

Information Circular 9372

Ground Control Safety Analysis of Extended Cut Mining

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm centimeter

ft foot

ft² square foot

in inch

m meter

m² square meter

mt metric ton

pct percent

st short ton

GROUND CONTROL SAFETY ANALYSIS OF EXTENDED CUT MINING

By Eric R. Bauer,¹ Deno M. Pappas,² and Jeffrey M. Listak¹

ABSTRACT

The ground control aspects of extended depth-of-cut mining are presented in this U.S. Bureau of Mines report. A trend analysis of extended cut approvals was performed. A comparative review of roof fall fatalities for extended and nonextended cut mining is included. Current ground control guidelines for extended cut approval are summarized. The problems and concerns of this extraction system are addressed, and typical extended cutting face operations are described.

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INTRODUCTION

With the introduction of continuous mining machines (CM's) in the late 1940's and subsequent enactment of the 1969 Coal Mine Health and Safety Act, which states "No person shall work or travel under unsupported roof..." (30 CFR 75.202b) (1),³ the accepted practice in the U.S. coal industry has been to advance the face until the CM operator's compartment is just outby the last row of bolts, then proceed to support the exposed mine roof. The result is a depth-of-cut of approximately 6.1 m (20 ft). This sequence of 6.1-m (20-ft) cuts and subsequent roof supporting is familiar to mine workers, limits the amount of unsupported mine roof, and minimizes the time between exposure and support. It is a safe and efficient system of extraction under most mining conditions.

Today, in contrast, mine operators are requesting approval to increase the depth-of-cut to as much as 15.2 m (50 ft). Extended cuts or deep-cut mining is simply the mining of cuts deeper than the standard 6.1 m (20 ft), using remotely controlled CM's equipped with scrubbers or fan spray systems (fig. 1). Production increases are realized through CM place change (tram time) reduction, because the mining machine stays longer in each working

face. One estimate suggests production increases ranging from 4 pct for a 9.1-m (30-ft) cut to 10 pct for a 18.2-m (60-ft) cut can be expected (2).

The United Mine Workers of America (UMWA) has raised safety concerns about ground control and roof stability of extended cutting, and whether this system exposes mine workers to greater risks of injury due to roof falls. Specific ground control concerns that may warrant investigation include the following:

1. Does extended cutting expose excessive unsupported roof, leading to an increase in roof failures during extraction and support?
2. How much roof movement occurs during standard and extended cutting and what limit is acceptable to ensure long-term roof stability?
3. Is the longer time between exposure and support adversely affecting roof stability outby the face because irreparable roof damage has occurred?
4. What role does geology play in roof stability during extended cutting and does this extraction system inhibit mine workers' recognition of changing roof and geologic conditions?
5. Is there a practical limit as to how deep a cut can be safely taken?

³Italic numbers in parentheses refer to items in the list of references preceding the appendixes at the end of this report.

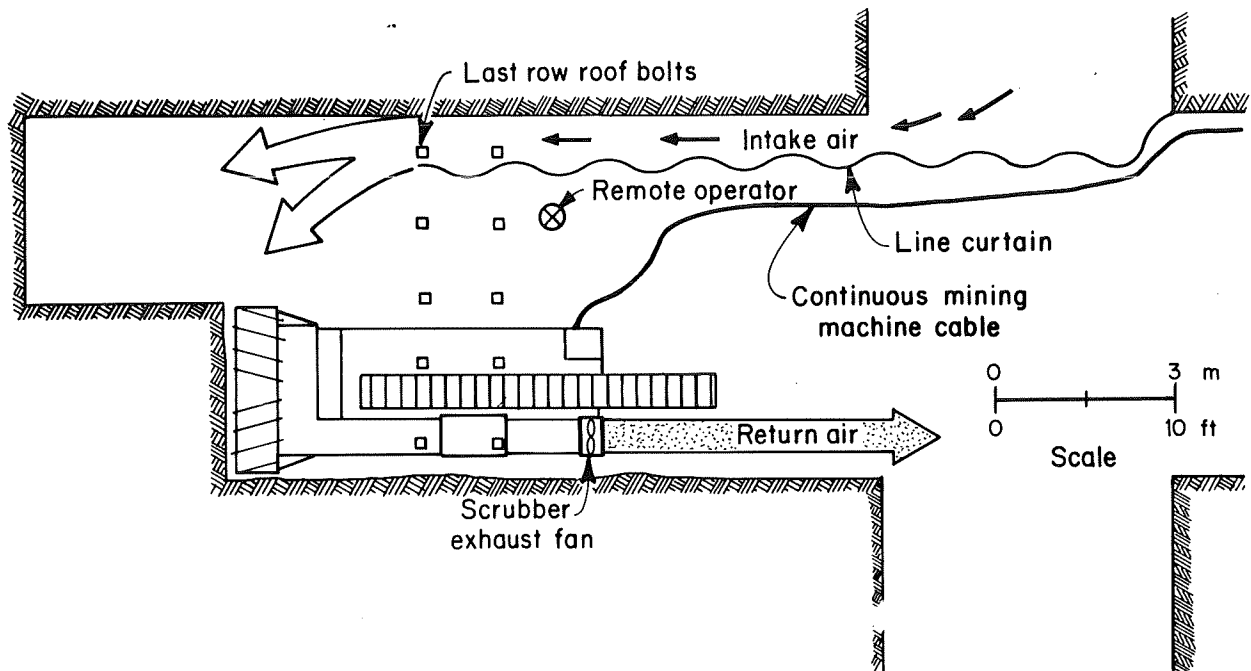


Figure 1.—Diagram of typical extended cut mining method.

This U.S. Bureau of Mines report examines the ground control safety concerns associated with extended cut mining. In-depth analyses of roof fall fatality reports were conducted, revealing many interesting insights about the similarities and differences between extended cut and nonextended cut fatalities. In addition, conversations

with UMWA and Mine Safety and Health Administration (MSHA) personnel provided valuable information on extended cut mining, much of which is included in this report.

This work was done in support of the USBM's goal to enhance the safety of the Nation's underground miners.

EXTENDED CUT NARRATIVE

Extended cutting followed the development and application of remote control continuous mining around the late 1960's or early 1970's (3-8) and scrubber-spray fan systems in the mid- to late 1970's (9-12). Some of the earliest reported instances of extended cut use were by Peabody Coal Co., Kentucky (2), and Clinchfield Coal Co., Virginia (13), in the mid-1970's. These installations employed cable remote-controlled CM's to mine depths up to 9.1 m (30 ft).

NUMBER OF MINES AND APPROVALS

MSHA information places the number of mines with extended cut approval at 217 for 1989, 282 for 1990, and 316 for 1991, a 45.6-pct increase in just 3 years (14). Table 1 shows a State-by-State listing of the number of mines with extended cut approval and the percentage of underground mines with extended cut approval in each State. There is significant variation between States, with an overall average of 22.3 pct of all U.S. underground coal mines having approval to mine extended cuts.

Table 1.—State listing of total mines and extended cut mines, 1991

State	Total underground mines ¹	Total extended cut mines	Extended cut mines, pct of total
Alabama	13	10	76.9
Colorado	16	9	56.3
Illinois	33	26	78.8
Indiana	4	2	50
Kentucky	542	63	11.6
Maryland	2	1	50
Montana	1	0	0
New Mexico	1	0	0
Ohio	12	4	33.3
Oklahoma	1	1	100
Pennsylvania	70	29	41.4
Tennessee	50	7	14
Utah	15	12	80
Virginia	222	51	23
West Virginia	434	99	22.8
Wyoming	4	2	50
Total or avg. ..	1,420	316	22.3

¹Estimated from 1991 totals, Energy Information Administration. Coal Production 1991, Dep. Energy EIA-0018 (91), 1992, p. 18.

The total number of mines with extended cut approval for 1985 to 1991 was determined (table 2) and plotted (fig. 2). From an estimated 59 mines in 1985 to the current number of 316 in 1991, a 62.2-pct-per-year increase has occurred. This is opposite the overall trend occurring in the U.S. coal industry, where the number of underground mines has steadily decreased, at about 4.6 pct per year (fig. 3).

Table 2.—Comparison of total underground coal mines and mines with extended cut approval, 1985-91

Year	Total underground mines ¹	No. of mines with extended cut approval
1985	2,103	59
1986	1,963	66
1987	1,887	147
1988	1,775	210
1989	1,653	217
1990	1,619	282
1991	1,420	316
Total change, pct	-32.5	+436

¹Does not include anthracite mines.

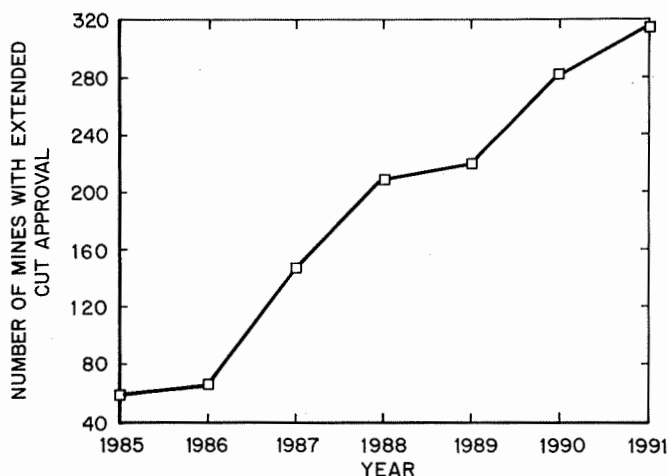


Figure 2.—Number of mines with extended cut approval, 1985-91.

The number and depth-of-cut of extended cut approvals for 1990 and 1991 are listed on table 3. There are more approvals than mines, indicating that some mines have been issued more than one approval. This is because differing roof conditions and extraction systems within a mine dictate the acceptable cutting depth. A histogram of approved depths-of-cut (fig. 4) shows that 12.2 m (40 ft) is the most approved extended cutting depth.

Table 3.—Number of extended cut approvals for various depths-of-cut, 1990-91

Extended cut depth, m (ft)	1990	1991
6.4 (21)	1	0
6.7 (22)	0	0
7.0 (23)	0	0
7.3 (24)	7	6
7.6 (25)	13	21
7.9 (26)	0	0
8.2 (27)	0	0
8.5 (28)	1	3
8.8 (29)	0	0
9.1 (30)	87	103
9.4 (31)	0	0
9.7 (32)	0	0
10.0 (33)	1	2
10.3 (34)	14	12
10.6 (35)	32	23
10.9 (36)	4	6
11.2 (37)	10	17
11.6 (38)	0	1
11.9 (39)	4	4
12.2 (40)	120	150
12.5 (41)	0	0
12.8 (42)	3	3
13.1 (43)	4	3
13.4 (44)	2	3
13.7 (45)	0	0
14.0 (46)	0	0
14.3 (47)	0	0
14.6 (48)	6	7
14.9 (49)	3	2
15.2 (50)	1	1
Total	313	367

TYPICAL FACE OPERATIONS

Extended cutting operations were observed in coal mines in the eastern United States. All the mines visited had over 5 years experience with extended cutting using radio remote-controlled CM's (fig. 5). Most of the mines employed one CM on the extended cut sections, but one operator used two CM's, operating simultaneously, on

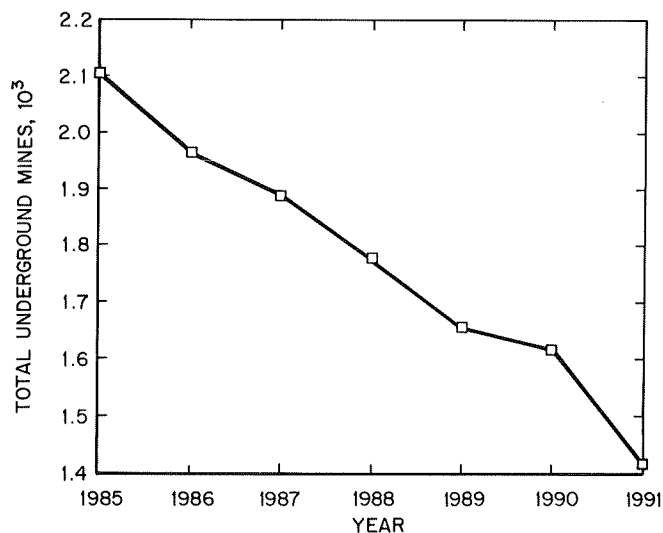


Figure 3.—Number of underground coal mines, 1985-91.

what was termed a "High Production Section." Face operations on the extended cut sections differed in the method of coal haulage. Specifically, either two, three, or four shuttle cars, two battery-powered coal haulers, or a continuous haulage unit was used to transport coal from the face to the section belt tailpiece.

Another difference observed was the variation of cut sequencing. Cut sequences varied because of the equipment used and the method of ventilation. Figure 6 illustrates several of the cut sequences observed. Finally, average production of the extended cut sections visited was 635 to 1,451 raw mt per shift (700 to 1,600 raw st per shift).

PROBLEMS, CONCERNS, AND OPPOSITIONAL ASPECTS

The commonly expressed ground control concerns center on the safety of extended cutting in terms of unplanned roof failures. Specifically, will more roof falls occur in extended cutting because a greater amount of unsupported roof is exposed, does the extended depth-of-cut hinder workers' ability to detect changing roof conditions, and is removal of the operator from the protective canopy an unsafe practice? Definitive answers to these concerns are not possible based solely on a roof fall fatality analysis, but valuable insight is gained by just such an analysis.

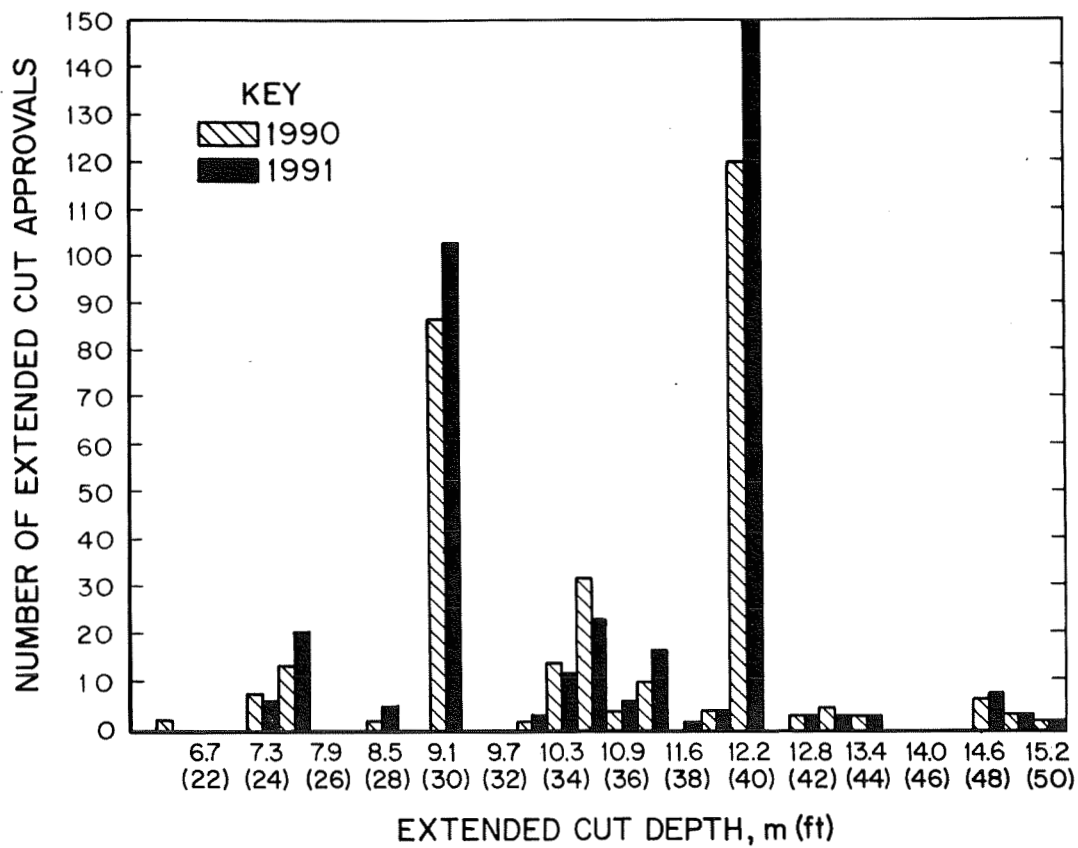


Figure 4.—Histogram of depth-of-cut and number of extended cut approvals.



Figure 5.—Remote operation of continuous mining machine.

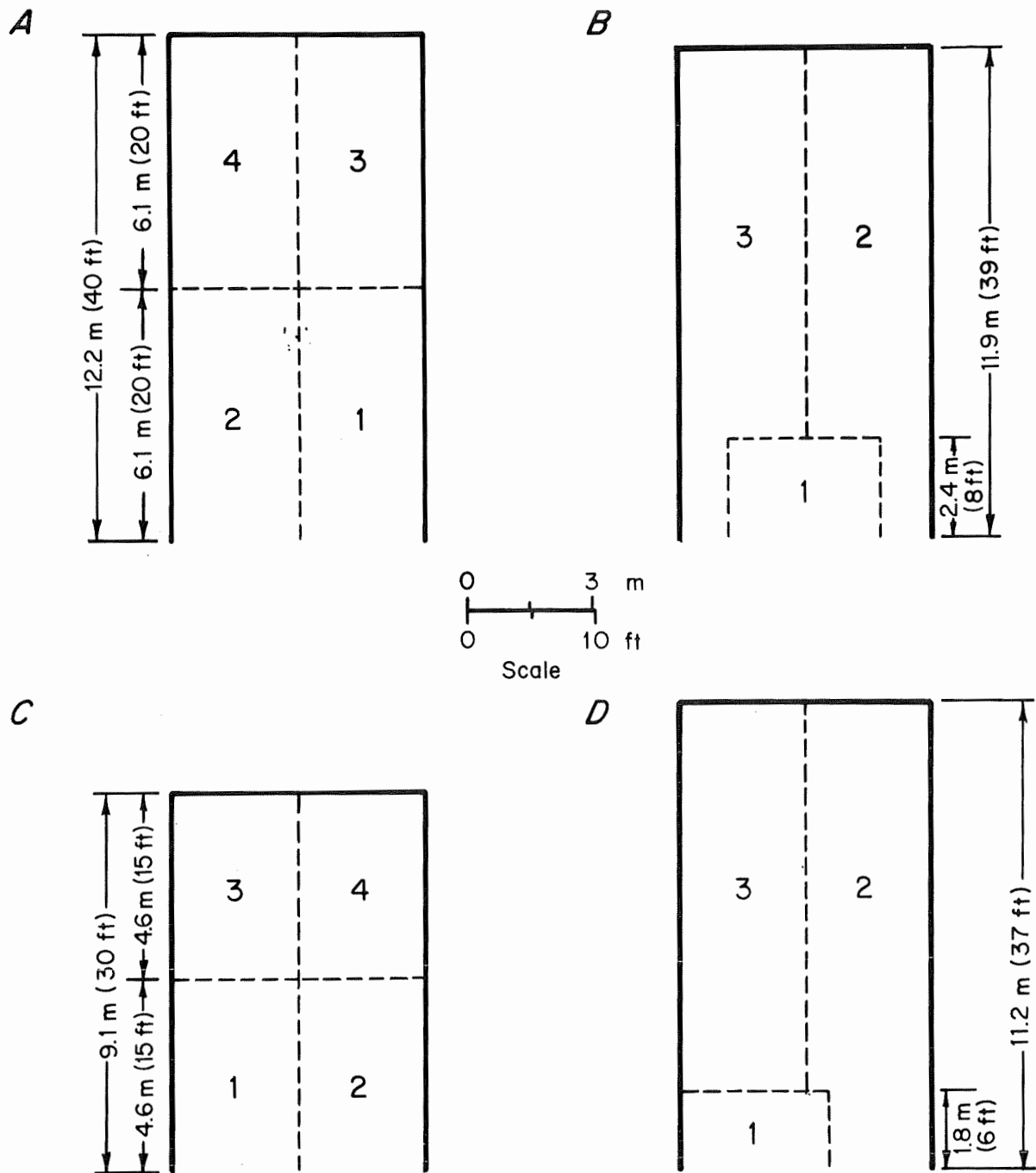


Figure 6.—Typical extended cut face mining sequences. A, Right to left method; B, center notch method; C, left to right method; and D, left side shuttle car notch method.

ROOF FALL FATALITY ANALYSIS

The objective of analyzing roof fall fatalities was to determine the roof falls resulting from extended cutting, then define specific characteristics of both extended and nonextended cut roof fall fatalities. All MSHA roof fall fatality reports for 1988 through 1992 were methodically reviewed. The results reported are based on the fatalities that occurred during this 5-year period, because all reports were available and the mines with extended cut approval were known. It is important to remember that the results of this analysis are based on a small population, and may not be statistically significant. Also, varying interpretation of the data is possible and could result in changes to the results reported. Figure 7 is a graph of the total roof fall fatalities for 1988 through 1992.

A roof fall fatality was classified as an extended cut fatality if the following conditions were met. First, the fatality had to occur at or near the active mining face. Second, the cut depth had to exceed 6.1 m (20 ft). Finally, roof failure in the deeper than 6.1-m (20-ft) cut had to be the direct cause of the fatality.

The number of extended and nonextended cut roof fall fatalities for each State is listed in table 4. There is considerable variation from State to State, but in general, the States with the most mines experienced the greatest number of roof fall fatalities (fig. 8). A comparison of the total extended and nonextended cut roof fall fatalities for

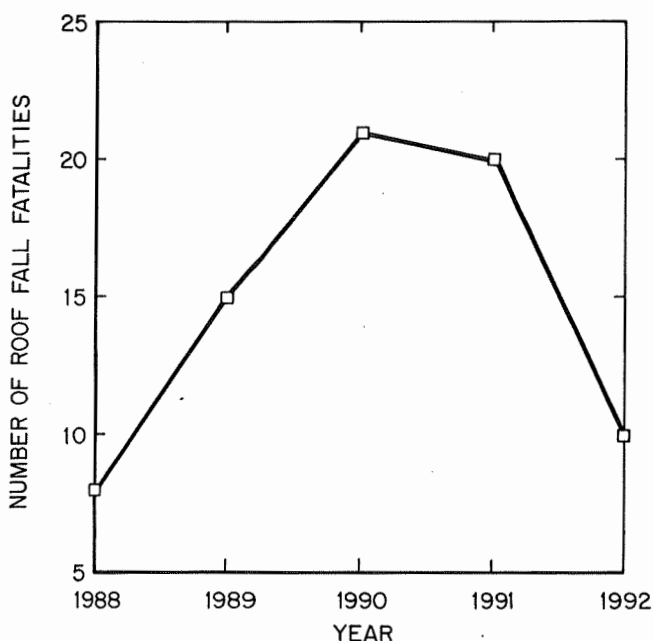


Figure 7.—Total roof fall fatalities, 1988-92.

1988 through 1992 is shown in figure 9. The number of both types of fatalities varies widely from year to year during this period. Of the 74 roof fall fatalities that occurred, 17 (23 pct) are believed to have occurred as a result of extended cutting, while 57 (77 pct) occurred for reasons other than the presence of extended cutting.

Table 4.—Number of extended cut and nonextended cut roof fall fatalities, 1988-92

State	Extended cut fatalities	Nonextended cut fatalities
Alabama	0	1
Colorado	0	1
Illinois	0	1
Indiana	1	0
Kentucky	8	20
Maryland	1	0
Montana	0	0
New Mexico	0	0
Ohio	1	1
Oklahoma	0	0
Pennsylvania	0	1
Tennessee	1	4
Utah	0	1
Virginia	1	12
West Virginia	4	15
Wyoming	0	0
Total	17	57

Table 5 lists some general characteristics of extended and nonextended cut roof fall fatalities. Nearly 65 pct of all extended cut fatalities were found to occur where non-MSHA-approved depths-of-cut were being mined. These were classified as non-MSHA approved for several reasons: Either the MSHA-approved extended depth-of-cut was being exceeded or because a cut deeper than the MSHA-approved standard cut depth of 6.1 m (20 ft) was being mined when the fatality occurred.

Table 5.—General characteristics of extended and nonextended cut roof fall fatalities, 1988-92

Fatality characteristics	Extended cut	Nonextended cut
Roof fall fatalities	17	57
Type:		
MSHA approved	6	57
Non-MSHA approved	11	NAP
Geologic influence, pct	82.4	77.2
Undetected geologic influence . . pct . .	21.4	11.4
Location of victim inby bolts pct . .	52.9	35.1
Avg. distance inby bolts m (ft) . .	1.2 (4.1)	1.7 (5.4)

NAP Not applicable.

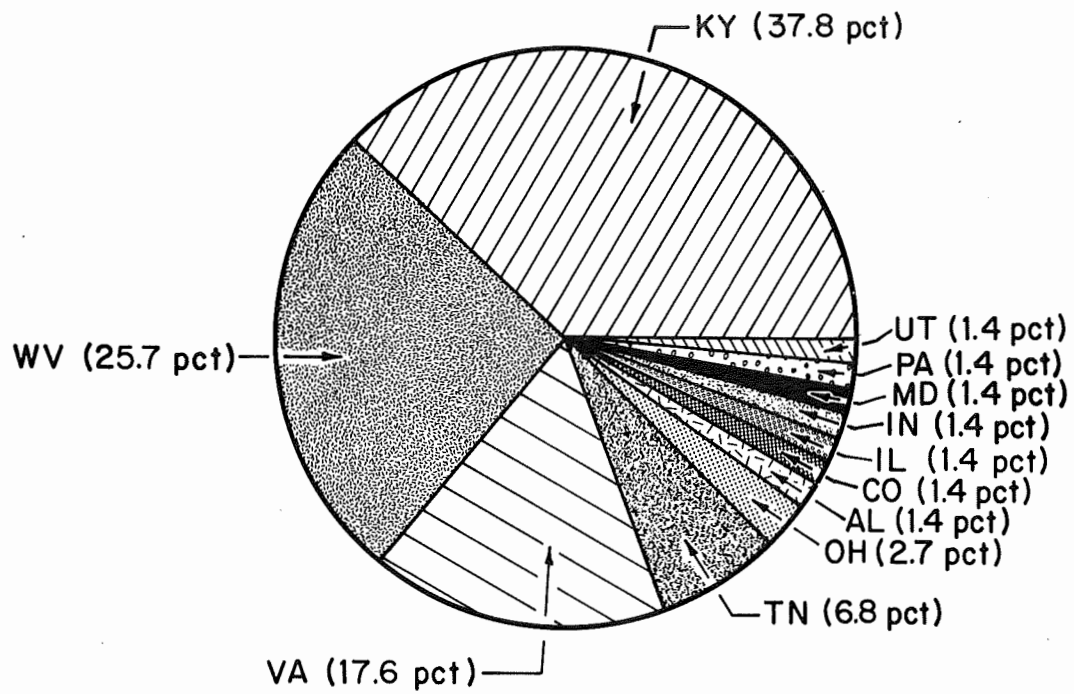


Figure 8.—State of occurrence and percent of roof fall fatalities, 1988-92.

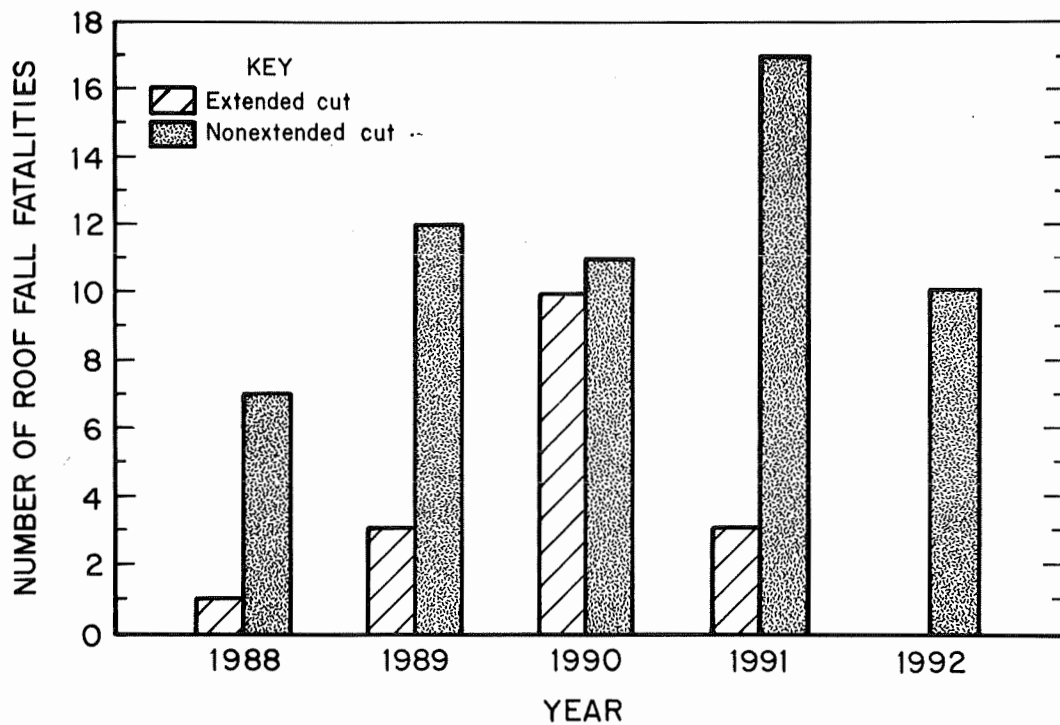


Figure 9.—Histogram of extended cut and nonextended cut roof fall fatalities, 1988-92.

Geologic influences were a contributing factor in both extended and nonextended cut roof fall fatalities. The geologic anomalies cited included slickensided slips, cracks, high-angle slip planes, laminated and unconsolidated shale roof, visible and undetected fractures, cutter roof, cap coal, draw rock, horsebacks, hillseams, water, stress fractures, and highly jointed rock. The fatality reports also stated that these geologic influences went undetected in 21.4 pct of the extended cut fatalities and 11.4 pct of the nonextended cut fatalities.

The reports also pointed out that, on the average, in nearly 40 pct of all roof fall fatalities the victim traveled beyond permanent supports. Specifically, 53 pct of the victims in extended cut fatalities and 35 pct of the victims in nonextended cut fatalities were inby permanent supports. The average distance was 2 m (6.7 ft) when extended cuts were extracted and 1.6 m (5.4 ft) when nonextended cuts were mined.

When possible, the size of the roof fall was calculated from the dimensions provided in the fatality reports. The calculations showed that considerably larger roof falls

occurred when extended cutting was practiced. Table 6 lists the average depth-of-cut, area of fall, and maximum rock thickness for extended and nonextended cut roof fall fatalities. The depth-of-cut at the time of the roof fall was 2 times greater, average fall area was nearly 3 times greater, and the average thickness of the rock that fell was almost 1.5 times greater for extended cut versus nonextended cut.

Another roof fall characteristic examined was the fall-bolt relationship. The fatality reports indicated that in over 47 pct of the nonextended cut fatalities and in almost 59 pct of the extended cut fatalities the fall rode over or in between the roof bolts (table 7). In the case of extended cuts where a distance was reported, the roof falls rode past the bolts an average of 1.9 m (6.2 ft), while for nonextended cut fatalities the distance was 2.2 m (7.4 ft).

Additional fatality characteristics determined from the reports were the job classification and task the victim was performing at the time the roof fall occurred (table 8), and the average underground employment of mines experiencing roof fall fatalities (table 9).

Table 6.—Comparison of depth-of-cut and size of falls for roof fall fatalities, 1988-92

Fatality characteristics	Extended cut	Nonextended cut
Avg. depth-of-cut m (ft) . .	10.0 (32.8)	5.1 (16.6)
Avg. area of fall m ² (ft ²) . .	107.7 (1,170.7)	38.9 (422.7)
Avg. maximum fall thickness . . . cm (in) . .	106.7 (42)	76.4 (30.1)

Table 7.—Fall-bolt relationship for roof fall fatalities, 1988-92

Fatality characteristics	Extended cut	Nonextended cut
Falls over bolts pct . .	58.8	47.3
Avg. distance over bolts m (ft) . .	1.9 (6.2)	2.2 (7.4)

Table 8.—Job classification and task of victim for roof fall fatalities, 1988-92

Fatality characteristics	Extended cut	Nonextended cut
Victim job classification, pct:		
CM-LM operator or helper	41.2	28.1
RB operator or helper	35.3	31.6
Section foreman	23.5	19.3
Task of victim, pct:		
Mine or cut coal	35.3	28.1
Installing supports	23.5	24.6
Observing mining	17.7	14.0
Barring down roof	11.8	7.0
CM Continuous mining machine.		
LM Loading machine.		
RB Roof bolting machine.		

Table 9.—Average underground employment for mines where extended cut and nonextended cut roof fall fatalities occurred, 1988-92

Roof fall type	Avg. no. of miners
Extended cut	71
Nonextended cut	45

EXTENDED CUT APPROVAL GUIDELINES

Guidelines for extended cutting were developed by the regulatory agencies to provide a basis for granting extended cut approvals. Although the guidelines may differ, the areas concerning ground control are similar. The ground control aspects common to nearly all guidelines include the following:

1. The CM operator shall not be positioned inby the second outby row of permanent supports while the CM is in operation;
2. The depth-of-cut shall be reduced when subnormal roof conditions are encountered. To resume extended cutting, at least two normal cuts in good roof must be taken and the roof must be evaluated by a certified foreman;
3. No more than two or three extended cuts shall be unsupported at any time during normal production shifts. Unsupported places that will be left standing over extended periods (holidays and weekends) will be limited to a normal cut depth (6.1 m (20 ft));

4. Prior to mining a sidecut, permanent supports shall be installed inby the inby rib of the proposed sidecut for a distance of at least one extended cut, or totally supported if less than one extended cut;

5. Sidecuts will be permanently supported prior to working inby the intersection; and

6. An ATRS-equipped roof bolting machine shall be used to install permanent supports in unsupported areas of an extended cut.

The guidelines were written to eliminate the major safety concerns of extended cutting and reduce the likelihood of unplanned roof falls. Concerns that are eliminated when the guidelines are followed include the necessity of workers to position themselves inby permanent supports, mining of extended cuts when subnormal roof conditions are encountered, leaving large areas of exposed roof unsupported for extended periods, and installing roof bolts without adequate temporary support.

CURRENT RESEARCH EFFORTS

Additional research on the ground control aspects of extended cut mining are being conducted by the USBM. Specific areas being examined include how the roof reacts as cuts are extended past 6.1 m (20 ft), how much and where roof movement occurs, and what amount of roof movement is acceptable to ensure long-term roof stability. Also, how critical the time between exposure and support is to long-term stability of the mine roof is under

evaluation. The conditions constituting subnormal roof, the depth to which mining should be reduced when subnormal roof conditions occur, and the circumstances (roof conditions) under which mining can return to full extended cuts are being investigated. Finally, research on the use of extended cutting on retreat mining sections is being considered.

SUMMARY

Extended cutting in U.S. coal mines has increased since it was introduced in the late 1970's. Over 300 mines now utilize this coal extraction method at depths-of-cut up to 15.2 m (50 ft). As of the end of 1991, the average depth-of-cut was 10.8 m (35.5 ft) based on 367 MSHA extended cut approvals. Over half of the extended cut roof fall fatalities occurred during the mining of non-MSHA-approved depths-of-cut. Workers performing the mining, cutting, or loading of coal at the face during extended cutting were the most likely victims of a fatal roof fall,

followed by workers installing supports. Extended cut roof falls averaged 3 times larger in area and 1.5 times greater in thickness than nonextended cut roof falls. Also, the depth-of-cut at failure was two times greater. The fall rode over or in between the bolts in 47 pct of the nonextended cut fatalities and nearly 59 pct of the extended cut fatalities. Workers traveling inby permanent supports and the presence of geologic influences are the two most common similarities of extended and nonextended cut roof fall fatalities.

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APPENDIX A.—EXTENDED CUT ROOF FALL FATALITY ANALYSIS, 1988-91

Table A-1.—Extended cut roof fall fatalities, 1988-89

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-11 ...	03/26/88	VA	5	Hagy	No	101.6 (40)	7.9 (26)	4.0 (13)	10.4 (34)	41.6 (442)	0-76.2 (0-30)
M-19 ...	05/15/89	KY	7	Hazard No. 4	Yes ...	241.3 (95)	6.4 (21+)	.9 (3)	.6 (2)	.6 (7)	15.2 (6)
M-64 ...	12/07/89	WV	4	Coalburg ..	Yes ...	251.5 (99)	9.1 (30)	2.4 (8)	1.4 (4.75)	3.5 (38)	0-15.2 (0- 6)
M-65 ...	12/07/89	KY	7	Poplar Lick	No	106.7 (42)	8.2 (27)	4.3 (14)	3.4 (11)	14.3 (154)	61.0 (24)
		Geologic influence		Roof fall classification—accident cause		Worker job classification		Job task or function		Location of victim, m (ft)	
M-11 ...	Large slickensided slips, horseback.		Non-MSHA-approved extended cut, worker inby supports, insufficiently supported roof.		Continuous mining machine helper		Installing safety posts		1.5 (5) inby supports.		
M-19 ...	Soft laminated slickensided shale roof.		Extended cut, worker inby supports, improper scaling.		Roof bolting machine operator ...		Barring down draw rock		At last row of bolts or just inby.		
M-64 ...	Undetected sandstone slip.		Extended cut, worker inby supports, improper ATRS use, 2-way intersection.		.. do.		Installing roof bolts		Do.		
M-65 ...	Visible cracks, slips, unconsolidated shale roof.		Non-MSHA-approved extended cut, insufficiently supported roof, worker inby supports.		Roof bolting machine helper		Installing roof bolts and straps		1.2 (4) inby ATRS.		
		Fall-bolt relationship, m (ft)	Bolt type		Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident		Underground employment	Radio or remote
M-11 ...	0.9 (3) inby bolts ..		ND		ND	137.2 (54)	01:30 pm	Saturday		13	Cable.
M-19 ...	0.3 (1) inby bolts ..		Conventional mechanical anchor or full-column resin.		76.2 (30)	121.9 (48)	07:50 pm	Monday		167	ND.
M-64 ...	0.3 (1) over bolts ..		Conventional mechanical anchor.		76.2 (30)	152.4 (60)	01:55 pm	Thursday		99	ND.
M-65 ...	1.2 (4) inby bolts ..		Full-column resin		121.9 (48)	149.9 (59)	04:00 pm	.. do.		46	Radio.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

Table A-2.—Extended cut roof fall fatalities, 1990

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-16 ..	03/17/90	KY	7	Creech	No	91.4 (36)	11.6 (38)	39.6 (130)	ND	ND	121.9-152.4 (48- 60)
M-19 ..	03/23/90	KY	7	Hazard No. 8	Yes	184.2 (72.5)	10.9 (36)	12.5 (41)	3.6 (12)	45.7 (492)	0 - 61.0 (0- 24)
M-20 ..	03/23/90	WV	4	Pocahontas No. 11.	No	111.8 (44)	10.7 (35)	9.4 (31)	2.6 (8.5)	24.4 (265)	71.1 (28)
M-24 ..	04/11/90	MD	3	Upper Freeport.	Yes	365.8 (144)	7.0 (23)	3.7 (12)	.9 (3)	3.3 (36)	10.2- 15.2 (4- 6)
M-29 ..	04/16/90	IN	8	Indiana No. 5	Yes	167.6 (66)	10.2 (33.5)	13.4 (44)	3.7 (12)	34.8 (375)	7.6- 35.6 (3- 14)
M-41 ..	08/04/90	OH	3	6-A	Yes	132.1 (52)	10.7 (35)	17.7 (58)	4.6 (15)	60.4 (650)	0 -101.6 (0- 40)
M-47 ..	09/06/90	KY	7	Highsplint ..	Yes	152.4 (60)	ND	27.4 (90)	36.6 (120)	1,002.8 (10,800)	609.6 (240)
M-51 ..	09/20/90	WV	3	Sewell	Yes	101.6 (40)	11.2 (36.7)	6.1 (20)	2.4 (8)	14.6 (160)	22.9 (9)
M-61 ..	11/27/90	TN	7	Jellico	No	101.6 (40)	18.6 (61)	10.4 (34)	15.2 (50)	58.1 (1,700)	0 - 30.5 (0- 12)
M-67 ..	12/31/90	KY	6	Pondcreek ..	Yes	127.0 (50)	12.2 (40)	18.3 (60)	5.5 (18)	100.7 (1,080)	182.9-243.8 (72- 96)
		Geologic influence		Roof fall classification—accident cause		Worker job classification		Job task or function		Location of victim, m (ft)	
M-16 ..	Visible cracks	Non-MSHA-approved extended cut, retreat mining, insufficiently supported roof, 4-way intersection.		Foreman-continuous mining machine operator.		Operating continuous mining machine.		Outby supports.			
M-19 ..	Slickensided slips, soft laminated shale roof.	Extended cut, non-MSHA-approved depth.		Section foreman		Examining face area		0.8 (2.5) outby supports.			
M-20 ..	Slickensided coal roof.	Non-MSHA-approved extended cut, worker inby supports.		Continuous mining machine operator.		Operating continuous mining machine.		3.5 (11.5) inby supports.			
M-24 ..	Cutter roof	Non-MSHA-approved extended cut due to roof conditions, improper ATRS use, 3-way intersection.		Roof bolting machine operator.		Installing roof bolts.		1.2 (4) inby supports.			
M-29 ..	Hidden slip, coal and shale roof.	Extended cut, 4-way intersection ...		Continuous mining machine operator.		Operating continuous mining machine.		1.2 (4) outby supports.			
M-41 ..	Undetected slip ...	Extended cut, insufficiently supported roof, 4-way intersection.		.. do.		.. do.		1.4 (4.5) outby supports.			
M-47 ..	Unconsolidated shale roof.	Retreat mining, insufficiently supported roof, 4-way intersection.		Section foreman		Observing roof		Outby supports.			
M-51 ..	None	Extended cut, worker inby supports, 3-way intersection.		Continuous mining machine operator.		Operating continuous mining machine.		0.3 (1) inby supports.			
M-61 ..	None	Non-MSHA-approved extended cut, worker inby supports, 2-way intersection.		.. do.		.. do.		9.1 (30) inby supports.			
M-67 ..	Laminated shale roof.	Non-MSHA-approved extended cut, retreat mining, insufficiently supported roof, 4-way intersection.		.. do.		Handling cable		Outby supports.			

See footnotes at end of table.

Table A-2.—Extended cut roof fall fatalities, 1990—Continued

MSHA case	Fall-bolt relationship, m (ft)	Bolt type	Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident	Underground employment	Radio or cable remote
M-16 ..	Over bolts	Conventional mechanical anchor.	91.4 (36)	ND	02:20 pm	Saturday	6	Cable.
M-19 ..	0.8 (2.5) over bolts	Full-column resin	121.9 (48)	121.9 (48)	10:00 am	Friday	57	ND.
M-20 ..	To bolts	Conventional mechanical anchor.	91.4 (36)	121.9 (48)	03:20 pm	.. do.	6	Neither.
M-24 ..	0.3 (1) over bolts ..	Tension rebar	182.9 (72)	121.9 (48)	09:50 pm	Wednesday	233	ND.
M-29 ..	3.7 (12) over bolts	Full-column resin	121.9 (48)	139.7 (55)	08:20 pm	Monday	54	ND.
M-41 ..	5.5 (18) over bolts	Conventional mechanical anchor.	91.4 (36)	152.4 (60)	06:30 pm	Saturday	249	Radio.
M-47 ..	Over bolts	Full column resin	121.9 (48)	121.9 (48)	05:15 pm	Thursday	95	Do.
M-51 ..	0.8 (2.5) over bolts	.. do.	121.9 (48)	121.9 (48)	08:40 am	.. do.	24	Cable.
M-61 ..	6.1 (20) inby bolts	.. do.	106.7 (42)	121.9 (48)	05:30 pm	Tuesday	45	Radio.
M-67 ..	Over bolts	Conventional mechanical anchor.	91.4 (36)	121.9 (48)	06:30 am	Monday	49	Do.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

Table A-3.—Extended cut roof fall fatalities, 1991

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-18 ..	03/22/91	KY	7	Jack Rock	No	106.7 (42)	7.1 (23.25)	2.3 (7.5)	1.7 (5.5)	3.9 (41.25)	0 - 25.4 (0-10)
M-33 ..	07/10/91	WV	4	Hernshaw	Yes	132.1 (52)	ND	27.4 (90)	6.1 (20)	167.1 (1,800)	121.9-213.4 (48-84)
M-34 ..	08/01/91	KY	6	Pond Creek	No	142.2 (56)	9.1 (30)	9.1 (30)	7.0 (23)	63.7 (690)	66.0 (26)
			Geologic influence	Roof fall classification—accident cause			Worker job classification	Job task or function		Location of victim, m (ft)	
M-18 ..	Diagonally running stress fractures.		Non-MSHA-approved extended cut, worker inby supports.			Roof bolting machine operator ...		Barring down loose rock		2.1 (7) inby supports.	
M-33 ..	Hidden slickensided formation.		Non-MSHA-approved extended cut, retreat mining, excessive unsupported roof, excessive widths, 4-way intersection.			Section foreman		Observing mining		Outby supports.	
M-34 ..	Laminated shale roof.		Non-MSHA-approved extended cut, retreat mining.			Roof bolting machine operator ...		Installing breaker posts		Do.	
		Fall-bolt relationship, m (ft)	Bolt type		Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident		Underground employment	Radio or cable remote
M-18 ..	1.5 (5) Inby bolts		Full-column resin		106.7 (42)	121.9 (48)	02:45 pm	Friday		25	NAp.
M-33 ..	Over bolts		Conventional mechanical anchor.		76.2 (30)	ND	03:15 am	Tuesday		30	Radio.
M-34 ..	Inby bolts		.. do.		106.7 (42)	ND	09:25 am	Thursday		16	Do.

NAp Not applicable.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

APPENDIX B.—NONEXTENDED CUT ROOF FALL FATALITY ANALYSIS, 1988-92

Table B-1.—Nonextended cut roof fall fatalities, 1988

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-7 ...	03/03/88	WV	4	Hernshaw	No	119.4 (47)	NAP	1.5 (5)	1.8 (6)	2.8 (30)	10.2- 35.6 (4-14)
M-12 ..	04/04/88	TN	7	Sewanee ..	No	91.4 (36)	3.0 (10)	3.3 (11)	1.7 (5.5)	5.6 (60.5)	0 - 45.7 (0-18)
M-13 ..	04/14/88	VA	5	Jawbone ..	No	144.8 (57)	6.1 (20)	ND	ND	ND	ND
M-14 ..	04/19/88	WV	4	Lower Kittanning.	No	152.4 (60)	5.5 (18)	1.8 (6)	1.2 (4)	2.2 (24)	0 - 10.2 (0- 4)
M-36 ..	09/26/88	VA	5	Red Ash ..	No	76.2 (30)	ND	15.2 (50)	6.4 (21)	97.6 (1,050)	121.9-213.4 (48-84)
M-43 ..	10/25/88	WV	4	Cedar Grove	No	231.1 (91)	6.1 (20)	3.3 (11)	2.7 (9)	9.2 (99)	0 - 12.7 (0- 5)
M-49 ..	12/05/88	KY	6	No. 1 Elk-horn	No	96.5 (38)	ND	5.5 (18)	5.0 (16.5)	27.6 (297)	22.9- 30.5 (9-12)
Geologic influence		Roof fall classification—accident cause			Worker job classification		Job task or function		Location of victim, m (ft)		
M-7 ...	None	Outby face, fall cleanup, worker inby supports.			Scoop operator		Operating scoop		3.2 (10.5) inby supports.		
M-12 ..	Undetected slip, horseback.	Conventional mining			Roof bolting machine operator ..		Barring down cap coal		Outby supports.		
M-13 ..	Slickensided slips forming a horse-back.	Failure to use adequate temporary supports.			.. do.		Installing roof bolts		Do.		
M-14 ..	None	Worker inby supports, 4-way intersection.			Continuous mining machine helper-electrician.		Helping on continuous mining machine.		0.3 (1) inby supports.		
M-36 ..	Separation in roof at 0.9 m (3 ft) depth.	Excessive widths, insufficiently supported roof, 4-way intersection.			Roof bolting machine operator ..		Installing roof bolts		ND.		
M-43 ..	Draw rock, stream valley.	Worker inby supports			Continuous mining machine operator.		Operating continuous mining machine.		0.9 (3) inby supports.		
M-49 ..	None	Conventional mining, worker inby supports, 4-way intersection.			Scoop operator		Operating scoop		5.2 (17) inby supports.		
Fall-bolt relationship, m (ft)		Bolt type		Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident		Underground employment	Radio or cable remote	
M-7 ...	0.6 (2) inby bolts ...	Conventional mechanical anchor.		106.7 (42)	121.9 (48)	08:05 am	Thursday		20	NAP.	
M-12 ..	0.5 (1.5) over bolts ..	ND		ND	152.4 (60)	10:50 am	Monday		26	NAP.	
M-13 ..	ND	ND		ND	121.9 (48)	01:45 am	Thursday		42	ND.	
M-14 ..	0.3 (1) inby bolts ...	Full-column resin		ND	121.9 (48)	11:00 pm	Tuesday		44.	Neither.	
M-36 ..	Over bolts	Conventional mechanical anchor.		91.4 (36)	121.9 (48)	04:10 pm	Monday		18	ND.	
M-43 ..	0.5 (1.5) inby bolts ..	Conventional mechanical anchor resin assisted.		182.9 (72)	121.9 (48)	12:10 am	Tuesday		100	Neither.	
M-49 ..	1.2 (4) over bolts ...	Full-column resin		121.9 (48)	121.9 (48)	10:48 am	Monday		12	NAP.	

NAP Not applicable.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

Table B-2.—Nonextended cut roof fall fatalities, 1989

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-1 ...	01/04/89	KY	7	Upper Hignite	No	213.4 (84)	3.7 (12)	5.5 (18)	12.2 (40)	66.9 (720)	228.6 (90)
M-2 ...	01/04/89	KY	7	.. do.	No	213.4 (84)	3.7 (12)	5.5 (18)	12.2 (40)	67.1 (720)	228.6 (90)
M-3 ...	01/04/89	KY	7	.. do.	No	213.4 (84)	3.7 (12)	5.5 (18)	12.2 (40)	67.1 (720)	228.6 (90)
M-5 ...	01/11/89	WV	4	No. 2 Gas ...	No	91.4 (36)	5.5 (18)	13.1 (43)	13.7 (45)	129.1 (1,390)	0- 91.4 (0-36)
M-8 ...	02/20/89	VA	5	Splashdam ..	No	96.5 (38)	3.3 (11)	.9 (3)	1.2 (4)	1.1 (12)	0- 10.2 (0- 4)
M-9 ...	02/22/89	KY	7	Hazard No. 4 Rider.	Yes	99.1 (39)	6.1 (20)	2.3 (7.5)	3.7 (12)	7.8 (84)	0- 30.5 (0-12)
M-13 ..	04/03/89	VA	5	Widow Kennedy.	Yes	127.0 (50)	6.1 (20)	12.2 (40)	6.4 (21)	78.1 (840)	106.7 (42)
M-21 ..	05/26/89	WV	4	Eagle	No	83.8 (33)	NAp	6.3 (20.75)	5.9 (19.5)	37.6 (405)	0- 33.0 (0-13)
M-37 ..	09/08/89	KY	7	Rim	No	81.3 (32)	3.7 (12)	3.7 (12)	2.7 (9)	9.7 (108)	0- 30.5 (0-12)
M-49 ..	09/13/89	VA	5	Red Ash	No	109.2 (43)	ND	12.2 (40)	6.1 (20)	10.0 (800)	152.4 (60)
M-54 ..	09/23/89	TN	7	Sewanee	No	96.5 (38)	6.4 (21)	1.8 (6)	1.5 (5)	2.8 (30)	50.8 (20)
M-62 ..	11/09/89	KY	6	Haddix	No	137.4 (50)	NAp	19.2 (63)	7.3 (24)	140.5 (1,512)	0-238.8 (0-94)
Geologic influence		Roof fall classification—accident cause		Worker job classification		Job task or function		Location of victim, m (ft)			
M-1 ...	Undetected slips, localized depression in coalbed.	Retreat mining, insufficiently supported roof, 4-way intersection.		Supplyman		Setting breaker post		Outby supports.			
M-2 ...	.. do.	.. do.		Roof bolting machine operator		.. do.		Do.			
M-3 ...	.. do.	.. do.		.. do.		.. do.		Do.			
M-5 ...	None	Conventional mining, 4-way intersection, excessive unsupported spans.		Cutting machine operator.		Operating cutting machine		Do.			
M-8 ...	None	Worker inby supports, 4-way intersection		Section foreman		Shoveling face coal		2.4 (8) inby supports.			
M-9 ...	None, kettle bottom nearby.	Ineffective setting of temporary supports		Roof bolting machine operator		Installing roof bolts		Last row supports.			
M-13 ..	Slickensided slip, mud seam.	Mining inby supports, 3-way intersection		Continuous mining machine helper		Helping on mining machine		Outby supports.			
M-21 ..	None	Worker inby supports, no temporary supports set, 4-way intersection.		Foreman		Charging bolt holes		1.8 (6) inby supports.			
M-37 ..	Cap coal, slickensided slip.	Conventional mining, worker inby supports.		Cutting machine operator		Barring down cap coal		1.2 (4) inby supports.			
M-49 ..	Slips, water, variable roof rock.	Known bad roof area, 4-way intersection		Roof bolting machine operator		Tramming roof bolting machine.		Outby supports.			
M-54 ..	Known loose roof ...	Conventional mining, worker inby supports, 2-way intersection.		Foreman		Operating scoop loader ...		5.5 (18) inby supports.			
M-62 ..	Shale and coal roof	Conventional mining, illegal retreat mining, excessive unsupported roof.		Cutting machine operator		Operating cutting machine		Outby supports.			

See footnotes at end of table.

Table B-2.—Nonextended cut roof fall fatalities, 1989—Continued

MSHA case	Fall-bolt relationship, m (ft)	Bolt type	Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident	Underground employment	Radio or cable remote
M-1 ...	Over bolts	Conventional mechanical anchor.	91.4 (36)	121.9 (48)	02:40 pm	Wednesday	12	Neither.
M-2 ...	.. do.	.. do.	91.4 (36)	121.9 (48)	02:40 pm	.. do.	12	Do.
M-3 ...	.. do.	.. do.	91.4 (36)	121.9 (48)	02:40 pm	.. do.	12	Do.
M-5 ...	.. do.	.. do.	91.4 (36)	170.2 (67)	12:44 pm	.. do.	14	NAp.
M-8 ...	1.8 (6) inby bolts ...	1.6-cm (5/8-in) high-strength, conventional mechanical anchor.	91.4 (36)	121.9 (48)	10:30 am	Monday	20	ND.
M-9 ...	To bolts	Full-column resin	91.4 (36)	121.9 (48)	09:45 pm	Wednesday	110	Radio.
M-13 ..	6.1 (20) over bolts ..	1.6-cm (5/8-in) high-strength, conventional mechanical anchor.	91.4 (36)	121.9 (48)	09:45 pm	Monday	39	ND.
M-21 ..	1.2 (4) inby bolts ...	Conventional mechanical anchor.	76.2 (30)	121.9 (48)	05:10 pm	Friday	15	NAp.
M-37 ..	ND	.. do.	91.4 (36)	ND	02:20 pm	.. do.	9	NAp.
M-49 ..	Over bolts	Full-column resin	121.9 (48)	121.9 (48)	04:20 pm	Wednesday	10	ND.
M-54 ..	To bolts	ND	ND	ND	11:30 am	Saturday	3	NAp.
M-62 ..	Over bolts	Full-column resin	121.9 (48)	121.9 (48)	05:15 pm	Thursday	14	NAp.

NAp Not applicable.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

Table B-3.—Nonextended cut roof fall fatalities, 1990

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-7 ...	02/08/90	WV	4	No. 2 Gas	No	106.7 (42)	6.1 (20)	1.5 (5) 2.4 (8)	2.1 (7) 2.7 (9)	3.2 (33) 7.3 (79)	0 - 17.8 (0- 7)
M-9 ...	02/22/90	VA	5	Splashdam	No	99.1 (39)	4.9 (16)	9.7 (32)	3.7 (12)	35.7 (384)	0 - 12.7 (0- 5)
M-12 ..	02/24/90	KY	6	Hazard No. 4	No	127.0 (50)	5.5 (18)	10.4 (34)	7.3 (24)	75.8 (816)	30.5-167.6 (12-66)
M-26 ..	04/17/90	KY	6	Elkhorn No. 2.	No	132.1 (52)	6.1 (20)	6.1 (20)	5.5 (18)	33.4 (360)	0 - 53.3 (0-21)
M-31 ..	06/11/90	WV	4	Douglas ...	No	91.4 (36)	NAP	18.3 (60)	6.1 (20)	111.5 (1,200)	61.0-106.7 (24-42)
M-34 ..	07/06/90	KY	6	No. 4 Elkhorn.	No	121.9 (48)	2.4 (8)	2.4 (8)	1.2 (4)	3.0 (32)	12.7 (5)
M-35 ..	07/23/90	IL	8	Herrin No. 6	Yes	223.5 (88)	NAP	1.2 (4)	1.2 (4)	.7 (7)	27.9 (11)
M-46 ..	08/27/90	WV	3	Middle Kittanning.	No	152.4 (60)	4.4 (14.5)	1.2 (4)	2.4 (8)	3.0 (32)	10.2- 14.0 (4- 5.5)
M-53 ..	09/25/90	PA	2	Pittsburgh	No	304.8 (120)	ND	12.2 (40)	10.0 (33)	122.6 (1,320)	0 -182.9 (0- 72)
M-56 ..	10/12/90	KY	6	Elkhorn No. 2.	No	104.1 (41)	4.7 (15.5)	1.5 (5)	1.1 (3.5)	1.6 (17.5)	5.1- 12.7 (2- 5)
M-65 ..	12/10/90	KY	7	Blue Gem	Yes	304.8 (120)	NAP	1.2 (4)	1.2 (4)	1.5 (16)	0 - 19.1 (0- 7.5)
Geologic influence		Roof fall classification—accident cause		Worker job classification		Job task or function		Location of victim, m (ft)			
M-7 ...	Drummy laminated shale roof, slickensides, draw slate.	Worker inby supports		Roof bolting machine operator-helper.		Barring down draw rock ...		Just inby supports.			
M-9 ...	Fragile shale roof, kettle bottoms, cracks, mud seams.	Worker inby supports, 4-way intersection, excessive unsupported roof.		Continuous mining machine helper.		Helping on miner		0.6 (2) inby supports.			
M-12 ..	Unstable roof conditions.	4-way intersection, bolts failed to support roof.		Section foreman		Observing mining		Outby supports.			
M-26 ..	Massive sandstone roof.	Worker inby supports, 2-way intersection		Continuous mining machine helper		Handling cable		Just inby supports.			
M-31 ..	Undetected slickensided formation.	Outby face, bolt torque loss, 4-way intersection.		General inside laborer		Obtaining ventilation curtain		Outby supports.			
M-34 ..	Laminated shale roof, 7.9 m (26 ft) inby outcrop.	Conventional mining, worker inby supports.		Section foreman		Stemming boreholes		1.8 (6) inby supports.			
M-35 ..	None	Longwall recovery		Longwall helper		Recovering shields		1.4 (4.5) inby supports.			
M-46 ..	Slip	Machine canopy smaller than required		Roof bolting machine operator ..		Changing drill steel		Just inby supports.			
M-53 ..	None	Retreat mining, insufficiently supported roof.		.. do.		Setting posts		Outby supports.			
M-56 ..	Draw slate	Conventional mining, worker inby supports.		Loading machine operator		Operating loading machine		0.9 (3) inby supports.			
M-65 ..	Jointed shale, over-mining.	Outby face, roof rehabilitation		General inside laborer		Operating power pack		Outby supports.			

See footnotes at end of table.

Table B-3.—Nonextended cut roof fall fatalities, 1990—Continued

MSHA case	Fall-bolt relationship, m (ft)	Bolt type	Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident	Underground employment	Radio or cable remote
M-7 ...	To bolts	Conventional mechanical anchor.	106.7 (42)	ND	10:30 am	Thursday	19	ND.
M-9 ...	.. do.	ND	ND	121.9 (48)	02:30 pm	.. do.	15	ND.
M-12 ..	Over bolts	Full column resin	91.4 (36)	121.9 (48)	09:00 pm	Saturday	83	Neither.
			121.9 (48)					
M-26 ..	To bolts	Conventional mechanical anchor.	26.2 (30)	121.9 (48)	08:20 am	Tuesday	6	ND.
			121.9 (48)					
			152.4 (60)					
M-31 ..	Over bolts	.. do.	76.2 (30)	ND	12:45 pm	Monday	32	ND.
M-34 ..	0.9 (3) inby bolts	ND	ND	91.4 (36)	10:15 am	Friday	5	NAp.
M-35 ..	0.6 (2) inby bolts	ND	ND	ND	10:40 am	Monday	264	NAp.
M-46 ..	To bolts	Full-column resin	121.9 (48)	170.2 (67)	10:45 am	.. do.	20	ND.
M-53 ..	Over bolts	Conventional mechanical anchor.	121.9 (48)	121.9 (48)	09:50 am	Tuesday	19	ND.
M-56 ..	0.9 (3) inby bolts	Full-column resin	121.9 (48)	139.7 (55)	07:45 am	Friday	10	NAp.
M-65 ..	Over bolts	.. do.	121.9 (48)	121.9 (48)	02:45 pm	Monday	70	ND.

NAp Not applicable.

ND Not determined.

¹Area may not equal length x width because in some instances the lengths and widths are averaged values.

Table B-4.—Nonextended cut roof fall fatalities, 1991

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-6 ...	01/14/91	KY	6	Pond Creek	No	106.7 (42)	ND	1.2 (4)	2.7 (9)	3.3 (36)	10.2 (4)
M-7 ...	02/13/91	VA	5	No. 3 Mason	No	127.0 (50)	NAP	35.0 (115)	10.7 (35)	373.9 (4,025)	91.4-457.2 (36-180)
M-8 ...	02/13/91	VA	5	.. do.	No	127.0 (50)	NAP	35.0 (115)	10.7 (35)	373.9 (4,025)	91.4-457.2 (36-180)
M-9 ...	02/13/91	VA	5	.. do.	No	127.0 (50)	NAP	35.0 (115)	10.7 (35)	373.9 (4,025)	91.4-457.2 (36-180)
M-10 ..	02/13/91	VA	5	.. do.	No	127.0 (50)	NAP	35.0 (115)	10.7 (35)	373.9 (4,025)	91.4-457.2 (36-180)
M-14 ..	03/08/91	WV	4	Dorothy ...	No	274.3 (108)	0.3 (1)	ND	6.1 (20)	ND	ND
M-19 ..	04/03/91	WV	4	Pocahontas No. 3.	No	182.9 (72)	5.5 (18)	1.2 (4)	1.2 (4)	1.5 (16)	30.5 (12)
M-20 ..	04/23/91	KY	7	Hazard No. 4	No	137.2 (54)	ND	24.4 (80)	6.1 (20)	148.6 (1,600)	61.0- 91.4 (24- 36)
M-21 ..	04/23/91	KY	7	.. do.	No	137.2 (54)	ND	24.4 (80)	6.1 (20)	148.6 (1,600)	61.0- 91.4 (24- 36)
M-25 ..	05/17/91	KY	7	Upper Mason	No	76.2 (30)	NAP	2.9 (9.5)	1.2 (4)	3.5 (38)	0 - 22.9 (0- 9)
M-26 ..	05/28/91	WV	4	Coalburg ..	No	160.0 (63)	4.9 (16)	2.7 (9)	2.4 (8)	6.7 (72)	0 - 25.4 (0- 10)
M-28 ..	06/11/91	AL	7	Blue Creek	Yes	205.7 (81)	2.9 (9.5)	3.7 (12)	.9 (3)	3.3 (36)	0 - 30.5 (0- 12)
M-38 ..	08/21/91	WV	4	Upper Cedar Grove.	No	182.9 (72)	NAP	1.4 (4.5)	.8 (2.5)	1.1 (11.25)	20.3 (8)
M-41 ..	08/28/91	KY	6	Clintwood ..	ND	106.7 (42)	9.1 (30)	22.5 (74)	6.1 (20)	137.5 (1,480)	2.5-228.6 (1- 90)
M-48 ..	10/23/91	OH	3	Pittsburgh No. 8.	Yes	391.2 (154)	NAP	.6 (2)	.3 (1)	.2 (2)	10.2- 15.2 (4- 6)
M-49 ..	10/27/91	WV	4	Chilton	No	137.2 (54)	NAP	6.9 (22.5)	4.3 (14)	29.3 (315)	61.0-106.7 (24- 42)
M-58 ..	12/04/91	KY	6	No. 1 Elkhorn	No	261.6 (103)	NAP	1.8 (6)	.9 (3)	1.7 (18)	22.9- 43.2 (9- 17)
Geologic influence		Roof fall classification—accident cause				Worker job classification		Job task or function		Location of victim, m (ft)	
M-6 ...	Roof transition from shale to sandstone.		Worker inby supports, conventional mining.			Roof bolting machine operator ..		Barring down cap coal and loose rock.		2.2 (7.25) inby supports.	
M-7 ...	High-angle slip plane, finely grained laminated shale roof.		Insufficiently supported roof, excessive widths, 3-way intersection.			Section foreman		Discussing mining		Outby supports.	
M-8 ...	.. do.		.. do.			.. do.		.. do.		Do.	
M-9 ...	.. do.		.. do.			Roof bolting machine operator ..		Preparing to install bolts ...		Do.	
M-10 ..	.. do.		.. do.			.. do.		.. do.		Do.	
M-14 ..	Cutters, soft carbonaceous sandy shale roof.		Retreat mining, 4-way intersection ...			Section foreman		Observing mining		Do.	
M-19 ..	Slickensided draw rock.		Excessive bolt spacing			Continuous mining machine operator.		Hanging line brattice		At last row of bolts.	
M-20 ..	Sandy shale immediate roof, visible hillseams and cracks.		Retreat mining, insufficiently supported roof, 4-way intersection.			.. do.		Operating continuous mining machine.		Outby supports.	
M-21 ..	.. do.		.. do.			Continuous mining machine helper.		Helping on continuous mining machine.		Do.	
M-25	Hillseams, water		Insufficiently supported roof, riding belt			Continuous mining machine operator.		Preshift examining		Do.	

See footnotes at end of table.

Table B-4.—Nonextended cut roof fall fatalities, 1991—Continued

MSHA case	Geologic influence	Roof fall classification—accident cause	Worker job classification			Job task or function	Location of victim, m (ft)	
M-26 ..	Roof cavities, slicken-sided carbonaceous sandy shale roof, coal, mud streaks, water in roof.	Worker inby supports, ineffective ATRS use.	Roof bolting machine helper ...			Bending roof bolts	0.9 (3) inby supports.	
M-28 ..	Undetected slickensided roll.	Excessive bolt spacing, bolts not installed to plan.	General laborer			Helping on continuous mining machine.	3.0 (10) outby supports.	
M-38 ..	Draw slate	Insufficiently supported roof, no canopy, 4-way intersection.	Electrician			Operating shuttle car	Outby supports.	
M-41 ..	Hairline cracks	Insufficiently supported roof, 4-way intersection.	Bridge operator			Operating bridge conveyor	Do.	
M-48 ..	Bad roof, intentionally caused roof fall.	Worker inby supports	Mine foreman			Examining roof fall	1.2 (4) inby supports.	
M-49 ..	Unconsolidated material, mud seams, water.	Fall of highwall	Continuous mining machine operator.			Operating continuous mining machine.	Outside portal.	
M-58 ..	Previous roof fall ...	Worker inby supports	Cutting machine operator			Cleaning up roof fall	1.8 (6) inby supports.	
	Fall-bolt relationship, m (ft)	Bolt type	Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident	Underground employment	Radio or cable remote
M-6 ...	0.6 (2) inby bolts ...	Full-column resin	121.9 (48)	152.4 (60)	09:15 am	Monday	34	NAp.
M-7 ...	Over bolts	.. do.	121.9 (48)	121.9 (48)	04:30 pm	Wednesday	25	NAp.
M-8 ...	.. do.	.. do.	121.9 (48)	121.9 (48)	04:30 pm	.. do.	25	NAp.
M-9 ...	.. do.	.. do.	121.9 (48)	121.9 (48)	04:30 pm	.. do.	25	NAp.
M-10 ..	.. do.	.. do.	121.9 (48)	121.9 (48)	04:30 pm	.. do.	25	NAp.
M-14 ..	.. do.	Conventional mechanical anchor.	121.9 (48)	152.4 (60)	12:15 am	Friday	14	Cable.
M-19 ..	0.5 (1.5) over bolts ..	ND	ND	193.0 (76)	05:45 pm	Wednesday	25	ND.
M-20 ..	Over bolts	Conventional mechanical anchor.	76.2 (30)	ND	11:15 am	Tuesday	21	Radio.
M-21 ..	.. do.	.. do.	76.2 (30)	ND	11:15 am	.. do.	21	Radio.
M-25 ..	.. do.	ND	ND	ND	05:15 am	Friday	10	NAp.
M-26 ..	0.3 (1) inby bolts ...	Full-column resin	182.9 (72)	121.9 (48)	05:30 pm	Tuesday	6	ND.
M-28 ..	Between bolts.	.. do.	182.9 (72)	152.4 (60)	07:00 pm	.. do.	460	Radio.
M-38 ..	.. do.	Conventional mechanical anchor.	121.9 (48)	175.3 (69)	08:05 pm	Wednesday	46	NAp.
M-41 ..	Over bolts	Full-column resin	106.7 (42)	121.9 (48)	08:40 am	.. do.	9	ND.
M-48 ..	1.2 (4) inby bolts ...	NAp	NAp	NAp	01:25 am	.. do.	131	ND.
M-49 ..	NAp	Point-anchor resin	182.9 (72)	ND	10:00 am	Sunday	6	Radio.
M-58 ..	Inby bolts	ND	ND	121.9 (48)	02:45 pm	Wednesday	11	NAp.

NAp Not applicable.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.

Table B-5.—Nonextended cut roof fall fatalities, 1992

MSHA case	Date	State	MSHA district	Coalbed	Extended cut approval	Mining height, cm (in)	Depth of cut, m (ft)	Length of fall, m (ft)	Width of fall, m (ft)	Area of fall, m ² (ft ²) ¹	Thickness of rock, cm (in)
M-1 ...	01/01/92	TN	7	Sewanee ..	No	106.7 (42)	ND	ND	3.0 (10)	ND	243.8 (96)
M-2 ...	01/01/92	TN	7	.. do.	No	106.7 (42)	ND	ND	3.0 (10)	ND	243.8 (96)
M-3 ...	02/05/92	WV	4	Upper Dorothy.	No	243.8 (96)	ND	12.2 (40)	10.7 (35)	130.1 (1,400)	ND
M-4 ...	02/11/92	UT	9	Upper O'Conner.	Yes	274.3 (108)	ND	1.8 (6)	1.5 (5)	2.8 (30)	61.0 (24)
M-5 ...	02/12/92	KY	6	Stockton ..	No	147.3 (58)	4.3 (14)	1.4 (4.75)	2.3 (7.5)	3.3 (35.6)	20.3- 30.5 (8-12)
M-7 ...	02/21/92	CO	9	"C" Seam ..	No	228.6 (90)	6.1 (20)	2.3 (7.5)	1.2 (4)	2.8 (30)	2.5- 30.5 (1-12)
M-26 ..	07/30/92	KY	6	Amburgy ..	No	116.8 (46)	NAP	1.0 (3.3)	.8 (2.7)	.8 (8.9)	7.6 (3)
M-27 ..	08/21/92	VA	5	Dorchester	Yes	185.4 (73)	NAP	2.9 (9.5)	.8 (2.5)	2.6 (27.8)	0 - 17.8 (0- 7)
M-40 ..	11/18/92	VA	5	Widow Kennedy.	Yes	101.6 (40)	6.1 (20)	4.6 (15)	2.4 (8)	11.2 (120)	213.4 (84)
M-46 ..	12/08/92	WV	4	Alma	No	111.8 (44)	NAP	2.0 (6.7)	1.7 (5.7)	3.6 (38.5)	19.1 (7.5)
		Geologic influence	Roof fall classification—accident cause			Worker job classification		Job task or function		Location of victim, m (ft)	
M-1 ...	Slickensided slips, fragile shale roof.		Conventional mining, retreat mining, insufficiently supported roof, 4-way intersection.			Roof bolting machine operator		Observing mining		Outby supports.	
M-2 ...	.. do.		.. do.			Utility man		.. do.		Do.	
M-3 ...	Undetected cracks ..		Retreat mining, 4-way intersection ..			Section foreman		.. do.		Do.	
M-4 ...	Previous fall		Cleaning up and resupporting fall ..			Ram car operator		Cutting steel crossbars		0.8 (2.5) inby supports.	
M-5 ...	Draw rock		Bolts not installed to plan, 3-way intersection.			Roof bolting machine operator ...		Installing roof bolt		At last row of bolts.	
M-7 ...	Wet, laminated, separated shale roof.		Insufficiently supported roof, 2-way intersection.			Roof bolting machine helper-trainee.		Marking bolt locations		Do.	
M-26 ..	None		Insufficiently supported roof, conventional mining.			General laborer		Riding in scoop bucket		Under bolts.	
M-27 ..	None		Insufficiently supported roof			Roof bolting machine operator ..		Loading bolts on machine		Outby supports.	
M-40 ..	Mud seams, vertical cracks, rock roll.		.. do.			Continuous mining machine operator.		Operating continuous mining machine.		Do.	
M-46 ..	Loose, broken, and drummy immediate roof.		Insufficiently supported roof, excessive bolt spacing.			Section foreman		Riding in personnel carrier		Under bolts.	

See footnotes at end of table.

Table B-5.—Nonextended cut roof fall fatalities, 1992—Continued

MSHA case	Fall-bolt relationship, m (ft)	Bolt type	Bolt length, cm (in)	Bolt spacing, cm (in)	Time of accident	Day of accident	Underground employment	Radio or cable remote
M-1 ...	Over bolts	Conventional mechanical anchor.	91.4 (36)	ND	07:45 am	Wednesday	9	NAp.
M-2 ...	.. do.	.. do.	91.4 (36)	ND	07:45 am	.. do.	9	NAp.
M-3 ...	.. do.	.. do.	121.9 (48)	ND	09:00 pm	.. do.	25	ND.
M-4 ...	NAp	ND	121.9 (48)	152.4 (60)	11:30 am	Tuesday	119	Radio.
M-5 ...	Inby bolts	Full-column resin	121.9 (48)	152.4 (60)	02:30 pm	Wednesday	28	ND.
M-7 ...	Between bolts	.. do.	182.9 (72)	121.9 (48)	10:40 pm	Thursday	32	NAp.
M-26 ..	.. do.	ND	ND	121.9 (48)	06:30 am	.. do.	15	NAp.
M-27 ..	.. do.	Point-anchor resin	182.9 (72)	121.9 (48)	07:40 pm	Friday	196	ND.
M-40 ..	3 (10) over bolts	Conventional mechanical anchor.	91.4 (36)	101.6 (40)	12:30 pm	Wednesday	9	ND.
M-46 ..	Between bolts	Conventional mechanical anchor and full-column resin.	121.9 (48)	152.4 (60)	12:15 am	Tuesday	30	ND.

NAp Not applicable.

ND Not determined.

¹Area may not equal length × width because in some instances the lengths and widths are averaged values.