



Examination Standard for Diesel Engine Fire Pump Drivers

Class Number 1333

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Foreword

This standard is intended to verify that the products and services described will meet the stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states testing and certification 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.

1.2 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 local jurisdictional requirements.
- 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 (VSPLC) may be examined within the scope of this 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, 1760, 1800, 2100, 2350, 2400, 2600, 2800, 3000, and 3600 rpm.

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 certification. Diesel engines having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated.

1.4 Basis for Certification

Certification 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 performance of the product as specified by the manufacturer and required for certification ; and,
 - As far as practical, the durability and reliability of the product.
- 1.4.2 An examination of the manufacturing facilities and audit of quality control procedures may be made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 Basis for Continued Certification

The basis for continual certification may include, but is not limited to, the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the the certification agencies product surveillance follow-up program.

1.6 Effective Date

The effective date of this examination standard mandates that all products tested after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard for compliance will 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. 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, *American National Standard for Metric Practice*.

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM D 975, *Standard Specification for Diesel Fuel Oils*
CISPR 11, *Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment - Electromagnetic Disturbance Characteristics - Limits and Methods of Measurement, Amendment 1*
FM 1321/1323, *Fire Pump Controllers for Electric Motor and Diesel Engine Drivers*
IEEE/ASTM SI 10, *American National Standard for Metric Practice*
International Organization for Standardization (ISO) 15540 *Ships and Marine Technology - Fire Resistance of Hose Assemblies -Test Methods*
NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*
SAE Standard J20, *Coolant System Hoses*
SAE Standard J537, *Storage Batteries*
SAE Standard J1393, *Heavy Duty Vehicle Testing Code*

1.9 Definitions

For purposes of this standard, the following terms apply:

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. 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.

Agency

A certification agency or test agency.

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).

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.

Fire Pump Controller

For the purpose of this 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.

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 3.3.1.

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.

Gross Power

Full Power at the speed listed on the nameplate.

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.

Range Rated Engine

For the purposes of this standard, a range rated engine is one that is certified for a range of speed between two end points. It may be manufactured and sold with a label stating it is certified over a range of speeds, with the rated power determined by linear interpolation between the end points of the range. No hardware changes are allowed to change from one speed to another in the range. Governor adjustments are allowed, but not governor spring substitutions.

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.

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.)

Raw Water Supply Loop

For the purposes of this standard, the raw water supply loop shall be a supply piping system consisting of two parallel paths that are normal and emergency by-pass in nature. This loop shall control the pressure of the raw water taken from the pump discharge and supplied to the heat exchanger, charge air cooler, aftercooler, and/or other engine cooling devices

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.

Variable Speed Pressure Limiting Control (VSPLC)

The VSPLC system is an accessory package which is manufacturer mounted and manufacturer set on a 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.

Variable Speed Suction Limiting Control (VSSLC)

The VSSLC system is an accessory package which is manufacturer mounted and manufacturer set on a diesel engine, and which shall initially operate only when a feedback signal indicates that suction pressure in the sprinkler system is less 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 increases pump suction pressure. When the pump suction pressure is at or more 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 certified 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. Sample diesel engine fire pump drivers, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Certification Application Requirements

The manufacturer shall provide the following preliminary information with any request for examination and/or certification 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 certification consideration;
- The number and location of manufacturing facilities.
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

Following set-up and authorization of an examination, the manufacturer shall prepare samples for examination and testing. Sample requirements are to be determined by the agency 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. 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 agency examination results may further define the limits of the final certification.

3.2 Components

Whenever certified components (contactors, valves, etc.) are available, these shall be used. Non-certified components must be successfully tested in accordance with their appropriate relevant standard prior to authorization of their inclusion on an engine submitted for examination, where the requirements of that standard are more extensive than the requirements of this standard.

3.3 Physical or Structural Features

- 3.3.1 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:

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

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:

$$P_{sc} = P_t \times \left(\frac{100.3}{P_a} \right) \times \sqrt{\frac{(T + 273.2)}{25 + 273.2}} \qquad P_{sc} = \frac{5.808 \times P_t \times \sqrt{(T + 273.2)}}{P_a}$$

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.

- 3.3.2 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.

- 3.3.3 Horsepower rating adjustments for installation conditions are made for increased elevation and increased operating temperature in accordance with NFPA 20, Sections 11.2.2.4, 11.2.2.5 and A11.2.2.4.

- 3.3.4 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.

3.4 Instrumentation and Controls

- 3.4.1 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. The tachometer shall read 0 rpm when the engine is not running (or have no reading if the tachometer is digital), with engine battery power supplied to the tachometer. 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.
 - C. Liquid-cooled and radiator cooled engines shall be equipped with a temperature gauge to monitor the primary coolant loop temperature. Air-cooled engines shall also be equipped with a temperature gauge to monitor either the lubricant temperature or the engine's external surface temperature in the area nearest the point of combustion.
 - D. When electrical starting is used, a gauge shall be provided to indicate either charging system current direction and magnitude (an ammeter) or state of charge of each battery (a voltmeter). If pneumatic starting is used, this instrument shall be replaced by a pressure gauge on the air reservoir.
 - E. Unless locally mounted elsewhere on the engine (e.g. ECM), all required control devices, starting and shut-down switches, and indicator lamps shall be mounted in an engine instrument panel. Any locally mounted devices must be securely fastened to the engine, readily accessible, and wired to the instrument panel. The instrument panel shall not be used as a junction box or conduit for any wiring that is not part of the fire pump package (e.g. AC wiring, louver wiring, pump room heating power or controls, etc). The instrument panel shall be securely mounted to the engine by the manufacturer in a location that does not subject operating personnel to unreasonable hazard from hot surfaces or moving parts of the engine, pump, belt drives, or power transmission equipment. Mounting shall be such as to protect the instrumentation from the effects of vibration, heat, or mechanical damage.
 - F. The engine instrument panel shall be, as a minimum, a NEMA Type 2 dripproof enclosure or an enclosure with an ingress protection (IP) rating of IP 31.
 - G. The engine wiring outside the instrument panel shall be harnessed, attached, protected and/or enclosed to minimize mechanical, thermal, or engine fluid damage. The use of protective coverings or cable trays is required to satisfy this requirement. Tensions in individual wires shall be eliminated. The wiring shall be connected to terminals in the instrument panel that correspond to the standard scheme shown in Figure A-1. All wiring and circuits providing signals to the controller shall be rated for 10 amps (minimum). All electrical connectors at the terminations of the engine harness at engine mounted equipment shall have positive locking mechanisms or screw terminals. (Plug connectors must be locking plugs).
- 3.4.2 Each engine shall be equipped with an adjustable speed controller to maintain the engine speed within plus or minus 10 percent of each speed. The speed controller shall be pre-set by the manufacturer to provide the required regulation at the speed for which the particular engine is ordered. Hybrid mechanical/electrical fuel control systems such as an electrically actuated piston for fine speed control are allowed, provided the engine is able to maintain speed within a range of 10 percent between shutoff and maximum load if any component in the hybrid system fails. VSPLC and VSSLC systems with actuated pistons are allowed as discussed in 3.12 and 3.13.

- 3.4.3 An overspeed shutdown switch shall be provided to shut down a diesel engine which attempts to exceed 110-120 percent of its nominal manufacturer pre-set rated speed as recommended by the engine manufacturer. The switch shall require manual resetting prior to restarting the diesel engine. An indication of overspeed shutdown shall be provided on the engine panel, and an overspeed signal of battery positive type shall be provided to the controller on terminal 3. When the engine is to be installed in a location where the locally applicable codes and standards allows or requires the engine to continue to run in an overspeed condition it shall be acceptable to disable the overspeed shutdown and only have the overspeed alarm.
- 3.4.4 Air shut-off valves installed in the air intake path shall be allowed. They shall fail in the open position and the resistance to air flow of the open valve shall be considered when the manufacturer states the maximum allowable air restriction in the Operations and Maintenance Manual. Air shut-off valves (when present) shall close when the overspeed alarm is active and automatically open when the overspeed alarm is not active.
- 3.4.5 A means for verifying the overspeed switch and circuitry shutdown function (without actually running the engine to an overspeed condition) shall be provided.
- 3.4.6 A cooling system high temperature switch or sensor shall be provided to monitor one of the temperatures specified in Section 3.4.1 C. The high temperature alarm shall activate at a temperature level indicating inadequate engine cooling. A high temperature alarm signal of battery negative type shall be provided to the fire pump controller on terminal 5.
- 3.4.7 A low engine temperature switch or sensor shall be provided to monitor one of the temperatures specified in Section 3.4.1 C, in order to detect a failure in the engine heater. A low engine temperature alarm signal of battery negative type shall be provided to the fire pump controller on terminal 312. The switch shall activate at a level chosen by the manufacturer, but not lower than 90 F (32 C).
- 3.4.8 A lubricant low pressure switch or sensor shall be provided and arranged to close at a lubricant pressure level that indicates inadequate engine lubrication. A low lubricant pressure alarm signal of battery negative type shall be provided to the fire pump controller on terminal 4.
- 3.4.9 The engine panel circuitry shall include a means for the fire pump controller to test the position of the low lubricant pressure switch contacts.
- 3.4.10 An adjustable manual throttle shall be provided. Increase and decrease buttons and an electronic speed control are acceptable. It shall be designed to provide positive locking for any setting, such that tools are required either for access to the adjustment or to actually make the speed adjustment. If an electronic speed switch is supplied, it shall be mounted inside the instrument panel. Other tamper-resistant measures can be considered if they provide equivalent security against accidental or unauthorized re-adjustment of the speed setting.
- 3.4.11 All critical controls and set points shall be within the lockable engine panel (or shall employ a tamper resistant measure) including:
- A. The set point of the overspeed switch
 - B. any VSPLC or VSSLC set points.
- 3.4.12 If the panel includes a touch pad or keypad to change any engine parameters it shall either be inside the lockable panel or require a password to access set points.
- 3.4.13 Engines shall be supplied with a speed-sensitive switch to signal when the engine is running, for the purposes of crank termination.
- 3.4.14 The control circuits of the engine and the controller shall operate on either 12 Volt D.C. or 24 Volt D.C. The engine is not required to be capable of switching between 12 and 24 Volt power supply.
- 3.4.15 Electronic fuel management controls are permitted. They must have dual electronic control modules (ECM) which control the fuel injection process. Both the primary and alternate ECM devices shall be hard mounted, programmed and wired so that full engine power shall still be available in the event of failure of the primary

ECM. The engine, including the primary ECM, shall not continuously draw current in excess of 0.5 amps during stand-by.

- 3.4.16 Engine control systems that include timer relays for shutdown or allow a shutdown sequence that includes a run period at reduced speed or other provisions to reduce engine stress are permitted provided the engine immediately returns to full speed and power if a start signal is received during this sequence.
- 3.4.17 Engine control panels that include one or more microprocessors shall not produce electromagnetic emissions that could interfere with nearby equipment. This requirement does not apply to the primary or alternate ECM.
- 3.4.18 Engine control panels that include one or more microprocessors shall be capable of starting (manually) if any one of the microprocessors is not functioning.

3.5 Starting System

- 3.5.1 Engines that have an electrical starting system shall have the capacity to provide a minimum six minute (15 seconds continuous cranking followed by 15 seconds of rest, repeated 12 times) cycle at full rated cranking speed at 40 F (4.5 C) ambient temperature. Termination of cranking, when initiated by an automatic controller, shall be controlled by a crank-speed monitoring device or other means of affording equivalent reliability of start monitoring. The starting system shall be compatible with certified automatic controllers, see Figure A-1, and shall also allow manual emergency starting in the event of controller failure.
- 3.5.2 The manufacturer shall specify the capacities of all auxiliary equipment required for starting, even when such equipment is to be provided by others. This auxiliary equipment includes storage batteries, air reservoirs, connecting cables, piping, etc. When storage batteries are required for starting, two identical batteries shall be specified, each capable of independently providing 6 of the 12 cranking cycles discussed in Section 3.5.1. Batteries shall, at a minimum, be rated for 900 cold cranking amps at 0 F (-18 C) and shall have a reserve capacity of at least 430 min. when evaluated in accordance with SAE Standard J537. Batteries shall be sized considering the maximum parasitic loads allowed by NFPA20 for the engine, controller, and other pump room equipment. Other starting methods shall provide equivalent redundancy of starting energy storage.
- 3.5.3 Electrical automatic controllers provide alternate starts on alternate batteries, so a design using battery starting shall include all necessary contactors and wiring. Alternatively, the monitoring system shall note the level of charge on both batteries, and select the battery with the highest level of charge remaining.
- 3.5.4 Pneumatic starting systems shall include all necessary solenoid valves and other interfacing devices for connection to an automatic controller. The system shall have an air capacity to permit 180 seconds of continuous cranking without recharging. Suitable supervisory service shall indicate high and low air pressure conditions.
- 3.5.5 In addition to responding to signals from a controller, all devices required for emergency starting using either battery shall also be operable by direct manual means. The engine fuel and cooling water supply valves shall be manually operable, or manual by-pass valves shall be installed. All manual starting devices shall be labeled as specified in Section 3.17, (Markings).
- 3.5.6 Engines with one cranking motor shall include a main battery contactor installed between each battery bank and the cranking motor for isolation.
 - A. Main battery contactors shall be designed for fire protection pump driver service and be tested as discussed in Section 4.24, (Battery Contactors). Battery contactors will carry the full cranking current of the engine and must be sized accordingly. The rolling current of the engine shall be below the rated rolling current of the battery contactor.
 - B. Main battery contactors shall be capable of manual mechanical operation using positive methods such as spring-loaded, over-center operation to energize the engine in the event of control circuit failure.
- 3.5.7 Engines with two cranking motors shall have one cranking motor dedicated to each battery bank.

- A. Each cranking motor shall have an integral solenoid relay to be operated by the controller. The cranking motor shall be energized by a cranking motor solenoid relay or other circuitry in the engine panel. This relay will not carry full cranking current of the engine and is not subject to the requirements of the battery contactor.
 - B. Each cranking motor integral solenoid relay shall be capable of being energized from a manual operator on the engine panel.
- 3.5.8 Hydraulic starting systems shall provide not fewer than six cranking cycles such that during each cycle the engine shall carry its full rated load within 20 seconds after cranking is initiated, with air intake, room ambient air temperature, and the hydraulic cranking system all at 32 F (0 C). Suitable electrical supervisory service shall monitor and provide the stored hydraulic pressure within the predetermined pressure limits.
- 3.5.9 Energize to Stop engines shall include control circuitry that accepts either a continuous or a short duration (approximately 5 seconds) signal from the fire pump controller on terminal 12 to stop the engine. The engine circuitry shall include a timer to release the fuel solenoid after the engine stops.
- 3.5.10 The engine panel shall be capable of starting the engine either if the fire pump controller provides simultaneous signals on terminal 1 and 9 (or 10) or if there is a short delay between the fire pump controller providing a signal on terminal 1 and then on terminal 9 (or 10).
- 3.5.11 The engine panel circuitry shall include a direct path from terminals 9 and 10 to the battery contactor, without any relays. This will allow the fire pump controller to monitor the electrical resistance of the battery contactor coil in order to detect a failed contactor. If the engine is equipped with dual starters and start solenoids in place of a single starter and battery contactors, the direct path shall be to the start solenoid's coil.

3.6 Charging System

All starting systems shall be rechargeable by both engine-driven and auxiliary devices. The systems shall be arranged so that the fire pump controller maintains fully charged starting energy reservoirs by means of the auxiliary recharging device.

3.7 Cooling System

The cooling system shall automatically maintain the engine within its desirable range of operating temperatures. The manufacturer shall state the desired normal operating temperature range of the engine in the operation manual.

3.7.1 Liquid Cooling

- A. Liquid cooling systems shall have a closed primary loop. The heat from the primary loop shall be dissipated directly to a secondary, open, raw water cooling circuit. Liquid cooling systems shall be equipped with a raw water supply loop for control of raw water flow to all cooling devices. This entire loop shall be provided by the engine manufacturer as part of the engine and included in the examination. Thermostats are permitted in the closed loop. Thermostats shall be readily replaceable. Liquid cooling systems shall be provided with an opening in the primary loop for replenishing coolant or checking the liquid level. An expansion reservoir shall also be provided to eliminate loss of coolant due to thermal expansion and contraction when the system has been properly filled. All liquid-cooled engines shall be equipped with a jacket water heater capable of maintaining the primary coolant temperature at 120 F (49 C). Elastomeric hose that meets or exceeds the requirements of SAE Standard J20, Class R1, *Coolant System Hoses* shall be used. If water filled, the engine manufacturer shall define the type and amount of anti-freeze and/or additives to be mixed with primary coolant water for the best protection and the suggested interval for replacement.
- B. When a vee belt is used to drive the coolant circulating pump, the pump drive shall include two or more belts, or two or more vees on a single belt. Belt(s) shall be suitably guarded to protect operating personnel from injury.