stress calculations.
- Care should be taken when entries or crosscuts are not oriented at 90° angles to ensure that the effective widths and percent extraction match the actual mine geometry.

Rock Properties

The rock mass properties needed for the non-seam elements in BEM modeling are minimal, because most BEM simulate the rock mass as linearly elastic material. Initially, it would appear that treating a complex rock structure in such a simplistic manner would not be appropriate. However, considering that stresses on pillars within the seam are generated through massive main roof loading (generally remaining in elastic compression), it is not unreasonable to expect an effective representation of pillar loading.

One widely used BEM program, LaModel, represents the rock mass as a stack of layers piled atop one another. The layered formulation in LaModel uses an additional input parameter, layer thickness, that can be adjusted to allow more flexible and realistic strata behavior. In LaModel, it is important to recognize the effect of layer thickness. Using thin laminations will result in roof that tends to sag readily into the mine openings and load the edges of pillars. As a result, the rock mass is less apt to span across openings or failing pillars and does not transfer load over a long distance.

Coal Properties

Establishing representative coal properties for a BEM analysis is a critical step in model formulation. Yielding seam capability is needed to accurately simulate the complex underground environment where localized coal failure results in the redistribution and concentration of stress into adjacent areas. The suitability of assigned coal properties can be assessed by comparing the simulation output to observed pillar conditions. Test models should include underground areas (varying depths and pillar sizes) where definite observed pillar behavior can be documented and reflects the differences in depth and pillar size. For instance, if a model with 8-ft.-wide elements predicts corner yielding, significant sloughing and crushing for a length of 8 ft. from the pillar corner should be obvious. A similar condition would be expected along the sides of pillars if perimeter yielding were projected. In general, more observed pillar deterioration than projected by the model suggests that the coal strength has been overestimated and less sloughing than predicted indicates it has been underestimated. There are occasions, however, where the element size itself can contribute to erroneous interpretations. For example,

a model using 10-ft. elements may indicate elevated stress at the pillar corners, but no yielding. However, underground observations reveal 4-ft. crushed zones at the pillar corners, suggesting that the model coal strength has been overestimated. Remodeling the area using 4-ft. elements (with corresponding recalculation of element properties) may result in the prediction of corner yielding that would match the in-mine conditions.

When constructing calibration models to verify coal strength, it is essential that:

- the element size selected is appropriate to illustrate phenomena (yielding) observed underground;
- element properties are recalculated when element sizes are changed or when different mining heights are simulated, as smaller elements have lower strength values than larger ones because of their proximity to the free face, and taller elements are inherently weaker than shorter ones.

Gob Properties

When numerical models contain large mined areas such as longwall or pillar line gobs, some mechanism must be employed to simulate caving and stress relief associated with those areas. Without it, the full weight of the overburden would be transferred to adjacent areas and result in a significant overestimation of abutment loads. The stress redistribution process is complex and is comprised of caving, bulking and subsequent compaction of the gob material. As with other material properties, the suitability of the gob material properties that essentially treat the gob as a backfill must be verified. The use of a gob material that is too stiff will result in excessive gob loading and reduced abutment loads. Conversely, a gob material that is too soft will generate excessive abutment loads and low-gob stress. The modulus of elasticity of the rock mass and other geometric parameters (panel width, lamination thickness, etc.) can have a significant impact on gob backfill loading and must be considered. Examining gob backfill stress can indicate the amount of stress redistribution simulated by the model and can be compared to known or anticipated cave heights associated with those areas.

APPENDIX G

PILLAR RECOVERY DESIGN, TECHNOLOGIES, AND PROCEDURES
IN ROOF CONTROL PLAN APPROVALS OR REVIEWS

MSHA's standard at **30 CFR 75.203 (a)** states in part that "[t]he method of mining shall not expose any person to hazards caused by ... faulty pillar recovery methods." MSHA Plan Reviewers should pay particular attention, including examining inputs and other factors used to support the proposed plan, when pillar recovery provisions of a roof control plan are submitted under any of the following conditions:

- Pillar recovery at depths exceeding 2,000 feet may not be appropriate due to the heightened risk of bursts at such unusual and extremely deep cover. In most cases, when an entire pillar is over 2,000 feet deep, careful analysis may determine that the pillar should be a "Leave Pillar" that should not be retreat mined. When any portion of a pillar is less than 2,000 feet deep (i.e., any portion of pillar is outside the 2,000 foot depth of cover contour), and the pillar is judged to have a stability factor or safety factor that meets design criteria, then in many cases it may be technically sound to allow the pillar to be recovered by retreat mining following an approved roof control plan.

At depths exceeding 1,000 feet, the practice of pillar splitting may be particularly problematic, due to the extremely high stresses and burst-prone conditions existing in the core of pillars adjacent to the gob. Plans including such a proposal should be carefully examined.

Instructions Pertaining to Roof Control Technologies

MSHA Plan Reviewers should pay special attention to the following roof control technologies when evaluating roof control plans or amendments for coal mine room and pillar retreat mining:

- Whether the plan leaves an engineered final stump rather than extracting the entire pillar. The final stump that is not to be mined should be clearly marked on the pillar rib or mine roof.
- For room and pillar retreat mining sections, whether supplemental roof bolts that are longer and stronger than the mine's primary roof bolting system are to be installed on advance, particularly in intersections.
- Whether the plan calls for mechanized Mobile Roof Support (MRS units), rather than traditional wood timbers, for the roof-to-floor standing support for the mining of cuts or lifts into the pillar.

Instructions Pertaining to Pillar Recovery Procedures

MSHA Plan Reviewers evaluating roof control plans for coal mine room and pillar retreat mining should pay particular attention to the following pillar recovery procedures:

- Whether the plan for pillar recovery describes a cut and support sequence that maximizes ground stability and safety.
- Whether the mine site ground conditions warrant limiting access to just one roadway into the intersection when the last lifts for a pillar are taken.
- Whether the mine site ground conditions warrant having supplemental support installed in the entry and/or crosscut in addition to being installed in the intersections.
- Whether the plan describes safe work locations for miners while coal is being mined or loaded.
- Whether the plan incorporates best practices for using MRS units identified in Appendix M Use of Mobile Roof Supports (MRS) Units for Retreat Mining.

Instructions Pertaining to Communication with the Mine Operator

When roof control plans for room and pillar retreat mining are being reviewed for approval, MSHA should discuss the following items with the mine operator so that the mine operator can develop a suitable roof control plan:

- Preshift and on-shift examinations should include a thorough assessment of geologic conditions, and hazards should be reported and dandered off, or appropriately supported. Examinations should include areas outby the pillar line to anticipate geologic conditions prior to pillar recovery. Roof fall accident studies reveal that in more than one-third of the fatal incidents, poor conditions were observed in the area before the fatality occurred, but no action was taken.
- Conducting a geologic assessment of the entire panel before retreat mining begins is a prudent practice. The assessment should identify major roof fractures, which can then be marked, mapped, and supported. It is good practice to plan to skip lifts or not recover pillars to leave coal as support to avoid such adverse features.
- Test holes are useful to determine if there is roof separation and they can be monitored during retreat mining to see if conditions worsen.
- The pressures and loading rates of MRS units can provide information on roof stability. Mine-specific trigger points indicating unusually high loads or loading rates can be identified and procedures developed to respond to loading.
- Where retreat mining is proposed and the depth of cover exceeds 1,000 feet, mine operators should assess areas of high burst likelihood in advance of mining. The assessments should identify these areas of high burst likelihood based on the depth of cover, the geological conditions, the potential for multiple seam interactions, and recent ground control experience. The assessments should be guided by an experienced ground control professional and should be conducted as mining conditions/experience warrant, but at least on an annual basis.

APPENDIX H

GUIDELINES FOR GEOTECHNICAL ASSESSMENTS PRIOR TO RETREAT MINING

Retreat mining, whether longwall or pillar recovery, increases the stress and deformation experienced by mine openings adjacent to the retreated areas. These changes can result in instability and roof falls. Roof that is already weak is most likely to become unstable when affected by retreat mining. A geotechnical assessment can identify the roof that is most at risk so that precautions can be taken.

The assessment should begin with a review of past experience and available geologic data. The geotechnical factors associated with roof falls, coal and rock bursts, rib falls, floor heave, and other problems encountered on previous retreat panels should be noted. Available surface borehole logs can provide information on the roof rock likely to be encountered, and the possible presence of sandstone channels, rider seams, transition zones, and other potentially troublesome features. Mine maps are essential for identifying areas of deeper cover, stream valley influence, and potential multiple seam interaction.

Underground mapping is the most important part of the geotechnical assessment. The mapping should not try to record every feature that is observed, but rather should focus on those features that are most significant to roof control at the mine. The following types of information should be collected:

- **Geologic features** that could create roof instability during retreat mining, such as major joints or slips, faults, drag folds, etc..
- **Current ground conditions** including the presence of sagging roof, open fractures, cutters, excessive rib slough, groundwater inflows, and floor heave.
- **Roof support installed** and any evidence of unusual weight on the supports.
- **Unusual mining dimensions** such as wide intersection diagonals and locations where the height may exceed the reach of the Mobile Roof Supports.

Test holes should also be checked using a scratch tool (such as a tape measure) or borescope to locate major cracks and features such as rider seams. It is a good practice to log and record the crack data, so that any new cracks can be identified when the holes are monitored during retreat mining.

The assessment creates a hazard map of the area to be retreat mined, whether it is a longwall headgate or a pillar recovery panel. The hazard map integrates the significant information obtained from the core logs, mine maps, and underground mapping. It should be presented in a format that is most useful to the miners that will be using it. The hazard map should also clearly define the actions to be taken prior to or during retreat mining, such as:

- Monitor more closely,
- Install extra support, or
- Do not mine—skip pillars or portions of pillars.

APPENDIX I

GUIDELINES FOR EVALUATING A MINE'S HISTORICAL RECORD (ROOF FALLS, INJURIES, BURSTS, ACCIDENT REPORTS, CITATIONS, AND PAST REVIEW FORMS)

The MSHA standard at **30 CFR 75.223 (d)** requires that “[t]he roof control plan for each mine be reviewed every six months by an authorized representative of the Secretary” and that “[t]his review shall take into consideration any falls of the roof, face and ribs and the adequacy of the support systems used at the time.”

MSHA’s review should include the following:

Roof Fall Injuries

- The **number** of roof fall injuries at the mine during at least the last six months.
- The **injury rates** (number of roof fall injuries per 200,000 hours worked) for the last two quarters. The rate is important because a large mine that has had several injuries may actually be safer than a smaller one with fewer injuries. The injury rate should be compared to the national and District rates. (Note: It should be noted, however, that injury rates are less meaningful when small numbers are involved. For example, a very small mine that experiences one injury in a decade will seem to have a very high rate in the year when the injury occurs, but it will have a zero rate during the other 9 years.)
- The **severity** of these injuries, including the body part injured and number of days lost. This information is normally available in the narrative for the accident.
- The **location in the mine and worker activity**. The goal is to determine whether the injury occurred primarily in the face area or outby, and whether a particular activity (such as roof bolting) is likely to cause injury.

When the accident and injury experience at the mine indicates that the plan is inadequate, MSHA’s standard at 30 CFR 75.223 (a) requires that “[r]evisions of the roof control plan shall be proposed by the operator.”

Research has shown that the vast majority of roof fall injuries are caused by pieces of rock that fall out from between the bolts. Improved roof skin control is generally the solution. Roof support devices such as headers, mats, and pizza pans can help, as can various protective devices that can be fitted to the roof bolting machine. By far, the most effective skin control technique is to install screen wire mesh when the roof is first bolted.

Rib Fall Injuries

- The **number** of rib fall injuries at the mine during at least the last six months.
- The **injury rate** (number of rib fall injuries per 200,000 hours worked) for at least the last two quarters.
- The **severity** of these injuries, including the body part injured and number of days lost.

- The **location in the mine and worker activity**. The goal is to determine whether the rib injury occurred primarily in the face area or outby, and whether a particular activity (such as roof bolting) is likely to cause injury.

As discussed in Appendix O, “Protecting Miners from Hazards Related to Rib Falls,” the mines most at risk are those with greater mining heights operating under deeper cover. Rib bolting on cycle is by far the most effective rib control technique. Inside-control, walk-through, roof bolters are also highly desirable.

Non-injury Roof Falls

- The **number** of roof falls at the mine during at least the last six months.
- The **roof fall rate** (number of non-injury roof falls per 200,000 hours worked) for at least the last two quarters.
- The **location in the mine** where the roof fall occurred (e.g., intersection or straight, face area or outby, etc).
- The **age** of the roof fall (the length of time between when the area was developed and when the roof fall occurred.)

A wide variety of strategies are available for reducing the risk of roof falls, including:

- Longer, stronger, and/or more closely spaced primary supports.
- Increased use of supplemental supports (cable bolts, trusses, standing support).
- Narrowed entry widths and reduced intersection diagonals.
- Shorter cut depths and reduced time that the roof remains unbolted.
- Mine layout changes, particularly entry or panel orientation.
- Focused support in areas where specific geologic factors are present.

MSHA’s standard at 30 CFR 50.11 requires each operator to investigate each accident because the information obtained may prevent future accidents. Under 30 CFR 50.2, an “accident” includes an unplanned roof fall at or above the anchorage zone in the active workings where roof bolts are being used. It also includes an unplanned roof or rib fall in active workings that impairs ventilation or impedes travel. Knowledge of the geology, mining parameters, and roof support associated with prior unplanned roof falls should be an essential element of any plan to improve the roof control system at a mine. Appendix N provides guidance on conducting an accident investigation so that the relevant information is obtained.

The mine map on which roof falls are plotted should also be reviewed. Under 30 CFR 75.223 (b), underground coal mine operators must plot on a mine map each unplanned roof fall and coal or rock burst that occurs in the “active workings.” (The term “active workings” is defined in 30 CFR 75.2.) Program Policy Letter (PPL) No. P12-V-3, which addresses Reporting of Unplanned Roof Falls In Accordance With 30 CFR 50.10 (www.msha.gov/regs/complian/ppls/2012/PPL12-V-03.asp), provides examples of what constitutes “active workings” for the purpose of reporting a roof fall.

The history of unplanned roof falls as plotted on the mine map assists mine operators and MSHA in evaluating the effectiveness of the roof control system and identification of hazardous trends, preferred orientations, or other common characteristics of the roof falls. This evaluation may be incomplete unless all known roof falls, both within and outside of “active workings,” are plotted on the mine map. Accurate plotting of all roof falls may also be highly valuable during a mine emergency, because rescuers need to be aware of blocked travelways. Therefore, the District Manager should consider using the authority granted in 30 CFR 75.222 (a) to require, on a mine-by-mine basis, that all unplanned roof falls, whether they occur in active workings or not, be investigated and plotted on a mine map. The map should be made available to any Representative of the Secretary upon request. Maintenance of this map could be required as part of the approved roof control plan, and failure of the operator to maintain this map could be considered as a violation of 30 CFR 75.220. The request to the operator should be based on the site-specific geologic conditions and accident experience at the mine.

Citation History -- violations involving the requirements of 30 CFR, Part 75, Subpart C–Roof Support should be evaluated as follows:

- The **number** of roof/rib control citations at the mine during at least the last six months.
- The **citation rate**—number of roof/rib control citations per 200,000 hours worked—for at least the last two quarters, compared to the district and national rates.
- The **standards** most often cited
- The **issues** most often involved in the citations—roof, ribs, support, equipment, etc.

Past Roof Control Inspection and Plan Review Forms (MSHA Form 2000-204): Particularly close attention should be paid to whether concerns raised in past reviews continue to be adequately addressed. For example, if past reviews identified rib conditions as a concern and the mine’s recent history indicates a high rate of rib fall injuries or citations, then changes might be needed to protect the miners from rib hazards.

A **Roof Rib Evaluation** (RRE) application has been developed to assist Districts with the historical review. The RRE application is easily accessed from the MSHA intranet. It is located at the MSHA Report Center, with the Data Warehouse Production reports. A direct link is provided below:

<http://lakwebdev2/Reports/Pages/Folder.aspx?ItemPath=%2fDW+Production+Reports%2fRoof+and+Rib+Evaluation&ViewMode=List>

Because the RRE application is linked directly to the MSHA Data Warehouse, it will generate reports using the most recent injury and accident data. While much of the same information is available on the MSHA Data Retrieval System, the advantages of the RRE application are that it:

- Separates the roof-related data from other data, and
- Calculates roof/rib injury and accident rates, and provides District and national rates for quick comparison.

Five different reports can be generated using the RRE application. The first is a summary that includes the number and rates of roof fall injuries, rib fall injuries, non-injury roof falls, roof-related citations, and S&S citations. The other four reports provide narratives obtained from the 7000-1 forms or citations. The default timeframes are 6 months or 2 years for numbers of incidents and two quarters or eight quarters for rates, because rates must be calculated using the data for hours worked, which is only available quarterly. The user may also define different time periods to analyze. The user may also print the results, or export them in a variety of file formats.

APPENDIX J

UNDERGROUND INSPECTIONS FOR SIX-MONTH PLAN REVIEWS

A thorough underground safety inspection is normally an essential part of the six-month roof control plan review. The inspection is designed to evaluate the effectiveness of a proposed or approved plan, and to ascertain compliance with an approved plan. This inspection may be a limited inspection (E20) or it may be conducted as part of a regular inspection (E01).

Onsite inspections begin with a pre-inspection conference. Items to be discussed include:

- The accident and injury experience at the mine.
- The roof control violation history.
- Preshift and on-shift examinations.
- Roof control plan content and revisions since the last review, if any.
- Roof and rib conditions.
- Issues with current support systems.
- Training issues.

Current mine maps on which roof falls are plotted should be reviewed. In addition, the plan should be discussed with a representative of the miners.

At least one section that is representative of each of the different mining systems used at the mine should be inspected, i.e., a CM section on advance and on retreat, a longwall section, etc. The inspection should focus on those sections known to have adverse roof conditions or a recent history of roof and rib falls, both injury and non-injury.

The underground inspection should evaluate compliance with MSHA's standards and with any approved roof control plan. It should also evaluate the suitability of the plan to the prevailing geological conditions and the mining method in use. The conditions at critical areas such as longwall tailgates, pillar retreat sections, and long-term entries are particularly important. The following items should be checked during underground mine inspections:

- Roof conditions and the adequacy of roof support, including skin control.
- Rib conditions and the adequacy of rib support.
- Opening dimensions, including entry heights, entry widths, and intersection diagonals as applicable.
- Sequence of advance mining.
- Sequence of retreat mining and dimensions of final stumps.
- Mobile Roof Support operation.
- Longwall support system.
- Roof bolting pattern.
- Supplemental roof support materials.
- ATRS and canopies.

The roof bolting operation is a critical part of the inspection. Items to check include:

- Roof bolt assemblies.
- Material specifications.
- Installation sequence.
- Resin bolt installation practice.
- Torque on tensioned bolts.

The MSHA CMI should discuss and question miners on current mining activities and conditions, and ask them questions to determine their understanding of the existing roof control plan protections. For example, CMIs should ask roof bolt operators whether the mine's roof control plan addresses soft layers or cracks while drilling the roof, bolts that don't anchor properly, or groundwater dripping or running out of holes during bolt installation and if not, whether they believe it should. They should also ask miners about the plan's effectiveness regarding roof skin control in protecting them from loose rocks.

The MSHA inspector should question the miners to determine whether their training with respect to the roof control plans is completed and adequate, focusing especially on training involving retreat mining activities. Guidance on documenting the information from miners during these discussions can be found in the CMS&H General Inspection Procedures Handbook.

APPENDIX K

TENSIONED CABLE BOLTS

Tensioned roof bolts have been used successfully to control mine roof since the 1940s. Tensioned cable bolts represent a unique and somewhat complex approach to this well-established means of roof control. The key elements of these supports are substantial anchorage, the ability to be tensioned, the strength of components and the installation of long supports without couplings.

The ability to maintain tension is an essential component to any partially grouted system used as required support. MSHA has determined that several factors should be addressed when considering tensioned cable bolts as a required roof support system. Additional factors may also need to be considered to address mine specific conditions, such as highly corrosive mine water in the roof strata. The component tests and demonstration may then require an evaluation of the measures to be taken to arrest or slow corrosion or to limit the expectations as to the safe, useful application life of a specific roof support appliance.

Because tensioned cable bolts are not addressed in ASTM F432-95, District Managers shall evaluate requests for approval of tensioned cable bolts. In determining whether to approve tensioned cable bolts, the District Manager should base his decision on the demonstration or tests specified in 30 CFR 75.204(b). These tests or demonstrations may include:

Component Tests: Laboratory tests should be conducted to determine the strength and compatibility of all of the individual components of the cable bolts. Any components covered by ASTM F432-95 must meet those specifications. The manufacturer should specify all other components. Any changes to the original components or additional components added to the support would warrant additional testing. Once a specific design has been successfully tested, no further testing should be required unless the quality of the components is suspected of being inferior.

Installation Procedure: Roof bolter operators should be trained in safe handling and proper installation techniques. In-mine testing should be conducted to determine if the supports can be installed safely and reliably. These tests should ensure that the safety of the operator is not jeopardized during the handling and installation of the tensioned cable bolts.

Pull Tests: Underground pull tests should be completed to determine the anchorage capacity and displacement characteristics of the support for the anchor length used. If the anchor length or type is modified, additional anchorage tests should be conducted.

Tension Tests: Underground tests should be conducted to determine the installed load range of the supports and verify that the tension level can be achieved and maintained as required in 30 CFR 75.204(f). These tests should be done with a load-measuring device that is capable of indicating the installed load of the support. Any anomalies that occur during the test, e.g., spring-back, should be noted in order to determine the effect on the installed load and the ability to comply with the regulations.

Test Area: Depending on the District's experience with tensioned cable bolts as required support and the roof conditions at a specific mine, a test area may be warranted. If deemed necessary, a test area could be established to demonstrate the effectiveness of the tensioned cable bolts. A test area can range from an area of the mine where a number of bolts are installed for observational purposes up to a fully instrumented area monitoring roof sag and bolt loading.

Based on District experience with the test area, the District could then review the tests or demonstration results of the bolts at the mine for possible inclusion in the mine's roof control plan. Technical Support will be available to assist in the evaluation of tensioned cable bolts.

MSHA recommends that when tensioned cable bolts are approved as required support, their specifications should be listed in the approved roof control plan. Some manufacturers have multiple designs of tensioned cable bolts. Listing the specification in the roof control plan will eliminate confusion between MSHA and the mine operator regarding the approval of a particular tensioned cable bolt. The listed specifications should include the following on a mine-by-mine basis:

- Each component of the system should be specified including all dimensions. For example, if a threaded tube is used, the tube length, tube thread strength, and thread length should be listed.
- A drawing depicting all components used with the system. This drawing should show the location of each component.
- For the cable itself, the plan should have a specification that includes the type of strand, (e.g., 7-strand epoxy coated), a minimum strength requirement, and the head/housing should be capable of breaking the cable without failing.
- Each cable bolt should have a marking to identify the length, manufacturer, and type of cable (epoxy, galvanized, etc.).
- Minimum resin cartridge length (actual length of the cartridge and not the grouted length), cartridge diameter and hole diameter should be listed.
- The installation procedure and remedial action if a bolt is improperly installed. For example, if the bolt is not properly tensioned, the head sprung back, or a spinner occurs, then another bolt should be installed.
- Tension range and a method of determining it in order to comply with 30 CFR 75.204 (f) (4) of the regulations. Also, a procedure should be established to verify this method.

APPENDIX L

BEST PRACTICES FOR TURNING CROSSCUTS WITH
REMOTE CONTROLLED CONTINUOUS MINING MACHINES

The following best practices have been identified as having the potential to reduce the number of roof fall accidents when crosscuts are turned with remote controlled continuous mining machines:

1. Use a notch or niche cut. A notch or niche cut is a shallow, triangular- shaped, initial cut (a single miner head in width) taken when turning a crosscut. The notch or niche cut is bolted to provide a buffer between the CM operator and unsupported roof created as the remainder of the crosscut is mined. If this option is used, it should be approved in the Roof Control plan.
2. Limit the depth of the first cut when turning a crosscut.
3. Allow the remote controlled CM operator to be positioned up the straight on the inby side of the intersection.
4. Limit the number of "turned crosscuts," thereby mining most of the crosscuts "head-on."
5. Install additional roof support at the continuous mining machine operator's projected work location.
6. Use visual indicators such as reflective markers to designate a "no work/travel zone," commonly referred to as a "Red Zone."

APPENDIX M

USE OF MOBILE ROOF SUPPORT (MRS) UNITS FOR RETREAT MINING

MRS units have been used in the mining industry for over 20 years, replacing roadside-radius (turn) and some breaker posts during pillar recovery. MRS units are stronger than posts and can be operated remotely. These units provide greater roof support protection and eliminate or greatly reduce the need for miners to travel close to the pillar line to install posts necessary for conducting retreat mining. If used properly, the MRS units can provide a safer form of roof support compared to installing posts during pillar mining. If not used properly, operating the MRS units and the removal of the units from the active pillaring area can be extremely hazardous.

The following Best Practices have been identified as having the potential for preventing accidents, injuries and fatalities when using MRS units as roof support during pillar mining:

- Onboard, manually operated controls should be "locked out" or under a "bolted down" cover plate to restrict their usage to maintenance and troubleshooting purposes only. *Because onboard, manual controls (sometimes referred to as manual overrides) are intended for maintenance and troubleshooting only, their use should be restricted to an outby area, between solid coal pillars. To prevent unintended use in an active pillaring area, these controls should be "locked out" or under a "bolted down" cover plate. Information on lock-out devices or bolt down cover plates for the manual controls should be obtained from the MRS manufacturers. Even in an outby area, temporary supports should be installed before pressurizing or depressurizing the units with the manual controls. Any material, such as thin pieces of rock, on top of the MRS that poses a fall hazard should either be removed or secured against movement prior to manual operation. Also, any roof damage incurred as a result of pressurizing and depressurizing the MRS unit should be addressed before removal of the temporary supports.*
- Umbilical remote controls should only be used for tramming the MRS units between solid coal pillars. *Umbilical remote control requires the operator to physically "plug-in" or retrieve the pendent control on the MRS unit. This connection should not be made until the MRS has been moved via the radio remote control into a safe location completely out of the active intersection following the last lift. Once away from the active pillaring area, the pendent can be safely plugged in or retrieved and used for tramming the MRS to the next pillaring location. However, the operator should use sufficient pendent cable length to maintain a safe operating distance and should never use the umbilically controlled unit to displace breaker timbers.*
- When tramming the MRS units, all personnel should be clear of pinch points between the units and between the units and the rib. *Under no circumstances should anyone, including the MRS operator, be permitted beside or within the turning radius of the MRS units when they are being moved.*

- When setting and lowering the MRS, the operator should be positioned in a safe location, at least 25 feet away from the units.

A greater distance may be required depending on the MRS working height, immediate roof conditions, the amount of accumulated debris atop the units, or the lift being mined. For example, during mining of the last lift the MRS operator should remain out of the active intersection. During the setting and lowering process, all personnel should be positioned outby the MRS operator. This includes personnel assisting the MRS operator by monitoring the pressure gages.

- While in the active pillaring area, the MRS units should be operated in pairs, using the radio remote control.

When moving the mobile roof supports from pillar lift to pillar lift, each MRS should be advanced sequentially such that one unit will never be offset more than one half the length of its companion unit. The MRS units should be advanced immediately after each lift, and should be kept as close as practical to the continuous mining machine during each lift. Upon completion of mining in a given pillar, the MRS units should be moved sequentially until they are between solid coal pillars. During this process, at least one unit will be pressurized against the roof at all times.

- While pillaring, MRS pressure gages or colored area lights should be used to monitor roof loading.

Gages or load indicating lights should be observed to first ensure that the MRS units have been properly set against the mine roof. (Mine management should determine a pressure level for setting the MRS units). Gages or lights are to be continually observed to ascertain if pillaring operations need to be stopped in a specific lift. These gages should be large enough to allow remote monitoring. Mining should cease in a lift either at the MRS yield pressure or at some lower level dictated by roof conditions (determined by mine management). Pillaring operations should also cease if neither the gages nor lights are operational.

- Install the MRS cables with break-away cable hangers so that the cable can be pulled down remotely.

Use of such devices will prevent personnel exposure to hazardous roof adjacent to the MRS units. No hangers should be retrieved from the blocks being pillared.

- Precautions should be included in the Roof Control Plan for supporting the roof in the event one of the MRS units becomes inoperative.

Depending on mine-specific circumstances, the roof control plan may permit the repositioning of one of four units to maintain a pair in the more critical area adjacent to the gob. For example, if an MRS unit in the straight becomes inoperative, an outby MRS from the crosscut could replace it. Wood supports may provide an acceptable replacement for an MRS unit in a breaker setting but should not be used in conjunction with an MRS unit in a radius turn post application. It is not advisable to simply substitute wood supports for an MRS and continue the same cut plan/lift sequence.

- When parking the MRS units for an extended period of time, they should be positioned between solid coal pillars outby the active pillaring area. The units should remain in contact with the roof to prevent dynamic loading in the event of a roof fall.
Pressurizing the MRS against the roof in areas where personnel will later be working or traveling may create a hazard by damaging the roof or permanent roof support. Therefore, in this circumstance, the MRS units should be pressurized with minimal force (just against the roof). Also, the radio remote control units should be stored in a safe area away from the machines.
- The roof control plan should include a statement that requires the submittal of a plan when an MRS is disabled or entrapped.
Train miners before using the plan.

APPENDIX N

ESSENTIAL ELEMENTS OF A ROOF FALL ACCIDENT INVESTIGATION

Roof falls that are reportable under 30 CFR Part 50 are considered accidents, even when there is no injury. Under 30 CFR 50.11 (b), each operator of a mine shall investigate each accident at the mine, and develop a report of each investigation. MSHA may also conduct an investigation. An operator may not use Form 7000-1 or an investigation report conducted or prepared by MSHA. The operator shall submit a copy of any investigation report at MSHA's request.

30 CFR 50.11 (b) [paragraphs (b) (4) and (5) and (b) (7) and (8)] also lists a number of items that each report prepared by the operator shall include, of which some of the most significant for a roof fall accident investigation are:

- (4) A description of the site;
- (5) An explanation of the accident, including any explanation of the cause of any accident,
- (7) A sketch, where pertinent, including dimensions depicting the occurrence; and
- (8) A description of steps taken to prevent a similar occurrence in the future.

MSHA's standards require an operator to investigate each accident because the information obtained may prevent future accidents. This is particularly true for accidents consisting of roof falls. Knowledge of the geology, mining parameters, and roof support associated with prior roof falls should be an essential element in any plan to improve the roof control system at a mine.

The following are the items that should be included in an accident investigation involving a roof fall, whether the investigation is conducted by MSHA or by the mine operator:

1. A ***sketch in plan view***, showing:
 - a. Approximate dimensions of the fall, including intersection diagonals if available, and
 - b. Widths of entries leading into the fall.
2. A ***cross-section sketch***, showing the approximate shape and height of the fall.
3. ***Geologic information***, including:
 - a. Thickness and rock type of the roof beds involved,
 - b. Noticeable geologic structures such as clay veins, slips, or drag folds
 - c. Approximate rate of groundwater inflow, if present.

This information may be shown on the sketches.

4. The ***roof support*** installed, including:
 - a. Type, pattern, diameter, and length of the primary roof bolts,
 - b. Type, pattern, and other characteristics of any supplemental support, and
 - c. Timing of the installation of any supplemental support.

5. The *sequence of events* leading to the fall, if known, and the general condition of the area. Answers to the following should be provided:
 - a. Were the roof bolts or standing supports taking weight?
 - b. Was the roof sagging?
 - c. Had tension fractures appeared?
 - d. Were roof cutters, rib spall, or floor heave noted?
 - e. Was water present, and when was it first noticed?
 - f. Did anyone witness the failure?
 - g. What was the duration of failure?

6. *Other critical information*, including:
 - a. When the area was developed,
 - b. Orientations of the headings and the roof fall,
 - c. Any workings above or below,
 - d. Depth of cover, and
 - e. Local topographic features such as stream valleys.

The information listed under item 6 should be available from the mine map(s).

Note that if the fall is to be cleaned up, then items 1-3 are usually best investigated once the fall cavity is visible.

A sample one-page roof fall accident investigation form is attached as an illustration of how the information may be collected and presented. Additional pages may be needed to fully document the conditions relevant to the investigation.

Roof Fall Investigation Data Form

Date of Fall: _____ Fall Location: _____ Date of Investigation: _____

Cross Section of Roof Fall. Show approximate shape and height of the fall, and also the geology (type and thickness of the rock beds observed).

Plan View of Roof Fall. Show approximate dimensions of the fall, including intersection diagonals if available, and the widths of entries leading into the fall.

Other geologic factors: _____

Primary roof support: _____

Supplemental support: _____

Groundwater inflow? _____

Depth of cover: _____ Multiple seam? _____

Sequence of events leading to the fall, general condition of the area, and other comments: _____

Steps to prevent re-occurrence: _____

Investigation conducted by:

APPENDIX O

PROTECTING MINERS FROM HAZARDS RELATED TO RIB FALLS

MSHA standards require that “[t]he roof, face, and ribs of areas where persons work or travel shall be supported or otherwise controlled to protect persons from hazards related to falls of ribs” (30 CFR 75.202 (a)). The roof control plan, which is developed by the mine operator and approved by the District Manager, must be “suitable to the prevailing geological conditions and the mining system to be used at the mine” (30 CFR 75.220 (a) (1)). The mine operator is required to propose revisions to the roof control plan “[w]hen conditions indicate that the plan is not suitable for controlling...the ribs...” (30 CFR 75.223 (a) (1)).

The two most significant geologic conditions that contribute to hazards related to falls of ribs are the *seam height* and the *depth of cover*. Analysis of the fatal accident reports from the 23 rib fall fatalities that occurred during 1995-2010 indicates that 22 (96%) occurred where the mining height was at least 7 feet and 18 (78%) occurred where the depth of cover was at least 700 feet. The reports indicate that rock partings (rock layers contained within the coal seam) or rock brows (rock layers above the coal seam) were present in nearly every instance.

Other conditions that have contributed to rib fall fatalities include:

- additional rib stress due to multiple seam interactions or retreat mining,
- large slickensides in the coal,
- unusually high places prepared for overcasts or belt drives, and
- unstable pillar corners.

Another significant factor associated with almost every fatal rib fall during 1995-2010 is that no rib support had been installed at the accident location.

Rib bolts provide the best protection against rib falls. Since most rib fall incidents occur on the working section, rib bolts are most effective when they are installed in a consistent pattern while the roof is being bolted. Where the ribs are highly stressed, the rib bolts can be more closely spaced and supplemented by additional surface coverage such as straps or mesh. Control of taller ribs (e.g., 9 feet or higher) may be best achieved if two or more rows of rib bolts are installed. Rib bolts should always be long enough to anchor securely beyond the disturbed portion of the rib.

Outside-control, non-walk-through roof bolting machines place the machine operators between the machine and the rib where they may be exposed to rib hazards. Every one of the roof bolt operators killed by rib falls during 1995-2010 was operating an outside-control machine. Inside-control, walk-through roof bolting machines significantly reduce the worker's exposure to hazardous ribs. These machines also are commonly configured to provide horizontal rib bolt hole drilling capability. Operators of mines where conditions create rib fall hazards are strongly encouraged to use inside-control, walk-through roof bolting machines with horizontal rib bolting capability.

Where rib bolting is not feasible, the rib fall hazard can be mitigated by other techniques including roof channels fabricated with angled extensions that buttress the pillar rib, straps or cables for wrapping the pillar rib, or standing supports. When standing supports are used for rib control, it is essential that they be secured in such a manner that a hazard is not created should a support be dislodged.

Mine safety programs and procedures should include methods for preventing, detecting, reporting, and correcting hazardous conditions related to falls of the roof, face, and ribs. These conditions can be detected during applicable preshift, supplemental, or on-shift examinations (refer to Sections 30 CFR 75.360, 75.361 and 75.362). Hazardous conditions found during such examinations must be corrected immediately or remain posted with a conspicuous danger sign until corrected, pursuant to 30 CFR 75.363 (a).