

AN ANALYSIS
OF BLASTING ACCIDENTS
IN COAL MINES

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INTRODUCTION

The use of explosives in underground coal mines presents a potential risk for serious injury and death to miners. A major hazard associated with the use of explosives in coal mines is the accidental ignition of methane and/or coal dust. Widespread disasters (loss of 5 or more lives) have been caused by the explosion of methane and/or coal dust initiated by blasting with explosives. Many of these disasters occurred in the early 1900's when the use of black powder in coal mines was prevalent. Since that time great strides have been taken, making blasting- safer in underground coal mines: (1) by eliminating the use of black powder, (2) by the development, testing, approval and use of safer explosives, (3) by the enactment and enforcement of safety requirements, (4) by improvements in blasting techniques, (5) by training and increasing the awareness of hazards. The combined efforts of industry, labor, government agencies and trade associations, such as the Society of Explosive Engineers (SEE) and the Institute of Makers of Explosives (IME) have also been very important in promoting safe blasting practices and reducing accidents.

BLASTING ACCIDENT DISASTERS

As evidenced by events over the past 20 years, coal mine disasters involving blasting continue to occur in spite of the great progress made in explosives technology and blasting safety. For example, the Hyden explosion which resulted in the loss of 38 lives occurred in December 1970, exactly one year after Congress

passed the comprehensive Federal Mine Health and Safety Act of 1969. The official agency report on this disaster (ref. 1) concluded that the explosion occurred when coal dust was thrown into suspension and ignited by detonating cord or by permissible explosives used in a nonpermissible manner or by use of nonpermissible explosives during the blasting of roof rock for a loading point (boom hole). In another instance, two disasters involving the use of explosives occurred within 6 weeks of each other. These accidents, one in December 1981 and the other in January 1982, were known by some as Topmost and RFH (Adkins Coal Company No. 11 Mine and RFH Coal Company No. 1 Mine). These two accidents resulted in the death of 8 and 7 miners, respectively. The official agency report on the Topmost accident (ref. 2) concluded that a coal dust explosion occurred when a blown-out shot ignited coal dust. In the RFH accident, the official agency report (ref. 3) concluded that a coal dust explosion occurred when a blown-out or blown-through shot ignited coal dust.

HISTORICAL ACCIDENT COMPARISON

In comparison to blasting accidents which occurred during the first decade of the 1900's, the reduction in injuries and fatalities has been dramatic. For example, there were 111 explosion disasters with a total of 3,316 fatalities in the 10 year period from 1901-10 (ref. 4). Many of these disasters resulted from the use of black powder and dynamite for blasting. During the 23 year period from 1970-92, there were three (3)

blasting accidents, each involving 5 or more fatalities. These three (3) accidents which resulted in a combined total of 53 fatalities were discussed earlier in this paper and are shown in Table 1.

As the extraction of coal by the use of explosives in underground coal mines continues to decline, so have fatalities and injuries from blasting accidents. The consumption of permissible explosives for blasting has fallen to 12.6 million pounds in 1991 (ref. 7). Figure 1 shows the continual decrease in the consumption of permissible explosives from 1980 through 1991. Nevertheless,, blasting accidents are still an important safety concern. The concerted efforts of the mining and explosives industry and labor and government agencies have greatly improved the safety record of blasting in coal mines. Great strides were made in reducing accidents in this Century as the use of black powder for blasting was eliminated. The use of safer explosives and better blasting procedures and requirements played an important role in improving the safety record. Serious blasting accidents are a rarity today, compared to the early 1900's, when they were all too commonplace.

Although no disaster involving explosives has occurred since 1982, multiple fatalities have occurred in several accidents. A recent accident resulting in three (3) fatalities from the use of explosives occurred at the Granny Rose Coal Company's No. 3 Mine in July 1990. This accident occurred when explosives located in a scoop bucket attached to a battery-powered tractor were

unintentionally detonated simultaneously with routine production blasting of a 3-way face (ref. 5).

Unfortunately, serious blasting accidents continue to occur in coal mines. A previous analysis by the Bureau of Mines showed that there were more blasting accident injuries in underground coal mining than in any other type of mining (ref. 6).

BLASTING ACCIDENT ANALYSIS

In the 12 year period from 1980 through 1991, there were 45 fatalities from blasting accidents in underground coal mines. Table 2 shows a list of these accidents which MSHA investigated and the type or method of mining. The Youngs Branch No. 15 Mine blasting accident is included in this list since it is an underground coal mine. However, the accident occurred on the surface of this mine from the burning of explosives. One fatality and one injury resulted from this accident.

Several hundred underground coal mines use explosives to extract coal. About 20 percent of these mines blast off-the-solid. Forty (40) of the 45 fatalities from the blasting accidents during the 12 year period (1980-91, Table 2) occurred at mines that blasted coal off-the-solid. Six (6) of the 40 fatalities occurred in anthracite mines. Almost 90 percent of these fatalities occurred in mines that blasted off-the-solid. As discussed earlier, two of the accidents which occurred within 6 weeks of each other were major disasters. Since the 1969 Coal Mine Health and Safety Act, there have been three (3) major

disasters caused by blasting. These three (3) disasters, listed in Table 1, resulted in 53 fatalities. An analysis of these three (3) disasters show a feature common to them was the resulting ignition and propagation of a coal dust explosion.

During the 12 year period from 1980-91, there were 16 accidents and 34 fatalities that occurred in mines that use blasting-off-the-solid techniques. These accidents all occurred in small mines employing less than 15 persons. A listing of the accidents, extracted from Table 2, is shown in Table 3. Multiple violations of federal mine safety standards occurred in each of these accidents. It is important to note that none of these accidents occurred as the result of using permissible explosives in a permissible manner. Inadequate safety practices were determined to be factors in all of these accidents. Each of the accidents was analyzed and important factors in these accidents were as follows:

- * Use of nonpermissible explosive materials
- * Failure to follow mine projection
- * Poor ventilation
- * Failure to withdraw persons from worksites adjacent to blast site
- * Drilling and loading of holes simultaneously
- * Detonators were not shunted
- * Explosives were not stored in a safe location
- * Angled boreholes were drilled beyond the rib line
- * Failure to conduct methane checks

- * Loading boreholes with more, than 3 pounds of explosive
- * Failure to stem explosive-loaded boreholes
- * Shot blew out or blew through to adjacent work area
- * Insufficient rock dusting
- * Excessive accumulations of coal dust
- * Lack of an accurate and up-to-date map of the mine
- * Insufficient burden parallel to a loaded borehole
- * Improper handling of misfires

As determined by a U.S. Bureau of Mines study published in the proceedings of the Society of Explosive Engineers (ref. 6), a lack of blast area security is a factor in about 50 percent of the blasting accidents.

BLASTING REQUIREMENTS

In order to improve the safety requirements, extensive revision has been made by MSHA on blasting regulations and approval standards for explosives used in underground coal mines. These final rules were published in the Federal Register on November 18, 1988, with an effective date of January 17, 1989. The revised regulations provide increased safety protection for miners by addressing specific blasting hazards and including more performance oriented requirements. The regulations also address advances in technology such as the sheathed explosive for unconfined blasting. These standards contain requirements for qualification of persons handling and using explosives. The standards address the use of permissible explosives and blasting equipment, transportation and storage of explosives and

detonators, preparation before blasting, blasting circuits, methane checks, firing procedures, examination after blasting and misfires. The standards also specify the amount of explosive that is permitted to be used in a borehole and address stemming and stemming material for boreholes.

A section in the revised standards addresses multiple-shot blasting which includes blasting of cut coal and blasting-off-the-solid. This standard addresses the sequence of firing and the delay intervals between shots with a limitation placed on total elapsed blasting time not to exceed 1000 milliseconds for bituminous and lignite mines. Further details may be found in Title 30, Code of Federal Regulations (ref. 8,9) and in several MSHA papers (ref. 10,11).

SUMMARY

The decline in the number of accidents and injuries in this Century from blasting in coal mines is largely due to the introduction and use of permissible explosives, improvements in blasting practices and adherence to safety requirements.

In this analysis, many of the fatalities from blasting accidents over the last 12 years occurred in mines that use blasting off-the-solid methods. An analysis of these accidents indicated that knowledge of and training on safe blasting practices are important to avoid explosives accidents. Moreover, constant vigilance and adherence to these safety practices and the applicable regulations when using explosives must be

maintained and followed to minimize blasting accidents and injuries.

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Table 1 -- Blasting accidents involving 5 or more fatalities in coal mines, 1910-92

<u>Date</u>	<u>Name</u>	<u>Fatalities</u>	<u>Injuries</u>
1/20/82	RFH, No. 1 Mine	1	0
12/7/81	Adkins, No.11 Mine	8	0
12/30/70	Hyden, No. 15 & 16 mines	38	1 (slightly)

Table 2 -- Blasting accidents in coal mines, 1980-91

<u>Date</u>	<u>Mine Name</u>	<u>Type or Method*</u>	<u>Deaths</u>	<u>Injuries</u>
11/19/91	Wolf Branch Collieries, No. 1 Mine	C	1	0
11/15/91	Youngs Branch No. 15 Mine	UGS	1	1
9/13/90	"D" Shaft, VP-5 Mine	x	0	0
9/10/90	"D" Shaft, VP-5 Mine	x	0	0
8/26/90	"D" Shaft, VP-3 Mine	X	0	0
7/31/90	Granny Rose Coal Co., No. 3 Mine	S	3	2
3/29/89	Tippy Coal Co., No. 1 Mine	S	0	1
3/8/88	Gordon Coal Co., #6	S	1	2
1/9/88	Rent. Mt.Res., No. 1 Mine	S(O)	1	0
9/22/86	T&R Coal Co. Mine No. 3A	C	0	1
12/12/85	Buck Mt. Slope	A	2	0
12/11/85	MSW Coal Co., No. 2 Slope Mine	A	3	1
8/15/85	R&R Coal Co., No. 3 Mine	S	3	1
7/9/85	G&G Coal Co., Mine No. 1	S	1	0
6/3/85	B&M Tunnel	A	0	4
3/16/84	Superior Coal Co., Mine No. 1	C	1	0
5/10/83	Consol, Arkwright No. 1 Mine	P	0	3
4/12/83	Golden Chip Coal Co., NO. 10 Mine	c	0	1
6/1/82	Coyt Earls, Jr. Coal Co., No. 1 Mine	S	1	2
1/20/82	RFH Coal Co., No. 1 Mine	S	7	0
1/5/82	W.R.W. Corp., No. 1 Mine	S	2	0
12/7/81	Adkins Coal Co., No. 11 Mine	S	8	0
11/30/81	Ensol Coal Co., No. 2 Mine	S	0	3
10/21/81	Meally Coal Co., No. 2 Mine	S	1	0
10/12/81	Big Hill Coal Co., No. 4 Mine	s	1	1
1/3/81	D.O. & W Coal Co., No. 5 Mine	C	1	1
12/18/80	Ziegler Coal Co., No. 5 Mine	C	1	0
10/27/80	Frank Crawford, Jr. Coal Co., No. 1 Mine	S	3	0
10/8/80	Adkins Coal Co., No. 11 Mine	S	1	2
g/3/80	Rebeca Coal Co., No. 2 Mine	S-R	1	2
9/1/80	C.S. and S. Coal Co., Mammoth Slope	A	1	1

* A, Anthracite O, outby location
 C, Cut coal P, Coal pillar stumps
 S, Solid coal CGS Surface of underground mine
 S-R, Solid with X, Shaft sinking
 rock partings

Table 3 -- Accidents that occurred during
blasting-off-the-solid

<u>Date</u>	<u>Mine Name</u>	<u>State</u>	<u>Fatalities</u>	<u>Injuries</u>
7/31/90	Granny Rose Coal Co., No. 3 Mine	KY	3	2
3/29/89	Tippy Coal Co., No. 1 Mine	KY	0	1
3/8/88	Gordon Coal Co., #6	KY	1	2
1/9/88	Kent. Mt.Res., No. 1 Mine	KY	1	0
8/15/85	R&R Coal Co., No. 3 Mine	KY	3	1
7/9/85	G&G Coal Co., Mine No. 1	TN	1	0
6/1/82	Coyt Earls, Jr. Coal Co., No. 1 Mine	KY	1	2
1/20/82	RFH Coal Co., NO. 1 Mine	KY	7	0
1/5/82	W.R.W. Corp., No. 1 Mine	KY	2	0
12/7/81	Adkins Coal Co., No. 11 Mine	KY	8	0
11/30/81	Ensol Coal Co., No. 2 Mine	KY	0	3
10/21/81	Meally Coal Co., No. 2 Mine	KY	1	0
10/12/81	Big Hill Coal Co., No. 4 Mine	KY	1	1
10/27/80	Frank Crawford, Jr. Coal Co., No. 1 Mine	KY	3	0
10/8/80	Adkins Coal Co., NO. 11 Mine	KY	1	2
9/3/80	Rebeca Coal Co., No. 2 Mine	VA	1	2

FIGURE 1

CONSUMPTION OF PERMISSIBLE EXPLOSIVES

