Conveyor belt entry fire hazards and control

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ABSTRACT: A fire in a coal mine conveyor belt entry represents a major safety and health risk to miners. Fighting belt entry fires can be a demanding effort. If there is a failure of one aspect in the fire-fighting needs such as a dissimilar hose-valve connection, then it can result in the inability to extinguish a fire. Fire incident data compiled over nearly 30 years for underground coal mines shows that fires in belt entries account for 15-20 percent of the total number of fires. Fires in the belt entries of coal mines have resulted in injuries and fatalities. New regulations have been promulgated that require an unplanned fire not extinguished within 10 minutes of discovery to be reported to the Mine Safety and Health Administration (MSHA). A fire that is not extinguished within several minutes may take hours or days to extinguish or may require sealing a section or the mine in some cases. The current fire protection regulations in the U.S. Code of Federal Regulations (CFR), Title 30, Part 75 are designed to prevent or control the fire hazards present in a belt entry. These requirements and other factors affecting belt entry fires are discussed, including fire detection and warning, fire suppression devices, type and location of fire-fighting equipment, waterlines, and cleanup and removal of combustible materials. The fire suppression systems used to extinguish/control a belt fire and the effect of ventilation on the propagation of conveyor belt fires are also discussed.

1 Introduction

A fire occurring in an underground coal mine conveyor belt entry represents a major safety and health risk to miners. If the fire is small when discovered, it most likely will be extinguished before becoming a major conflagration. Fighting a conveyor belt entry fire can be a demanding effort and failure of one aspect can result in losing control of extinguishing the fire.

Fire incident data compiled over nearly 30 years for underground coal mines show that fires in belt entries account for 15-20 percent of the total number of fires. Fires in the belt entries of coal mines have resulted in injuries and fatalities. Most of the fire incident data compiled was obtained from mine operator reports of underground coal mine fires lasting 30 minutes or longer. Prior to December 8, 2006, an unplanned underground mine fire not extinguished within 30 minutes of discovery was to be reported by the mine operator to MSHA. However, beginning December 8, 2006, new MSHA regulations (1) require a mine operator to report an unplanned underground mine fire that is not extinguished within 10 minutes of discovery. A fire that is not extinguished within several minutes may take hours or days to extinguish or may require sealing a section or the mine in some cases. The current fire protection regulations in 30 CFR Part 75 are designed to prevent or control the fire hazards present in a belt entry. These requirements and other factors affecting belt entry fires are discussed which include fire detection and warning, fire suppression devices, type and location of fire-fighting equipment, waterlines, and cleanup of combustibles. The fire suppression systems used to extinguish/control a belt fire and the effect of ventilation on the propagation of conveyor belt fires are also discussed.

2 Conveyor Belt Fire Incident Data

A large amount of data has been collected and analyzed on underground coal mine fires (2), (3), (4). The data shows over the past 30 years that fires in conveyor belt entries continue to represent about 15 to 20 percent of all underground coal mine fires. More recent fire incident data for conveyor belt entries in U.S. underground coal mines has been summarized by year, 1980-2005 (4). As indicated in Figure 1, which is prepared from the 1980-2005 data on ignition sources indicated in Francart’s paper (4) and the MSHA presentation on “Reducing Belt Entry Fires in Underground Coal Mines” (5), there were 63 conveyor belt entry fires. Of the 63 fires, friction at the belt drive and along the belt served as the ignition source for 36 percent. Frictional heating continues to be a most common ignition source in underground coal mine conveyor belt entry fires.

Figure 1 – Ignition Sources for U.S. Underground Coal Mine Belt Entry Fires, 1980-2005

The data published in Francart’s paper (4) preceded the more recent underground coal mine conveyor belt fire that
have shown the magnitude of the fire hazard, including the threat of explosion (9). Large-scale conveyor belt tests on conveyor belt. In a conveyor belt entry there is an abundant supply of combustible materials including the conveyor belt itself, coal and coal fines, grease and oil and possibly wooden supports. Belt entry fires have occurred from various sources of ignition as shown in Figure 1. It doesn’t take much time for a conveyor belt fire to build in intensity and create a potentially lethal atmosphere. Conveyor belt fires have burned as much as 610 meters (2000 feet) of belting. A conveyor belt that has poor resistance to fire will spread flames along the exposed surfaces of the belt and eventually ignite other combustibles such as the coal. As the belt fire progresses and extends to other combustibles, the concentrations of toxic gases increase to potentially lethal levels. The mine ventilation can be disrupted from a propagating conveyor belt fire. The disruption of the ventilation can introduce a threat of explosion from the accumulation of methane and the release of flammable gases. As an example, mine rescue teams fighting a conveyor belt fire at the Marianna Mine were withdrawn because high levels of methane accumulated, posing the threat of explosion (9). Large-scale conveyor belt tests have shown the magnitude of the fire hazard, including the various flammability characteristics of conveyor belting as affected by the ventilating airflow and the potential of the fire to spread to other combustibles (10), (11), (12), and (13). These large-scale conveyor belt fire tests have shown that a ventilating airflow of about 92 meters per minute (300 feet per minute) is optimum for flame propagation. Figure 2 shows the propagation of a conveyor belt fire during a large-scale test at the National Institute for Occupational Safety & Health (NIOSH) Lake Lynn Laboratory.

Increasing the fire resistance of the conveyor belt and limiting the amount of combustibles in the belt entry are among the measures that will reduce the potential for a disastrous fire. As a matter of fact, the accumulation of combustible materials was the most frequently cited underground coal mine safety standard (30 CFR 75.400) by MSHA enforcement personnel in 2006 (www.msha.gov). Cleanup of combustible materials, particularly the extraneous coal is one of the most important fire safety measures in a belt entry.

The federal Technical Study Panel on the Utilization of Belt Air and the Composition and Fire Retardant Properties of Belt Materials in Underground Coal Mining has made recommendations that encompass conveyor belt entry and conveyor maintenance and improved fire resistant standards for conveyor belting. Information on the Panel’s recommendations and final report may be found on MSHA’s website at http://www.msha.gov/BeltAir/BeltAir.asp

Figure 2 – Propagation of a Conveyor Belt Fire during a Large-scale Test at the NIOSH Lake Lynn Lab

4 Fire Protection Requirements

There are extensive MSHA regulations addressing belt conveyor fire protection and control in 30 CFR, Part 75, Subpart L, Fire Protection (14). The regulations address slippage and sequence switches, fire resistant conveyor belting, fire detection and warning systems, fire hose and waterlines including suitable fittings, and automatic fire suppression equipment. For underground coal mines that
use belt air to ventilate working sections there are fire protection requirements specified in the MSHA regulations under Part 75, Subpart D Ventilation (15). Another source is the U.S. Department of Labor eLaws® which include an MSHA Fire Suppression and Fire Protection Advisor. This Advisor provides minimum fire protection requirements for underground coal mine electrical equipment which includes conveyor belts (http://www.dol.gov/elaws/msha/fire/fire_3.asp).

The MSHA regulations pertaining to conveyor belt fire protection and control are minimum requirements intended to reduce the incident of fire in a belt entry and to control a fire should one develop. Of primary importance are properly designed and maintained fire detection and fire suppression systems. The requirements for the use and installation of fire suppression systems, including water deluge, water sprinklers, foam generator, and dry powder chemical systems are specified in 30 CFR, Part 75, Subpart D (14). The importance of properly designed fire suppression systems, particularly as the use of wider belts increases, is one of the outcomes from on-going large-scale research being conducted by NIOSH in partnership with MSHA on the suppression of conveyor belt fires. The design of a fire suppression system must include measures to appropriately cover wider belts with the fire suppressing agent and to address the effect of higher rates of airflow where employed in belt entries. Also, early fire detection through the use of carbon monoxide (CO) and smoke detectors, is critical to alerting miners and attending to a fire incident and can mean the difference between extinguishing a fire and having to contend with a fire that has grown out of control. Another key component is waterlines used with a fire hose for fighting a fire in a belt entry. Waterlines shall be capable of delivering 189 liters (50 gallons) of water a minute at a nozzle pressure of 3.5 kilograms per square centimeter (50 pounds per square inch). This is a minimum performance standard specified in 30 CFR, Part 75.1100-1(a) and is commonly referred to as the “50/50” rule. The length, size and type of hose affect compliance with this performance standard because water flowing through a hose will create pressure loss along the hose due to friction. The magnitude of this friction pressure loss will depend upon the water flow rate and the length, size and type of hose (16).

Undoubtedly, those measures needed to reduce the hazards of conveyor belt entry fires are prevention, early detection, improved belt fire resistance, proper response and communication, extinguishment, and proper maintenance and examinations. Another source of detailed information for fire prevention and control in underground coal mine belt entries is the National Fire Protection Association Standard 120 (17). Other key factors are preparedness and proficient response to a fire in a belt entry. An excellent source for fire preparedness is the report “Fire Response Preparedness for Underground Mines” prepared by Ron Conti, et. al. (18).

5 Cost of Belt Entry Fires

There are inherent costs associated with a conveyor belt entry fire, especially if the fire is not quickly extinguished. These costs can encompass lost production days, costs for extended work hours, extinguishment costs for chemical agents and equipment, costs of sealing a section of the mine or the mine itself, and costs for rehabilitation of the affected area(s).

The effect and impact of the Marianna Mine fire is an example of the expenses that are incurred in fighting a belt-entry fire. Personnel and equipment from nearby mines were brought to the mine to fight the fire. Food, lodging, and wages were provided for these personnel by the mine operator. When the rescue teams were withdrawn, all equipment was left in the mine, and mines that loaned the equipment were reimbursed. More than 30 boreholes were drilled in an attempt to form underground seals for controlling the fire by using materials pumped from the surface. Access rights were purchased from landowners, and roadways were cleared and built so that drilling equipment could be installed. Material was pumped into the mine through the boreholes in an attempt to create underground seals. When this attempt to extinguish the fire failed, the entire mine was sealed. During the 30 days between the discovery of the fire and sealing of the mine, the direct cost of the fire fighting efforts was reported to have been between $5 and $6 million. Costs other than the fire fighting efforts not included in this $5 to $6 million amount would significantly increase the total cost of the Marianna Mine fire. The annual lost revenue at the time of the fire in 1988 would have been about $24 million. Miner benefits were maintained for a time following the mine shutdown. Underground mining supplies, equipment, and firefighting equipment owned by the mine operator were left underground when personnel were withdrawn. The cost of this abandoned mining equipment alone was in the millions of dollars. Of the 327 employees employed at the Marianna mine site, only a few remained employed in mining. In the case of the Marianna underground coal mine conveyor belt entry fire that occurred in 1988, the significant cost impact was the permanent sealing and closing of the mine and the loss of resources.

6 Summary

A primary fire hazard in a conveyor belt entry is the belt itself. The fire resistant level of a conveyor belt will have a significant impact on the occurrence and extent of a belt entry fire, should one develop. The first line of defense in strictly limiting the propagation of fire involving a conveyor belt is to use a conveyor belt of high fire resistance. The safety measures discussed for conveyor belt fire protection and control are systems that encompass redundancy. Early detection of a fire is paramount to determining the nature of a fire incident and subsequent warning of miners. Nonetheless important are all the other requirements and measures that address slippage and sequence switches, fire hose and waterlines, automatic fire
suppression equipment, cleanup of combustibles, proper maintenance, communications, and fire response and preparedness. The combination of all the safety elements discussed is intended to reduce the hazard of conveyor belt entry fires. The success in this endeavor will not only result from the regulations, policies and technologies employed, but also from the dedication of the mine operator and miners to belt entry fire safety.

References


MSHA database for reported underground coal mine fires from 2006 through July 2007.


U.S. Code of Federal Regulations, Title 30, Part 50, Section 50.2 Definitions, 50.2h(6), July 1, 2007.
