

Approval Standard

Diesel Engine Fire Pump Drivers

Class Number 1333
December 2008

Approval Standard

for

Diesel Engine Fire Pump Drivers

Class Number 1333

December 2008

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Foreword

Approvals are intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for Approval shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing and/or applications shall ensure a consistently uniform and reliable product or service. Approval Standards strive to be performance-oriented and to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and Listing depends on compliance with the Master Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility or service/application.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states Approval criteria for diesel engines used to drive fire pumps that supply water to fire protection systems. These diesel engines must have an extended service life, throughout which they must be capable of operating reliably at rated power and speeds during emergency fire incidents, despite being idle for extended periods.
- 1.1.2 Approval criteria include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.
- 1.1.3 Approval standards are intended to verify that the product described shall meet stated conditions of performance, safety, and quality useful to the ends of property conservation.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for diesel engines used in fire pump service that are designed and installed in accordance with FM Global Property Loss Prevention Data Sheets.
- 1.2.2 This Standard does not address National or Local Codes which require specific emission levels to be met by stationary diesel engine installations.
- 1.2.3 Accessories such as a Variable Speed Pressure Limiting Control System may be examined within the scope of this Approval Standard.
- 1.2.4 This standard encompasses mechanical speed controller (governor style), in addition to electronic fuel management systems.
- 1.2.5 This standard encompasses diesel engines that are normally aspirated, turbocharged, twin turbocharged, and those fitted with aftercoolers.
- 1.2.6 This standard encompasses diesel engines with liquid cooling or open air cooling.
- 1.2.7 This standard encompasses diesel engines with operating speeds at or below 3600 rpm. Typical engine speeds are: 1000, 1200, 1450, 1800, 2100, 2400, 2600, 2800, 3000, and 3600 rpm.
- 1.2.8 Newly developed accessories will be examined on a case-by-case basis.

1.3 Basis for Requirements

- 1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.
- 1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of diesel engines for the purpose of obtaining Approval. Diesel engines having characteristics not anticipated by this standard may be FM Approved if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, diesel engines which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate:

- The suitability of the product;
- The performance of the product as specified by the manufacturer and required by FM Approvals; and,
- As far as practical, the durability and reliability of the product.

1.4.2 An initial facilities and procedures audit shall be conducted to evaluate the manufacturer's ability to consistently produce the product that was examined and tested as part of the Approval project. The audit shall review the facility and in-place quality control procedures used in the manufacturing of the product. Typically, areas of review are incoming inspection, work in progress, production testing, final quality control, marking, calibration of equipment, shipping procedures, and document and drawing control. These examinations are repeated periodically as part of the FM Approvals' product follow-up program. (Refer to Section 5.2, Facility and Procedures Audit.)

1.5 Basis for Continued Approval

Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Master Agreement;
- Satisfactory re-examination of production samples for continued conformity to requirements; and
- Satisfactory Facilities and Procedures Audits (F&PAs) conducted as part of the FM Approvals' product follow-up program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior written authorization by FM Approvals. (Refer to Section 5.1.3 for further details regarding changes.)

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or forfeit Approval.

The effective date of this standard is **December 31, 2009** for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with the Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing and Materials (ASTM) SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*.

1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard or are beneficial in understanding this standard:

ASTM D 975-2003, *Standard Specification for Diesel Fuel Oils*

FM Approvals, Approval Standard 1321/1323-2007, *Fire Pump Controllers for Electric Motor and Diesel Engine Drivers*

FM Global Property Loss Prevention Data Sheets

IEEE/ASTM SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*

National Fire Protection Association (NFPA) 20-2007, *Standard for the Installation of Stationary Pumps for Fire Protection*

NFPA 37-2006, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

Society of Automotive Engineers (SAE) Standard J20-2006, *Coolant System Hoses*

SAE Standard J537-2000, *Storage Batteries*

SAE Standard J1349-2004, *Engine Power Test Code – Spark Ignition and Compression Ignition – Net Power Rating*

SAE Standard J819-1987, *Engine Cooling System Field Test (Air-to-Boil) Standard*

1.9 Definitions

For purposes of this standard, the following terms apply:

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules. When the authority is FM Global, such locations are termed “FM Global Accepted.” Acceptance is based upon an overall evaluation of the installation. Factors other than the use of FM Approved equipment impact upon the decision to accept, or not to accept. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast this definition with FM Approved.)

Aftercooler

This is a type of heat exchanger. The spinning turbocharger heats the inlet air to the engine during the process of compressing it. This heated air then passes through one side of a heat exchanger. Cooling water or atmospheric cooling air passes through the other side of the heat exchanger, cooling the inlet air before it is pushed into the cylinder head. The large temperature reduction in the compressed inlet air, compared with a turbocharged only air supply, provides an increase in power output as a result of a more dense air charge in the cylinder.

Battery Contactor

For the purpose of this standard a battery contactor is an electrically actuated solenoid that provides a means to electrically connect the battery and the starter motor. The battery contactor carries full cranking current. The contactor should be manually operable and of the snap-action type.

Breakaway Current

The starter current required to initiate engine rotation during crank. (See rolling current).

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix B. Their use is mandatory on all units of FM Approved diesel engine fire pump drivers. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

Diesel Engine

An internal combustion engine in which the fuel is ignited entirely by the heat resulting from the compression of the air supplied for combustion. (See direct and indirect injection below.)

Direct Injection

A fuel system where fuel is injected directly into the cylinder where the complete combustion cycle takes place.

ECM

Electronic Control Modules (ECM) are electronic systems that manage engine performance. See Section 3 for complete requirements.

Fire Pump Controller

For the purpose of this Approval standard, a group of devices that serve to control, in some predetermined manner, the starting and stopping of the fire pump driver as well as monitoring and signaling the status and condition of the fire pump package.

Fire Pump Package

An assembled unit consists of a fire pump, driver, controller, and accessories.

Flexible Drive Coupling

A device used to connect the shafts or other torque-transmitting components from a driver to the pump. The device shall not rely on the elastomeric or polymeric element as a sole means of torque transmission without having metal-to-metal contact of components to drive the pump in case of elastomeric or polymeric element failure. The coupling assembly shall permit minor angular and parallel misalignment as restricted by both the pump and coupling manufacturers.

FM Approved

This term refers to products FM Approved by FM Approvals. Such products are listed in the Approval Guide, an online resource of FM Approvals. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. The Master Agreement obligates the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approval's discretion. It further requires the manufacturer not to deviate from the as-FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is product specific.

Full Load (Full Power)

The dynamometer load corresponding to the maximum sustainable power output, corrected for ambient air pressure and temperature, as determined in Section 3.2.1.

Grade Number 1-D Fuel

An ASTM designated grade of diesel fuel oil described as a special-purpose, light distillate fuel for automotive diesel engines in applications requiring higher volatility than that provided by Grade Number 2-D fuels.

Grade Number 2-D Fuel

An ASTM designated grade of diesel fuel oil described as a special-purpose, middle distillate fuel for automotive diesel engines, which is also suitable for use in non-automotive applications, especially in conditions of frequently varying speed and load.

Grade Number 4-D Fuel

An ASTM designated grade of diesel fuel oil described as a heavy distillate fuel, or a blend of distillate and residual oil, for low-and medium-speed diesel engines in non-automotive applications involving predominantly constant speed and load.

Hollow Shaft

This pertains to the hollow vertical drive shaft of electric motors or right angle gear drives used to drive vertical turbine pumps. The hollow drive shaft is designed to accept the solid line shaft of the pump. The design facilitates impeller adjustment within the bowl assembly and the installation of a non-reverse ratchet into the motor or gear drive.

Indirect Injection

A fuel system where fuel is injected into a combustion chamber sometimes referred to as a pre-combustion chamber that is remote from the cylinder and connected to the cylinder via a gas passage. The fuel is injected into the pre-combustion chamber where combustion begins, then passes through the gas passage to the cylinder where the combustion process is completed. Indirect Injection engines shall not be allowed for this service.

Line Shaft

A shaft which transmits the power from the driver to the pump shaft.

Liquid Cooled Engine

For the purposes of this standard, a liquid cooled engine shall be defined as any engine utilizing raw water to cool the primary coolant of the engine (oil or water). The engine is then cooled by circulation of the primary coolant.

Maximum Power

The greatest speed-corrected power required to drive the pump at rated speed and at any point along pump's characteristic curve, and through the pump's total run-out condition.

Mechanical Governor

A mechanical device which maintains a manually adjustable set point to obtain the operating speed of the engine.

Non-Reverse Ratchet

A mechanism installed as an integral part of the hollow shaft electric motor or hollow shaft right angle gear drive to prevent reverse rotation of the pump-driver assembly.

Radiator Cooled

For the purposes of this standard, a radiator cooled engine shall be defined as any engine utilizing air to cool the primary coolant of the engine (oil or water). The engine is then cooled by circulation of the primary coolant.

Raw Water Cooled

For the purposes of this standard, a raw water cooled engine shall be defined as any engine using raw water to cool the primary coolant of the engine (oil or water). The engine is then cooled by circulation of the primary coolant. (See liquid cooled engine.)

Rated Power

The power resulting from the calculation of full load power times a de-rating factor in order to account for reliability of performance and for normal deterioration of output over anticipated service life. This is discussed in detail in Section 3.2.2.

Rated Pressure

The pressure at which the sprinkler system is designed and installed. This is normally 175 psi (1205 kPa) unless specifically specified otherwise.

Rolling Current

The starter current that is required to maintain engine rotation during crank (see breakaway current).

Set Pressure

For Variable Speed Pressure Limiting Control (VSPLC) service, set pressure is the pressure at which the control circuit is factory set. At any sprinkler system pressure higher than this set point, the diesel engine shall start to slow from the factory preset rated speed.

System Pressure

The pressure that the fire pump and relief valve, in concert, maintain in the sprinkler system piping at any flow condition.

Variable Speed Pressure Limiting Control (VSPLC)

The VSPLC system is an accessory package which is manufacturer mounted and manufacturer set on a standard FM Approved diesel engine, and which shall initially operate only when a feedback signal indicates that pressure in the sprinkler system is greater than the set pressure of the pressure limiting device. The accessory package then acts to slow diesel engine speed, which thereby slows the fire pump, and as a consequence reduces pump discharge pressure. When the pump discharge pressure is at or less than the set pressure for which the accessory package is manufacturer preset, the accessory package disengages, and diesel engine speed control is returned to the engine speed controller. A data plate on the diesel engine shall indicate the lowest speed that the variable speed control system shall reduce engine speed to, and the set pressure for engagement of the accessory package.

2. GENERAL INFORMATION

2.1 Product Information

- 2.1.1 Diesel engine fire pump drivers are expected to perform reliably under normal application conditions for a minimum of 2,000 hours or five years without an overhaul, whichever comes first. Each engine shall provide its full rated power throughout its service life.
- 2.1.2 All FM Approved engines shall operate on diesel fuel meeting one of the grades as defined in ASTM Standard D 975, Grades 1-D, 2-D, or 4-D, or an internationally recognized equivalent. The engines shall be of the direct injection type. The use of glow plugs shall not be allowed. Spark ignited internal combustion engines shall not be allowed.
- 2.1.3 In order to meet the intent of this standard, diesel engine fire pump drivers must be examined on a model-by-model, type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample diesel engine fire pump drivers, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

- 2.2.1 To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to:

Group Manager - Hydraulics
FM Approvals
Member of the FM Global Group
743A Reynolds Road
West Glocester, RI 02814 USA

- 2.2.2 The manufacturer shall provide the following preliminary information with any request for Approval consideration:
- A complete list of all models, configurations [normally aspirated (NA), turbocharged (TC), twin turbocharged (TCAC), or twin turbocharged with aftercoolers (TCAC)], speed control systems (ECM or mechanical), cooling system, operating speeds, and voltage (12V or 24V) for the products or services being submitted for Approval consideration;
 - The number and location of manufacturing facilities.
- 2.2.3 All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All foreign language documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

Following set-up and authorization of an Approval examination, the manufacturer shall prepare samples for examination and testing. Sample requirements are to be determined by FM Approvals following review of the preliminary information. Sample requirements may vary depending on design features, results of prior testing, and results of the foregoing tests. It is the manufacturer's responsibility to submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. The manufacturer shall provide the test facilities, which are required to evaluate the diesel engine fire pump drivers.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

During the initial investigation and prior to physical testing, the manufacturer's specifications, technical data sheets, and design details shall be reviewed to assess the ease and practicality of installation and use. The product shall be capable of being used within the limits of the Approval investigation. These documents shall be controlled as outlined in the Manufacturer's Quality Assurance Plan.

3.2 Physical or Structural Features

- 3.2.1 Power outputs determined by testing, per Sections 4.7 (Full Power Test - Raw Water Cooling Only - Base Engine without VSPLC), 4.8 (Full Power Test - Radiator Cooling Only - Base Engine without VSPLC), 4.12 (Full Power - Other Speeds (Raw Water Cooling Only) - Base Engine without VSPLC) and 4.13 (Full Power - Other Speeds (Radiator Cooling Only) - Base Engine without VSPLC), shall be adjusted to standard conditions to compensate for changes in volumetric efficiency by use of the formula:

$$P_{sc} = P_t \times \left(\frac{29.61}{P_a} \right) \times \sqrt{\frac{(T + 460)}{77 + 460}}$$

$$P_{sc} = \frac{1.278 \times P_t \times \sqrt{(T + 460)}}{P_a}$$

Where:

- P_{sc} - Actual power at 300 feet above sea level, standard atmospheric conditions of 77°F and 29.61 inches of Mercury (Full Load Power)
- P_t - Power obtained in testing under atmospheric conditions of P_a and T
- P_a - Ambient pressure in inches of Mercury
- T - Air inlet or ambient air temperature in degrees Fahrenheit

The equivalent formula for International System units of measure is:

$$P_{sc} = P_t \times \left(\frac{100.3}{P_a} \right) \times \sqrt{\frac{(T + 273.2)}{25 + 273.2}}$$

$$P_{sc} = \frac{5.808 \times P_t \times \sqrt{(T + 273.2)}}{P_a}$$

Where:

- P_{sc} - Actual power at 91 m above sea level, standard atmospheric conditions of 25°C and 100.3 kPa (Full Load Power)
- P_t - Power obtained in testing under atmospheric conditions of P_a and T
- P_a - Ambient pressure in kPa
- T - Air inlet or ambient air temperature in degrees Celsius

These formulas are based on the ideal gas laws. (Reference SAE J1349).

- 3.2.2 The desired rated power output for each fire pump driver is increased by 10 percent to determine the actual power required in testing to justify that rating. The relations are:

$$P_{sc} = 1.1 \times \text{Rated Power or } \text{Rated Power} = P_{sc} / 1.1$$

This 10 percent power overrating is required to allow for reliability of performance and for normal deterioration of output over the anticipated service life.

- 3.2.3 Horsepower rating adjustments for installation conditions are made for increased elevation and increased operating temperature in accordance with NFPA 20-2007, Sections 11.2.2.4 and 11.2.2.5, plus Graphs A11.2.2.4 and A11.2.2.5.
- 3.2.4 The diesel engine fire pump drivers shall be arranged to allow power takeoff from a stub shaft or flange-mounted to the engine's rotating element. The power takeoff must be designed to allow the working space required to service a fire pump when a fire pump is connected directly to an engine. If a flexible drive coupling is used, it shall not have a center element that is elastomeric or polymeric without having metal-to-metal contact of components to drive the pump in case of center element failure. The coupling assembly shall permit minor angular and parallel misalignment as restricted by both the pump and coupling manufacturers.

3.3 Instrumentation and Controls

- 3.3.1 The following minimum instrumentation shall be installed in a panel and mounted on the engine by the manufacturer:
- A. A tachometer shall be provided to indicate engine speed. If the tachometer is not of the totalizing type, a separate hour meter shall be provided to indicate total time of operation.
 - B. An oil pressure gauge shall be provided to indicate engine lubricant pressure.