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THE USE OF ATMOSPHERIC MONITORING SYSTEMS IN U.S. UNDERGROUND COAL MINES

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ABSTRACT

In 1995 and 2003, the Mine Safety Health Administration (MSHA) conducted surveys to determine the number of atmospheric monitoring systems (AMS) being used in underground coal mines in the United States. The survey reports showed data for the different AMS manufacturers, the different types of equipment monitored, and the different type of gas sensors and their locations. Since the last survey in 2003, MSHA has changed the regulation requirements for early fire detection along the belt haulage entries. As of December 31, 2009, point-type heat sensors were prohibited for use for an early fire detection system; instead carbon monoxide (CO) sensors are now required. This report will examine the number of AMS currently used in underground mines in the United States to see if there is a change in their use. The locations and parameters monitored by AMS are also discussed.

INTRODUCTION

The last survey conducted by the Mine Safety and Health Administration (MSHA) on atmospheric monitoring systems (AMS) used in underground coal mines in the United States (US) was in 2003 [1]. The survey report states that since 1995 there had been a steady increase in the use of AMS in underground coal mines as the technology of CO sensors was improved by manufacturers. AMS had become more reliable and some CO sensors could be purchased with the capability to discriminate between the CO produced from a fire versus CO produced from diesel equipment. This increase in reliability had reduced the number of false alarms and the response time. The faster response time to a developing fire allowed for the miners to take the necessary action to put out the fire or exit the mine.

It should also be noted that at the time of last MSHA survey, some mines still used point-type heat sensors to detect the presence of a fire on conveyor belts. This detection method works by measuring the temperature of the air around the sensor. As a fire starts to develop, smoke and hot gases are produced from the combustion process, and the air is heated up. Once the air and gases reach a designated temperature detected by the point-type heat sensor, a fire alarm signal is generated. Studies have shown that the response times for detecting the presence of a fire using CO sensors are much shorter than using point-type heat sensors [2].

Finally, since the last MSHA survey, regulations have changed on the type of automatic fire detection systems permitted to be used in conveyor belt entries. As of December 31, 2009, point-type heat sensors are not permitted to be used for fire detection in underground coal mines in the US; instead CO sensors are required as a replacement (30 CFR 75.1103-4).

This study will examine how the changing of the above regulations has impacted the use of CO sensors in underground coal mines in the US compared to their use based on the last MSHA survey. Importantly, in the previous MSHA survey, the data was recorded for producing and non-producing coal mines. In this study, only the data from the producing coal mines was recorded. Data was collected from a total of 235 coal mines for this study with the help of the MSHA district offices.

CO SYSTEM VERSUS AMS

Although it is mandated by MSHA regulations to use CO sensors in the belt entry in underground coal mines for an early fire detection, MSHA makes a distinction between an AMS and a CO system. AMS is defined in the 30 CFR 75.301 as a network consisting of hardware and software meeting the requirements of 30 CFR 75.351 and 30 CFR 75.1103-2 and capable of: measuring atmospheric parameters; transmitting the measurements to a designated surface location; providing alert and alarm signals; processing and cataloging atmospheric data; and, providing reports. Early-warning fire detection systems using newer technology that provide equal or greater protection, as determined by the Secretary, will be considered atmospheric monitoring systems for the purposes of this subpart 30 CFR 75.301. A CO system is a network of CO sensors that is placed at fixed locations to measure CO and provide automatic warning signals at the location of the sensor when the concentration of CO reaches the warning level. An AMS is basically a CO system with additional sensors. It can be a network of CO sensors to measure CO concentrations, but the network has the capability to add other types of sensors to measure different types of gas concentrations and other parameters such as fan stoppage, fan pressure, ventilation parameters etc. The difference between the two systems is determined by how they are used (30 CFR 75.351(a)). The system is defined as being an AMS when it is monitoring the methane concentration at the section return (30 CFR 75.323(d)(ii)), when air ventilating electrical installations is used to ventilate working sections (30 CFR 75.340(a)(1)(ii)), when the belt air is used to ventilate the working section or an area where mechanized mining equipment is being installed or removed (30 CFR 75.350(b)), or when it is used for the on-shift examination for methane in each return split of air from each working section during each shift that coal is produced (30 CFR 75.362(f)).

Based on the current survey data reported here, Table 1 lists the numbers of CO systems and AMS and their respective percentages. It is apparent that the majority of surveyed coal mines have installed CO systems. This may be explained by the fact that a CO system is less expensive and has fewer regulatory requirements in relation to inspection, operation, and maintenance to meet than an AMS. Considering the downturns that coal mines has been experiencing in recent years, this could also simply be a reflection of the current financial situation of the US coal mine industry. In the 2003 MSHA survey, the CO system and AMS were not distinguished, so a direct comparison between the surveys is limited.

Table 1. CO system versus AMS data based on the current survey for producing coal mines in the US

	Quantity	Percent
CO Systems	204	86
AMS Systems	33	14

TYPE OF SENSORS

Table 2 shows the types of sensors in mines and the maximum and minimum numbers of CO, CH_4, oxygen (O_2), smoke, air velocity, thermal, and hydrogen (H_2) sensors. All of the mines utilized CO sensors as required by the law that all belt conveyors be equipped with CO sensors for early fire detection. Depending on the size of the

system, the number of CO sensors in a system can vary between 2 and 300. Compared to the previous survey, the maximum number of CO sensors used in a system increased from 215 to 300, while the minimum number stayed the same.

Table 2. Percent of different sensors used in underground coal mines.

	Percent of Mines	Minimum Number of Sensors	Maximum Number of Sensors
CO	100	2	300
CH_4	17	1	20
O_2	6	1	20
Smoke	2	1	14
Air velocity	9	1	20
Thermal	2	4	191
NO	1	1	3
H_2	2	1	3

The CH_4 sensors were used at 17 percent of the mines compared to 25 percent of the mines from the previous MSHA survey. The maximum number of CH_4 sensors used at a mine was 20 and the minimum number was 1. The percentages of O_2 and smoke sensors used in mines—6 percent and 2 percent, respectively—are comparable to the results from the 2003 survey, where less than 10 percent of the mines utilized O_2 and smoke sensors. From the current survey, air velocity sensors were used by 9 percent of the mines, with the maximum number at a mine at 20 and the minimum number at 1. Thermal, NO, and H_2 sensors were used by 2 percent or less of the mines. Although very few mines used thermal sensors, one mine had installed 191 of them. The minimum number of thermal sensors was 4. The maximum and minimum numbers of the NO and H_2 sensors were the same—3 and 1, respectively—compared to data from the previous MSHA survey.

PARAMETERS MONITORED

Table 3 shows the parameters that are monitored by AMS and CO systems in US mines. As mentioned before, regulations govern that CO sensors be used on belt conveyor systems for fire detection in underground coal mines in the US. When the 2003 survey was taken, point-type heat sensors were still allowed to be used for fire detection on belt conveyors, and 90 percent of the mines used an AMS in the belt entry. Battery charging stations were monitored by 14 percent of the mines, which has not changed since the 2003 survey. Fan stoppage was monitored by 27 percent of the mines, while the 2003 survey numbers were 42 percent—a decrease of 15 percent. Fan pressure was monitored by 11 percent of the mines compared to 32 percent in the 2003 survey—a decrease of 21 percent. Electrical installations were monitored by 8 percent of the mines, compared to 32 percent of the mines in the 2003 survey—a decrease of 24 percent. This basic decreasing trend continues as motor amperage monitoring decreased by 20 percent, pumps monitoring by 18 percent, water level pressure monitoring by 15 percent, coal storage monitoring by 12 percent; and ventilation parameters monitoring by 8 percent. The other parameters that were monitored by 6 percent of mines were air locks, diesel fuel storage, seals, vibration on fans, temperature of bearings, and air compressors.

Table 3. Parameters monitored by AMS and CO system.

Paramter	Percent
Conveyor Belt	100
Battery Charging Station	14
Fan Stoppage	27
Fan Pressure	11
Electrical installations	8
Moto Amperage	9
Pumps	11
Water Level Pressure	14
Coal Storage	3
Ventilation Parameters	7
Others	6

USE OF DIESEL EQUIPMENT

Table 4 shows the number of mines with diesel equipment and the percentages based on the current survey. Out of a total 235 mines surveyed, only 85 mines (36 percent) utilized diesel equipment. This percentage is lower than that from the last survey—48 percent—indicating a trend of less diesel equipment usage in the coal mining industry.

Table 4. Diesel equipment in underground coal mines**.**

	Quantity	Percent
Diesel Equipment	85	36
No Diesel Equipment	150	64

SYSTEM MANUFACTURERS

Combining AMS and CO systems, Table 5 shows the number of systems installed by manufacturer. Pyott-Boone was the leading manufacturer with 161 systems, or 67 percent of all installations surveyed. Compared with the previous MSHA survey, Pyott-Boone greatly increased its number of installed systems from 53 to 161—i.e., from 36 percent to 67 percent of all installations. By comparison, AMR, which had the second-most systems installed in the last survey, only increased its number from 28 to 32. Conspec, with the third-most systems installed in the last survey, decreased its number from 27 to 25. The percentage of total installations for both AMR and Conspec dropped in this survey, indicating the dominance of Pyott-Boone for current AMS installations in the mining industry.

Table 5. Systems installed by manufacturers.

Manufacturers	Number of Systems	Percent
Pyott-Boone	161	67
AMR	32	13
Conspec	25	10
Matrix	15	6
Other	9	4

Table 6 shows the average number of CO sensors per mine by manufacturer and the largest and smallest system of CO sensors. The highest average number of CO sensors used in the surveyed mines is 84, from Conspec. In the 2003 survey, the highest average number of CO sensors used by a manufacturer was 91, from MSA. In the current survey, MSA had no CO/AMS systems installed in underground coal mines. The largest system of CO sensors installed in an underground coal mine was 300, by AMR. The smallest number of CO sensors installed in an underground coal mine was 2, by Pyott-Boone. In the 2003 survey, the smallest number of CO sensors installed in underground coal mines was 2, by Rel-Tek and Pyott-Boone.

Table 6. Average number of sensors per mine by manufacturers.

Manufacturers	Average Number of CO Sensors per System	Largest System	Smallest System
Pyott-Boone	27	246	2
AMR	54	300	6
Conspec	84	179	12
Matrix	45	194	4

SUMMARY

The implementation of AMS or CO systems in underground coal mines in the US has ensured the necessary fire detection capability as required by federal regulations. Early detection is important for preventing the growth of a fire on a belt conveyor to minimize the damage to the mine and improve the safety for miners. In the survey results reported here for 235 producing coal mines, 14 percent of the mines used AMS and 86 percent used CO systems. The difference between the two systems depends on how they are used in the mine. The low percentage use of an AMS may be due to their stricter regulatory requirements.

Compared to data from the previous MSHA survey from 2003, the percentage of mines that utilized CH_4 sensors decreased 8 percent, while there were no significant changes in using other sensors. The percentages of parameters monitored in underground coal mines were

significantly lower compared to the data from the 2003 survey in every category except for belt conveyor—probably because of financial constraints. The diesel equipment usage in coal mines also dropped by 12 percent compared to data from the 2003 survey. Finally, there are fewer sensor manufacturers in the market today compared to in 2003. As one related example, Pyott-Boone has increased its market share to 67 percent from 36 percent compared to the previous survey. It is possible that the number of manufacturers could continue to decrease as more mines close due to the current condition of the coal mine industry.

DISCLAIMER

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health (NIOSH). Mention of any company or product does not constitute endorsement by NIOSH.

REFERENCES

1. Francart, W. 2003 MSHA Survey – Atmospheric Monitoring Systems in U.S. Underground Coal Mines. 2005 SME Annual Meeting Preprint 05-27.

2. Conti R. S, and Litton C. D. A Comparison of Mine Fire Sensors. US Bureau of Mines, Report of Investigations 9572, 1995.