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Diesels in Underground Coal Mines: an Historical Perspective

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Introduction

The use of diesel-powered equipment in underground coal mines has resulted from the need for machines with greater power and mobility than electric-powered equipment can provide. Diesel equipment has demonstrated its ability to meet these needs in a wide range of applications. It has been successfully employed in powering utility trucks and personnel carriers where mobility is the prime concern and in haulage equipment where high power output is needed. Further, diesel equipment is used not only in outby areas but it has also been developed to meet MSHA's permissibility requirements for use inby. Diesel-powered equipment's major impact in mining; however, has been in its use as longwall support equipment. Diesel-powered equipment has contributed to the trend of increasing productivity of longwall mining operations.

The benefits of diesel-powered equipment have been recognized, but so too have the unique safety and health hazards associated with the its use. The use of diesel equipment has raised concerns over the fire and explosion potential presented by these machines as well as concerns over the possible adverse health

affects of diesel exhaust emissions. The unique hazards presented by diesel machines can be successfully controlled; however, through their proper design, operation, and maintenance. Further, MSHA has issued proposed regulations to specifically address the hazards associated with the use of diesel equipment.

Diesel-Powered Equipment Regulations

Currently, there are no regulations specific to the use of diesel-powered equipment in underground coal mines. Title 30, Code of Federal Regulations, or 30 CFR, does contain general safety and health regulations that cover the use of equipment regardless of its power source. Consequently, these requirements are applied to diesel-powered equipment. MSHA also typically requires that mine operators specify the use of any diesel equipment in the mine's ventilation plan. The ventilation plan is then approved with controls on the diesel equipment.

The most significant control placed on diesel equipment through the ventilation plan is that only 30 CFR, Part 36 approved, permissible equipment can be used where permissible electrical equipment is required. Part 36, entitled "Mobile Diesel-Powered Transportation Equipment for use in Gassy Noncoal Mines and Tunnels" contains requirements covering machine safety features such as brakes as well as fire, explosion, and exhaust emissions requirements. Although Part 36 is intended for noncoal mines, the only requirement in Part 36 that is not applicable to coal mines is the maximum allowable surface temperature it permits. For noncoal mines, Part 36 limits the maximum allowable surface temperature of the engine to 204EC. This is not acceptable for coal mines since some types of coal can ignite below this temperature. MSHA policy limits the maximum engine surface temperature of diesels used in coal mines to the same 150EC limit applied to permissible electrical equipment used in coal mines. All of the other Part 36 requirements are as applicable and provide protection regardless of whether the equipment is operated at inby areas of coal mines or at inby areas of noncoal mines.

In many cases, other controls are established in the mine's ventilation plan to also cover the use of non-permissible, outby diesel equipment. These controls include minimum ventilation requirements, exhaust gas sampling, and specific requirements on the operation of this diesel equipment.

Although the ventilation plan is used to control the use of diesel equipment in underground coal mines, the lack of uniform, diesel specific requirements has led to concerns that the potential safety and health hazards of diesel equipment are not

being adequately addressed. Because of these concerns, the secretary of labor established the Diesel Advisory Committee. This committee provided recommendations on safety and health standards for diesel-powered equipment in underground coal mines. MSHA acted on the committee's recommendations and published proposed rules containing approval, safety, and exposure monitoring requirements for diesel-powered equipment. These regulations are being developed through the rule making process. MSHA has requested and has received public comments on the proposed regulations. These comments must now be addressed and the required regulatory impact analyses completed.

Use of Diesels

Trends in the use of diesel equipment were determined from analysis of CMS&H Inspector reports on diesel equipment in operation at the mines they inspect. This data has been compiled to form MSHA's Diesel Inventory. For each diesel unit, the Inventory lists the mine's identification number and name, and the mine's i.D. number for the machine. Machine information such as the manufacturer, the machine type, and its model number, serial number, and date of manufacture are listed. For the diesel engine, the engine's manufacturer and the engine's model number are listed. The MSHA Part 36 approval number is specified, if it is a permissible machine. The type of lighting system used on the machine is also specified. Any inspector's comments on special machine features such as any field modifications made to the machine are listed at the end of each entry.

As of July 20, 1993, the Diesel Inventory listed 2227 units of all types of diesel-powered equipment. This equipment was located at 156 mines. Of these 156 mines, 124 are conventional mines and 32 are longwall mines. The most telling trend in the use of diesel equipment is the division of equipment between conventional and longwall mining operations. Approximately 44% of the 2227 units of diesel equipment is concentrated at the 32 longwall mining operations. This breaks down to an average of 31 units at each of the 32 longwall mines compared to an average of only 10 units at each of the other 124 conventional mines. The range in the number of machines used in conventional compared to longwall mining is similar. In conventional mines the number of diesel machines ranges from a low of 1 to a high of 96 and in longwall operations the number of machines ranges from 2 to 117.

The demand for powerful and highly mobile longwall support equipment has resulted in the three to one ratio in the average number of diesel machines used in longwall compared to

conventional mines. The extensive use of diesel equipment reflects its role in the increasing productivity of longwall operations.

Growth in the Use of Diesel Equipment

The Diesel Inventory indicates that from 1988 through 1992, over 648 units of all types of new diesel equipment have been introduced into underground coal mines. The total number of new units placed in use each year averages 130.

The most recent data on their growth rate indicates that the number of diesel units has grown on average by approximately 9% per year. During this same time period, 33 additional mines began using diesel equipment for an average annual growth of 7%.

Diesel Equipment Types

Of the 2227 units listed in the Diesel Inventory the six major types of equipment are locomotives which account for 4% of the total; tractors for 6%; haul trucks for 10%; LHD's for 17%; utility trucks for 19%; and, personnel carriers for 30%. All other types of equipment such as air compressors, ambulances, crane trucks, forklifts, generators, graders, longwall component retrievers, lube units, and welders account for the remaining 14%. The types of machines used in longwall and conventional mining are nearly identical as is the proportion of the types of machines used. The only slight difference is that approximately 3% more LHD's are used in conventional than longwall operations. It is noted that for the total Diesel Inventory, utility trucks and personnel carriers account for almost half of the diesel equipment in use. A more significant trend; however, can be seen in the percentage of new machines introduced from 1988 through 1992. When considering this group the most numerous types of equipment are still the utility trucks and personnel carriers but their percentage of the total is much greater. Utility trucks account for 24% of the total new machines and personnel carriers account for 42%. Combined, these two types of equipment account for two thirds of the new machines being placed in use each year. These two types of vehicles are significant not only because they are the fastest growing types of equipment but also because of how they are treated under the proposed diesel regulations.

Diesel Equipment Categories

One of the recommendations of the Diesel Advisory Committee was that a specific classification, limited to outby or nonpermissible, light duty equipment, be established. The proposed regulations subsequently included requirements for a

category of equipment referred to as "Limited Class". This is generally commercial equipment, designed for use outside of the mining industry. An example would be a common, half-ton, diesel-powered pick up truck. Under the proposed regulations this equipment would be required to have extensive safety features but would not require a formal MSHA approval.

Limited class equipment is almost exclusively used as utility trucks and personnel carriers. These vehicles are relatively inexpensive, can be readily adapted to mine use, and have a short life span. The number of machines currently being used which could meet the proposed rule's definition of limited class has been growing faster than other categories of equipment. Machines which could meet the proposed definition of limited class equipment account for an average of 49 units or approximately 38% of the total new machines introduced each year. In comparison, other non-limited class or large outby utility trucks and personnel carriers, account for an average of only 36 machines or 28% of the total introduced each year. Overall, limited class equipment makes up approximately 27% of the equipment listed in the total Diesel Inventory.

Another major category of equipment is the inby or permissible machines approved under Part 36 of 30 CFR. Most of the permissible machines placed in use have been either haul trucks or LHD's. These two types of permissible machines have been introduced at an average of 22 machines each year. This accounts for approximately 17% of the total new machines introduced. Overall, Part 36 approved equipment makes up approximately 22% of the equipment in the total Diesel Inventory. This category has been growing at an average of approximately 3% per year.

The safety features required on permissible machines result in both a high initial cost and a high maintenance cost. They also require additional attention by MSHA enforcement personnel. The additional safety features require mine operators pay much more attention to these machines than similar nonpermissible machines.

To assist mine operators and CMS&H inspectors in insuring the safe operation of permissible machines, permissibility checklists are provided by the machine manufacturer. These checklists are developed as Part of MSHA's approval process. The checklists provide a straightforward means to insure the proper operation of the key safety features of permissible equipment. The checklists include items such as a field test of the machine's braking ability, checks of the engine's fire and explosion prevention features, and checks of the machine's permissible electrical devices such as the alternator and lights. MSHA provides training to inspectors and mine personnel on the use of

permissibility checklists as requested.

After separating the limited class and permissible categories of machines out of the Diesel Inventory, nearly all of the remaining units are specially designed mining machines, similar in types to permissible equipment, but without the fire and explosion protection features required on permissible machines. This category of large outby equipment makes up approximately 45% of the machines listed in the Diesel Inventory. The remaining 6% of the equipment in the Diesel Inventory consists of miscellaneous machines such as ambulances, generators, and lube units.

Current Safety and Health Problems

In an attempt to analyze recurring problems with the use of diesel equipment, citations issued in MSHA's Coal Mine safety and Health (CMS&H) District 9 were reviewed. District 9 was chosen because it contains the largest number of diesel-powered machines of any CMS&H District. A total of 484 citations issued over the period of January 1989 through March 1992 were reviewed. These citations were issued to mine operators for using diesel equipment not in compliance with existing safety and health regulations.

A breakdown of the citations revealed that the single largest group, approximately 28%, had been issued under section 75.400 Of 30 CFR. This section, entitled Accumulations, requires that "...Loose coal, and other combustible materials, shall be cleaned up and not be permitted to accumulate in active workings, or on electrical equipment therein." For all accumulations reported, approximately 77% were found on hot surfaces such as the engine, transmission, or exhaust system. The type of equipment most often cited was the LHD which accounted for approximately 41% of these citations.

The next largest number of citations were issued under subsections of 75.1722 "Mechanical Guards" and 75.1725 "Machinery and Equipment". Combined, these sections which cover mechanical features of the machines, accounted for approximately 22% of the citations issued. A majority of these citations were concerned with the lack of guards on radiator fans, inadequate or improperly adjusted brakes, and inoperative safety systems on permissible diesel equipment. LHD's, which accounted for approximately 33% of the total, was again the machine type most cited.

The remaining citations were written under sections covering ventilation, other safeguards, permissible electrical equipment, and fire protection. Approximately 18% of the citations were

written under subsections of 75.300 Dealing with ventilation. As previously noted, the use of diesel equipment is controlled through the mine's ventilation plan; therefore, many citations were written under this section. Most of these citations required correction of inoperative safety systems on permissible equipment and correction of engine emissions problems. LHD's showed up again, as the largest group cited, with 54% of the total. Approximately 12% of the citations were written under subsections of 75.1403, "Other Safeguards". Most of these citations dealt with the failure to chock wheels and inoperative electrical systems. The trend continues with LHD's as the largest group cited with 26% of the total. Approximately 10% of the citations were issued under subsections of 75.500 "Permissible Electrical Equipment" for defects in the electrical components installed on diesel machines. In this group, LHD's tied with haul trucks for the type of equipment with the most citations. Each accounted for 33% of the total. And finally, approximately 10% of the citations were written under subsections of 75.1100 "Fire Protection" for inoperative fire extinguishers. Here too, LHD equipment was the largest group, accounting for 31% of these citations.

The number of problems found by CMS&H and the various regulations cited, confirms the need for clearer, more specific requirements. A concern with the number of citations issued on LHD's also arises. Although LHD's account for only 17% of the equipment in the Diesel Inventory, they account for the largest group of all citations, when sorted by equipment type, with 38% of the total. The analysis of the citations by equipment type indicates that mine operator's had a significantly greater problem maintaining and using LHD's in a safe and healthful condition than the other types of equipment.

Diesel Fire Accidents

The accumulation of combustible material, the inoperative safety systems on permissible equipment, the electrical problems, and the presence of inoperative fire extinguishers accounted for the vast majority of citations issued on diesel machines. All of these conditions directly increase the potential fire and explosion hazard.

MSHA has studied occurrences of fires on diesel-powered equipment used in both surface and underground coal mines. Reportable fires, which are fires lasting 30 minutes or longer, occurring on underground diesel equipment have been too few to provide adequate information to determine their causes. Although the proposed diesel regulations cover only underground diesel mining equipment, fires on surface diesel mining equipment are more

numerous and provide a means to understand the potential causes for fires on similar underground equipment.

Reports of 121 fires over the eleven year period covering 1982 through 1992 were reviewed. These 121 fires include reportable fires and also shorter duration fires, that were voluntarily reported by mine operators. An approximate breakdown of the fires by machine type indicates that 32% of the fires occurred on LHD's, 26% occurred on haul trucks, 15% occurred on dozers, 7% occurred on scrapers, 5% occurred on utility trucks, and various other equipment accounted for the remaining 15% of the fires.

General information on surface equipment populations indicates that LHD's account for a disproportionally larger number of the fires. Problems with LHD's noted during the review of citations on underground equipment apparently also extend to surface equipment. Dozers and scrapers appear to have less than the number of fires that would be expected from their populations.

Determining the cause of these fires is difficult since the cause was not determined, or otherwise reported, in 70% of the accidents. However, the source of fuel in approximately 50% of the fires was reported as a leaking hydraulic or fuel line.

It is noted that the ignition of leaking oil or fuel is much more likely on surface than underground equipment because surface equipment generally operates at a higher duty factor, has a higher horsepower, and carries relatively greater amounts of hydraulic fluid and fuel. The higher duty factor and horsepower provide for higher temperatures of the exhaust systems of surface equipment. These temperatures can be well above the auto-ignition temperature of diesel fuel and most hydraulic fluids which can leak onto the exhaust systems. The factors which increase the chance for fires on surface equipment are addressed in the proposed regulations to prevent them from introducing the same hazard on underground equipment.

Summary

Both the current use of diesel equipment and its growth are keyed to its support role in longwall mining. The gains in productivity made in longwall mining reflect the benefits provided by diesel-powered equipment.

The types of diesel equipment used in mines is varied, but the major types are locomotives, tractors, haul trucks, LHD's, utility trucks, and personnel carriers. Personnel carriers are the fastest growing type. The important categories of diesel equipment are limited class equipment, Part 36 permissible

equipment, and large outby equipment. Equipment which could meet the proposed limited class requirements is the fastest growing category of equipment. Permissible equipment requires much greater attention to insure its safe operation. And finally, large outby equipment accounts for approximately half of the diesel machines in the Diesel Inventory.

The vast majority of problems with diesel equipment cited by CMS&H are directly related to the fire and explosion hazards which diesel equipment can pose. An analysis of fires on diesel-powered equipment also supports the need for emphasis in the final regulations on controlling the fire hazard presented by these machines.

Diesel-powered equipment does present unique safety and health concerns. Further, LHD's appear to pose more problems than other types of diesel equipment. The proposed regulations; however, will clarify the requirements, making it easier for CMS&H and mine personnel to insure the safe and healthful use of all diesel equipment.

Future of Diesel Equipment

Looking into the future, diesel equipment will likely continue to play a major role in support of longwall mining. The number of diesel machines in use will likely continue growing, in the short term, at about 9% per year. In the long term, diesel equipment's growth will be dependent on general economic conditions and, more importantly, any change in longwall production and the continual need for diesel equipment for longwall support.