Energy, Mines and Resources Canada
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CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

PRELIMINARY DRAFT (ITERATION NO. 2):

THE CERTIFICATION OF FLAMEPROOF DIESEL-POWERED, RUBBER-TIRED, TRACKLESS, SELF-PROPELLED VEHICLES FOR USE IN UNDERGROUND COAL MINES IN CANADA

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CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY

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ENERGY RESEARCH PROGRAM
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Report ERP/MRL 79- 68 (TR)

PREFACE

Sections 1 and 2 of this draft document are designed to replace EMR Certification Memorandum No. 3 (1971). The following sections 3 and 4 are technical in nature and have been produced at the request of the Senior Mechanical/Electrical Mining Inspectors of the Canadian Provinces in order to standardize the requirements for testing and certification of all diesel equipment intended for use in hazardous (gassy) underground locations in Canadian mines.

Such standardization substantially reduces confusion on the part of manufacturers, mining companies, labour, the inspectorates and the certifying authority which inevitably occurs when different jurisdictions (federal and provincial) require compliance with their own regulations and/or some other respected off-shore standard(s), all of which contain considerable variations in their requirements.

This document represents the result of: R/D and consultation among the scientists of the Canadian Explosive Atmospheres Laboratory of the Federal Department of Energy, Mines, and Resources; study of the provisions of several of the more prominent off-shore national standards; and feedback from field experience and from iteration No. 1 of this document from three provincial inspectorates.

It is intended that this document will serve as a point of departure for refinement and finalization by a committee, formed as a result of the request of the provincial inspectorates, by the Canadian Standards Association, and composed of representatives from manufacturers, mine management, labour, federal and provincial inspectorates and the certifying authority. The final document will therefore represent the views of all the contributors to the industry and, as a consequence, it will foster the ready availability of safer, higher quality diesel-powered equipment for use in Canadian coal mines.

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THE CERTIFICATION OF FLAMEPROOF DIESEL-POWERED, RUBBER-TIRED, TRACKLESS SELF-PROPELLED VEHICLES FOR USE IN UNDERGROUND COAL MINES IN CANADA

1.0 INTRODUCTION

1.1 PURPOSE

This document describes the administrative and technical requirements and procedures necessary for the testing, approval and certification on a cost recovery basis, of flameproof diesel-powered, rubber-tired, trackless, self-propelled vehicles designed for use in underground coal mines in Canada. The requirements outlined herein will also be applicable in whole or in part to other environments which pose similar flameproof and/or emissions hazards, such as gassy non-coal mines and tunnels.

1.2 DEFINITIONS

1.2.1 Applicant means the manufacturer, responsible for the final assembly and completion of a flameproof component, sub-assembly or machine ready in every respect for marketing, and for which approval or certification is sought.

1.2.2 Approval, Letter of, means the document issued by the Certification Officer indicating that a sub-assembly or component has been investigated in accordance with the provisions of this document and found to be suitable for installation in a flameproof diesel machine.

1.2.3 Caution Statement means the document issued by the Certification Officer summarizing the conditions of certification or approval and emphasizing major safety aspects treated in detail in the safety system manual.

1.2.4 Certificate means the document issued by the Certification Officer indicating that a complete diesel machine has been investigated in accordance with the provisions of this document and found suitable for operation underground in Canadian coal mines, provided it is installed and maintained in a correct manner.

1.2.5 Certification Extension means the document issued by the Certification Officer indicating that a modification to a certified diesel machine has been investigated in accordance with the provisions of this document and found suitable for implementation.

1.2.6 Certification Officer means that officer of the Department of Energy, Mines, and Resources of the Government of Canada, empowered by an Order-in-Council to investigate and certify flameproof equipment for use underground in Canadian coal mines.

1.2.7 Certification Plate means the brass metal plate upon which the flameproof mark and appropriate ventilation for the machine are etched and prominent display of which is necessary for the certification of the machine to remain valid.

1.2.8 Component means a piece, part, or fixture of a flameproof diesel vehicle which is essential to its operation as an approved assembly.

1.2.9 EMR/CANMET/CEAL means the investigation, testing, approval and certification facility styled the "Canadian Explosive Atmospheres Laboratory" (CEAL) of the Canada Centre for Minerals and Energy Technology (CANMET) of the federal Department of Energy, Mines and Resources (EMR).

1.2.10 Explosion-proof enclosure means an enclosure for apparatus which is capable of withstanding, without damage, an explosion which may occur within it, of a specified gas or vapour, and capable of preventing ignition of a specified gas or vapour surrounding the enclosure from sparks or flames from the explosion of the specified gas or vapour within the enclosure,

1.2.11 Flameproof means explosion-proof.

1.2.12 Flame Arrester means a device so constructed that flame or sparks from the diesel engine cannot propagate an explosion of a flammable mixture through it. For the purposes of this document, a water bath conditioner cannot be considered to be an effective flame arrester.

1.2.13 Rejection, Letter of,means the document issued by the Certification Officer indicating that investigation of the component, sub-assembly or machine has shown that its construction is not in accordance with this document and that it is therefore not suitable for use as a flameproof device in Canadian coal mines.

1.2.14 Safety Systems Manual means that document which summarizes the construction, operation and maintenance of the safety systems installed on flameproof machines. These can include but are not necessarily limited to: intake and exhaust systems, safety shutdown system, and all systems designed to improve the level of safety such as extinguishing systems, flameproof lighting, special materials etc.

1.2.15 Sub-Assembly means a group or combination of components.

1.3 SCOPE

1.3.1 Federal/Provincial Authority

The provincial governments possess and exercise the constitutional authority for the coal mining activity which occurs within their respective jurisdictions. In 1953, the federal government, at the unanimous request of the mines ministers, established a federal facility, hereinafter styled "The Canadian Explosive Atmospheres Laboratory" (CEAL), to undertake the certification of electrical equipment for underground coal mine use. The "Certification Officer" of CEAL has been empowered federally to certify such equipment by an Order-in-Council (see Appendix I).

The electrical service was extended in 1970 to include the certification of flameproof diesel machines, and these services continue to be offered to the provincial authorities.

Whereas certification by the federal authority signifies that the equipment complies with the requirements set forth in this document, ultimate approval for the operation of the machinery underground must be forthcoming from the provincial or other authority having jurisdiction.

1.3.2 Types of Services Provided

(a) Certification: After satisfactory completion of the investigations described below, the Certification Officer will issue a certificate signifying that the entire machine adheres to the requirements set forth in this document and as such is suitable for service in underground coal mines.

(b) Approval: Investigations of components or sub-assemblies of a machine (for example an engine package or a flametrap) will be carried out at the request of the manufacturer. Successful equipment will then be issued an approval which will indicate that the equipment tested is suitable for inclusion in a flameproof machine.

(c) Contracted Studies: Flameproof and/or exhaust emissions research under contract or in connection with an approval and/or a certification, will be undertaken by CEAL subject to the judgement of the Certification Officer and the outcome of negotiations with the applicant regarding disclosure for the public benefit, of knowledge gained.

1.3.3 Types of Equipment Suitable for Investigation

This document is designed to be directly applicable to all diesel-powered, rubber tired, trackless self-propelled underground coal mining vehicles. Examples of such vehicles are: load-haul-dump machines, loaders, trams, personnel carriers, trucks, and self-propelled drilling machines. Substantial portions of this document will also apply to other equipment such as diesel locomotives (rail or monorail) for which special requirements not included herein, are required. Likewise, the exhaust emissions provisions of this document are also applicable to most underground non-coal workings where diesel equipment is employed.

2.0 GENERAL REQUIREMENTS

2.1 PROCEDURE

2.1.1 Prior Consultation

By appointment, applicants or their representatives may visit the Canadian Explosive Atmospheres Laboratory, located in Building 9 of the Bells Corners Complex of the Department of Energy, Mines, and Resources (Haanel Drive, 1.5 miles West of Bell's Corners off Highway 17 - near Ottawa, Ontario), to discuss with qualified CEAL personnel, the requirements set forth below and their applicability to the diesel-powered equipment proposed for certification by the applicant. No charge is made for such consultation and no report will be submitted to the applicant.

2.1.2 Application for Tests and/or Certification

(a) An Application Form may be obtained from:

The Certification Officer,
c/o CANMET, Mining Research Laboratories,
555 Booth Street,
Ottawa, Ontario.
Canada K1A 0G1

a copy of which is provided in Appendix 2 herein.

(b) The application can be completed by either the manufacturer or his agent and submitted to the Certification Officer along with a filing fee of $300. Such an application must be submitted for each complete machine to be tested or certified assuming each machine to be in a final developed state and ready for marketing.

2.1.2 (continued)

(c) The applicant shall provide all information requested in the form including a brief general technical description of the equipment (the vehicle specifications) and any prior testing done by the manufacturer or others which may make similar testing by the certifying authority unnecessary.

(d) Should no reapplication for certification be made within six months after a rejection because of failure of equipment to meet the standards set forth herein, it will be assumed that a withdrawal of application has resulted and the file will be closed. However, any drawings furnished in connection with the withdrawn application will be retained for a period of two years in case a reapplication at a later date should be made.

2.1.3 Preliminary Examination

(a) This examination determines if the design of the machine in general appears to comply with requirements set forth in this document. The examination entails the scrutiny of (i) the general technical description provided in the application, (ii) the drawings supplied in accordance with clause 2.2 below, and (iii) other explanatory matter, brochures etc.

(b) Should the preliminary examination of the design of the machine indicate non-compliance with the standard, the Certification Officer will communicate the deficiencies to the applicant for possible rectification before the certifying process continues.

(c) If the preliminary examination indicates that the machine conforms in general to the requirements, the Certification Officer will confirm that the certification process will be continued and will forward to the applicant a drawing of the CEAL engine coupling, if applicable, in order that the applicant can manufacture and supply a suitable fly wheel adaptor flange.

(d) The equipment to be tested will then be forwarded, prepaid FOB-CEAL, by the applicant to:

> The Certification Officer, Mining Research Laboratories,
> CANMET, Bell's Corners Complex (near Ottawa), Building 9,
> Haanel Drive, 1.5 miles West of Bell's Corners of Highway #17,
> Ontario, Canada.

The extent of the equipment that must be shipped for testing will be determined by the Certification Officer in consultation with the applicant.

2.1.4 Factory Inspection

(a) In cases where the entire vehicle has not been shipped to CEAL, a factory or field inspection of the assembled vehicle will take place after all documentation has been received and approved. This inspection will confirm to the extent possible the performance data submitted on the factory inspection form, and will confirm that construction conforms to the documentation received.

(b) This factory inspection may take place after the testing described below. In this case, the examination will confirm that the certification, and other plates, are affixed to the machine in prominent places. Otherwise photographs of all such plates in position must be taken by the applicant and furnished to the Certification Officer.

2.1.5 Tests and Reports

(a) All, or the major portion of the testing of equipment, will be performed in the CEAL facilities. With the approval of the Certification Officer, some tests may be performed in the field for the convenience of, and at the expense of, the applicant.

(b) The tests to be performed are defined below in clause 4.0.

(c) The timing of tests, the presence of witnesses, and the presence of members of the applicants technical staff required for assistance in assembly or dis-assembly of equipment, are to be determined by consultation with the Certification Officer.

(d) The results of such tests are classified "Industrial Confidential" and as such cannot be shared without the consent of the applicant. This limitation does not restrict distribution to Canadian Federal and Provincial Government Mining Inspectorates, which institutions are likewise bound to honour the confidential classification of the test results.

(e) It should be noted that test reports when furnished to the applicant by CEAL, do not in themselves represent an approval.

2.1.6 Issuance of Reports, Approvals, and Certificates or Rejections

(a) After all the documentation described below in clause 2.2, and subsequent to a satisfactory outcome of all tests and inspections, the Certification Officer will issue to the applicant a Certificate or Letter of Approval which affirms that the machine or component

2.1.6 (a) (continued)

respectively, complies with the requirements of this document and is therefore suitable for use underground in coal mines (see Appendix 3).

(b) The Certification Officer will at the same time, release to the applicant, information in the form of reports and/or test data tabulations that result from the certification investigation, also as described below in clause 2.2.2.

(c) Alternatively, should the equipment submitted by the applicant not conform to the requirements of this document, the Certification Officer will forward a Letter of Rejection accompanied by a statement giving the reasons for rejection.

2.2 DOCUMENTATION REQUIRED

2.2.1 Documentation Furnished by the Applicant

(a) A completed Application Form with the requested information on the form will be furnished (see clause 2.1.2 (c) above).

(b) All other items of documentation must be furnished by the applicant to the Certification Officer in duplicate. Approved documentation will be so stamped, dated and initialled. One copy of the documentation will be kept on file at CEAL for reference; the other set will be returned to the applicant on completion of the investigation.

(c) The documentation should include all approvals, certificates and pertinent test data acquired by the applicant as a result of certification or approval of the equipment by other certification authorities, in order to prevent the unnecessary duplication of acceptable tests and approvals.

(d) The documentation shall include a blank factory inspection form used by the applicant to confirm satisfactory operation of the machine before shipment to the user. A copy of the completed form will be presented to the Certification Officer or his agent at the time of CEAL's factory inspection of the prototype or as otherwise agreed upon. In addition, a completed Form for each subsequent production machine will be completed and a copy forwarded to the Certification Officer. (see clause 2.1.4 above)

2.2.1 (continued)

(e) All documentation is classified as "Industrial Confidential" and as such cannot be shared without the consent of the applicant (see clause re: distribution to Inspectorates 2.1.5 (d) above).

(f) Drawings and Manuals shall be furnished in accordance with the following requirements:

(i) One or more general arrangement drawings showing:

(1) the overall dimensions of the vehicle or equipment, the location and capacity of the fuel tank, the location of flame trap, exhaust gas conditioner and its water supply tank (if applicable), exhaust gas dilution system, safety devices, electrical apparatus (including cable runs), and any other components that are essential to the functions of the equipment. The above items must be clearly designated on the drawing by name, or by number if a tabular identification key is provided.

(2) a list of titles and numbers of all associated drawings relevant to the application. Apparatus which has already been approved or certified should be identified and the certificate number for electrical apparatus which has been certified flameproof or intrinsically safe, and the gas group(s) to which the certificate applies, should also be shown. The test approval reference should similarly be shown for any apparatus previously tested separately (eg., engines, flame traps).

(ii) Detail drawings showing:

(1) the inlet, combustion and exhaust systems of the diesel engine, including joints and gaskets, cylinders and cylinder heads, pistons and any other features that affect the approval. Drawings showing the water cooling circuit, hydraulic circuits and cab control layout and diagrammatic sketches showing the engine safety circuit and braking systems will also be required. The drawings must clearly indicate manufacturing tolerances on components forming flameproof enclosures on diesel engines, clearances of valve stems in their guides, and the location of holes in any cylinder head gasket in relation to the cylinder edge. A diagrammatic sketch must be provided indicating the path of the exhaust gas as guided by baffles through the conditioner box.

2.2.1 (f) (ii) (1) (continued)

In addition, the path of the exhaust gas and that of the diluting air must also be shown diagrammatically to illustrate how mixing takes place and the approximate ratio of dilution when the engine is working at maximum and idling speeds.

(2) full details of all electrical circuits including schematic diagrams. The types of electrical cables used and the way in which they are protected and secured should also be shown. Any electrical apparatus certified flameproof or intrinsically safe or otherwise approved by the Certification Officer for use in mines may be shown in outline provided it is clearly identified. Each detailed drawing must carry the titles and numbers of the associated drawings. Detailed drawings of components must specify the material of construction of the individual parts, quoting any relevant standard, or other appropriate specification.

(iii) Each drawing should be clearly numbered and dated and have provision for insertion of revision or issue numbers and dates to cover subsequent modifications in design or arrangement.

(iv) After finalization of technical details two copies of each drawing will usually be required, each with a clear space, measuring 125 mm by 75 mm and preferably above the drawing number, for affixing the approval stamp of the Certification Officer.

(v) Each drawing should also have the following statement which, for convenience, can appear on the original tracings:

"THIS DRAWING HAS BEEN APPROVED BY THE CERTIFICATION OFFICER OF THE DEPARTMENT OF ENERGY MINES AND RESOURCES AND NO MODIFICATIONS MAY BE MADE TO ANY DETAIL WITHOUT PERMISSION".

(vi) A copy of drawing from which approval plate is etched will be furnished in addition to a sample of the certification plate (see Appendix 4).

(vii) A schedule of approved drawings including the most recent modifications, will be listed as part of the Certificate or Letter of Approval issued by the Certification Officer.

2.2.1 (f) (continued)

(viii) Materials from Sub-Suppliers, Brochures, pamphlets, specifications and affidavits from sub-suppliers providing and attesting to the technical aspects of the operation, materials employed and safety aspects of the sub-supplied components of the applicant's machine, may be required in duplicate by the Certification Officer.

(ix) Operating, Service, Parts and Safety Systems Manuals: Single copies of operating, service, parts, and safety systems manuals will be required for retention at CEAL. Modifications to these manuals may be required to ensure that users are acquainted with information which is vital, in the opinion of the Certification Officer, to the safe operation and maintenance of the machine.

2.2.2 Documentation Furnished to the Applicant by the Certifying Authority

In summary, the documentation to be furnished by the Certification Officer to the successful applicant is:

(a) A Certificate or Letter of Approval whichever is applicable in the circumstances, with accompanying schedule of approved drawings.

(b) One set of approved drawings.

(c) One set of report(s) and test data tabulations.

(d) One caution statement.

Alternatively, should the equipment submitted by the applicant not conform to the requirements of this document, the Certification Officer will forward a Letter of Rejection accompanied by a statement giving the reasons for rejection.

2.3 CONDITIONS AND TERMS OF CERTIFICATION

2.3.1 Certificates will be issued only in the name of the manufacturer of the complete machine by whom, or on whose behalf, the application was made in the first instance.

2.3.2 Each machine marketed under this certification must be fitted with the appropriate plate for the certification of the machine to be valid (see Appendix 4). Each machine must be identical to the prototype machine investigated by the Certification Officer and his staff in the first instance and in accord with the documentation on record at CEAL. Any changes not covered by a Certification Extension described below in clause 2.4, will invalidate the certification.

2.3.3 All drawings, results of tests and other materials supplied to the Certification Officer in the course of an investigation are classified "Industrial Confidential". Release of any such material or information will be made only after written approval from the applicant or sub-supplier has been obtained (see clause re: distribution to Inspectorates 2.1.5 (d) above).

2.3.4 Damage to equipment under test in the CEAL facility which results from the implementation of normal testing procedures such as explosion tests will be modified or repaired at the expense of the applicant.

2.3.5 Rejection of equipment without re-submission of an application within six months constitutes withdrawal of the application.

2.3.6 Certification of equipment is subject to review from time to time at the discretion of the Certification Officer at no cost to the applicant to ensure that quality of manufacture and adherence to the documentation on file at CEAL is maintained (see clause 2.4 below).

2.3.7 The Certification Officer reserves the right to revocation of certification or approval for contravention of the provisions of this document after certification has taken place or for failure of the equipment to function safely in practice.

2.3.8 The Certification Officer may require modifications of equipment to retain certification if safety can be significantly improved by the application of new technology. A reasonable time for transition to the improved model will be allowed for the introduction of such modifications.

2.4 CHANGES REQUIRING EXTENSION OF CERTIFICATION

If an applicant desires to change any feature of certified equipment, he shall first obtain the Certification Officer's approval of the change, by implementing the following procedure:

2.4.1 Application shall be made as for an original certification requesting that the existing certification be extended to cover the proposed changes and shall be accompanied by drawings , specifications, and related data showing the changes in detail.

2.4.2 The application will be examined by the Certification Officer to determine whether inspection and testing of the modified equipment or component or sub-assembly will be required. Testing will be necessary if there is a possibility that the modification may affect adversely the performance of the equipment. The Certification Officer will inform the applicant whether such testing is required, which component, sub-assembly, and related material must be submitted for that purpose, and what fee will be required (see clause 2.5 below).

2.4.3 If the proposed modification meets the requirements of this document a formal extension of certification will be issued, accompanied by a list of new and corrected drawings and specifications to be added to those already on file as the basis for the extension of certification.

2.5 FEES

2.5.1 Procedure and Requirements for Payment of Fees and Other Costs

(a) The application fee is a non-refundable credit which will be deducted from the total of the fees assessed for the services performed as described below in clause 2.5.2. It will not be refunded should the application be withdrawn before the investigation has begun. No work will be undertaken until the application fee has been received.

(b) The fees must be paid in advance of the issuance of a Certificate or a Letter of Approval, made out in favour of the Receiver General of Canada, and sent to the Certification Officer (see clause 2.1.2(a) for the mailing address).

(c) Fees are payable in the form of a cheque, bank draft, money order or postal note.

(d) Charges to the applicant for partial tests and investigation will be made on a pro-rata basis relative to the degree of completion of the tests defined by the fee schedule below (see clause 2.5.2).

(e) Estimates will be provided to the applicant should the following fee schedule not cover the needs of a particular investigation.

(f) Field expenses in connection with the certification investigation for all participating representatives of the Certification Officer will be borne by the applicant.

2.5.1 (continued)

(g) All the shipping costs of the equipment to be certified will be borne by the applicant.

2.5.2 Schedule of Fees

(a) Application for certification fee (a non-refundable credit to the following fees)	... $ 300.00
(b) Examination and recording of drawings and specifications	... $ 300.00
(c) Dynamometer engine emission tests (see caution in clause 4.6.2 below)	... $ 2,500.00
(d) Diesel engine explosion hazard and surface temperature tests including tests of automatic shut down systems	... $ 400.00
(e) Intake and exhaust systems explosion tests	... $ 800.00
(f) Electrics investigation, each component:	
Examination and recording of drawings	... $ 100.00
Inspection of component	... $ 100.00
Explosion testing of component	... $ 150.00
(g) Inspection of completed assembly	... $ 400.00
(h) Examination and recording of drawings and specifications requisite to the issuance of an extension of certification, each change	... $ 50.00

The above fee schedule is in force at the time of compilation of this document. The fees are subject to change without notice.

3.0 DESIGN AND CONSTRUCTION REQUIREMENTS

3.1 GENERAL

3.1.1 Equipment Quality

CEAL, or other designated test agencies, will test only equipment that in the opinion of its qualified representatives is constructed of suitable materials, is of good quality workmanship, based on sound engineering principles, and is safe for its intended use. As all possible designs, arrangements, or combinations of components and materials cannot be foreseen, the Certification Officer reserves the right to modify the construction and design requirements of subassemblies or components and tests thereof in order to ensure to the greatest extent possible, the safety of the equipment in question.

Reference: MESA 36.20

3.1.2 Innovations

Unusual or innovatory design or construction techniques will be permitted provided that the Certification Officer can be satisfied as to their efficacy and safety. Special tests, possibly pertinent only to the equipment in question, will be devised as necessary to determine the adequacy of the equipment.

Reference: TM 12/1977 (20)

3.2 INDUSTRIAL SAFETY REQUIREMENTS

3.2.1 Lighting Systems

(a) The preferred power source for a vehicle lighting system is an engine-driven flameproof alternator. Inter-connecting cables to the lights must be suitable for the electrical load and mechanically protected against damage. The system must be fused for overload protection.

Reference: CEAL

(b) Any electrical system components must be flameproof and constructed in accordance with the provisions of clause 3.3.2 below.

Reference: CEAL

3.2.1 (continued)

(c) Headlights with a battery source constructed as a unit will be acceptable if flameproof and appropriately sealed against disassembly during service.	Reference: MESA 36.33(a)
(d) All vehicles must be equipped with a white headlight with a range of at least 60 metres and a red tail light of sufficient power to be clearly visible at a distance of 60 metres. Notwithstanding the generality of the above, headlights must have a sufficient range to enable the driver to stop within the limits of his vision when the vehicle is travelling at its maximum operational speed. Where a vehicle is capable of normal operation in both directions, arrangements must be made to enable the headlight always to be on the front of the vehicle. Head and tail lights should be interlocked with the direction control lever to ensure correct operation.	Reference: TM12/1977 (56)
(e) The headlight unit shall be so mounted that it is in a fixed position and protected from external damage by recessing or other means acceptable to the Certification Officer.	Reference: MESA 36.33(c)
(f) Red reflecting, non-incendive, adhesive tape or reflectors will be applied to the front and the rear of the vehicle to indicate its side extremities.	Reference: CEAL
(g) Each vehicle will be equipped with a portable flameproof lamp located in the cab of the vehicle.	Reference: CEAL

3.2.2 Hydraulic and Pneumatic Systems

(a) Hydraulic and pneumatic systems will incorporate the safety shutdown features described below in clause 3.2.8. These include shutdown due to fluid over heating and/or loss of pressure, application of the brakes in the case of pressure loss, and prevention of start up as long as the lack of pressure condition lasts.

(b) Such systems will conform to the fire and explosion prevention precautions described below in clause 3.4. These include surface temperature limitations (3.4.2), use of fire resistant fluids and compatible hoses and seals (3.4.3), and mechanical protection of hoses (3.4.4).

3.2.2 (continued)

(c) The hydraulic system filler pipe must be located to minimize the possibility of inadvertent introduction of diesel fuel. — Reference: TM12/1977 (24.4)

(d) The pneumatic system must be constructed according to safe engineering practices including provision of adequate intake air filtration, and a relief valve on the receiver. Incorporation of a fusible plug in the air compressor outlet will be acceptable in lieu of the safety shutdown sensor of clause 3.2.8 (i) (5) below.

3.2.3 Fuel System

(a) Fuel tanks shall be of substantial construction and shall be fitted with an internal bladder or other approved means of minimizing leakage due to damage, and shall be securely mounted on the vehicle in such a position as to be reasonably secure against accidental damage resulting from a collision, and the radiation of heat. — Reference: TM12/1977 (26.1)

(b) The capacity of any fuel tank shall not exceed that required for eight hours normal operation of the engine. — Reference: TM12/1977 (26.2)

(c) The tank must pass water-tightness tests carried out by the manufacturer at a pressure of at least 30 kPa. The assembly drawing must note this routine test requirement and the Factory Inspection Form must list it and indicate that such a test has been carried out.

(d) Fuel tank vent openings shall be provided to maintain atmospheric pressure within the tank and shall be designed to prevent leakage of fuel especially when the tank is inverted. Filler caps, whether incorporating vent openings or not, must also meet this requirement. These must be located remotely from hot surfaces and permanently attached to the vehicle to prevent loss. Connections or openings for the drawing of fuel from the tank are not permitted. — Reference: TM12/1977 (26.4)

(e) In addition to the fuel safety shutdown system described below in clause 3.2.5(b), means must be provided to shut off the fuel supply to the engine manually in the event of the normal means of engine shutdown failing to operate. Such means must stop the engine in the shortest practicable time and must be operable from the driving cab. — Reference: TM12/1977 (26.5)

3.2.3 (continued)

(f) Pipes containing fuel or lubricating oils shall be constructed of fire-resistant material and shall be routed away from hot engine surfaces, and in such a manner as to afford a maximum of mechanical protection. Any connections shall be of a type designed to minimize leakage of oil.

Reference: TM12/1977 (26.6)

(g) Wherever practicable fuel systems shall be so designed that in the event of a failure of any fuel pipe on the suction side of the fuel pump, fuel will not flow from the tank either by gravity or syphon.

Reference: TM12/1977 (26.7)

(h) The fuel transfer and injection pumps are referred to in clause 3.2.5(c) below.

3.2.4 <u>Cab, Controls and Indicating Instruments</u>

(a) Operator's Compartment:
In general, the operator's cab shall be equipped with a comfortable seat positioned to afford adequate all round vision, and shall be so designed that the operator can easily read the instrumentation, and conveniently actuate the control devices. The cab shall protect the operator against excessive heat, noise and vibrations to the extent possible.

Reference: TM12/1977 (27.2)
Consultation should take place regarding how FOPS may be integrated with ROPS to improve protection

The cab shall be designed to prevent so far as reasonably practicable, injury to the driver from falls of roof, accidental contact with the roof or ribs, collision with other vehicles or the vehicle overturning. Such protection shall be afforded by the provision of lap seat belts and a roll-over protective structure (ROPS).

(i) Seat belts should be equipped with a quick release device that can be operated with a gloved hand and designed in accordance with pertinent SAE and/or CSA standards. Vehicles carrying personnel in addition to the driver and not furnished with seat belts must be provided with a protective ROPS or roll over bars.

Reference: Canadian Guidelines P. 8
see deceleration of clause 3.2.7 (f)

3.2.4 (continued)

(ii) The ROPS shall be designed in accordance with SAE Recommended Practice as defined by SAE J 1040 b "Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines."

Reference: Canadian Guidelines p. 11

Each ROPS should be permanently marked showing: (i) the manufacturer's name and address, (ii) model number, and (iii) make and model of machine which the ROPS is designed to fit.

Exemption from the ROPS requirements may be granted for vehicles which only operate under circumstances and conditions where no rollover hazard exists.

Means shall be provided in the cab for the accommodation of a self-rescuer, a cap or hand lamp, first aid box and fire extinguisher.

(b) Controls:

Reference: TM12/1977 (28.5)

The design of control systems should take into account the benefits to safety and ease of operation of standardised control movements. Wherever possible common sense should prevail so that, for example, a clockwise or right handed movement of the control results in comparable movement of the item controlled; with push/pull type switches - pull for on, push for off; and valves should turn anti-clockwise to open and clockwise to close.

(c) Instrumentation :

Every cab where applicable, shall be provided with instruments as follows:

(i) a speedometer
(ii) hydraulic drive pressure gauge
(iii) pneumatic system pressure gauge
(iv) brake system pressure gauge
(v) engine coolant temperature
(vi) engine oil pressure
(vii) transmission oil temperature

The brake gauge should be at least 60 mm (2.5 inch) in diameter and of the 270° sweep type with an accuracy of plus or minus 2.5% of full scale.

Reference: Canadian Guidlines

3.2.4(c) (continued)

A warning (incorporated in the brake system pressure gauge) or an alarm device will be furnished in the cab to alert the operator to insufficient brake system pressure (see clause 3.2.7 (c) below).

Reference: Canadian Guidelines

All instruments provided in the cab must be so positioned as to be easily visible by the driver from his seated position.

Reference: TM12/1977 (30)

Illumination of instruments by cap lamps will be acceptable in lieu of other means of illumination.

3.2.5 Engine and Drive

(a) De-rated water-cooled diesel engines producing half (or less) of the amounts of toxic constituents defined in clause 3.5.1 below are preferred. Both the engine and its exhaust manifold will be water-cooled. Air-cooled engines are considered unsuitable for use in coal mines and gassy non-coal mines because of the high surface temperatures encountered.
(b) The engine construction, including the flywheel housing must conform to the flameproof requirements outlined below in clause 3.3.5 (h)
(c) The engine will be equipped with a fuel transfer and injection pump incorporating both an adjustable maximum engine speed governing system, and a maximum injection rate adjustment which are to be totally enclosed and sealed so that any required adjustments can be performed only by authorized service personnel. The governor/injection system must function such that the air flow is not directly affected.
(d) The maximum fuel rate will be limited by the emissions requirements described below in Clause 3.5.1.. Because the maximum allowable fuel rate varies with the altitude, the Certification Officer will include a table of maximum fuel rates for altitudes over 300 m (approx 1000 ft) as part of the certification documentation.

(e) The maximum allowable fuel injection rate setting shall be stamped on a plate affixed to the pump along with the high idle engine speed. When the Certification Officer's approval has been given to adjust the fuel rate, the plate will likewise be changed or replaced.

(f) The fuel employed will conform to that specified below in clause 3.4.1.

(g) The maximum rated output will be that which the engine delivers at the maximum allowable fuel injection rate and rated speed.

Reference: USBM Draft September 1972 (31.61 (f))

(h) The engine selection must be made noting that the intake flametrap and the exhaust conditioner and flametrap, impose engine flow system losses (see clauses 3.3.4 and 3.3.6 below), increasing intake vacuum and exhaust back pressure respectively.

(i) The engine submitted for test will be pre-run to the extent required to allow it to be operated immediately at full load and speed in the EMR certification facility.

(j) Couplings or adapters for attachment of the engine to the EMR Certification facility dynamometer will be furnished by the Applicant. Clutches, transmissions or torque converters, are not generally required in the coupling train.

3.2.6 Steering

All vehicles exceeding 2 metric tonnes or 2,000 kg (4400 lbs) gross weight and designed to travel at speeds higher than 3 kilometers per hour (1.9 mph) shall be equipped with a power-assist steering mechanism, as well as a manually-operated steering mechanism which operates effectively should the power-steering system fail. Any power operated steering mechanism must include either an auxiliary power source or can accumulator capable in either case of producing sufficient capacity to enable the vehicle to be brought safely to rest in the event of a failure of the main power source.

Reference: TM12/1977 (29.1,2 and 3)

Sufficient capacity is defined as that providing 'lock-to-lock' motion once during an emergency.

3.2.7 Braking Systems:

(a) Braking Systems for rubber-tired, trackless, self-propelled vehicles should consist of:

Reference: TM12/1977 (22.1)

(i) service brakes - to be used as the primary braking system,

(ii) emergency brakes - to be used in the event of failure of the service brakes, and

(iii) parking brakes.

These systems may use common components, but any one failure in the common component shall not reduce the capability of the emergency brakes to stop the vehicle safely. At least one of the braking systems must be operated by direct mechanical action by the driver. Brakes applied by springs on the release of fluid pressure may, exceptionally and at the discretion of the Certification Officer, be permitted in lieu of this requirement. Nothing in this paragraph shall prevent the service brakes or the emergency brakes being used as parking brakes provided they meet the requirements of paragraph 3.2.7 (j) below.

(b) Braking systems must be designed to eliminate or minimize so far as practicable, the generation, in any part of the system, of temperatures capable of igniting combustible material likely to be present in the vicinity of that part. To maintain the component parts of braking systems at acceptably low temperatures, the following maximum power dissipation to brake surface area ratio criteria are to be applied to the brake design:

( ) 'enclosed' shoe/drum systems where enclosed infers inhibited cooling — $0.20\ kw/cm^2$ ($1.7\ bhp/in^2$)

Reference: CEAL CANMET Report ERP/MRL 78-38 (TR) J.P. Mogan

(ii) 'open' caliper/disc systems where open infers rapid cooling — $0.40\ kw/cm^2$ ($3.5\ bhp/in^2$)

Reference: SMRE RR #236 based on ignition of methane by friction of steel on steel

(iii) fluid immersed disc system - maximum system surface temperature — $150\ C^{\circ}$ ($300^{\circ}F$)

Brake linings must be of a type which are designed to minimize incendive sparking by frictional contact, and the brake system design must ensure that the brake linings are prevented

Reference: TM12/1977 (22.2)

3.2.7 (continued)

from unintentional contact with rotating parts when not in braking position. Totally-enclosed fire resistant fluid immersed systems are preferred as they eliminate the incendivity of conventional open surface contact braking systems.	Reference: CEAL
(c)	
(i) No power-assisted braking systems shall be rendered ineffective by non-rotation of the engine.	Reference: TM12/1977 (22.4)
(ii) Braking systems which depend on accumulated hydraulic or pneumatic power must incorporate a reservoir capable of sustaining at least 5 consecutive applications of the brakes with the power source inoperative.	Reference: TM12/1977 (22.5)
(iii) A gauge indicating a brake system reservoir pressure must be placed on the instrument panel of the operator's cab (see clause 3.2.4 (c) above).	
(iv) Vehicles employing air, air-over-hydraulic, hydraulic (single and dual systems) shall have a suitable warning or alarm device placed in the operator's cab to alert the operator to unsafe levels of system pressure and/or failure in any one hydraulic circuit of dual systems (see clause 3.2.4 (c) above).	Reference: BC Inspectorate and Canadian Guidelines
(d) No vehicle shall be put into service until full details of the braking system have been submitted to, and accepted by, the Certification Officer.	
(e) Service and emergency braking systems shall be so designed that the response time between initiation and commencement of braking does not exceed 1 second for automatic (eg. operation of a safety trip) or manual operation.	
(f) Service braking systems for rubber-tired, trackless, self-propelled vehicles must be capable of developing a brake effort equivalent to 50% of the maximum gross weight of the vehicle (which for this purpose shall include the maximum permissible unbraked load which may be drawn by the vehicle). The tests described in clause 4.2.5 below are designed to ensure that the vehicle is capable of brake performance in accordance with this criterion.	Reference: TM12/1977 (22.7 (c)) See Appendix 6 for calculations relevant to this provision.

3.2.7 (continued)

(g) The inherent braking effect of a hydrostatic drive system can be considered as the service brake provided that the crawling speed, resulting from complete removal of any demand for power on the part of the operator, may not exceed 10 m/minute (0.37 mph).

Reference: German NRW Regulations (5.2)

In this case, the emergency brake may be deployed to bring the vehicle to a complete stop, provided that, in the judgement of the Certification Officer, the emergency brake system design is adequate and reliable from the point of view of requiring infrequent maintenance and its performance does not deteriorate with age and/or use.

Reference: B.C. Inspectorate's Comments

(h) Emergency Brake systems must be capable of developing a brake effort equivalent to 75% of that of the service brakes (i.e., deceleration rate on a 25% downward grade is halved relative to that of the service brake). Tests described below in clause 4.2.5 are designed to confirm the functioning of the emergency brake in accordance with this criterion.

(i) The automatic actuation of the emergency brake of some vehicles (such as LHD units and ore carriers of over 150 kw or 200 bhp output), where the maximum vehicle speed specified by the manufacturer is exceeded by 30%, may be required at the discretion of the Certification Officer.

Reference: German NRW Regulations (5.3.2)

(j) Every vehicle shall be equipped and maintained with an effective mechanically actuated parking brake, the holding power of which shall not be affected by any loss of fluid or air pressure that may occur over a period of time, and the brake effort shall be produced by a force of not more than seventy kilograms (~150 lbs) for a foot-operated system and forty kilograms (~90 lbs) for a hand-operated system.

Reference: Canadian Guidlines

(k) Parking brakes must be capable of exerting 150 percent of the equilibrium brake effort required to maintain the vehicle stationary on the maximum grade for which the vehicle is designed

Reference: German NRW Regulations (5.3.3)

3.2.7(k) (continued)

(assuming adequate coefficients of friction), when the vehicle is carrying or hauling the maximum load which it may carry or haul on the gradient. Tests described below in clause 4.2.5 are designed to indirectly confirm the functioning of the parking brake in accordance with this criterion.

3.2.8 Safety Shutdown System

(a) General
Each vehicle must be provided with a safety shutdown system, actuated pneumatically, hydraulically or electrically or combinations thereof. The safety devices must be designed and installed such that damage or deterioration resulting from service, maintenance, impact, dust, water etc., will be minimized.

(b) Sensing Devices Required:

(i) Those safety shutdown devices which are required to ensure safety from the fire and flameproof aspects and each of which must automatically actuate the fuel shut off independently, include but are not necessarily limited to the following:

(1) A thermal sensor must be placed in the engine and exhaust system water coolant circuit at the point of highest coolant temperature before return to the radiator. The maximum allowable coolant temperature at this point shall be 100°C (212°F) in order to prevent overheating and destruction of the engine.

Reference: TM12/1977 (48.1)

Reference: USBM Draft September 1972 (31.62(b))

(2) A thermal sensor(s) must be so positioned upstream of the flame arrester in all types of exhaust gas conditioners, that loss of water and the consequent increase of surface temperatures beyond 150°C (300°F) and gas temperatures in excess of 85°C (185°F) are prevented.

Reference: TM12/1977 (46) German NRW Regulations (3.2.2)

Reference: MESA 36.25(c)(1)

(3) A float type shut down or other water level sensing device will be furnished when necessary and in addition to that required in clause 3.2.8 (a) (2) above.

Reference: note comments in clause 3.3.6 (b)(2)

3.2.8(b) (continued)

(4) An engine oil pressure sensor shall be incorporated to guard against loss of engine oil pressure (in order to reduce the incidence of bearing failure and possible ignition of the sump atmosphere). The sensor setting for fuel shut-off shall be 70 kilopascals (10 psig). An override feature will be furnished for start up, which will not however override those sensors detecting an unsafe start up condition.

(5) A thermal sensor shall be installed to prevent overtemperatures in systems including but not limited to air compression, and hydraulic drives. Such devices will be preset to actuate according to the following examples:

- hydrostatic drive reservoir fluid temperature - 85°C (185°F) — Reference: TM12/1977 (24.3)
- hydrokinetic drive reservoir fluid temperature - 150°C (300°F) — Reference: TM12/1977 (24.3)
- pneumatic system receiver air temperature - 160°C (320°F) — Reference: TM12/1977 (25.3)

(ii) Additional shut down devices and interlocks affecting the general safety of a vehicle which must be furnished include, but are not necessarily limited to, the following:

(1) the engine intake air shut-off will be interlocked with the fuel shut-off in accordance with clause 3.3.4(d) below.

Reference: MESA (36.23(c))and SABS (3.3.4(a))

Reference: TM12/1977
Should the air shut-off be actuated independently of the manual lever and the fuel shut-off if the governed engine speed is exceeded by more than 20 percent?

(2) lack of fluid or fluid pressure in pneumatic or hydraulic braking systems will make vehicle motion impossible from a standstill. An automatic warning or alarm device must be used to alert the driver to a low pressure condition (see clause 3.2.7 (c)(iv) above).

(3) the emergency brake system shall be automatically actuated when there is a loss of hydraulic pressure in the drive systems.

Reference: TM12/1977 (24.6)

(4) In the case of non-flameproof flywheel housings, the safety system must be so designed that it is not possible to engage the start mechanism when the engine is running (see clause 3.3.3(c) below).

3.2.8(b) (continued)

(5) The starting mechanism is to be interlocked with the safety shut down system in such a way that start-up is not possible if the exhaust scrubber water level is controlled and the level is below the designed minimum (see clause 3.3.3(d) below).

Reference: MESA (36.25(c)(1))

(6) If it is intended that the vehicle shall be operated in return air, then the vehicle will be equipped with an indicating methanometer on the control console continuously sampling the air of the operator's cab. The methanometer system will be equipped with a meter coloured green from 0 to 0.5% methane by volume in dry air, amber from 0.5% to 1.0% and red above 1.0%. The system will provide an audible alarm when the indicator reads 1.0% or more and the safety shut down system will be actuated at a threshold of 1.25% methane in air.

Reference: Meeting in Edmonton November 1978 Including Inspectorate, Manufacturers and Users.

(7) When technology permits, the Certification Officer may require the installation of additional analysis instrumentation regardless of the operating location of the vehicle or its type.

Reference: as in clause 3.2.8(b)(ii)

3.2.9 Signal or Warning Device

Diesel vehicles shall be provided with a horn, or other adequate audible warning device convenient to the operator. Warning devices shall be operated manually or pneumatically.

Reference: MESA (36.28) and TM12/1977 (19c)

3.2.10 Noise Control

(a) The design of vehicles must take into account the need to keep noise to the lowest practical levels consistent with current technology. The additional noise created when the vehicle is moving should be taken into account when assessing overall noise levels.

(b) Noise levels, at the position of the driver's head, during normal operations underground should, so far as is reasonably practicable, be kept below 90 dB(A). When this is not possible, obligatory use of ear muffs by the operator is indicated.

Reference: TM12/1977 (31)

3.2.10 (continued)

(c) Surveys should be made of emitted noise levels, both in the cab and at such positions one meter from the nearest part of the vehicle as will give a representative picture of the noise emitted by the vehicle details of which, including the conditions of test chosen by the manufacturer, must be submitted to the Certification Officer prior to the approval.

3.3. EXPLOSION-PROOF (FLAMEPROOF) REQUIREMENTS

3.3.1 General

(a) Safe Gaps and Joints:
A summary of some major requirements follows for convenient reference; the quoted standards must be referred to for elaboration and additional detail:

(i) The International Electrotechnical Commission (IEC) Publication 79-1 describes in general Canadian requirements for all joints suitable for coal mines (Group I), including the flame arrester, with the exception of simple flanged joints.

Reference: IEC 79-1

(ii) For simple flanges, the Canadian Standards Association (CSA) Standard 22.2 No. 30, p. 22 defines acceptable joint gaps. The latter are half those of the IEC. These smaller gaps are consistent with good machining practice for simple flat joints. A summary of the IEC and CSA Standards is presented in Appendix 5. Where complex joints are found, such as in plate-type flame arrester assemblies (excluding the plate to plate clearance), IEC Publication 79-1 applies.

(b) Threaded Fasteners and Joints:
A summary of some major requirements follows for convenient reference; IEC Publication 79-1 and CSA Standard 22.2 No. 30, must be referred to for elaboration and additional detail:

(i) The acceptable minimum distance from the inner edge of a flange to a bolt hole in that flange is defined by CSA 22.2 No. 30 page 14 (Appendix 5).

3.3.1 (b) (continued)

(ii) Blind tapped holes must be bottom tapped to a sufficient depth to provide a proper clamping action even if the washer(s) is omitted.

(iii) Metric standard fasteners will be preferred; other recognized standards are acceptable.

(iv) A minimum of 5 full engaged threads will be required for both fasteners and screwed joints (scrubber filler plug for example).

(v) Tapered threads for plugs in flameproof enclosures are preferred. Straight threads and gaskets in such joints may be acceptable upon examination of the joints in question.

(vi) All bolts or nuts which are required to properly close and clamp flameproof joints shall be fitted with lockwashers.

Reference: CEAL
CANMET Report
ERP/MRL 79-33 (CF)
J. Bossert and
D. Dainty

(vii) Those bolts or nuts securing joints which do not require frequent attention (such as those securing exhaust manifolds) are to be wire locked to guarantee maintenance of the flameproof joint in service. Such joints include all intake and exhaust systems joints, except:

(1) flame trap joints
(2) scrubber filler plug
(3) others subject to the judgment of the Certification Officer

(viii) The torque applied to tighten threaded fasteners shall be in accordance with recognized practice.

(c) Restricted Use of Light Alloy Materials:

(i) The use of aluminum paint, aluminum decals and information plates is not permissible. These must be fabricated from non- sparking materials such as brass.

(ii) Exposed, non-rotating external light alloy parts are to be avoided wherever possible.

(iii) Such light alloy parts may be permitted where no suitable substitute can be found if:

(1) they are zinc sprayed (0.004 in. to 0.006 in. thick), and

(2) located in non-vulnerable areas from an impact point of view, and/or

3.3.1 (c) (iii) (continued)

(3) protected by an impact deflection baffle.

It is desirable that at least 2 of the above 3 conditions be met. If not, exemption can be granted if one of the three measures, in the judgement of the Certification Officer, provides adequate safety.

Interim use of light alloy parts (until replacement by the non-light alloy parts) for which it is known that substitution can be made, has been permitted. No such interim use will be permitted after June 30, 1981.

(iv) Alloy materials, not modified by the provisions of clause (iii) above, are limited to the following light alloy content:

Reference: EEC 13th Mine Safety Report 1976

(1) Aluminum plus Titanium plus Magnesium in any combination shall not exceed 15% of the total metal by volume in the alloy, and,

Reference: TM12/1977 (21.(2))

(2) Titanium plus Magnesium shall not exceed 6%.

3.3.2 Electrical Equipment

(a) Electrical Components: Electrical components shall be either enclosed in flameproof enclosures conforming with CSA Standard C22.2, No. 30 or shall be intrinsically safe in accordance with the latest draft of CSA Standard C22.2, No. 157. Other methods of explosion protection such as increased safety, sand filling and purging will be considered depending upon their application. For these techniques, reference will be made to the applicable IEC Publication for requirements. In addition, electrical components shall, where practicable, meet the applicable Canadian Standards for the type of equipment involved.

(b) Interconnecting Wiring: Wiring between components shall be either run in fire-resistant hose conduit or shall be in fire-resistant shielded portable trailing cable complying with the trailing cable requirements of CSA Standard C22.5 "Use of Electricity in Mines".

3.3.2 (b) (continued)

Hose conduit shall have a minimum wall thickness of 3/16 in. and shall be capable of passing the test for fire resistance given in Clause 4.4.4 below. Wiring shall be routed in the manner most likely to protect it from contact with sharp objects and from accidental damage. Cable glands and terminations shall comply with the requirements for the enclosures which they enter (eg., flameproof).

(c) Protection and Control: All undergrounded conductors shall be provided with suitable overcurrent devices for the purpose of automatically opening the electrical circuit in the event of dangerous overload or a short-circuit. Such control, where practicable, shall meet the requirements of CSA Standard C22.1 "Safety Standards for Electrical Installations". Where the source of electrical power is external to the machine, such protection may be provided external to the machine.

3.3.3 Starting System

(a) Electric/battery starting is not permissible. Pneumatic or hydraulic starting or other mechanical means such as springs are acceptable subject to examination for hazards.

Reference: TM12/1977 (51)

(b) Steel pinions will be permitted if the engagement mechanism cannot apply more than 20 kg-m (150 ft-lbs) of impact energy; with the use of beryllium - copper pinions, 50 kg-m (350 ft. lbs) will be permitted. Alternatively, the engine fly wheel housing in which the pinion and ring-gear are located, must be manufactured to flameproof requirements as outlined in clauses 3.3.1 above, and 3.3.5(h) below.

Reference: CEAL CANMET report ERP/MRL 78-38(TR) J.P. Mogan

(c) In the case of non-flameproof flywheel housings, the safety system must be so designed that it is not possible to engage the start mechanism when the engine is running (see clause 3.2.8(b)(5) above).

3.3.3 (continued)

(d) The starting mechanism is to be interlocked with the safety shut down system in such a way that start-up is not possible if the exhaust scrubber water level is float controlled and the level is below the acceptable designed minimum (see clause 3.2.8(b)(5) above).

3.3.4 Engine Air Intake System

(a) General: The intake system (exclusive of the air cleaner) shall be designed to withstand internal pressures equal to those generated by the tests defined in clause 4.3.1 below. Joints in the intake system shall be formed by metal flanges fitted with metal or metal-clad gaskets, positively positioned by through bolts or other suitable means for secure assembly, or shall meet the requirements for flanged metal-to-metal flame-proof joints both in accordance with the requirements of clause 3.3.1 above. Either type of joint shall withstand repeated explosions within the intake system without permanent deformation and shall prevent the propagation of flame through the joint into a surrounding flammable mixture.

Reference: MESA (36.25(a))

(b) Air Cleaner: An air intake filter, suitably sized to reduce maintenance to a minimum and maintain the intake manifold vacuum to a maximum of 28 mm Hg gauge (15 in. water gauge), is required as part of the air intake system. Dry type filters which incorporate automatic indication of unacceptable filter loss are preferred. Wet filters will be accepted provided they are designed to function with non-toxic fire resistant fluids.

Note: 28 mm Hg gauge is equivalent to 3.7 kilopascals

(c) Intake Flame Arrester:

(i) Mandatory: The installation of a flame trap in the intake system of a diesel machine used underground in gassy coal or non-coal mines is mandatory in order to reduce the hazard of explosion transmission from the combustion systems of the engine to external inflammable environments. The design and construction of the arrester must be in accordance with the following principles:

Reference: CEAL CANMET Report ERP/MRL 77-133(TR) D. Dainty

3.3.4 (c) (continued)

(ii) Mounting Location: The intake flame trap shall be mounted in the intake system between the air filter and the intake manifold. The arrester shall be mounted rigidly to the intake manifold making flexible connections in the flameproofed connecting ducting unnecessary. The arrester must be located in such a way that its temperature is not increased more than 30°C (54°F) above the ambient intake air temperature.

Reference: TM12/1977 (40(2)(a))

(iii) Acceptable Types of Arresters: The stacked plate type of flame arrester having integral bosses to form the safe gaps (see Figure 1), is acceptable. Other types of plate separation as well as other types of arrester fabrication (such as the corrugated and wrapped element type) will be accepted if such arresters conform to generally accepted safety requirements and pass explosion tests, as required by the testing authority (see clause 4.3.1 below).

(iv) Permissible Element Dimensions of Plate-Type Arrester:

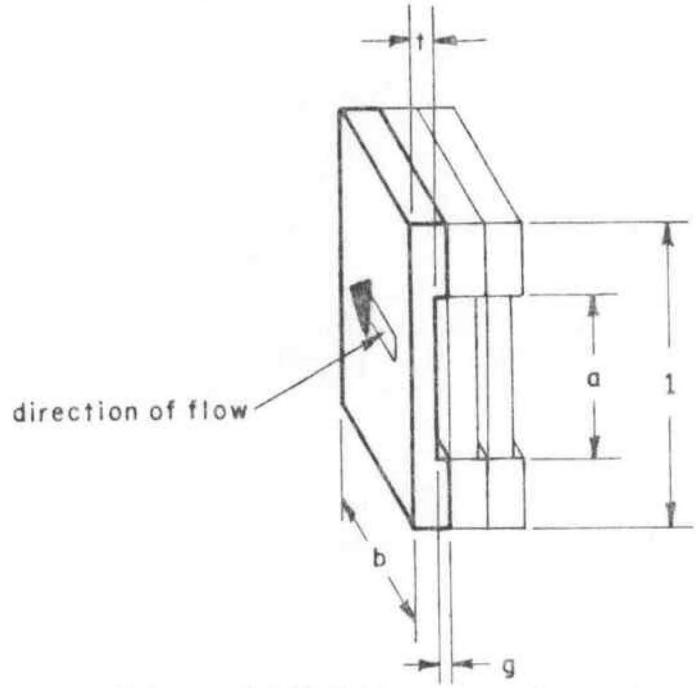
Reference: SABS 868/1967 (p.12) contains similar provisions

Dimension in Figure 1	Description of Dimension	Permissible Value of Dimension (mm)	(in.)
a	maximum unsupported element length	-	-
b	minimum breadth in direction of flow	50	2.0
g	maximum allowable gap	0.5	0.018
l	overall length of element	-	-
t	minimum thickness of unsupported element	*	*

*t min = $a/(35\ b^{1/3})$ or 1.0 mm (0.039 in.) whichever is greater

3.3.4 (c) (iv) (continued)

Fig. 1 - Dimensions of Element in Plate Arrester (see 3.3.4.(c)(iv) above)



(v) Bosses and Shims: Solid full size shim plates of an appropriate thickness, must be used to ensure that the plates are packed tightly in the frame. Partial shims are not to be used.

(vi) Free Area Requirement: The minimum acceptable free area of the intake arrester is to be determined by the application of the following ratio:

$$\frac{\text{Minimum free area}}{\text{actual volumetric flow rate}} =$$

7.0 $cm^2/(m^3/min)$ or 0.031 in^2/cfm in order to prevent excessive flow restriction thus avoiding undue pressure drop across the intake arrester and undue abrasion of the elements. Values in excess of this value are preferable, and may be required by the engine manufacturer.

Note: Bosses or shims used to separate the plates should be the same width as the plates as required in TM12. However, alternatives are possible and must be decided upon their merits.

Reference: CEAL CANMET Report (Guidlines) ERP/MRL 77-133(TR) D. Dainty

Reference: CEAL CANMET Report (ΔP) ERP/MRL 77-136 (TR) D. Dainty

3.3.4 (c) (continued)

(vii) Arrester Element Mareria1: The material from which the elements are to be fabricated is austenitic stainless steel in order to provide acceptable resistance to corrosion and permit fabrication by welding. Other materials will be accepted provided adequate documentation is submitted indicating that the materials have as good or better corrosion, weldability and abrasion properties as austenitic stainless steel.

(viii) Additional Design Guidlines: The following principles shall be incorporated into the design of the intake flame arrester assembly:

(1) the arrester must be easily removed as an assembly in order that it may be properly inspected, and cleaned with a minimum of difficulty. — Reference: TM12/1977 (40(2)(d))

(2) flanged metal-to-metal joints are preferred. The use of gaskets is discouraged but metal or metal-clad gaskets will be acceptable depending on the circumstances.

(3) the design must be such that the flame trap cannot be disassembled for repair. Should inspection show a defect(s), then the trap must be returned to the manufacturer or a recognized agent, for repair.

(4) prototype arresters submitted to the Certification Officer for examination and approval must be in a dismantled condition (for example, flat plate retaining flange must not be welded in place). After examination of the 'hidden' flameproof joints, the staff of the certifying laboratory will complete the assembly before flameproof testing is begun.

(ix) Protection: The arrester assembly must be protected against accidental external damage and designed in such a way as to resist without significant distortion the effect of the internal explosion tests require in clause 4.3.1 below. — Reference: MESA (36.23 (b)(1))

3.3.4 (c) (continued)

(x) Maintenance: The intake arrester shall be removed, inspected, cleaned and refitted when the intake vacuum between the arrester and the intake manifold is excessive (example: exceeds a recommended maximum of 47 mm of mercury gauge or 25 in. of water gauge, at full speed idle including air filter loss). The mine management shall designate a specific person(s) who will be responsible for carrying out this maintenance function.

(d) Connecting Ducting:

(i) The connecting ducting from the arrester to the manifold must be sized so that the air velocity at minimum idle engine rotational speed is a miminim of 3 m/s (10 fps) in order to reduce the possibility of "afterburning" and the consequent dangerous increase in the temperature of the arrester elements.

(ii) No holes or flame paths in the intake system from the flame trap inlet flange to the intake manifold inlet flange for vacuum measurement or other purposes, will be permitted.

(iii) No flexible connections in the flameproof portion of the system will be acceptable.

(e) Air Shut-off Valve: An air shut-off valve will be furnished between the intake air filter and the intake flame arrester, in order to permit emergency engine shut down. This shut off valve must be designed to be actuated by forces transmitted through a mechanical linkage system initiated by the operator in his compartment, and automatically following actuation of the fuel shut-off in the safety shut down system (see clause 3.2.8 above). On start up the air shut off valve must be open before full injection may occur.

(f) Engine Intake Manifold: The engine intake manifold must be constructed to the flameproof joint requirements of clause 3.3.1 above. Its design, whether of welded or cast construction, must be such as to withstand the test pressures specified in clause 4.3.1 below.

Reference: SABS (3.3.4(a))
MESA (36.23(c))

Reference: CEAL CANMET Paper #C-3 XVIIth Int. Conf. on Safety in Mines Research Varna Bulgaria 1977 - B.Stewart& N.Kallio

Reference: Commentary by Dr. B.P. Mullins (SMRE) on CEAL's paper C3 at Varna: "SMRE experiments have indicated that a slightly retarded (say 5 to 10 second) closure period of the intake stop valve, i.e. a 'damped' action would be effective in preventing the reverse rotation occasionally induced by a 'quick-acting'stop valve. Emphasis on 'quick acting' is perhaps not a good thing in the mining context where exhaust conditioners are in use."

3.3.5 Engine Requirements

(a) General:

(i) The engine will be water-cooled in accordance with the provision of clause 3.4.2 below.

(ii) The major engine joints of concern from the flameproof point of view are:

(1) piston to cylinder wall and ring clearances,
(2) cylinder head joint,
(3) valve stem and guide diametral clearances, and
(4) injector body cylinder head clearances.

Normal industrial design and machining practice reduces these clearances below those required to ensure flameproof joints. Not withstanding this fact, it is necessary that engine construction conforms to the following principles.

(b) Piston to Cylinder Joint: Normal industrial clearances between cylinder and piston will be acceptable in conjunction with the degree of seal provided by the rings. Ring failure in a worn engine might result in a hazard with respect to ignition of a crankcase mixture but experience has not identified this as a hazard for high speed diesel engines of the sort generally applied to vehicles underground.

(c) Crankcase: Notwithstanding clause (b) above, certain precautions are easily taken. Therefore it is required that:

Reference: German NRW Regulations (3.2.3)

(i) the crankcase breather assemblies be flameproof and that the materials used in their construction be non-incendive from the point of view of particle ejection as a result of internal explosions. The engine crankcase breather must not be connected to the air intake system of the engine. The discharge from the breather must be directed away from hot surfaces and in such a way as to ensure that the external surface of the engine and exhaust system do not become fouled with oil.

Reference: TM12/1977 (50)

(ii) The oil filler and dipstick must incorporate screwed caps to restrain their ejection in the case of an internal crankcase explosion, and prevent the passage of an explosion.

Reference: German NRW Regulations (3.2.3)

3.3.5 (c) (continued)

(iii) the joint between the pan and the block should be designed such that the joint width is a minimum of 9 mm (0.375 in.) and sealed by a soft gasket, ejection of which by internal explosion, is however prevented. Exemption from this pan joint requirement may be made at the discretion of the Certification Officer.

(d) Cylinder Head Joint: The joint between the cylinder head and block of the engine shall be fitted with a metal or metal-clad gasket satisfactory to the Certification Officer, and held securely in position by through bolts or other suitable means to prevent a change in alignment. This joint shall have a minimum width of 9.0 mm (0.375 in.) and shall provide an adequate flame barrier with the gasket in place.

Reference: TM12/1977 (42(a))

(e) Valve Stem and Guide: The diametral clearance between valve stems andvalve guides must not exceed 0.15 mm (0.006 in.) for a minimum length of 25 mm (1 inch).

Reference: TM12/1977 (42(c))

(f) Injector Body/Head Joint: The injector body shall be positively sealed to the cylinder head. The seat shall be backed up by a minimum flame-path of 12.5 mm (0.5 in.) with a maximum diametral clearance of 0.15 mm (0.006 in.)

Reference: TM12/1977 (42(b))

(g) All other joints connecting the combustion chamber directly or indirectly to the surrounding atmosphere must be flameproof in accordance with clause 3.3.1 above.

Reference: SABS (3.8) and German NRW Regulations 3.2.1

(h) If applicable, the engine flywheel, clutch and starter ring gear housing must be flameproof as described above in clause 3.3.1, unless special measures have been taken to prevent or reduce clutch and starter impact energies to values below the levels for ignition of methane/air mixtures.

3.3.6 Engine Exhaust System

(a) General:

(i) The exhaust system shall be designed to withstand internal pressures equal to those generated by the tests defined in clause 4.3.1 below.

(ii) All joints in the exhaust system shall be tight to prevent the flow of exhaust gas through them under any condition of engine operation prescribed by the Certification Officer. A tight system shall be obtained by the use of ground metal to metal joints, or by metal or metal-clad gaskets. All such joints shall be fitted with adequate through bolts and all gaskets shall be aligned and held firmly in position by the bolts or other suitable means. Such joints shall be constructed to the flameproof joint requirements of clause 3.3.1 above, and shall remain tight to prevent passage of flame or propagation of repeated internal explosions to a surrounding flammable mixture.

(iii) The system shall withstand repeated internal explosions as prescribed in clause 4.3.1 below without permanent deformation or deterioration except as noted in item (d) of that clause.

(iv) The system, including but not necessarily limited to the exhaust manifold, the exhaust piping (including a bellows if applicable), the exhaust gas conditioner and the flame arrester, shall be cooled in accordance with the surface temperature provisions of clause 3.4.2 below.

(v) Stainless steel sheet and pipe will be used in the construction of the water scrubber and all other components of the exhaust system for reason of resistance to high temperatures and corrosion, thus preventing unsafe conditions arising from rapid material deterioration.

(vi) A rigidly-connected exhaust system between the exhaust manifold and the water conditioner, is preferred. A flexible bellows connection will be permitted, provided:

(1) that it is water cooled (i.e., a double-walled bellows),

3.3.6 (a) (vi) (continued)

(2) that if required by the Certification Officer, the bellows is fatigue tested and found to possess adequate resistance to failure,

(3) that the design is such that permanent deformation of the bellows system during explosion and hydraulic pressure testing does not occur,

(4) that a plate showing the hours of engine operation, at which the bellows replacement is required, is mounted adjacent to the bellows, and,

(5) that special mention is made of the bellows replacement period in the service and safety system manuals, and on the appropriate drawings.

(b) Water conditioner:

(i) For the purpose of cooling the exhaust gas before dilution to satisfactory levels and to ensure that the flame trap will be effective in preventing transmission of explosions to the external atmosphere, a water bath conditioner is preferred. Innovative cooling methods will be entertained by the Certification Officer if it can be demonstrated that the emissions are not inordinately increased by the omission of the water bath, and that the surface temperature limitations of clause 3.4.2 are satisfied.

(ii) The preferred variety of water conditioner is the 'batch-type scrubber', for the reason that neither replenishing float-controlled systems nor simple float-actuated shut down systems have proven practicable under mine operating conditions (as of 1979). Innovations which overcome these operational and flame proofing problems will be considered by the Certification Officer if evidence of satisfactory operation without undue outage can be furnished by an independent investigator. A separate fresh water reservoir, not connected to the water scrubber, and requiring engine shut down before refilling, is a less desirable but acceptable method of furnishing an adequate water supply as specified in clause 3.3.6 (b)(v) below.

Reference: CEAL (Canadian experience)

3.3.6 (b) (continued)

(iii) Likewise an exhaust spray cooling system incorporating the pumping of scrubber water around a flameproof circuit to an exhaust pipe spray nozzle, has been shown to be impracticable in some cases. Therefore, water jacketing of the exhaust pipe is preferred but other cooling innovations will be considered.

Reference: CEAL (Canadian experience)

(iv) The scrubber shall be designed to cool the exhaust gases to 80°C (176°F).

Reference: MESA (36.25 (c)(1))

(v) The minimum effective scrubber water volume shall be such as to permit the engine to operate at a load factor of 1/3 for a period of 8 hours. Flameproof turbocharged units will require an effective scrubber water volume suitable for full load operation for 1/3 of the shift period.

Reference: MESA (36.25(c)(4)), and TM12/1977 (41.1).

Scrubber volumes less than specified above will be permitted if an audible alarm is installed to indicate low water level before automatic shutdown occurs.

(vi) A thermal shutdown sensor (see clause 3.2.8(b)(i) above) will be installed in the scrubber before the flame arrester entrance. It shall be located so as to cause shutdown when the temperature of the exhaust gases before the arrester reaches 85°C (185°F) and so that no surface temperature in the system including the arrester, becomes greater than 150°C (300°F) before shutdown occurs when no water is in the system. The thermal element shall be of such design as to reduce the thermal lag time from cold start up to shutdown to a minimum in order to provide satisfactory performance under operating conditions (acceptable example: from 20°C with no scrubber water and operating at 2/3 load factor, shutdown occurs after a maximum period of 3.5 minutes at a maximum exhaust over-temperature above 85°C of Δ35C° (63F°) measured at the flame trap).

Reference: CEAL (required because of negative Canadian experience with water level control)

(vii) The design of the conditioner will take into consideration the possibility that scrubbing baffles can contribute to high explosion pressures causing excessive outer surface deformation. Such deformation can be reduced to acceptable levels by redesign of baffling and/or the use of heaver plates or stiffeners.

Reference: CEAL CANMET Report ERP/MRL 79-36 (TR & OP) P.Mogan et al

3.3.6 (b) (continued)

(viii) The use of copper or copper-clad gaskets to seal water-filled or water-splashed joints in the water scrubber is not acceptable due to rapid corrosion of copper in such acidic environments.

Reference: CEAL (Canadian experience)

(ix) No drains will be permitted in the base of the scrubber. All openings (such as for refilling) will be sealed by
 (1) taper threaded plugs or,
 (2) straight threads plus a gasket seal or tapered bearing metal surface seal,
each equipped with a chain to prevent loss, and having at least five (5) threads engaged.

Reference: BC Inspectorate

(x) Provision must be made to prevent water from the conditioner box being sucked into the engine when the air shut off is actuated, or closed on start-up.

(c) Exhaust Flame Arrester:

(i) Mandatory: The installation of a flame trap in the exhaust system of a diesel machine used underground in gassy coal or non-coal mines is mandatory in addition to provisions for cooling the exhaust gases in order to reduce the hazard of explosion transmission from the combustion system of the engine to the external inflammable environment. The exhaust arrester requirements are the same as those described for the intake arrester in clause 3.3.4. (c) above except as follows:

Reference: CEAL CANMET Report ERP/MRL 77-133(TR) D.Dainty

(ii) Mounting Location: Preference will be given to the design incorporating the exhaust on the outlet of the water scrubber. Consideration will be given to other mounting locations if examination shows that, in the opinion of the Certification Officer, such a location is equally as safe as the preferred location. The mounting location shall be such as to facilitate the design of the ducting to the exhaust dilution and diffusion equipment.

Note: British research indicates that a flame trap remains effective when immersed in hot gas the temperature of which is 300°C (572°F) or below. As exhaust gas is almost always hotter than this, the location of the arrester after the scrubber is preferred.

(iii) Acceptable Types of Arresters: Plate arresters are acceptable. Flame traps other than the spaced plate type may be acceptable provided tests show that they are at least equal to the space plate type in performance, and can easily be removed for inspection, cleaning and replacement.

3.3.6 (c) (continued)

(iv) Free Area Requirement: The minimum acceptable free area of the exhaust arrester is to be determined by the following ratio:

$$\frac{\text{minimum free area}}{\text{actual volumetric rate}} = 9.8 \frac{cm^2}{(m^3/min)}$$

or

$$0.043 \frac{in^2}{cfm}$$

in order to prevent excessive flow restriction, to avoid undue pressure drop across the exhaust arrester, undue abrasion of the elements, and to reduce the pressure drop due to the build up of exhaust deposits during operation for one shift.

Reference: CEAL CANMET Report (Guidlines) ERP/MRL 77-133 (TR) D. Dainty

Reference: CEAL CANMET Report (ΔP) ERP/MRL 77-136(TR) D. Dainty

(v) General Design Guidelines: In addition to those principles described in clause 3.3.4(c)(viii) above, the following principles shall be incorporated into the design of the exhaust flame arrester assembly:

(1) Scrubber-mounted exhaust arresters must be situated such that only cooled gases are passed through them so that any exterior surface temperature of the arrester assembly does not exceed 150°C (300°F) under any condition of operation.

(2) Attempts should be made to design the exterior exhaust surfaces including the arrester in such a configuration that the accumulation of combustible dust is discouraged.

(3) The material from which the exhaust arrester elements are to be fabricated are described in clause 3.3.4(c)(vii) above.

(vi) Maintenance: The exhaust arrester shall be removed, inspected, cleaned and replaced at the end of each 8-hour shift, unless the exhaust pressure immediately before the arrester is excessive (example: exceeds a recommended minimum of 47 mm of mercury gauge or 25 in. of water gauge at full speed idle).

Reference: CEAL

Note: This gauge pressure <u>includes</u> the loss through the water portion of the water scrubber and that its measurement necessitates the inclusion of wire-locked plug on the scrubber which is not deemed to be safe by the BC Inspectorate.

3.3.6 (c) (vi) (continued)

The mine management shall designate a specific person(s) who will be responsible for the carrying out of this maintenance function.

3.3.7 Brake and Clutch

Fully enclosed oil-immersed brakes are preferred for flameproof diesel equipment. External brake components which can accumulate coal dust layers (ie., disc brake calipers) may not exceed 150°C in normal operation. If internal brake and clutch components which can accumulate coal dust layers exceed 150°C in normal operation, the assembly (drum plus backing plate or clutch housing) must meet Specification CSA-C22.2, No. 25 Dust Tight Enclosures for Use in Class II Group E, F, and G Hazardous Locations.

To prevent ignition of methane/air atmospheres, the brake design criteria of clause 3.2.7(b) above must be employed.

3.3.8 Anti-Static Materials

(a) Where supplies of adequate anti-static materials exist, provision of such products will be required. Such items may include, but are not necessarily limited to, the following:

(i) anti-static rubber V-belts
(ii) anti-static plastic engine cooling fan
(iii) anti-static rubber tires where feasible.

(b) Such materials will be subjected to tests as specified below in clause 4.3.3 (a) below to determine if their resistances conform to accepted maximum values.

3.3.9. Safety Shutdown System

For both Explosion-Proof and Fire Prevention aspects of the Safety Shutdown System refer to clause 3.2.8(b) above.

3.4 FIRE PREVENTION REQUIREMENTS

3.4.1 Fuel Specifications: Any oil used to fuel a diesel engine underground shall be graded No. 1D or 2D by ASTM D975. In addition the fuel must meet these additional requirements.

(a) Flash point shall bot be less than 52°C or 125°F (closed cup);

(b) Recommended maximum sulphur content is 0.20% by mass. Greater values will result in appropriate ventilation assessment increases.

(c) API Gravity (ASTM D1298-IP160) shall be greater than 32° API;

(d) Fuels with a heavy asphalt base shall not be used; and

(e) Maximum content of aromatic hydrocarbons shall be 35 percent by volume as determined by ASTM D 1319.

Reference: USBM 1973 Draft (31.61(b))

Note: Input from CEAL regarding underground diesel fuel requirements will be made to the "Middle Distillate Fuels Sub-Committe" of the "Petroleum Committee of Canadian Government Specification Board" on a continuing basis with two main objectives in mind: (1) limiting the aromatic content of diesel fuels particularly those derived from tar sand synthetic crude in order to limit the generation during combustion of inordinate amounts of ring-type and other carcinogenic hydrocarbons, and, (2) assuring continuing supply of low-sulphur fuel option for the underground mining industry in Canada.

3.4.2 Surface Temperature Limitations

The external surface temperature of all vehicle components must not exceed 150 C (300 F - measured in still air in an ambient temperature of at least 14 C), under any operating condition.

Exterior surfaces shall be designed to minimize the accumulation of dust and combustible material and facilitate the removal of same. Insulating materials and coverings shall not be used to control surface temperatures. The use of water sprays in lieu of water jacketed components is discouraged.

Reference: TM12/1977 (46), and German NRW Regulations (3.2.2)

Reference: Note comments in clause 3.3.6(b)(2)

3.4.3 Fire Resistant Fluids

(a) Chemical Compositions: The chemical composition of the fluids used in all hydraulic systems intended for underground coal and gassy mines shall be non-flammable, mechanically stable, preferably non-toxic and must conform to the (interim) test requirements as described under clause 4.4.1 below.

(b) Compatibility: All hydraulic systems employing fire-resistant fluids shall be compatible with respect to seals, gaskets, hoses and metals. Pure mineral oils and their blends with other synthetic oils including phosphate esters are not acceptable.

3.4.3 (continued)

(c) Thermal Shutdown: A thermal shutdown device, shall be installed in the hydraulic fluid circuit(s) to render the system(s) inoperative whenever the fluid temperature reaches the value approved and specified in the certificate (see also Section 3.2.8(b)(i)(5)).

(d) Exceptions: Where technological innovation and therefore development time is required to furnish items of equipment employing fire resistant hydrualic fluids, exceptions to clause 3.4.3(a) above will be made and speci fied for suitable period of transition at the discretion of the Certification Officer in consultation with the provincial and federal inspectorates. Possible examples of exempted equipment are fluid transmission and drives and air compressor crank cases.

3.4.4 Fire Resistant Materials

Wherever fire resistant materials can be obtained they will be employed in the manufacture of flameproof machines. Such materials will be used, but not limited to, the manufacture of hose materials, conveyor belts, V-belts-and tires. All such materials will be tested in accordance with the requirements described in clause 4.4.4. below.

3.4.5 Mechanical Protection

Mechanical protection of fuel lines is specified above in Section 3.2.3 (f) above. In general, design should be such as to protect parts containing flammable fluids from damage by impact, including the engine pan.

3.4.6 Extinguishing System(s)

(a) An approved multi-purpost hand-held fire extinguisher shall be fitted to each diesel vehicle. It shall be readily accessible from the operator's compartment, and conform to the following minimum requirements:

Reference: Federal Ministry of Transport Regulations for trucks.

3.4.6 (a) (continued)

Vehicle Power Rating kw(bhp)		Fire Extinguisher Rating kg(lb)	
0-37	(0-50)	ABC 2.3	(5)
37-175	(50-100)	ABC 4.5	(10)
75-112	(100-150)	ABC 9	(20)
112 plus	(150 plus)	ABC 9 an automatic fire suppression system	(20) plus

(b) The automatic system when required shall deliver fire suppressant chemical to each location on the machine where a hazard exists or a minimum of 5 locations including one for each side of the engine compartment. Dry chemical systems shall supply at least 2.3 kg (5 lbs) per hazardous area, with a minimum total of 14 kg (25 lbs).

(c) Manual actuation of the automatic fire suppression system shall be possible from each side of the machine and in the cab.

Reference: Alberta Inspectorate/Users/Ceal/ Manufacturer's meeting Edmonton, November 1978.

(d) It is recommended that cylinders containing dry fire suppressant chemicals be stored horizontally to reduce compaction effect of vibration due to vehicle operation.

Reference: as in (c) above)

3.5 EXHAUST EMISSIONS EQUIPMENT

3.5.1 Fuel Rate Setting

(a) The liquid fuel supply to the new engine shall be adjusted, fixed and sealed so that the undiluted exhaust gas shall contain not more than 2500 ppm of carbon monoxide, not more than 1500 ppm of oxides of nitrogen (NO_X), and not more than 125 mg/m^3 of particulate, under any conditions of engine operation prescribed by the Certification Officer, when the intake air mixture to the engine contains either 100 percent air, or 1.5 percent methane by volume.

(b) The engine shall be re-adjusted or overhauled when the untreated, undiluted exhaust gas contains more than 3000 ppm carbon monoxide or 150 mg/m^3 particulate under normal conditions of operation.

3.5.1 (continued)

(c) Reduction in the maximum allowable fuel injection rate for increases in altitude above 300 metres (approximately 1,000 ft) will be made.

3.5.2 Fuel Alteration System

Innovations which alter the fuel and which beneficially affect the emissions are permissible provided that they are practicable and that emissions tests of clause 4.6 below reflect their beneficial effects.

3.5.3 Exhaust Treatment Devices

(a) Exhaust treatment may be accomplished by a number of devices; for example, filters, catalytic purifiers, and water scrubbers, applied singly or in combination. Where evidence can be furnished that treatment performance does not deteriorate with use, and that suitable procedures can be instituted to maintain the device(s), their application will result in reduced ventilation assessments as defined in clause 4.6.4. below.
(b) Where there is doubt with respect to the maintenance of emission reduction efficiency of such devices, the Certification Officer will assess the allowable ventilation reduction.
(c) The emissions reduction performance of all such devices will be assessed during dynamometer exhaust emissions tests as described in clause 4.6.1 below.

3.5.4 Permissible Mine Air Concentrations

(a) The concentration of the various pollutants contained in diesel exhaust will be considered additive in accordance with the following criterion:

Reference: Result of CANMET contract with I.W. French and Associates (Toronto)

$$HEI = \frac{(CO)}{50} + \frac{(NO)}{25} + \frac{(RCD)}{2} + 1.5\left[\frac{(SO_2)}{3} + \frac{(RCD)}{2}\right] + 1.2\left[\frac{(NO_2)}{3} + \frac{(RCD)}{2}\right]$$

3.5.4 (a) (continued)

where:

HEI = Health Effects Index
(CO) = Carbon Monoxide concentration (ppm)
(NO) = Nitric Oxide concentration (ppm)
(RCD) = Respirable combustible dust concentration (mg/m^3)
(SO_2) = Sulphur dioxide concentration (ppm)
(NO_2) = Nitrogen dioxide concentration (ppm)

(b) Sufficient ventilating air must be supplied to reduce the HEI to 3.0 or less in the general mine air in accordance with the calculation prescribed in clause 4.6.4 below.

Reference: as in 3.5.4.(a) above

(c) In circumstances where unusually low amounts of diesel particulates are emitted from the machine, it may be that the concentration of one or more of the gaseous emissions will exceed the ACGIH-TLV. In such a case sufficient ventilating air must be provided to ensure that the concentration of each toxic constituent, taken separately, does not exceed its TLV at its maximum rate of generation.

Reference: CEAL unpublished tests

(d) In the case of mines with a quartz content in excess of 20% in the ore, a term "concentration of quartz ÷ TLV quartz" will be added to the value of the HEI and the HEI in such circumstances should not exceed 2.0.

Note: the AECB has specified a value of 0.2 mg/m^3 for an "Interim Respirable Silica Dust Exposure Standard" "Feb. 27, 1979.

3.5.5 <u>Exhaust Dilution System</u>

Each machine will be equipped with an exhaust dilution system. The system will be capable of diluting the exhaust, under any condition of vehicle operation (by directly or indirectly mixing with adequate fresh air ventilation as specified in clause 4.6.4 below), such that HEI shall not exceed 6.0 and each individual constituent shall not exceed its ACGIH/TLV at a location adjacent to the cab at the operators' head level.

4.0 TEST REQUIREMENTS

4.1 MANUFACTURER'S TESTS

4.1.1 Documentation Required

This standard permits some tests to be performed by the manufacturer on the completed machine prior to either factory inspection or laboratory inspection by the Certifying Investigating Officer. Such tests would include for example, checks of the safety shutdown system and leak tests of fuel and scrubber tanks. All such tests will be listed in the Factory Inspection Form. Other tests requiring more specialized laboratory equipment and expertise, such as anti-static V-belt resistance tests, brake performance tests etc., may be performed by sub-suppliers or private laboratories provided that:

(a) an affidavit is furnished to the Certification Officer, whish is signed by a responsible officer (professional Engineer or equivalent) of the test performing agency, and which indicates, where applicable, that the tests have been performed in accordance with a reputable and generally-accepted standard, and that the materials or equipment performed satisfactorily.

(b) an affidavit as in (a) above is furnished, but where no recognized standard exists, the document must describe the test in detail and the results obtained.

4.1.2 Confirmatory Tests

Notwithstanding the fact that all the requirements of clause 4.1.1 above are met, such tests may be judged to inadequately ensure the safety or performance of the product involved. Consequently, the Certification Officer may require that independent tests be carried out either by a recognized private laboratory, or in the EMR certification laboratory.

4.2 MECHANICAL TESTS

4.2.1 Engine Intake and Exhaust System Pressure Losses

(a) The engine intake vacuum and the exhaust back pressure will both increase as the intake filter, the intake arrester, and the exhaust arrester become fouled in operation. Good practice for naturally aspirated engines indicates that pressure drop maxima for clean systems is 28 mm Hg gauge (15 in. water gauge) and for fouled systems is 47 mm Hg gauge (25 in. water gauge). These values are such that excessive generation of carbon monoxide will not occur nor will the power output be adversely affected and the cleaning frequency of the filters and arresters will conform to current acceptable standards.

(b) Both the intake manifold vacuum and the exhaust manifold pressure for clean systems, will be measured at high idle engine speed using a plugged tap on each manifold which will be wired in position to prevent inadvertent loosening in service or loss (see clauses 3.3.4(b)(x) and 3.3.6(c)(vi)).

Note: Measurement of intake vacuum and exhaust pressure is not possible without taps in the intake and exhaust systems for gauge pressure measurements. Current levels of diesel maintenance performance suggest that opening up flame paths in these flameproof systems is unwise. Hence this document omits such items as a result of consultation with the BC Inspectorate. Were vacuum and pressure taps to be acceptable, the suggested text for these items could be worded as in item (b).

4.2.2 Bellows Tests

A flexible connection will be permitted between the engine and the exhaust or intake flame arrester if required by the design of the machine. A dual bellows with engine coolant circulating in the annulus is the preferred arrangement. Single bellows may be permitted at the discretion of the certifying authority if an accelerated fatigue test demonstrates that the component has an adequate life, and a replacement schedule ensuring an adequate factor of safety is rigorously followed.

4.2.3 Exhaust System Cooling Capacity

Tests will be undertaken to determine directly by dynamometer tests or indirectly by engineering calculations, the capacity of the exhaust system to continuously cool the exhaust gases to

4.2.3 (continued)

$80^{\circ}C$ ($176^{\circ}F$) for a period of 8 hours at the load factor of 1/3 (see clause 3.3.6(b)(iv) and (v).

4.2.4 Safety Shutdown System Operation

The operation of all safety shutdown devices on a completed machine will be checked against the specified performance during factory or field inspection.

4.2.5 Braking Systems Tests

(a) Brake system tests which are developed by the SAE pertaining to underground rubber-tired, trackless, self-propelled vehicles will be adopted as part of this standard with modifications as required by the Certification Officer in order to adapt the provisions to Canadian mining conditions. Alternatively, the following tests shall be applied.

(b) Service Brake Test: The vehicle shall be driven at full throttle or at 4.5 m/s (10 mph) whichever is greater, on a dry level asphalt surface, having a road adhesion coefficient in excess of 0.6. The service brake will then be applied and the stopping distance measured. The stopping distance is defined as including the distance traversed at maximum velocity during the period of response from the start of brake actuation to the engagement of brake linings with the drive train components, plus the distance traversed during the period of deceleration to a complete stop. Both distances are defined by the following equation:

$$S = \frac{1.15\ u^2}{2g\left[\frac{F}{W} - \sin\Theta\right]} + u.t_r$$

where:

S is the stopping distance
u is the maximum initial velocity
F/W is the brake force to weight ratio (0.5 min)
Θ is the slope angle (0 for level)
t_r is the brake system response time

Note: See Table 10, p. 124 final report entitled "Brake Evaluations and Recommendations" by Skelly and Loy (USBM Contract J0166051 November 1977), for data on tire road surface coefficients.

4.2.5 (b) (continued)

Vehicles which fail to stop within 7 metres under these conditions will be considered to provide an inadequate brake force to gross vehicle weight ratio relative to that specified in clause 3.2.7(f) above (see calculations clause 5.6.1).

(c) Emergency Brake Test: The vehicle shall be driven at the same speed and on the same surface as that specified in clause 4.2.5(ii) above. The emergency brake will then be applied and the stopping distance measured as defined above. Vehicles which fail to stop within 8 metres under these conditions will be considered to provide an inadequate brake force to gross vehicle weight ratio relative to that specified in clause 3.2.7 (k) above (see calculations clause 5.6.2).

(d) Parking Brake Tests:

(i) The maximum parking brake actuation efforts will be measured and compared to those specified in clause 3.2.7(j) above.

(ii) The vehicle shall be parked on the same dry level asphalt surface (μ=0.6) as specified for the service and emergency brake tests in clauses 4.2.5(ii) and (iii) above. An axial load at wheel axle level, will be applied to the frame or other suitable point as agreed between the client and the Certification Officer. The magnitude of the load will be computed from the following equation:

$$T.L. = W \left[1.5 \sin\theta - f_r(1.5\cos\theta - 1) \right]$$

where T.L. is the applied axial test load

W is the gross vehicle weight

θ is the slope for which the machine is designed

f_r is the rolling resistance coefficient for the tire/road surface combination

Rotation of the wheels under this condition of load will be an indication of insufficient parking brake capacity (see calculations of clause 5.6.3).

4.2.6 Headlight Intensity Check

The headlight intensity will be assessed in accordance with the requirements of clause 3.2.1 above.

4.3 EXPLOSION-PROOF (FLAMEPROOF) TESTS - ENGINE SYSTEMS

4.3.1 Explosion and Hydrostatic Tests

(a) IEC draft document 31A (Central Office) 23 describes in detail both the flameproofness and overpressure tests for structural adequacy of explosion proof enclosures. Canada is incorporating this statement in CSA standard C22.2 No. 30. Therefore, explosion tests will be required in accordance with this document.

(b) Prior to pressure testing the equipment, drawings will be studied and the prototype examples inspected in order to see that construction, particularly the joints and gaps, conforms to the joint requirements defined above in clause 3.3.1.

(c) In brief, flameproof electrical/mechanical equipment will be subjected to the following pressure tests as applicable and in order:

(i) Leak Test: All intake and exhaust castings and weldments, including water scrubbers will be leak tested to 0.3 atmospheres pressure pneumatically or hydrostatically on a routine basis at the factory, in order to ensure leakproof and flameproof fabrication. This test requirement shall be noted on all appropriate assembly drawings and listed on the Factory Inspection Form as a routine inspection requirement.

(ii) Maximum Explosion Pressure Test: All prototype electrical enclosures, and prototypes of both the entire engine intake and exhaust systems, each will be explosion tested in a dry condition in the Certification Laboratory using 9.8%±0.5 methane in air mixtures, internally only, in order to determine the maximum explosion pressure generated in each system.

4.3.1 (c) (continued)

(iii) Routine Hydrostatic Test: All electrical enclosures and both of the entire engine intake and exhaust systems each will be hydro-statically overpressure tested to 1.5 times the maximum explosion pressure or a minimum of 3.5 atmospheres, whichever is greater, for a period of not less than 10 seconds and not more than one minute, in the case of routine testing at the factory, to ensure adequate structural strength of all components of the system before incorporation into a certified machine. This test requirement shall be noted on all appropriate assembly drawings and listed on the Factory Inspection Form as a routine inspection requirement. One example of each piece of equipment will be tested in the EMR Certification Laboratory initially.

(iv) Hydrostatic Type Test: Should the Applicant opt for type testing in lieu of routine testing, all prototype electrical enclosures, and prototypes of both the entire engine intake and exhaust systems, each will be hydrostatically overpressure tested to 2.0 times the maximum explosion pressure in the case of fabricated steel enclosures and 4.0 times the maximum explosion pressure in the case of cast enclosures, or a minimum of 3.5 atmospheres, whichever is greater. The pressure will be maintained for a period of not less than 10 seconds and not more than one minute. This type test will be performed at the EMR Certification Laboratory and will ensure components of the system without the necessity of testing each production item.

(v) Flameproof Test: All flameproof systems, excepting the engine, will each be tested for flameproofness at the Certification Laboratory using a mixture of 12.5% fuel gas in air both internally and externally to the system. The fuel gas will be composed of 42%±1 Hydrogen and 58%±1 Methane, in accordance with the above standard. If no transmissions

4.3.1 (c)(v) (continued)

to the external atmosphere occur with the inherent equipment gaps and clearances after a minimum of 5 such tests, the equipment will be considered flameproof. It should be noted that the fuel gas/air mixture employed results in a 42% flameproof factor of safety compared to methane/air mixtures.

(d) Deflections caused as a result of the applicable hydrostatic and the maximum explosion pressure tests will be measured. Small stress-relieving distortions in plates will be tolerated to the extent that safety, in the opinion of the Certification Officer, is not jeopardized.

(e) 'Dynamic' maximum explosion pressure and/or flameproof tests involving flowing gas/air mixtures produced by motoring the diesel engine without fuel injection and with the entire intake and exhaust systems in place, may be required at the discretion of the Certification Officer.

(f) Copies of the test results will be provided to the Applicant as part of the Certification documentation.

4.3.2 Impact Tests on Coated Light Alloy Parts

External parts made from coated light alloy materials shall be evaluated for frictional impact hazard on the basis of results obtained from drop tests and judgements made with respect to their intended application.

(a) Test Apparatus: The test apparatus shall be of the vertically dropped-weight design with a sample of the coated light alloy material securely attached to the bottom of the falling weight so as to strike a rusted inclined steel target plate when dropped from a predetermined height. Each test impact shall take place with an untested portion of the sample at a location on the plate not previously struck by the sample.

Alternative: - drop the rusted steel weight onto the coated sample to represent the case of fixed coated parts.

(i) The test apparatus shall be of enclosed construction so that the test gas concentration used is accurately maintained for the duration of the test.

4.3.2 (a) (continued)

(ii) The explosive atmosphere surrounding the target plate shall consist of 6.4 ± 0.2% methane in air by volume with relative humidity maintained at 50 ± 5%.

(iii) The angle of impact between falling weight and plate shall be 50°.

(b) Samples: The applicant shall provide sufficient test samples of size and shape as required by the certification authority. This shall include a data sheet stating chemical composition and Brinell hardness number of the alloy, and type and method of coating used by the manufacturer.

(c) Tests: Thirty drop tests shall be performed with an available impact energy of 30 kg - m (217 ft. lb.).

(d) Criteria: There shall be no ignitions of the explosive mixture during any of the tests performed.

4.3.3 Anti-Static Materials Tests

(a) Anti-Static Rubber V-Belt Test: The method of ISO standard 1813-1976(E) entitled "Anti-Static Endless V-Belts (sections Y,Z,A, B,C,D,E) - Electrical Conductivity - Characteristic and Method of Test" shall be used to "ensure that the belt is sufficiently conductive to dissipate charges of electricity which may form in it in service". This standard pertains to new belts intended to be used in an explosive atmosphere or in situations where there is a fire risk. These tests will be performed in the EMR Certification Laboratory if no adequately documented tests in accordance with the Standard have been previously performed. The number and selection of belts required for testing will be at the discretion of the Certification Officer. The test values of resistance thus determined must be less than the specified maxima as determined by the following relation:

$$R_{max} = 6 \times 10^5 \times \frac{L}{I} \text{ ohms}$$

4.3.3 (a) (continued)

where L is the distance between the inner edges of the two electrodes and where I is the sum of the heights of the two sidewalls of the belt.

(b) Anti-Static Plastic Engine Cooling Fans: CSA Standard C22.2 No. 145 clause 2.3.3 states - "External rotating parts of non-metallic material shall be investigated for the generation of electrostatic charges if the resistance between the extreme ends of the part exceeds 10 megohoms." The tip-to-tip and tip to hub resistances of the fan will be determined in the EMR Certification Laboratory. If the resistance exceeds 10 megohms the fan will not be acceptable.

4.4. FIRE PREVENTION TESTS

4.4.1 Fire Resistant Fluid Tests

(a) Samples: Five-litre samples of all hydraulic fluids used in the machine to be certified, will be submitted to the EMR Certification Laboratory for evaluation. Such samples shall be accompanied by the following information:

(i) identification number, mark and colour.

(ii) chemical composition including the percentage of each constituent by volume.

(iii) recommended operating temperature range.

(iv) density or specific gravity at 20°C.

(v) a graph of kinematic viscosity (centistokes) vs temperature (°C) for the temperature range 20°C to 150°C.

(b) Flammability, Stability and Toxicity Tests: All fluid samples shall be subjected to flammability, stability and toxicity tests as follows:

(i) Spray Ignition (Flammability) Test: All fluids shall be tested in accordance with the NCB Specification #570/1970 with the following exceptions:

(1) The spray nozzle shall be 80° hollow cone combustion type with a flow of 0.114 l/m (1.5 imperial gallons/hr) rated at 639 kPa (100 p.s.i.). The test pressure, however shall be 6,890 kPa (1000 p.s.i. - constant).

4.4.1 (a)(i) (continued)

(2) The continuous burning time after the removal of the ignition source located at 15 cms and 45 cms (6 in. and 18 in.) from the nozzle tip, shall not exceed five (5) seconds in any of the trials.

(3) The tests shall be performed in clear quiescent air while the products of combustion escape vertically above the nozzle point.

(ii) Wick (Flammability) Test: All fluids shall be tested in accordance with the N.C.B. Specification #570/1970 with the following exceptions:

(1) The wick shall be made of 1/16" thick woven asbestos cloth.

(2) The average of the continuous burning times recorded for each trial shall not exceed 45 (forty-five) seconds.

(iii) Freeze/Thaw Stability Test: This test is designed to demonstrate the stability of water-in-oil and oil-in-water emulsions in accordance with the N.C.B. Specification #570/1970, Appendices E & G.

(iv) Toxicity Tests: The fluids shall not burn or irritate the skin, nor shall semi-prolonged breathing of the vapors at normal ambient temperatures be toxic and injurious to health. Wherever possible the toxicity levels of all components of a fluid shall be compared to the Threshold Limit Values for chemical substances as published from time to time by the American Conference of Governmental and Industrial Hygienists. When this document is not definitive the acceptance criteria shall be at the discretion of the Certification Officer.

(c) Witness of Tests: Permission may be granted to the clients to witness testing of their products at the EMR Testing Laboratory provided sufficient advance notice is given.

(d) Tests by Other Laboratories: Suitable evidence of approval of fluids by other recognized authorities, shall be considered in lieu of EMR tests, at the discretion of the Certification Officer in accordance with Section 4.1.2 above.

4.4.1 (continued)

(e) Period of Certificate Validity: All approval certificates issued by the Certification Officer will be valid for a period of twelve months from the date of issue.
(f) Detailed test procedures and other relevant information will be supplied upon request.

4.4.2 Surface Temperature Checks

Tests will be carried out at various engine load/speed combinations with up to 1.25% methane-in-air mixture in the intake to determine the maximum external surface temperatures of the various vehicle components. The testing sequence will also ensure that the vehicle safety devices prevent excessive surface temperatures in the event of:
(a) Shortage of water in the cooling circuits;
(b) Pneumatic or hydraulic system malfunctions; and
(c) Any other malfunctions which could produce elevated external surface temperatures on one or more of the vehicle components.

4.4.3 Extinguisher System Checks

The Certification Officer will consider Manufacturer's documentation of automatic system performance in lieu of tests. Such documentation will indicate that nozzle discharge rate is adequate to suppress fire produced by maximum discharge of fire-prone material at each nozzle station.

4.4.4 Fire Resistant Materials Tests

(a) Conveyor Belt Tests: The conveyor belt tests and specifications are described in Certification Memorandum No. 2 entitled "Certification of Fire-Resistant Conveyor Belting for use in Mines".
(b) Hose Tests: The hose tests and specifications are identical to those described for conveyor belts, paragraphs 9 to 11 in Certification Memorandum No. 2 except for test purposes only 4 specimens each 6 inches long by ½ wide thickness of the hose are required.

4.4.4 (continued)

(c) Other Tests: Other fire-resistant materials, such as V-belts, will be tested in a manner similar to the tests described above.

(d) Replacement: Parts composed of fire-resistant materials must be replaced with parts manufactured to the same specification as those defined in the Schedule associated with the Certificate or Letter of Approval. Should exact duplication of parts not be possible, then approval for use of an alternative must be sought from the Certification Officer.

4.5 ELECTRICAL SYSTEMS TESTS

4.5.1 Flameproof Enclosures - Electrical Systems

All tests of flameproof electrical enclosures shall conform to the provisions of Section 6 - "Tests" of CSA Standard C22.2 No. 30 - 1970, entitled "Explosion-Proof Enclosures for use in Class I Hazardous Locations". This document describes:

(a) the maximum explosion pressure test
(b) overpressure tests
(c) temperature tests
(d) impact tests (including glass lenses) and,
(e) materials flammability tests

4.5.2 Intrinsic Safety Systems

All tests of intrinsically safe electrical systems shall conform to the provisions of Section 6 - "Tests" of CSA Standard C22.2 No. 157 (July 78 draft) "Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations."

4.5.3 Lighting System Lens Strength Test

See clause 4.5.1 item (d) above.

4.6 EMISSIONS SYSTEMS TESTS

4.6.1 Dynamometer Emissions Tests (see clauses 3.5 above)

Dynamometer tests on all systems which affect the levels of toxic emissions, will be performed in the dynamometer facility of the Canadian Explosive Atmospheres Laboratory. Such tests shall include, but not necessarily be limited to:

(a) confirmation of the maximum fuel rate setting

(b) fuel alteration system performance evaluation if applicable

(c) determination of untreated engine emissions

(d) exhaust treatment device(s) performance evaluation if applicable

(e) exhaust dilution system performance evaluation

Variations due to the addition of methane (CH_4) in the intake air will be determined for items (b)(c) and (d) above.

4.6.2 Caution Regarding Cost of Testing

The evaluation of emission systems may significantly increase the total cost of the vehicle certification investigation outlined in the schedule of fees (clause 2.5.2 above) for engine emissions tests only. The applicant will be informed of the anticipated extra cost of this evaluation in order to determine whether to proceed with the test work. Should the applicant elect not to proceed, the untreated engine emissions will be used for the assessed ventilation requirement unless there is reason to believe that the exhaust treatment system might adversely affect the engine emissions.

4.6.3 Confidential Nature of Emissions Test Results

The results of the above tests are classified "industrial confidential" and as such cannot be shared without the written permission of the manufacturer(s) of the equipment tested. This limitation does not restrict distribution to Canadian Federal and Provincial Government Mining Inspectorates, which institutions are likewise bound to honour the confidential classification of the test results.

4.6.4 Assessed Ventilation Requirement

(a) The results of tests at the engine operating conditions which produce the greatest toxicity hazard, and as specified in clause 4.6.1 above, will be employed in the following equation to assess the ventilation requirement for the exhaust leaving the last exhaust treatment device prior to exhaust dilution and emission into the environment (see Appendix 7 for an example ventilation calculation).

$$Q_{dva} = \frac{M_{dxg} \times \frac{HEI}{3} + \left[\frac{9H2\%}{100} - 1\right] M_f}{60\ \rho}\ m^3/min.$$

Where:

Qdva is the flow rate of dry ventilating air for the diesel machine in cubic metres per minute

HEI is the Health Effects Index defined by clause 3.4.4 above

M_{dxg} is the dry exhaust gas rate produced by combustion of the fuel in kg/hr.

M_f is the fuel consumption rate in Kg/hr.

ρ is the dry ventilating air density in kg/m^3

(b) The ventilation rate derived from 4.6.4 (a) above is a maximum, which will be reduced to better reflect in-service operating cycle conditions, by an appropriate factor in the following table:

Type of Rubber-Tired Trackless, Self-Propelled Vehicle	Ventilation Reduction Factor
(i) drilling machine	1.00
(ii) LHD vehicle	0.85
(iii) truck haulage (Between 0° and 5°)	0.50

4.6.5 Exhaust Dilution System

The exhaust dilution system performance will be assessed in accordance with the requirements of clause 3.5.5 above. The location of the point after exit from the dilution system at which the HEI $\leq$ 6 and each toxic constituent is equal to or less than twice the TLV (for NO -2 x 25 = 50 ppm), will be determined. This dilution distance relative to the location of the cab will be judged in order to establish the adequacy of the system from the point of view of operator exposure.

5.1 APPENDIX 1 FINANCIAL ADMINISTRATION ACT (CANADA)

5.1.1 1958 Version of the Act

The following was published March 12, 1958 in the Canada Gazette Part II, No. 5, Volume 92, page 72. The fees schedules are omitted.

FINANCIAL ADMINISTRATION ACT

Equipment Certification Fees Regulations

P.C. 1958-313

AT THE GOVERNMENT HOUSE AT OTTAWA

Tuesday, the 25th day of February, 1958

HIS EXCELLENCY THE GOVERNOR GENERAL IN COUNCIL

His Excellency the Governor General in Council, on the recommendation of the Minister of Mines and Technical Surveys, pursuant to section 18 of the Financial Administration Act, is pleased hereby to revoke Order in Council P.C. 1956-56 of 11th January, 1956[1] and to make the annexed Regulations Respecting Fees for Tests, Investigation and Certification of Equipment for the Underground Use in Mines or in Places where Explosive Dust or Gases may be Present in substitution therefor.

REGULATIONS RESPECTING FEES FOR TESTS, INVESTIGATION AND CERTIFICATION OF EQUIPMENT FOR UNDERGROUND USE IN MINES OR IN PLACES WHERE EXPLOSIVE DUST OR GASES MAY BE PRESENT

Short Title

1. These Regulations may be cited as the EQUIPMENT CERTIFICATION FEES REGULATIONS.

2. Every person for whom the services of testing, investigation and certification of flameproof or other electrical apparatus for underground use in any mine or in places where explosive dust or, gases may be present shall pay a fee determined in accordance with Schedule A.

3. Every person for whom the services of testing, investigation and certification of fire-resistant conveyor belting for underground use in any mine or in places where explosive dust or gases may be present shall pay a fee determined in accordance with Schedule B.

5.1.2 1971 Amendment to the Act Incorporating Diesel Machinery

The following amendment was enacted June 8, 1971 and numbered P.C. 1971-1069. The fee schedule is omitted.

HIS EXCELLENCY THE GOVERNOR GENERAL IN COUNCIL, on the recommendation of the Minister of Energy, Mines and Resources and the Treasury Board, pursuant to section 18 of the Financial Administration Act, is pleased hereby to amend the Equipment Certification Fees Regulations made by Order in Council P.C. 1958-313 of 25th Feburary, 1958, as amended, in accordance with the Schedule hereto.

(1). Sections 2 and 3 of the Equipment Certification Fees Regulations are revoked and the following substituted therefor:

"2. Every person for whom are provided the services of testing, investigation and certification of flameproof or other electrical apparatus for underground use in any mine or in places where explosive dust or gases may be present shall pay a fee determined in accordance with Schedule A.

3. Every person for whom are provided the services of testing, investigation and certification of fire-resistant conveyor belting for underground use in any mine or in places where explosive dust or gases may be present shall pay a fee determined in accordance with Schedule B.

4. Every person for whom are provided the services of testing, investigation and certification of diesel apparatus for underground use in any mine or in places where explosive dust or gases may be present shall pay a fee determined in accordance with Schedule C."

(2). The said Regulations are further amended by adding thereto the following Schedule: (fee schedule omitted).

5.2 APPENDIX 2 FASCIMILE OF APPLICATION FORM

LETTER OF APPLICATION FOR MINING MACHINE CERTIFICATION OR COMPONENT APPROVAL

Mr. John Bossert,
Federal Certification Officer (Canada),
CANMET, Mining Research Laboratories,
555 Booth Street, Ottawa
CANADA K1A 0G1

Dear Sir,

Enclosed you fill find a cheque for $300 made out in favour of the Receiver General of Canada in payment of the application fee for:

☐ certification of a complete mining machine, or

☐ approval of a component suitable for incorporation into a mining machine, designed for use in:

☐ a coal mine,

☐ a gassy non-coal mine or other confined gassy working area, or

☐ a non-gassy, non-coal mine or other confined working area.

It is understood that this fee is a non-refundable credit which will be deducted from the total of the fees assessed for the services performed during the course of the investigation.

The equipment to be investigated is defined by the following:

1. type of machine service ______________________
2. name of machine/component ______________________
3. manufactured by ______________________
4. machine/component model number ______________________
5. serial number of prototype to be investigated ______________________
6. engine model number (if applicable) ______________________
7. serial number of engine prototype to be investigated ______________________

The general specifications of the machine are provided as follows:

8. engine maximum rated power __________ (kw) @ __________ (rpm)
9. mode of engine cooling ______________________
10. fuel capacity ______________________ (litres)
11. exhaust coolant capacity (if applicable) ______________________ (litres)
12. type of transmission ______________________
13. fluid used in transmission (if applicable) ______________________
14. maximum vehicle speed on level ______________________ (km/hr)

15. maximum allowable operating grade (loaded)________________(%)
16. maximum vehicle speed on maximum grade (loaded)________________(m/s)
17. type of braking system: service________________
emergency________________
parking________________
other________________
18. fluid used in braking system________________
19. net vehicle weight________________(kg)
20. gross vehicle weight________________(kg)

Enclosed promotional literature which further defines the machine and its operation is listed as follows:

This model of machine or component has been the subject of prior investigations by applicant or other certification and/or testing establishments as follows:

□ the machine has been certified □ , or this component approved □ by ________________ and a copy of the document(s) is attached.

□ the item has been the subject of prior testing by________________ and a copy of the test results are attached.

□ the machine or component has not been the subject of prior certification, approval or testing.

This application is made by:

company: name ________________
address ________________
____
____
telephone number ________________
telex number ________________
liaison officer ________________

Yours very truly,

signature ________________

name ________________

position ________________

enclosures: promotional literature
prior investigation documentation
cheque in payment of application fee.

5.3 APPENDIX 3 FACSIMILE OF CERTIFICATE

THIS CERTIFIES THAT

MODEL 9 LHD DIESEL MACHINE

MANUFACTURED BY

ALPHA MINING MACHINERY COMPANY LIMITED

OF OMEGA, NEW BRUNSWICK

WITH ENCON ENGINE MODEL V-6/3

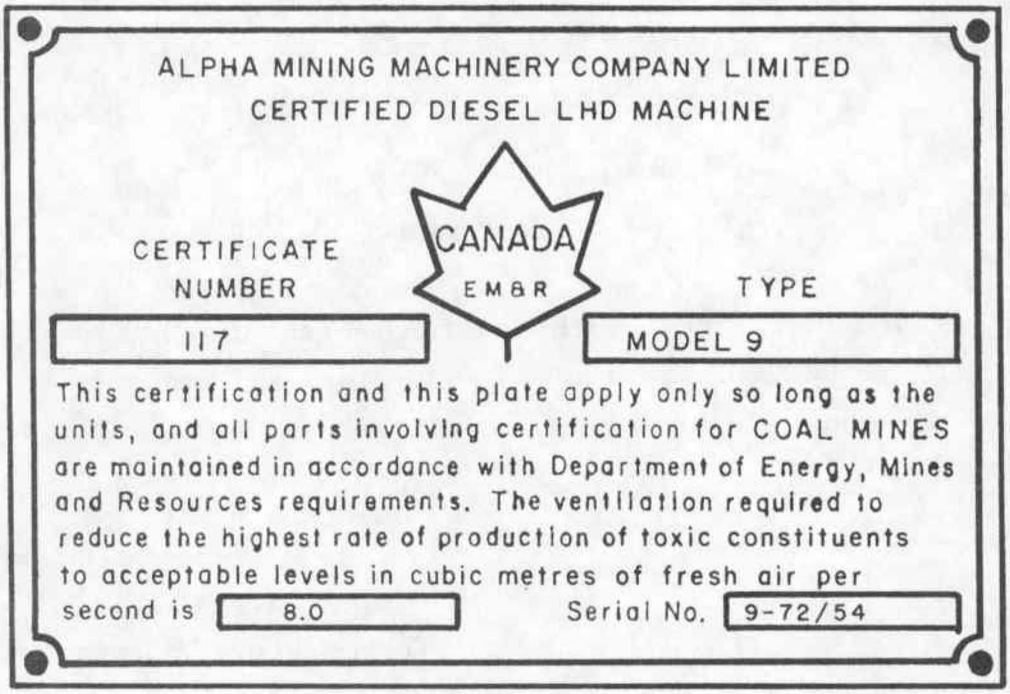
and designed in accordance with the attached Schedule, has been investigated by the Department of Energy, Mines and Resources and found to be suitable for use in coal mines.

John A. Bossert
Certification Officer

Certificate No. 117

Date: May 18, 1972

5.4 APPENDIX 4 FACSIMILE OF SAMPLE CERTIFICATION PLATE



5.5 APPENDIX 5 SUMMARY OF SAFE GAPS FROM IEC/CSA STANDARDS

The following are excerpts from CSA Standard C22.2 No. 30-1970:

B.4 Maximum Safe Gaps. In Tables 1, 4, 5, and 6 of these requirements, the gaps shown are taken directly from the latest (1966) data from IEC Technical Subcommittee 31A. These figures are based upon a factor of safety of 2 times (i.e. the shafts would have to wear the joint to twice the clearance dimensions shown to actually be in danger of causing an explosion). The figures in Tables 2 and 3 are also based upon IEC data, but the allowable joint gaps for the ¼, ½, and 1 inch widths are half of those shown by the IEC as the "Maximum Gap". The reason for this is that the larger IEC gaps, although safe, are considered to be too great for good machining practice on new equipment unless there is a valid reason for the larger clearances as in the case of power shafts. The gap dimensions from IEC are shown in Table B2. These dimensions may be used in evaluating the safety of explosion-proof (flame-proof) enclosures which have been in service for some time. Enclosures whose gaps exceed those shown in Table B2 should be taken out of service immediately and repaired or replaced.

TABLE B2

MAXIMUM GAPS FROM IEC TC31A*

Size of Enclosure†	Dimensions of Joint—millimeters (inches)‡		
		Maximum Gap	
	Minimum Width of Joint	Group II A (Class I, Group D)	Group II B (Class I Group C)
Up to and including 100 cm^3 (6 cubic inches)	6 (¼)	0.3 (0.012)	0.2 (0.008)
Above 100 cm^3 and up to and including 2,000 cm^3 (122 cubic inches)	12.5 (½)	0.3 (0.012)	0.2 (0.008)
Above 2,000 cm^3	12.5 (½) 25 (1)	0.2 (0.008) 0.4 (0.016)	0.15 (0.006) 0.2 (0.008)

**Draft IEC Document 31A (Central Office) 2, September 1965.*

†*The size of the enclosure shall be taken as the free internal volume (with the apparatus installed unless the enclosure is likely to be used without the apparatus).*

‡*Inch conversions shown in brackets are approximate.*

5.5 APPENDIX 5 (continued)

TABLE 3

JOINT WIDTHS AND GAPS FOR ENCLOSURES FOR CLASS I GROUP D HAZARDOUS LOCATIONS

Size of Enclosure*	Dimensions of Joint—Inches	
	Minimum Width of Joint	Maximum Gap
Up to and including 6 cubic inches	¼	0.006
Above 6 cubic inches and up to and including 366 cubic inches†	⅜	0.0015
Above 6 cubic inches and up to and including 122 cubic inches	½	0.006
Above 122 cubic inches	½ 1	0.004 0.008

**The size of the enclosure shall be taken as the free internal volume (with the apparatus installed unless the enclosure is likely to be used without the apparatus).*

†In order to qualify for this joint, the cover or removable part must have a thickness of at least ⅜ inch at the joint.

TABLE 6

JOINT WIDTHS AND GAPS FOR POWER SHAFTS FOR ENCLOSURES FOR CLASS I, GROUP D HAZARDOUS LOCATIONS

Size of Enclosure*	Dimensions of Joint—Inches		
	Minimum Width of Joint	Maximum Gap Sleeve Bearings	Maximum Gap Ball and Roller Bearings
Up to and including 6 cubic inches	¼ ½ 1 1½	0.012 0.014 0.016 0.020	0.018 0.020 0.024 0.030
Above 6 cubic inches up to and including 122 cubic inches	½ 1 1½	0.012 0.016 0.020	0.018 0.024 0.030
Above 122 cubic inches	½ 1 1½	0.008 0.016 0.020	0.012 0.024 0.030

**The size of the enclosure shall be taken as the free internal volume (with the apparatus installed unless the enclosure is likely to be used without the apparatus).*

5.5 APPENDIX 5 (continued)

TABLE 7

MINIMUM FLAME PATH AT BOLT HOLES

Required Minimum Width of Joint (W) Inch	Minimum Flame Path (w) Inch
¼	¼
⅜	5/16
½	5/16
⅝ or wider	⅜

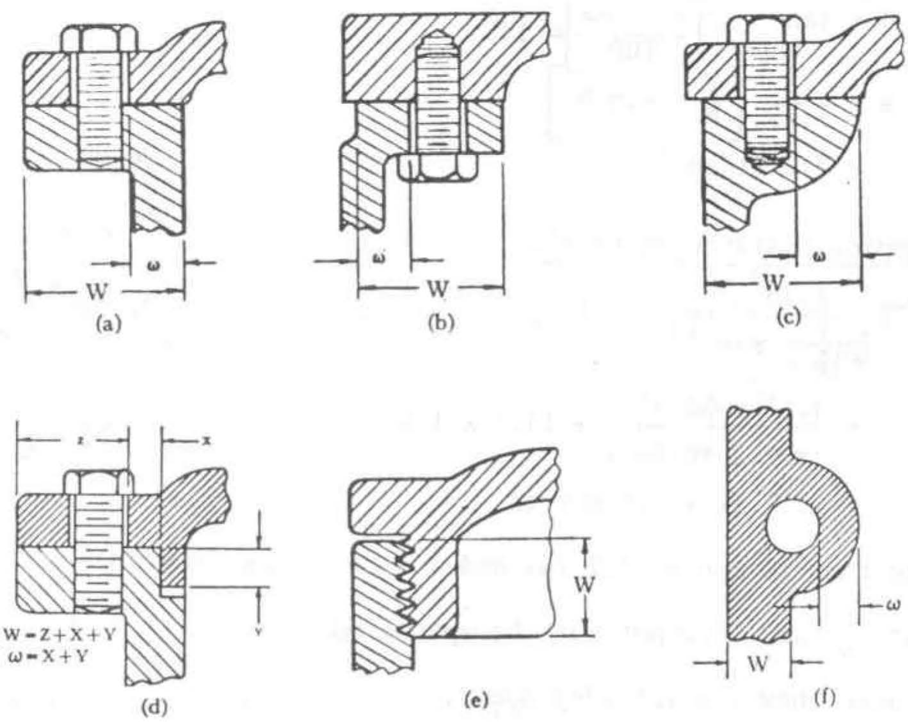


FIGURE 2

METHOD OF MEASURING WIDTH OF TYPICAL JOINTS

6.2.15 M R (66) 3 Fire-Resistant Fluids for Use in Machinery and Hydraulic Equipment (Safety Requirements and Physical Characteristics (6th)) Reference: 4.4.1(b)(2).

6.2.16 Certification Memorandum No. 7, 1969 (UK) Certification of Fire-Resistant Conveyor Belting for Use in Coal Mines. (Reference: 4.4.1)

5.5 APPENDIX 5 (continued)

TABLE 7

MINIMUM FLAME PATH AT BOLT HOLES

Required Minimum Width of Joint (W) Inch	Minimum Flame Path (w) Inch
¼	¼
⅜	5/16
½	5/16
⅝ or wider	⅜

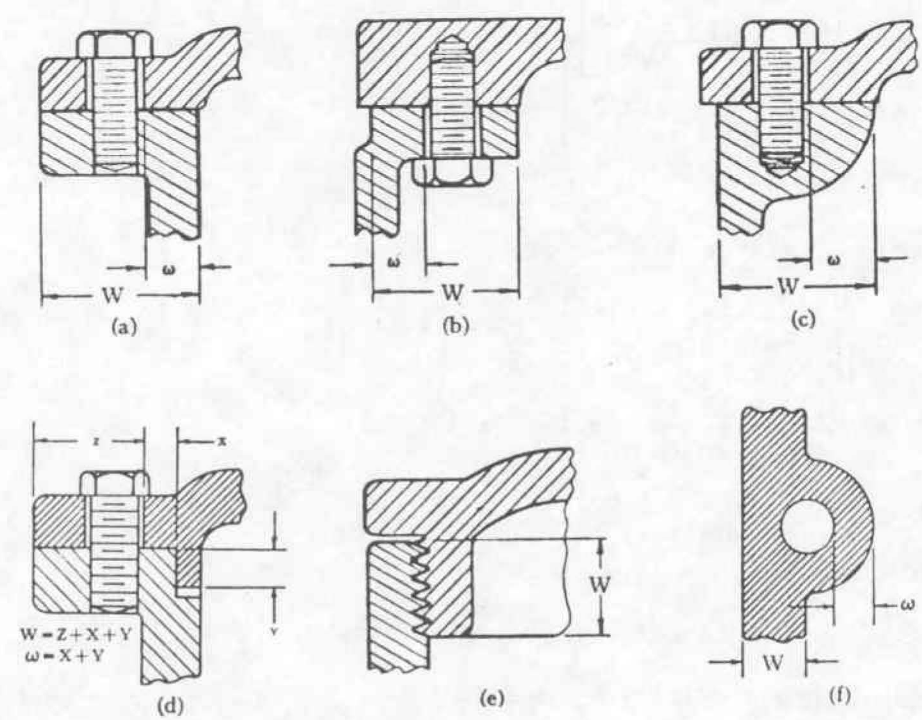


FIGURE 2

METHOD OF MEASURING WIDTH OF TYPICAL JOINTS

5.6 APPENDIX 6 BRAKE PERFORMANCE AND TEST CALCULATIONS
(for the meaning of the symbols refer to clause 4.2.5(b)).

5.6.1 Service Brake Calculations (refer to clause 3.2.7(f))

These calculations assume non-slide braking.

(a) Braking on Level:

$$\left[\frac{F}{W}\right] \text{service} = \frac{1.15a + g \sin \theta}{g} = 0.5 \text{ min. as required in clause 3.2.7(f)}$$

Therefore: $a = \frac{0.5g}{1.15} = 14 \text{ ft/sec}^2$

Note that this corresponds approximately to the projected SAE standard.

(b) Braking on 25% grade:

$$\theta = \tan^{-1}\left[\frac{\%\ \text{slope}}{100}\right] = 14^o$$

$$a = \frac{g}{1.15}\left[\frac{F}{W} - \sin \theta\right]$$

$$= 7.3 \text{ ft/sec}^2$$

(c) Stopping Distance on Level:

$$S = \frac{1.15\ u^2}{2g\left[\frac{F}{W} - \sin \theta\right]} + u.t_r$$

$$= \frac{1.15 \times 14.7^2}{2 \times 32.2\ (0.5-0)} + 14.7 \times 1.0$$

$$= 22.4 \text{ ft} = 6.8 \text{ metres}$$

Note that 10 mph = 14.7 fps and

that $\frac{F}{W}$ and S cannot both be specified

because they are interdependent.

5.6.2 Emergency Brake Calculations (refer to 3.2.7 (h))

(a) For an emergency brake deceleration rate of half that of the service brake on a 25% slope:

$$\left[\frac{F}{W}\right] \text{emergency} = \frac{1.15 \times 7.3 \times 0.5 + 32.2 \times 0.24}{32.2}$$

$$= 0.37$$

$$\frac{\text{emergency}}{\text{service}} = \frac{0.37}{0.50} = 0.75 \text{ as required in clause 3.2.7 (h).}$$

5.6.2 (continued)

(b) Emergency Brake Stopping Distance

$$S = \frac{1.15\ u^2}{2g\left[\frac{F}{W} - \sin\theta\right]} + u.t_r$$

$$= \frac{1.15 \times 14.7^2}{2g\ (0.75 \times 0.5 - 0)} + 14.7 \times 1.0$$

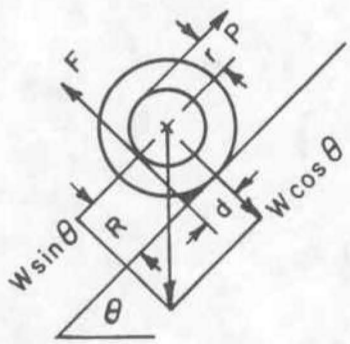
$$= 10.3 + 14.7$$

= 25 ft = 7.6 m < 8m required in clause 4.2.5(c).

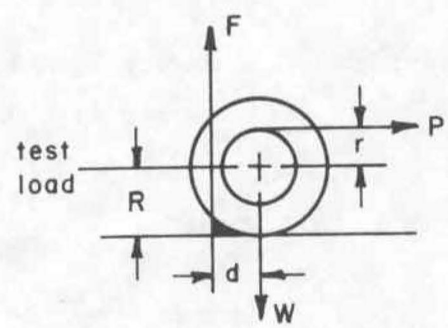
5.6.3 Parking Brake Calculations

(a) Derivation of Parking Brake Test Load Equation

Vehicle on Slope



Test on Level



brake torque at equilibrium on slope (es)

$$= (P \times r)_{es}$$

and the actual axial load for these conditions is

$$W \sin\theta = \frac{(P \times r)_{es} + f_r R\ W \cos\theta}{R}$$

For a brake torque increase of 50% applicable to the gradient for which the machine is designed, but evaluated on level ground, the actual test load at equilibrium is:

5.6.3 (continued)

$$T.L = \frac{1.5\ (P \times r)_{es} + f_r RW}{R}$$

$$= \frac{1.5\ (R\ W \sin\theta - f_r RW \cos\theta) + f_r RW}{R}$$

$$= W \left[1.5 \sin\theta - f_r\ (1.5 \cos\theta - 1) \right]$$ referred to in clause 4.2.5(d)

where:

- f_r is the rolling resistance coefficient (see USBM Conract report No. J0166051, page 105)
- P is the force at the brake drum
- r is the radius of the brake drum
- F is the rolling resistance force
- d is the rolling resistance radius
- R is the wheel radius
- W is the vehicle weight
- T.L. is the axial test load

(b) Test Load Calculation Example:

$$T.L = 66{,}000 \left[1.5 \sin 14 - 0.0292\ (1.5 \cos 14 - 1) \right]$$
$$= 23{,}074 \text{ lbs}$$

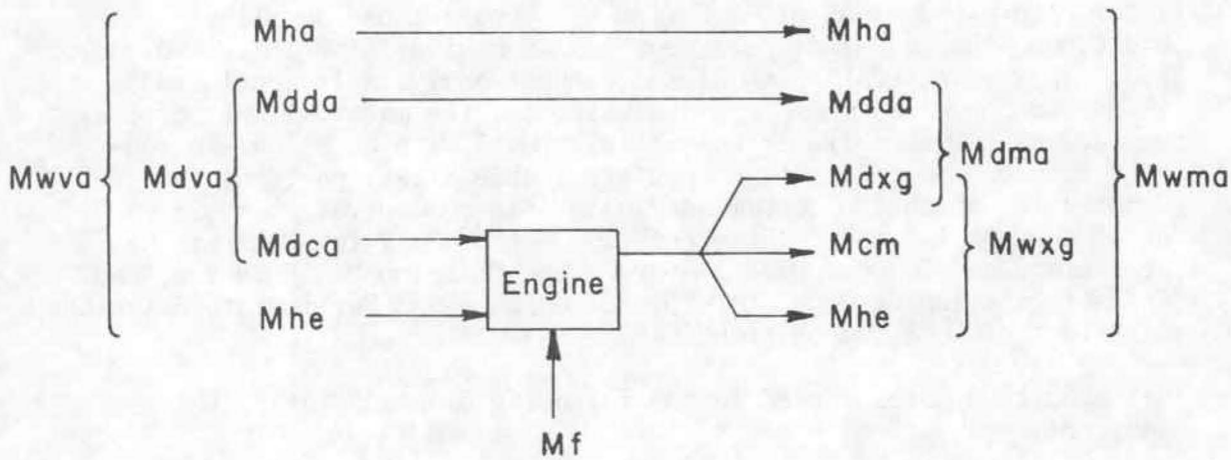
$W \sin\theta = 66{,}000 \sin 14 = 15{,}967$ lbs

μ asphalt required $= \frac{L}{W} = \frac{23{,}074}{66{,}000} = 0.35$ (OK)

5.7 APPENDIX 7 HEALTH EFFECTS INDEX (HEI) VENTILATION CALCULATION EXAMPLE

5.7.1 Derivation of the Basic Ventilation Equation

The symbols and units to be used are defined in the figure and table below:



dilution ratio	DR	--
concentration of gaseous constituents	(x)	ppm
concentration of respirable combustible dust	(RCD)	mg/m^3
humidity in ventilating air and mine atmosphere	Mha	kg/hr
humidity in combustion air	Mhe	kg/hr
dry mine atmosphere flow rate	Mdma	kg/hr
wet mine atmosphere flow rate	Mwma	kg/hr
dry exhaust gas flow rate	Mdxg	kg/hr
wet exhaust gas flow rate	Mwxg	kg/hr
Health Effects Index	HEI	--
dry combustion air flow rate	Mdca	kg/hr
fuel flow rate	Mf	kg/hr
combustion moisture production flow rate	Mcm	kg/hr
dry dilution air flow rate	Mdda	kg/hr
dry ventilation air flow rate	Mdva	kg/hr
humid (wet) ventilation air flow rate	Mwva	kg/hr
volumetric dry ventilation flow rate	Qdva	m^3/min
density of dry ventilation air	P	kg/m^3

5.7.1 (cont.d)

The Health Effects Index (HEI) is defined by the following equation:

$$HEI = \frac{(CO)}{50} + \frac{(NO)}{25} + \frac{(RCD)}{2} + 1.15\left[\frac{(SO_2)}{3} + \frac{(RCD)}{2}\right] + 1.2\left[\frac{(NO_2)}{3} + \frac{(RCD)}{2}\right]$$

the combined value of which should not exceed 3 in order not to pose a long-term health hazard.

Currently at CEAL, the undiluted diesel exhaust gas is collected via a center line probe, with the particulate captured on a glass fibre filter maintained at about $55^{o}C$ ($130^{o}F$). Under these sampling conditions, the actual diesel "soot" is augmented 10 to 15% by sulphuric acid. Therefore, CEAL's raw diesel exhaust analysis is considered similar to the mine atmosphere analysis, ie. the material collected is regarded as RCD (Respirable Combustible Dust) with an allowable concentration of 2 mg/m^3, rather than respirable diesel particulate ("soot") for which the recommended allowable concentration would be 75% of RCD, or 1.5 mg/m^3 (References: "Methodology for Determining Particulate and Gaseous Diesel Hydrocarbon Emissions" SAE 790422, and "Characterization of Heavy Duty Diesel Gaseous and Particulate Emissions and Effect of Fuel Composition" SAE790490).

This condition is expressed in the following dilution ratio (DR) equation:

$$DR = \frac{M_{dma}}{M_{dxg}} = \frac{HEI}{3}$$ which when rearranged, becomes

$$M_{dma} = M_{dxg} \times \frac{HEI}{3}$$ and

$$M_{dma} = M_{dda} + M_{dxg}$$ and

$$M_{dxg} = M_{dca} + M_f - M_{cm}$$ therefore

$$M_{dma} = M_{dda} + M_{dca} + M_f - M_{cm}$$

$$M_{dva} = M_{dda} + M_{dca}$$ therefore

$$M_{dva} + M_f - M_{cm} = M_{dxg} \times \frac{HEI}{3}$$ therefore

$$M_{dva} = M_{dxg} \times \frac{HEI}{3} - M_f + M_{cm}$$ but

$$M_{cm} = \frac{9H_2\%}{100} \times M_f$$ therefore

5.7.1 (continued)

$$M_{dva} = M_{dxg} \times \frac{HEI}{3} + \left[\frac{9H_2\%}{100} - 1\right] M_f \qquad \text{and}$$

$$Q_{dva} = \frac{M_{dva}}{60\ \rho} \qquad \text{therefore}$$

$$Q_{dva} = \frac{M_{dxg} \times \frac{HEI}{3} + \left[\frac{9H_2\%}{100} - 1\right] M_f}{60\ \rho}\ m^3/min., \qquad \text{or}$$

$$Q_{dva} = \frac{\left[M_{dca} + M_f - M_{cm}\right] \frac{HEI}{3} + \left[M_{cm} - M_f\right]}{60\ \rho}\ m^3/min.$$

5.7.2 Example Ventilation Calculation

The exhaust emissions analysis and performance data for a 6-cylinder V-type, air cooled, IDI engine operating at the condition for maximum toxicity of emissions from a ventilation air flow requirement point of view, are tabulated as follows:

(CO)	215 ppm	M_f	22.7 kg/hr	(50.1 lb/hr)
(NO)	641 ppm	M_{dca}	545.6 kg/hr	(1203 lb/hr)
(NO_2)	0 ppm	M_f/M_{dca}	0.0416	
(SO_2)	95 ppm	% H_2	13.47 in the fuel	
(RCD)	97.7 mg/m³	ρ	1.2 kg/km³ (0.075 lb/ft³)	

$$HEI = \frac{215}{50} + \frac{641}{25} + \frac{97.7}{2} + 1.5\left[\frac{95}{3} + \frac{97.7}{2}\right] = 199.7$$

$$M_{cm} = 9 \times \frac{13.47}{100} \times 22.7 = 27.5\ kg/hr\ (60.7\ lb/hr)$$

$$Q_{dva} = \frac{(545.6 + 22.7 - 27.5)\ \frac{199.7}{3} + (27.5 - 22.7)}{60 \times 1.2} = 500\ m^3/min.\ (17{,}657\ scfm)$$

Therefore, ventilation for LHD service is 0.85 x 500 = 420 m³/min, subject to the requirement that each individual constituent does not exceed its TLV as follows.

5.7.3 Individual Constituent Requirement

Note that in some cases, such as the use of low sulphur fuel and/or the use of an engine generating very little particulate matter, the ventilation requirement calculated by the HEI method above will not sufficiently dilute the exhaust such that each toxic constituent concentration will be less than the specified ACGIH-TLV. Therefore, additional ventilation must be supplied under such circumstances.

In the above example, the toxic constitutents are diluted by the HEI-calculated ventilation as follows:

$$DR = \frac{HEI}{3} = \frac{199.7}{3} = 66.6$$

$$CO \text{ in dry mine atmosphere} = \frac{215}{66.6} = 3.2 \leq 50$$

$$NO \text{ in dry mine atmosphere} = \frac{641}{66.6} = 9.6 \leq 25$$

$$SO_2 \text{ in dry mine atmosphere} = \frac{95}{66.6} = 1.4 \leq 5$$

$$RCD \text{ in dry mine atmosphere} = \frac{97.7}{66.6} = 1.5 \leq 2$$

Therefore, no additional ventilation than 420 m^3/min is required for individual constituents.

5.7.4 Effect of Residence Time on Nitrogen Dioxide Content

It has been established that even the low levels of nitric oxide (NO) in the diluted diesel exhaust oxidize to nitrogen dioxide (NO_2), and that the amount of conversion is predictable according to the following equation:

$$(NO_2) = \frac{2.28 \times 10^{-7} \times T \times (\text{NO initial})^2 \times (\%O_2)}{2.28 \times 10^{-7} \times T \times (\text{NO initial}) \times (\%O_2) + 1}$$

where: (NO_2) is the nitrogen dioxide produced in ppm at time "T"

(NO initial) is the nitric oxide concentration in ppm at start

T is the time in seconds

($\%O_2$) is the percent oxygen in the reacting atmosphere.

If workers are exposed to the diluted diesel exhaust some distance from the source, the dilution calculated from the raw exhaust would not be sufficient to ensure that the HEI does not exceed 3 at the downstream location because of the NO oxidation. Adding extra ventilating air would reduce (NO initial), however, so that the calculation of the actual amount of ventilation required becomes an iterative process.

5.7.4 (continued)

The impact of the factor may be illustrated from the example of 5.7.2 above for the case in which a worker is exposed to the diluted exhaust gas one half hour after it is emitted from the diesel.

The dilution ratio calculated for the raw exhaust in the example is 66.6

Therefore the (NO initial) $= \frac{641}{66.6} = 9.6$ ppm

and NO_2 after one half hour

$$= \frac{2.28 \times 10^{-7} \times 1800 \times 9.6^2 \times 21.0}{2.28 \times 10^{-7} \times 1800 \times 9.6 \times 21.0 + 1} = 0.74 \text{ ppm}$$

which is equivalent to 0.74 x 66.6 = 49.3 ppm in the undiluted exhaust.

Accordingly, the equivalent HEI:

$$= \frac{215}{50} + \frac{(641-49.3)}{25} + \frac{97.7}{2} + 1.5\left[\frac{95}{3} + \frac{97.7}{2}\right] + 1.2\left[\frac{49.3}{3} + \frac{97.7}{2}\right]$$

$$= 276.3$$

which would require a D.R. of $\frac{276.3}{3} = 92.1$

so that (NO initial) would then be $\frac{641}{92.1} = 7.0$

This in turn would yield a (NO_2) after one half hour of 0.40 ppm, which would be equivalent to 92.1 x 0.4 = 36.8 ppm in the undiluted exhaust.

The HEI could then be recalculated:

$$HEI = \frac{215}{50} + \frac{641 - 36.8}{25} + \frac{97.7}{2} + 1.5\left[\frac{95}{3} + \frac{97.7}{2}\right] + 1.2\left[\frac{36.8}{3} + \frac{97.7}{2}\right]$$

$$= 271.7$$

So that the new DR would be $\frac{271.7}{3} = 90.6$

(which is sufficiently close to the 1st iteration)

$$\text{and } Q_{dva} = \frac{(545.6 + 22.7 - 27.5)\ \frac{271.7}{3} + (27.5 - 22.7)}{60 \times 1.2}$$

$$= 680 \text{ m}^3/\text{min}$$

(24,025 scfm)

5.7.4 (continued)

compared to 500m^3 if no NO to NO_2 conversion is considered. This points out the advantage to be gained by the selection of a power plant which produces relatively low concentrations of NO and NO_2 in the raw exhaust, particularly in the case of mines with large stopes in which ventilation residence time is prolonged.

6.0 RELATED CODES AND REFERENCE STANDARDS

6.1 RELATED UNDERGROUND COAL MINING DIESEL CODES

6.1.1	MESA (USA) Part 36, 1975	"Mobile Diesel-Powered Transportation Equipment for Gassy Noncoal Mines and Tunnels."
6.1.2	TM 12 (UK) 1976	"Test and Approval of Diesel and Storage Battery Powered Locomotives and Trackless Vehicles and Diesel Powered Equipment for Use in Underground Mines."
6.1.3	Canadian Guidelines, 1977	"Canadian Provincial and Territorial Mines Inspection Authorities Proposed Guidelines for the Design, Construction and Testing of Mobile and Other Mining Equipment."
6.1.4	German NRW Regulations, 1976	"Requirements of the Chief Mines Inspectorate of Northrhine-Westphalia for the Design of Diesel-Engined Locomotives for Monorail Systems Haulage in Coal Mines Underground."
6.1.5	USBM Draft (USA) 1972	"Diesel Powered Equipment for Coal Mines and Gassy Metal and Nonmetallic Mines; Tests for Permissibility; Fees."
6.1.6	SABS 868 (South Africa) 1967	"Standard Specifications for Diesel Engines for Use in Fiery Mines."
6.1.7	Certification Memorandum No. 3, 1971 (Canada/EMR)	"Certification of Diesel Apparatus for Underground Use in Mines."

6.2 REFERENCE STANDARDS

6.2.1	SAE J 10406 Recommended Practice, 1977	"Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines." (Reference: 3.2.4(a))

6.2 (continued)

6.2.4	CSA C22.2 No. 157, July, 1978	"Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations." (References:3.3.2(c) & 4.5.2)
6.2.5	CSA C22.5, 1977	"Use of Electricity in Mines." (Reference: 3.3.2(b)).
6.2.6	CSA C22.1, 1978	"Safety Standards for Electrical Installations." (Reference: 3.3.2(c)).
6.2.7	CSA C22.1 No. 25	"Dust Tight Enclosures for Use in Class II Group E, F, and G Hazardous Locations." (Reference: 3.3.7)
6.2.8	ASTM D 975-74, 1974	"Standard Specifications for Diesel Fuel Oils." (Reference: 3.4)
6.2.9	ASTM D 1319-70, 1975	"Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Absorption." (Reference: 3.4)
6.2.10	ACGIH, 1977	"Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents with the Workroom Environment with Intended Changes for 1977." (Reference: 3.5.4(c)).
6.2.11	AECB, February, 1979	"Interim Respirable Silica Dust Exposure Standard."
6.2.12	SAE	Not as yet published relevant to underground vehicles.
6.2.13	ISO 1813, 1976	"Antistatic Endless V-Belts (Sections Y, Z, A, B, C, D, E) Electrical Conductivity-Characteristics and Method of Test." (Reference: 4.3.3(a)).
6.2.14	CSA C22.2 No. 145, 1972	"Motors and Generators for Use in Hazardous Locations Class I Groups C and D, Class II Groups E, F, and G." (Reference: 4.3.3(h)).

6.2.15	NCB (UK) 570/1970, 1970	"Fire Resistant Fluids for Use in Machinery and Hydraulic Equipment (Safety Requirements and Physical Characteristics Only)." (Reference: 4.4.1(b)(i)).
6.2.16	Certification Memorandum No. 2, 1969 (Canada/EMR)	"Certification of Fire-Restant Conveyor Belting for Use in Coal Mines." (Reference: 4.4.4)