A PERMISSIBILITY CHECKLIST FOR APPROVED DIESEL POWERED COAL MINING EQUIPMENT

by

George J. Dvorznak, Supervisory Mechanical Engineer
U.S. Department of Labor
Mine Safety and Health Administration
Triadelphia, West Virginia

ABSTRACT

Safe operation of diesel-powered equipment in areas of underground coal mines, where methane may be present, requires the incorporation of special features to eliminate fire and explosion hazards. These features are specified in Part 36, Title 30 of the Code of Federal Regulations (30 CFR 36).[1] The diesel engine and those control devices required to reduce surface and exhaust gas temperatures to safe levels, and to prevent flames and sparks from being emitted to the mine atmosphere, are evaluated during the approval process by the Mine Safety and Health Administration (MSHA).

Recognizing the diverse nature of the techniques used by equipment manufacturers to provide the required protection, and the importance of ensuring that the safety devices continue to provide the required protection, permissibility checklists have been developed. These permissibility checklists allow mine maintenance personnel, equipment manufacturers, and MSHA personnel to determine if the required control devices are operating properly.

This report describes the sources of the fire and explosion hazards introduced by the diesel engine, explains the permissibility checklist concept as applied to the engine and safety controls, and how the concept has been expanded to include other machine related safety features.

INTRODUCTION

In the confined underground environment of a coal mine, diesel engines pose two principal problems: they are a potential fire and explosion hazard and they produce noxious exhaust gases and particles which must be diluted to safe levels.[2] Manufacturers of diesel-powered equipment select engines whose design ensures that minimum quantities of gaseous emissions are produced. Special design features are incorporated into the diesel engine power package to address the fire and explosion hazards. The MSHA Approval and Certification Center (A&CC) evaluates the diesel power package to ensure that the special design features provide the protection required and, if Federal requirements have been met, issues a certification.

In order to be considered approved, mining equipment which utilizes a certified power package must also fulfill certain other specific safety requirements which primarily address the mechanical hazards inherent in the equipment. Additionally, any electrical systems installed on a machine must incorporate the same permissibility protection provided by the certified diesel power package. All of these features are evaluated during the machine evaluation process and if the equipment is in compliance, an approval is issued. Diesel-powered mining equipment approved under the requirements of Part 36, Title 30 Code of Federal Regulations, is considered to be permissible .

and can be operated in areas of underground mines where methane may be encountered.

To help ensure the continued permissibility of such equipment after it has been in use, permissibility checklists have been developed. These checklists identify the features of the diesel power package, electrical system, and total machine that must be checked to insure that the initial permissibility protection is retained. The permissibility checklists describe inspection techniques and measurement procedures to be followed for the specific item of equipment.

DIESEL ENGINE FIRE AND EXPLOSION HAZARDS

Some mine operators have found that diesel-powered equipment offers a number of advantages in their mining conditions. Diesel powered haulage gives a great deal of flexibility in the design of haulage systems because of the elimination of the trailing cable. When compared to battery powered equipment, the greater power density of diesel fuel has extended the time that the equipment is available each operating shift.

As a result of these and other advantages, the number of diesel powered units has increased quite dramatically in the last ten years. After a relatively slow start, the diesel population has grown from approximately 150 units in 1974 to the point that there are about 1400 diesel units in underground coal mines. Of that total about 960 are nonpermissible and the remainder are permissible diesel machines.[3] While the initial usage of diesel powered equipment was primarily in the west, in recent years many of the eastern states including Virginia, Kentucky, Illinois, and Alabama have seen the introduction of substantial numbers of machines.

When introduced into the underground environment of a coal mine, diesel engines bring with them two principle problems; they are a potential fire and explosion hazard and, they produce noxious exhaust gas and particles which must be removed or diluted to acceptable levels, The principal fire and explosion hazards are introduced by the ignition sources created by the engine. Hot surfaces of the engine could reach temperatures exceeding 1000° F. The discharge of hot exhaust gas and flames and sparks which might be generated within the engine can ignite diesel fuel, hydraulic fluid, coal dust or methane that may be in the vicinity of the mining equipment. When addressing these issues, it is important to realize that they are real issues and not merely a theoretical problem. Diesel engines which have not been modified to remove fire hazards have been involved in major equipment fires.[4] Furthermore, the discharge of an incendive spark into a combustible mixture of methane and air has been demonstrated repeatedly to produce an explosion. Both the fire and explosion hazards must be eliminated to operate diesel engines with the required degree of safety.

Engine and exhaust system surfaces must be maintained below 302° F. The most effective means for reliably controlling this temperature has proven to be water-jacketing the exhaust manifold and associated piping. Furthermore, without the addition of proper safeguards, combustible concentrations of methane surrounding the engine may be ignited by flames passing back through. the engine intake system; passing through joints in the engine intake or

exhaust system; or by glowing particles and flames discharged through the exhaust system. Intake flame arresters eliminate the possibility of flame passage from the engine through the intake system to the surrounding atmosphere by causing the flame to pass through small openings in a heat absorbing metallic matrix. The possibility of flame passing through joints is addressed by the classical techniques usually applied to electrical enclosures or by the use of tightly fitting metal gaskets. The technique presently used in the United States to eliminate glowing particles and flames discharged through the exhaust system is to pass the exhaust gas through a water bath using a device called a water scrubber. This device cools the exhaust gas, traps and quenches glowing particles, and serves as a hydraulic flame arrester. Any flames or glowing particles in the exhaust gas are quickly extinguished in the water scrubber.

To ensure that the protection provided by the additional safety related components is maintained during operation of the equipment, sensors are installed in the engine and associated components. In the water scrubber, the sensors include a float to sense and maintain the water level at the proper height and frequently, a temperature sensor in-the exhaust gas stream to monitor exhaust gas discharge temperatures. When properly designed, manufactured, and maintained, water scrubbers and associated components have proven to be an effective means of providing protection against fire and explosion hazards in the exhaust system.

Those specific features that must be incorporated into diesel power packages to provide protection against the fire and explosion hazards inherent in uncontrolled diesel engines are described in 30 CFR 36.

THE APPROVAL PROCESS

Because of the possible presence of methane, certain areas of underground coal mines are designated as areas where permissible equipment is required. Both diesel-powered equipment and electrical equipment must be of the permissible type. Diesel powered equipment approved under 30 CFR 36 is considered to be permissible. Manufacturers of diesel-powered equipment who wish to receive approval for their machines submit applications to the MSHA Approval and Certification Center at Triadelphia, West Virginia. Applications contain drawings describing the construction features of the equipment and sufficient descriptive material to allow the Agency engineers to determine if design requirements have been met.

A complete diesel power package consisting of a diesel engine and additional components necessary to provide protection against the fire and explosion hazards introduced by the engine is submitted for evaluation. An engineering evaluation of the power package is conducted following procedures specified in Part 36. After it has been determined that all of the performance and design requirements of Part 36 have been successfully fulfilled, a formal document called a certification is issued to the manufacturer. This document allows the manufacturer to incorporate the power package into subsequent equipment types without further evaluation of the power package.

Following a similar process, drawings detailing other machine features including the brakes, fuel system and operator's compartment are evaluated to determine if specific requirements of Part 36 have been satisfied.

Any electrical systems, which may include a vehicle lighting system or a methane monitor system, are evaluated against the requirements of Part 18 Title 30, Code of Federal Regulations.

As a final step in the approval process, a factory inspection of the completely assembled machine is conducted to evaluate those machine features that can be best considered by a performance test. These features include the brake system and the exhaust gas dilution system. Additionally, the machine is inspected to ensure that the method of installation of the certified diesel power package and electrical system has not adversely altered their performance.

If all these tests and evaluations have demonstrated that the machine complies with the provisions of Part 36, an MSHA approval is issued to the manufacturer,

THE PERMISSIBILITY CHECKLIST

Development of the Concept

The overall thrust of the diesel approval program is to ensure that provision has been made to eliminate fire, explosion and certain safety related hazards inherent in equipment design and operation and that these provisions are achieved through the incorporation of certain design features. These design features are evaluated at a number of points in the machine's useful life. The first is during the approval process as part of the laboratory evaluation and preapproval factory inspection performed by MSHA as described above. The second time is during the fabrication of subsequent production of the same model machine by the equipment manufacturer. The third occasion is during normal usage in the mine by mine maintenance personnel, while the final instance is during equipment permissibility evaluations by MSHA inspectors. In all these cases, it is vital that the critical features be clearly identified; that any test *or* measurement procedures be specified; and that pass-fail criteria be stated.

The Agency has recognized the importance of the establishment of documents to achieve these ends. Section 36.6 addresses these issues as follows:

> 36.6(f) With each application, the applicant shall submit evidence of how he proposes to inspect his completely assembled mobile diesel-powered transportation equipment at the place of manufacture or assembly before shipment to purchasers. Ordinarily such inspection is recorded on a factory inspection form and the applicant shall furnish to MSHA a copy of his factory inspection form or equivalent with his application. The form shall direct attention to the points that must be checked to make certain that all

> components of the assembly are in proper condition, complete in all respects, and in agreement with the drawings, specifications, and descriptions filed with MSHA.
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> 36.6(g) With the application, the applicant shall furnish to MSHA complete instructions for operating and servicing his equipment. After completing MSHA's investigation, if any revision of the instructions is required, a revised copy thereof shall be submitted to MSHA for inclusion with the drawings and specifications.

In the past, manufacturers satisfied the factory inspection form requirement by developing a special document to be used by factory quality control personnel during the manufacturing process. Generally, these factory inspection forms incorporated the permissibility features and a number of other features not related to permissibility but vital from the manufacturer's point of view to the production of a quality machine. Approval and Certification Center engineers evaluated the factory inspection form during the approval process, incorporated the form into official approval documentation, and used the form during the preapproval factory inspection. However, because the form was primarily intended to be used for production purposes, it contained a great deal of extraneous, from a permissibility perspective, information. The extraneous information made the form unwieldy to use during the preapproval inspection. Because it was incorporated in official approval documentation, the manufacturer was required by regulation to gain A&CC approval for changes in the form even if the change did not effect permissibility.

Manufacturers generally satisfied the requirement of Section 36.6(g) for operating and servicing instructions by submitting the machine maintenance manual. Again, the manual covered a great many features other than permissibility and suffered from the same weaknesses described for the factory inspection form. Moreover, the permissibility related maintenance procedures were normally scattered throughout the book making it difficult for maintenance personnel to use the manual for regular inspections.

One of the strong points of Part 36 is that a great many of the requirements are expressed in performance oriented terms. Consequently, the manufacturer is free to innovate and apply new technology to achieving the desired goals. This same freedom to innovate creates difficulty for those personnel who are responsible for maintaining and inspecting permissible diesel-powered equipment. For example, the means provided to limit the surface temperature is evaluated utilizing a performance test to ensure that the surface of the engine and exhaust system does not exceed 302° F. There is no obvious means available by which continued compliance with this requirement can be assured. Part 36 is not a reference book for the in-mine evaluation of permissibility. Inspection personnel, both mine maintenance or MSHA, must rely on documentation specific to the machine being evaluated.

In past inspections of permissible diesel-powered equipment at a number of mines, it was discovered that many vehicles approved under Part 36 were not

being operated in permissible condition This situation had developed over a period of time because the vehicles were not maintained properly, changes were apparently made to the equipment after purchase, or because the vehicles had not been manufactured in accordance with drawings and specifications on file at the Approval and Certification Center.

Permissibility Checklist Description

It was apparent that there was a real need to develop a single document which could be used to make permissibility determinations. Ideally, such a document could be used by A&CC personnel during the preapproval factory inspection; by manufacturer's quality control personnel during the manufacturing process; and by mine maintenance personnel and MSHA inspectors in the underground mines. Such a document was developed and given the name "Permissibility Checklist ."

Permissibility checklists are not maintenance procedures per se, but are instead a list of the actual characteristics that must be examined or tested to determine if approved diesel-powered equipment is being maintained in permissible condition. Test procedures are described for the specific features *as* installed along with pass-fail criteria.

The original problems identified in the field were primarily in the diesel power package. Consequently initial A&CC efforts were focused on developing permissibility checklists for the diesel power package on existing units in the field. Power package checklists were developed by A&CC engineers for all the units in the MSHA district in question to address the imnediate problem. Manufacturers were also notified that any power packages submitted for certification were to be accompanied by a permissibility checklist to satisfy the requirements of Section 36.6(f) and 36.6(g). The draft checklists submitted by the applicant were evaluated during the power package evaluation process.

Permissibility checklists were developed for power packages used in a number of approved machines. These units are most easily identified by their approval numbers. The approval numbers of certain machine types for which power package checklists have been developed are shown in Table 1.

Table 1 - Approvals Having Only Power System Checklists

Approval No.	Machine Type	Machine Manufacturer
31-14-6	Wheel Loader	NMS (Eimco)
31-17	Diesel Loader	Wagner
31-26-l	Wheel Loader	Eimco
31-29-l	Shuttle Car	NM (Eimco)
31-33-0,l	Diesel Truck	Eimco
31-35-3	Hauler (changed to Ramcar)	Jeffrey
31-37-O,1	Loader	Eimco
31-44-0,l	Powder Loading Truck	Young's
31-51-2	Loader	Eimco
31-56-O	Loader	Eimco

Subsequently, A&CC engineers worked with equipment manufacturers to develop machine checklists to evaluate the other permissibility features of a machine such as the fuel system, fire suppression system, and brake system, Finally, permissibility checklists were developed for the electrical system installed on diesel-powered machines.

In April 1985, MSHA notified manufacturers who had previously obtained Part 36 approval of diesel-powered equipment that future applications for approval under Part 36 were required to contain a complete permissibility checklist -5 Checklists submitted after that date consist of separate checklists for the permissibility features of the overall machine, the diesel power package, and the electrical system if the machine is so equipped. Each portion of the permissibility checklist is evaluated during an appropriate part of the approval process. The final draft checklist is used, along with certain composite drawings, by A&CC engineers during the preapproval factory inspection. Use of the checklist in this fashion has advantages. First, it provides a final check of the appropriateness of the checklist as a tool for evaluating the permissibility features of the machine, Secondly, because the equipment manufacturer has the same checklist, he is able to properly prepare the machine for the inspection and minimize delays.

When the entire Part 36 machine evaluation process is successfully completed, the final permissibility checklist is made part of the approval documentation in the same manner that manufacturing drawings and specifications are incorporated. Finally, and most importantly, manufacturers are to ensure that purchasers of the equipment are provided with copies of the complete permissibility checklist package.

Approvals which incorporate all three permissibility checklists have been issued for a number of machine types. These approval numbers are listed in Table 2.

Table 2 - Approvals With Complete Permissibility Checklists

Approval Number	Machine Type	Manufacturer	Approval Number	Machine Type	Manufacturer
31-68	Scoop	Simmons-Rand	31-95	Scoop/Fork	Eimco
31-73	Ramcar	Jeffrey	31-96	Lube Truck	Getman
31-82	Scooptram	Wagner	31-97	Lube Truck	Lake Shore
31-83	Teletram	Wagner	31-98	Anfo Truck	Eimco
31-84	Mini Bore Jumbo	Gardner-Denver	31-99	Roof Drill	Fletcher
			31-100	Ramcar	Jeffrey
31-85	Scooptram	Wagner	31-101	Scooptram	Wagner
31-86	scoop	Eimco	31-102	Scooptram	Wagner
31-87	Tow Tractor	Getman	31-103	Shield Hauler	Eimco
31-88	Rock Duster	Jeffrey	31-104	LHD	Eimco
31-89	Scoop	Eimco	31-105	Face Drill	JOY
31-90	Scooptram	Wagner	31-106	Ramcar	Jeffrey
31-91	Roof Drill	Fletcher	31-107	Utility Shield Hauler	Petitto
31-92	Lube Truck	Wagner			
31-93	Personnel Carrier	Getman	31-108	Roof Drill	Fletcher
			31-109	Locomotive	Balco
31-94	Roof Drill	Fletcher	31-110	scoop	Eimco

To assist manufacturers in developing permissibility checklists, staff engineers at the A&CC assembled a publication, Program Circular PC 4017-0 entitled "Permissibility Checklists for Equipment Approved Under Part 36, 30 CFR."[6] The publication is an example of a complete permissibility checklist and contains sample copies of individual checklists for the diesel power system, an electrical system, and the machine portion. The samples are intended to be used as a guide; some of the information may not be directly applicable to specific types of equipment. Experience has demonstrated that preparation of the final permissibility checklist is expedited if the draft

permissibility checklist submitted by the applicant closely adheres to the sample document.

Use of the Checklist

Permissibility checklists are designed and intended to be self-explanatory. One of the points considered during- the evaluation process of the product and the checklist is the clarity and appropriateness of the descriptions and test procedures as applied to the specific product.

Certain portions of the Power System Permissibility Checklist and of the Machine Checklist have been extracted from PC 4017-0 and incorporated in this paper to illustrate highlights of the permissibility checklist concept. These are presented below.

Power System Checklist

The cover page of the Power System Checklist, Sheet 1 of 12, specifically identifies the diesel power system described within the checklist. It identifies the engine model to which the permissibility checklist pertains as a simple check of the appropriateness of the checklist. The underlined words alert the individual making the permissibility evaluation that "ALL INSPECTIONS AND TESTS SHALL BE PERFORMED IN FRESH AIR." This is vital, because certain of the checks, inspections, and tests defeat the permissibility protection features of the power package and could create a hazardous situation if they were conducted in the presence of methane.

The permissibility evaluation is intended to be performed in the order described by the numbered steps. Completion of Step Number 1 leads into Step Number 2 and then into Step Number 3 consecutively. The general flow of the evaluation is similar to the general flow of the air through the power package. The intake system is described first proceeding to the exhaust system.

The item numbers shown on the photographs on Sheet 3 of 12 correspond to a specific step in the checklist and are intended to assist the evaluator in locating specific components of interest. Some more recent permissibility checklists utilize line drawings in place of photographs. It has been found that line drawings are more easily duplicated and convey information more clearly than some photographs because they eliminate unnecessary clutter.

Step Number 4 on Sheet 4 of 12 alerts the evaluator to the need to ensure that a copper gasket in installed between the air inlet adapter and the engine head. When properly installed, the gasket ensures that there is no flame path in the joint. Copper material is specified to ensure that no fiber or composition gasket has been mistakenly installed.

Sheets 4 and 5 of 12 contain specific procedures to be followed to evaluate the intake flame arrester. The size of the inspection gage and the inspection procedure for the particular type of flame arrester is specified. By following the remainder of the steps, the system evaluator is guided through a proper reassembly of the intake system.

Step 16 on Sheet 9 of 12 describes procedures to be followed for evaluating the engine intake vacuum restriction. The proper instrumentation, in this case a manometer or magnehelic; the engine operating conditions; and the specific evaluation criteria upon which to make a pass/fail decision are all specified in sufficient detail to allow the evaluator to make an informed decision as to the condition of the intake system restriction. Maintaining the intake restriction within the engine manufacturer's recommended limits has been shown to be an important factor in limiting emissions of carbon monoxide and particulate matter.[7]

Sheet 11 of 12 describes two alternative test procedures for evaluating the temperature sensor valve. This valve is intended to shut the engine down in the event that the engine block water temperature exceeds 212° F. Tests conducted during the certification process demonstrate that the surface temperature of the engine and exhaust components will be below 302° F if the engine water temperature is below 212° F. Alternative test procedures are given so that the system evaluator can make the best use of the facilities available at his location.

Steps 24 through 26 on Sheet 12 of 12 describe the procedures to be followed to ensure that the exhaust scrubber sensors and controls are properly adjusted. Certification tests demonstrate that the scrubber operates properly and provides flame arresting protection, spark arresting protection, and controls the exhaust gas discharge temperature when the water level is adjusted properly.

When all of the steps presented in the Power System Permissibility Checklist have been completed with the system parameters falling within the allowable criteria, the system evaluator can have confidence that the power package is in permissible condition.

Machine Checklist

The Machine Permissibility Checklist primarily evaluates those features incorporated into the machine design to provide fire protection and protection against mechanical hazards. The cover sheet of the Machine Checklist, Sheet 1 of 9, identifies the particular machine to which the checklist applies. Again, the evaluator is alerted that "ALL INSPECTIONS AND TESTS SHALL BE PERFORMED IN FRESH AIR." The permissibility section of Sheet 1 of 9 describes for the evaluator those factors that should be considered in making a permissibility evaluation, and alerts him to the fact that the machine checklist must be used in conjunction with the power system checklist and an electrical system checklist. During the certification evaluation of the power package, the water scrubber was studied to determine gradability limits that might affect its flame arresting capabilities. During the evaluation of the adequacy of the brake system, those gradability limits were evaluated. Both limits are specified, along with guidelines to be followed to determine which limit is appropriate. Finally, the ventilation rate is noted which corresponds to the ventilation rate appearing on the machine approval plate.

Sheets 2, 3, and 4 of 9, incorporate the checks to be made on the fuel system and identify specific points of interest.

One of the most significant contributions of the permissibility checklist is to establish specific procedures for evaluating machine braking systems. Sheet 5 of 9, which addresses the service brake, is representative of the A warning section alerts the machine evaluator to safety considerations that must be taken into account before initiating a brake system test and must be strictly adhered to. During the machine approval evaluation, a detailed engineering analysis is conducted of the brake system. An evaluation of the brake system's stopping capability, expressed in stopping distance or in deceleration terms, is generally inappropriate for a factory or mine permissibility evaluation. Instead, the stopping capability of the service brake system is translated into the ability of the brake system to hold the vehicle stationary against the vehicle's power capabilities under specific conditions. These specific conditions are expressed in terms of the engine speed or throttle position and the gear ratio of the transmission. Finally, specific criteria are stated for evaluating adequate brake capability. A similar procedure is followed to evaluate the parking brake.

Step 5 on Sheet 8 of 9 describes a specific test to evaluate the neutral start capability of the machine. The manufacturer is required to provide a means to prevent the vehicle from being started unless the equipment transmission is in a neutral or park position. This feature is intended to ensure that pushing the engine start button does not result in a surprise lurching of the vehicle. In the confined areas of underground environments, such lurching could create a hazardous condition to personnel in the vicinity of the equipment. Because equipment manufacturers utilize a variety of techniques to achieve this goal, the test procedure appropriate to the machine of concern is specified in the permissibility checklist.

Sheet 9 of 9 contains a machine layout diagram. A plan view is provided that indicates the approximate position of items on the machine that are of interest during the permissibility evaluation. This has proven useful to evaluators because the location of these items can vary widely on different machine types.

The Electrical System Permissibility Checklist has not been addressed because the concepts inherent in that checklist are similar to those in the Diesel Power System Checklist and the Machine Checklist, and because electrical permissibility determinations are familiar to the majority of mine operating personnel.

Because permissibility checklists identify those features that must be evaluated, describe test procedures to be used, and specify pass/fail criteria, they have eliminated much of the subjectivity inherent in field permissibility evaluations. They are available to the mine operator through the equipment manufacturer and to MSHA enforcement personnel upon request. They serve as an excellent means of communication between the mine operator and MSHA regarding what specifically will be evaluated during a permissibility inspection.

SUMMARY

Safe operation of diesel-powered equipment in areas of underground coal mines where methane may be present requires the incorporation of special features to eliminate fire and explosion hazards. Similar safety features are incorporated into the electrical systems installed on diesel powered mining equipment. These features, as well as other machine related safety and health features, are evaluated during the MSHA approval process. Permissibility checklists have been developed to assist those persons evaluating the equipment to determine its permissibility status. MSHA engineers evaluate the checklists during the approval process and utilize them during the preapproval factory inspection of the completed machine. Manufacturers utilize the checklist to prepare for the preapproval factory inspection of the initial unit and prior to shipping subsequent production units. Equipment operators and mine maintenance personnel can utilize a checklist during daily operations to verify that normal maintenance practices are keeping the equipment in permissible condition. MSHA enforcement personnel can utilize the checklists to perform mandatory permissibility inspections of the equipment. The permissibility checklist has given those parties interested in diesel equipment permissibility a useful tool for performing the required evaluations.

REFERENCE

[1] U.S. Code of Federal Regulations. Title 30 (30 CFR 36)--Mineral Resources; Chapter l--Mine Safety and Health Administration, Department of Labor; Subchapter E--Mechanical Equipment for Mines; Tests for Permissibility and Suitability; Fees; Part 36--Mobile Diesel-Powered Transportation Equipment for Gassy Noncoal Mines and Tunnels, U.S. Government Printing Office, Washington, DC, 1987, pp. 227-240.

[2] Waytulonis, R. W. and G. J. Dvorznak. New Control Technology for Diesel Engines Used in Underground Coal Mines, Proceedings of the 3rd U.S. Mine Ventilation Symposium, Penn State, 1987, pp. 279-285.

[3] Approval and Certification Center Permissible Diesel Equipment Inventory, Inspectors' Inventory for Coal Hines. Report prepared Feb. 1988, 252 pp.

[4] Bickel, K. L. Analysis of Files on Diesel-Powered Mine Equipment, Proceedings: Diesels in Underground Mines; BuMines Technology Transfer Seminar, BuMines IC 9141, 1987, pp 9-17.

[5] Mine Safety and Health Administration. Permissibility Checklists for Equipment Approved Under Part 36, Title 30, Code of Federal Regulations, Policy No. 85-40-TSF, April 1985, 2 pp.

[6] U.S. Department of Labor. Permissibility Checklists for Equipment Approved Under Part 36, 30 CFR. Approval and Certification Center Program Circular PC 4017-0, 1985, 23 pp.

7 Branstetter, R., R. Burrahm, and H. Dietzmann. Relationship of Underground Diesel Engine Maintenance to Emissions (BuMines contract H0292009, SwRI.) Volume 1. BuMines OFR 110(l)-84, NTIS PB 84-195510, 1984, 104 pp.

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