Methane Ignitions on Roof Bolters in Underground Coal Mines

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ABSTRACT

Although not as frequent in nature as ignitions on continuous miner or longwall faces, ignitions of methane on roof bolters have caused serious injuries to underground coal miners. After reviewing the accident reports for all roof bolter ignitions from 1981 to 1998, a summary of the forty-one accidents has been developed. Of interest in the database is the ignition source, method of face ventilation, local velocity, methane liberation, size of the methane body ignited, and the duration of the flame. Three example ignitions are included.

KEYWORDS

Face Ignitions, Roof Bolter, Methane Liberation, Face Ventilation, Ignition Sources

INTRODUCTION

Upon notification of a methane ignition, MSHA enforcement personnel conduct an investigation of the accident. The reports are kept in an accident database by MSHA Technical Support for future reference. Ignitions on roof bolters were reviewed to determine similarities and trends for this type of accident. The database was searched from 1981 to 1998, including all reported methane ignitions. Most ignitions did not cause serious injury. However, the potential for disaster does exist as seen in the accident database analysis. This paper summarizes the data from 41 accident investigation reports for ignitions on roof bolting machines in underground bituminous coal mines.

TYPICAL BOLTER IGNITIONS

With few exceptions, the typical roof bolter ignition has been a non-injury accident. Injuries to miners as a direct result of ignitions have occurred in cases where ventilation controls were not properly maintained, required airflow quantities were not maintained, or permissibility of equipment was not maintained.

Most ignitions required miners to extinguish flames using fire extinguishers, rock dust or water. Only six were self-extinguishing. Most events lasted less than six minutes. Ignitions lasting more than one minute were normally ignitions which ignited methane feeders in the face or along the rib. While methane is generally ignited at the drill hole, three in four ignitions propagated beyond the drill hole.

Many ignitions seem to coincide with unusual mining conditions. Many reports indicate unusually hard roof conditions and excessive bit wear as contributing factors. Other circumstances include bolting in caved areas, where methane accumulations are more likely to occur. It seems a significant factor in these ignitions is the mine methane liberation rate.

METHANE LIBERATION

The distribution of methane liberation rates for all underground coal mines is shown in Figure 1. Approximately 10 percent of the mines liberate in excess of 200,000 cubic feet of methane per day, and 5 percent exceed one million cubic feet in a single day. Bolter methane ignitions have occurred in a small percentage of all underground mines, which are all considered to be some of the gassiest. For all forty one ignitions, mine methane liberation exceeded 850,000 cubic feet per day.

Two of the 41 ignition accident reports indicated methane tests were not made prior to bolting. Of the remaining thirty-nine, measured levels did not exceed 1 percent. The highest methane reading reported was 0.9 percent prior to bolting.

"Legal" gas checks are required by 30 CFR 75.362 before a bolter is taken into or operated in a working place. Testing is also required every 20 minutes while in the working place. All tests must be taken while under supported roof, which in the case of a roof bolter requires the use of an extendable probe to test the area between the bolter and the face.

The location of tests is specified in 30 CFR 75.323 as at least one foot from the roof, face, ribs and floor. This may be one reason bolter operators do not detect very thin methane accumulations in pockets or layers along the roof.

Another is that it is very difficult to detect thin layers along the roof (Mitchell, 1996). In describing the ignitions, accident reports indicate the methane bodies are very small and are not of an ignitable concentration within the entire working place. Most were identified as thin layers along the roof. Methane layers can be avoided by providing adequate air velocity in the bolting place. Velocities required to control layering in typical working places may be as high as 200 feet per minute or more depending upon the methane inflow rate (Hartman, 1997).

IGNITION SOURCES

Accident reports identified ignition sources in all but two of the ignitions. One was ignited by equipment electrical conductors as the bolter was not maintained in permissible condition. The remaining 38 accidents were caused by similar circumstances, including overheated drill steels, frictional heating, overheated bits or sparking bits. A graph of the ignition sources is included in Figure 2. All of the 38 accidents were ignited at the drill hole.

Ten of the ignitions were confined to the immediate drill hole location. Eighteen propagated to the face and 9 propagated both to the face and outby the bolting machine. Three propagated to the rib from the bolt hole.

FACE VENTILATION METHOD

Much work has been completed by MSHA and the former US Bureau of Mines concerning the comparison of the effectiveness of blowing and exhausting face ventilation systems. Blowing systems have a greater effectiveness in controlling methane, while exhaust systems are more effective for dust control (Dalzell, 1966, Mundell, 1977).

While some ventilation systems were not described within the accident reports, most did report the type of face ventilation system used while bolting (Figure 3). The majority (59 percent) of the ignitions occurred on sections using exhaust ventilation. A total of 28 percent used blowing face ventilation, or a combination of blowing and exhausting ventilation. Five accident reports indicated adequate ventilation was not provided to the bolter as required by the approved ventilation plan.

INJURIES

Most bolter ignitions do not cause injuries to equipment operators. Of the 10 injuries reported, only three occurred as a direct result of the initial ignition. All three of these injuries occurred in the two ignitions where no methane checks were made prior to bolting.

The remaining seven were due to firefighting activities. One operator fell off of his machine and another received burns in one accident. Five persons were burned in a secondary ignition while rock dusting in the cavity of a fall area.

EXAMPLES

The following report excerpts have been taken from actual MSHA accident investigation reports. All three are for accidents which occurred in Alabama - sixty-three percent of all roof bolter ignitions from this study happened in Alabama mines.

Example 1

The greatest number of injuries caused by a bolter ignition was in 1990 at a mine in Alabama. The mine liberated 14.4 million cubic feet of methane daily.

Approximately 21 feet of the roof 2 ½ feet thick near the face in an entry had fallen out and needed to be cleaned up before bolting in the place could be completed. The entry was being bolted up to the fall. Methane checks prior to bolting indicated 0.8 to 0.9 percent methane was present in the place.

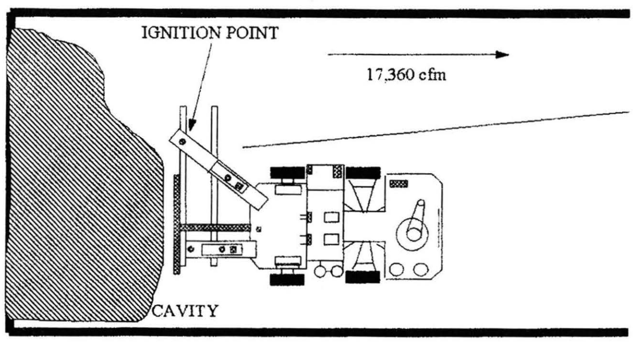
The bolter operator was in the process of spinning the bolt resin for a bolt in the fourth row in the place which was just outby the fall as shown in Figure 4. This location was approximately 18 feet from the face. Sparks caused by contact between the roof bolt plate and strap ignited a methane mixture. The flames were extinguished by using four fire extinguishers.

The miners, after concluding the flames were extinguished, backed out the bolter and trammed in a scoop to rock dust the area. After applying dust for a few seconds, flames started from the face area and came outby over the men causing five miners to be treated for burns, smoke inhalation and shock.

The flames were extinguished with water and foam from a foam generator. The methane body in the cavity had not been extinguished prior to rock dusting. The slow burning body became explosive with the disturbance caused by the rock dusting.

The section used a blowing face ventilation system - however, the blowing curtain was not installed as per the requirements of the approved mine ventilation plan. An exhaust curtain was installed with the air quantity behind the curtain measured to be 17,360 cubic feet per minute.

Example 2



This second example also occurred at an Alabama mine in 1993. The mine liberated 20 million cubic feet of methane each day. Methane checks prior to bolting indicated 0.6 to 0.8 percent methane was present in the section. The section used a combination blowing and exhausting brattice face ventilation system. The curtains provided 10,400 cubic feet per minute to the face, but the curtains were hung so tight that they allowed methane from a feeder in the roof to

Figure 4. Bolter ignition example number 1.

accumulate in a roof layer between the curtains.

The bolter operator was drilling through steel channel into the roof approximately 25 feet from the face when sparks caused by contact between the drill steel and channel ignited the methane mixture which had migrated out of the curtained area. The flames were extinguished by using fire extinguishers, water and foam. One head injury to a roof bolter operator occurred at the onset of the ignition. A second injury due to inhaling fire extinguisher material occurred during fire fighting activities.

Example 3

This third example also occurred at an Alabama mine in 1982. The mine liberated over 20 million cubic feet of methane each day. Methane checks prior to bolting indicated 0.4 to 0.7 percent methane was present no closer than 12 inches from the roof, ribs and faces in the bolting place. The section used an exhausting face ventilation system. The curtain provided 27,000 cubic feet per minute to the face area as measured at the end of the curtain, and was 6 ½ feet from the face at the time of the ignition.

The bolter operator was drilling through extremely hard sandy shale in the roof when the drill steel became stuck. While lowering the steel from the hole, it fell against the face, igniting the body of methane. The flames were extinguished by using a fire extinguisher. This accident occurred in spite of the ventilation provided.

CONCLUSIONS

Most roof bolting ignitions can be avoided by maintaining ventilation requirements and making required examinations for methane. Awareness of potential for methane layering is also important for bolter operators for identifying this potential hazard. Additional tests for methane layering nearer to the roof, and additional ventilation measures in the gassiest seams, would decrease the potential for ignitions and methane layering.

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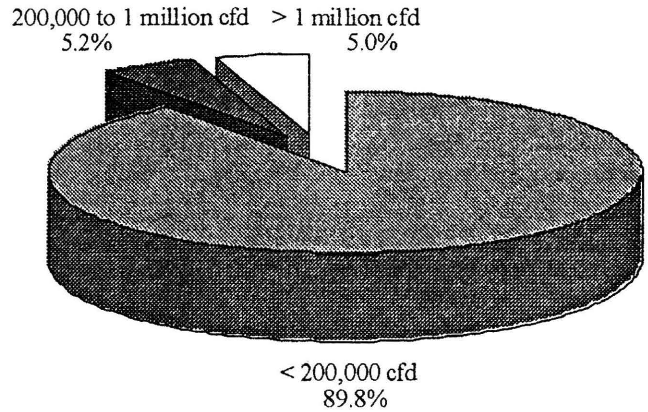

Figure 1. Methane liberation rates in U.S. underground coal mines

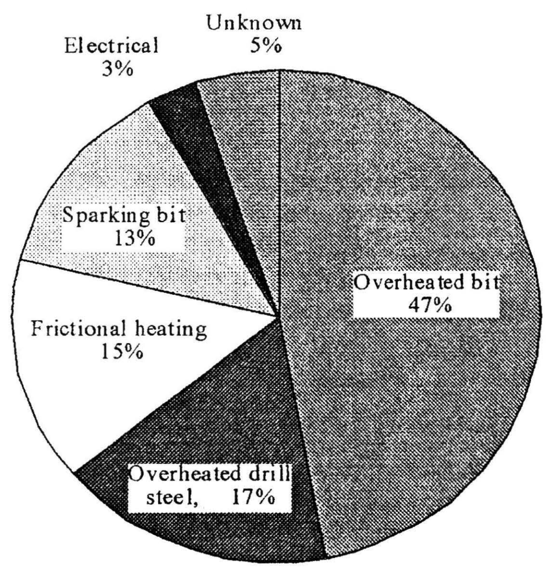

Figure 2. Roof bolter ignition sources.

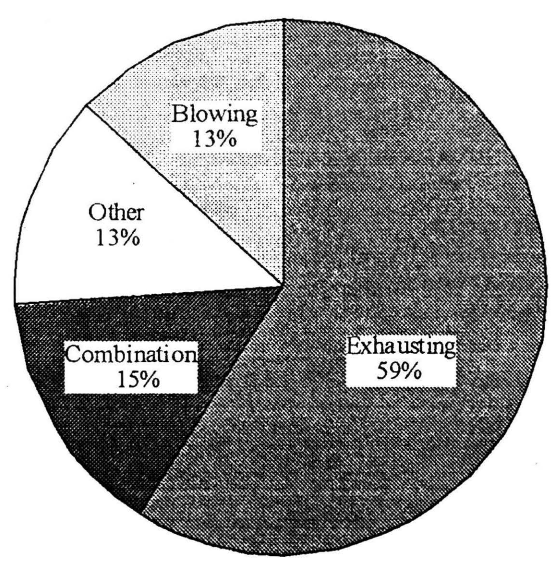

Figure 3. Type of face ventilation system used in mines with ignitions.