FM Approvals

CLASS NUMBER 1313

Examination Standard for Positive Displacement Fire Pumps

(Rotary Gear Type)

August 2023

Foreword

This standard is 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 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.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 PURPOSE

1.1.1 This standard states testing and certification requirements for rotary gear type, positive displacement fire pumps that supply water and/or foam concentrates to water mist or foam fire protection systems. These pumps must be available for many years to operate reliably at rated capacities and pressures during emergency fire incidents, despite being idle for extended periods.

1.1.2 Testing and certification criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance audit program.

1.2 SCOPE

1.2.1 This standard encompasses the design and performance requirements for rotary gear type, positive displacement fire pumps for use in fire protection systems. Certification is limited to such pumps which have a rated pressure of a minimum of 40 psi (2.75 bar). In cases where metric size pumps are to be examined for certification, test criteria comparable to the United States equivalent size shall be used.

1.2.2 Requirements for other types of fire pumps are detailed in the following examination standards:

Class	Type
1310	Multi-Stage, Multi-Outlet Type
1312	Vertical Shaft Centrifugal Turbine Type
1319	Horizontal End-Suction Centrifugal Type
1370	Vertical Turbine Barrel Centrifugal Type
1371	In-Line Centrifugal Type

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 rotary gear type, positive displacement fire pumps for the purpose of obtaining certification.

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 suitability of the product;
- the performance of the product as specified by the manufacturer and required by the certification agency; 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 shall be made to evaluate the manufacturer's ability to produce the product which was 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;
- compliance with the terms stipulated in the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agency's surveillance program.

1.6 EFFECTIVE DATE

The effective date of this examination standard mandates that all products tested for certification 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 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. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

Two units of measurement (liter and bar), outside of but recognized by SI, are commonly used in international fire protection and are used in this standard.

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 dated references, only the cited edition applies.

ANSI/IEEE/ASTM SI 10-2016, *American National Standard for Metric Practice*

FM 1359, *Trim Water Pressure Relief Valves, 1/4 through 2-1/2 in. Nominal Size*

FM 5560, *Water Mist Systems*

IEC 60034-1, *Rotating electrical machines - Part 1: Rating and performance*

NEMA MG 1, *Motors and Generators*

1.9 TERMS AND DEFINITIONS

For purposes of this standard, the following terms apply:

Accepted

Installations acceptable to the authority having jurisdiction and enforcing the applicable installation rules. Acceptance is not a characteristic of a product. A product accepted for one installation may not be acceptable elsewhere.

Corrosion Resistant

Having resistance to corrosion equal to or exceeding that of bronze alloy having a minimum copper content of 80 percent or be of Series 300 Stainless Steel construction. More specific corrosion resistance may be specified by referencing another material as the minimum corrosion benchmark.

Design Working Pressure

The maximum pressure for which a pump component is designed. This pressure is equal to or greater than the maximum pressure developed by the pump at maximum speed, prior to relief valve opening, plus the maximum suction pressure for the pump.

Efficiency

The ratio of the energy delivered by the pump to the energy supplied to the pump shaft (liquid power divided by applied power).

Fire Pump Alternate Manufacturing Location

A location that manufactures a complete pump to the design requirements of the Fire Pump Manufacturer (OEM) or modifies (i.e. trimming of a pump impeller) an OEM supplied (bare-shafted) fire pump.

The Fire Pump Alternate Manufacturing Location may be an alternate facility owned and operated by the OEM or a facility owned by others that performs the complete, or partial, manufacturing of the complete fire pump and/or package under direct control of the OEM.

Fire Pump Manufacturer

The manufacturer of the certified fire pump, is also referred to as the Original Equipment Manufacturer (OEM) of the fire pump.

Fire Pump Package

An assembled fire pump, driver, controller and components, see Appendix D, necessary to provide a complete pump installation.

Fire Pump Packager

The Fire Pump Manufacturer can delegate, through a legal agreement, the function of assembling the fire pump package to a third party known as the fire pump packager. Alternatively, or in addition to, a Fire Pump Packager may package or just distribute complete private labeled fire pump packages.

The Fire Pump Packager may be a facility owned and operated by the Fire Pump Manufacturer or a facility owned by others that performs the assembly of the complete fire pump package under direct control of the OEM.

Fire Pump Private Labeler

A company, other than the Fire Pump Manufacturer (OEM), that has a legal agreement with the OEM whereby the pump is manufactured and labeled by the OEM in the name of the Private Labeler.

To enter into a Fire Pump Private Label agreement, a Fire Pump Private Labeler must be one of the following entities:

- Fire Pump Manufacturer
- Fire Pump Alternate Manufacturer
- Fire Pump Packager

Maximum Power

The greatest speed-corrected power required to drive the pump at rated speed and at maximum flow.

Net Positive Inlet Pressure Available (NPIPA)	The total of the inlet and barometric pressure minus the vapor pressure of the liquid at the inlet temperature. This value must be equal to or greater than the net positive inlet pressure required (NPIPR) as established by the pump manufacturer for the speed, pressure and fluid characteristics which exist.
Net Positive Inlet Pressure Required (NPIPR)	The pressure required above liquid vapor pressure, to fill each pumping chamber or cavity while open to the inlet chamber.
Pump Rotor	A gear in which the pumped liquid is confined by the sidewalls of the pump housing and gear tooth void open area.
Rated Capacity	Fluid volume moved per unit time - gal/min (L/min), at rated pressure and speed.
Rated Pressure	Pressure - psi (bar) developed by the pump when operating at rated capacity.
Relief Valve	A pressure-operated valve which is used to limit the pressure of the system to which it is connected by venting fluid at a rate greater than the replacement rate.
Rotary Gear, Positive Displacement Fire Pump	A pump with shafts normally in a horizontal position, incorporating meshing gears in a housing and in which the pressure is developed by the transportation of fluid around the interior perimeter of the housing confined between gear teeth and the housing walls.
Off-Site Test Facilities	The location where testing will be performed that is not operated by the certification agency and which provides all of the following: a. All required test and data collection equipment. b. A formal calibration system with traceability to nationally recognized standards by an ISO 17025 accredited calibration service. c. Test personnel who possess a thorough understanding of, and the ability to conduct, the required tests.
Total Differential Pressure	The algebraic difference between the total discharge head and the total suction head. Where suction head exists, total head equals total discharge head minus total suction head. Where suction lift exists, total head equals total discharge head plus total suction lift.
Total Discharge Head	The gauge reading in psi (bar) at the discharge of the pump, referred to the pump centerline, plus the velocity head at the point of gauge attachment.
Total Suction Head	The pressure condition at the inlet of an operating pump when the suction pressure is above atmospheric. The total suction head is the algebraic sum of the gauge reading in psi (bar) at the pump suction nozzle, referred to the pump centerline, and the velocity head at the point of gauge attachment. Also called “positive suction pressure.”
Total Suction Lift	The pressure condition at the inlet of an operating pump when suction pressure is below atmospheric. The total suction lift is the algebraic sum of the gauge reading in psi (bar) at the suction nozzle of the pump, referred to the pump centerline, and the velocity head at the point of gauge attachment.

Unloader Valve	A relief valve set at a lower pressure than the main relief valve and that vents its discharge back to the suction side of the pump. Unloader valves are used in water mist systems to limit pump flow to that demanded by the downstream system. The intent is that the unloader valve limits flow and that the relief valve limits maximum pressure of the system. A single valve cannot perform both functions as the unloader valve relieving pressure will change in response to suction pressure changes.
Water Mist	A water spray, for which the Dv 0.99, for the flow weighted cumulative volumetric distribution of water droplets, is less than 1,000 microns at the minimum design operating pressure of the water mist nozzle.
Water Mist System	A distribution system connected to a water supply that is equipped with one or more nozzles capable of delivering water mist intended to control, suppress, or extinguish fires.

2. GENERAL INFORMATION

2.1 PRODUCT INFORMATION

2.1.1 Pumps within the scope of this standard include those designed for flow capacities based upon the minimum and maximum operating speeds for their designs.

2.1.2 Pumps shall have a minimum rated pressure of a minimum of 40 psi (2.75 bar).

2.1.3 To meet the intent of this standard, pumps 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 pumps, 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 certification consideration:

- a complete list of all models, types, sizes, and options for the products or services being submitted for certification consideration;
- anticipated pump performance, including total head, power requirements, and efficiency versus flow characteristics. If different rotors or a range of rotors are used to obtain the rated head and flow ranges for the pump being examined, complete details shall be provided concerning the range of performance specifications to be evaluated;
- calculations to determine shaft size, housing wall thickness, housing bolt size, and anti-friction bearing life;
- general assembly drawings (showing the pump and attachments), one complete set of manufacturing drawings, materials list(s) and physical property specifications, anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures; and,
- 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 foreign language documents shall be provided with English translation.

2.3 REQUIREMENTS FOR SAMPLES FOR EXAMINATION

2.3.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing based on the following:

- Sample requirements are to be determined by the certification agency.

2.3.2 Sample requirements may vary depending on design features, results of prior or similar testing, and results of the foregoing tests.

2.3.3 The manufacturer shall submit samples representative of production.

2.3.4 It is the manufacturer’s responsibility to provide the test facilities, which are required to evaluate the rotary gear type positive displacement fire pumps.

3. GENERAL REQUIREMENTS

3.1 REVIEW OF DOCUMENTATION

3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications, and details shall be reviewed to assess the ease and practicality of installation and use. The certification examination results may further define the limits of the final certification.

3.2 PHYSICAL OR STRUCTURAL FEATURES

3.2.1 Pump Assemblies

Pumps shall be designed for flow rates equal to or greater than 1 gal/min (3.75 L/min). Rated pump pressures shall be a minimum of 40 psi (2.75 bar). Castings shall be free of defects which could make them unfit for their intended use. Flange dimensions, bolt layouts, and threaded openings used in pipe connections shall conform to a recognized national or international standard. Two or more pump ratings may be assigned to a single characteristic curve; however, the maximum power requirements used in selecting a driver shall be based on the highest power requirement, regardless of where it occurs on the entire characteristic curve.

3.2.2 Pump Housing

The pump housing shall be designed to permit examination and removal of rotors and other interior parts without disturbing suction or discharge piping. A drain opening(s) shall be provided so that all parts of the pump housing can be drained. The opening shall be threaded to receive a corrosion resistant pipe plug a minimum of 1/2 in. nominal size. Replaceable housing wearing liners may be provided.

3.2.3 Liquid Passages

All liquid passages shall be designed to minimize the possibility of foreign materials becoming lodged in them.
Pump housing design strength calculations shall show the wall thicknesses to be adequate with maximum stresses not to exceed 0.25 of allowable for the material. Housing bolt strength calculations shall demonstrate design stresses no greater than 0.154 of allowable for the material.

3.2.4 Rotors

Rotors driven by a shaft shall be keyed to the pump shaft and so designed to prevent contact with the housing under normal operating conditions.

3.2.5 Shaft

Shafts shall be of adequate size and strength to successfully transmit the torques encountered in starting and during operation while supporting the rotor and other rotating parts.

To safeguard against shaft failure, the maximum torsional shearing stress, as calculated by the following formula, shall not exceed 0.284 of the elastic limit in tension and 0.124 of the ultimate tensile strength of the shaft material. For shafts with keyways, a further 25 percent reduction is required.

English Units

$$S_s = \frac{\left(3.21 \times 10^5 \times P\right)}{n \times d^3}$$

Metric Units

$$S_s = \frac{\left(4.86 \times 10^4 \times P\right)}{n \times d^3}$$

Where: S_s - Torsional Shear Stress, psi (kPa)
P - Maximum Input Power demand, hp (W)
n - Rated Speed, r/min
d - Shaft diameter, in. (mm)

3.2.6 Shaft Seals

The shaft seals shall adequately safeguard against excessive fluid leakage out of the pump when suction pressure is above atmospheric, and prevent air leakage into the pump when the suction pressure is below atmospheric. Shaft sealing by means of packing is not acceptable per NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection*, Chapter 5. Use of mechanical seals requires that only clean fluids be pumped. Suction supplies shall not be open bodies of water, e.g., retention ponds, lakes or rivers. Systems shall be designed so that suction pressure is always positive.

3.2.6.1 Seals of the component, cartridge, and split types shall be acceptable, if used in strict accordance with the seal manufacturer's specifications for pressure, peripheral velocity, seal face flatness, and perpendicularity, seal chamber concentricity, and shaft deflection and alignment.

Mechanical seals shall be tested in each pump model; it does not necessarily follow that acceptance of a mechanical seal for one model of pump translates to acceptance for other pump models, even by the same manufacturer. The pump assembly is certified; not the mechanical seal.

Complete detailed instructions for the removal and replacement of the mechanical seals shall be included in the manufacturer's maintenance, operation and installation instructions.

3.2.6.2 The seal shall be suitable for the vacuum level which may be experienced during startup to prevent air from leaking into the system. This shall be verified during NPIPR testing. Seal faces shall be mechanically loaded to prevent leakage when the pump is not running.

3.2.6.3 Hydraulically balanced seals shall be used to reduce heat generation and face wear.

3.2.6.4 Seal loading springs shall either be isolated from the pumped liquid or shall be of the single spring design to prevent clogging and corrosion which may affect seal loading. Springs shall be of materials offering corrosion resistance equivalent to or greater than that of 304 stainless steel. Springs in contact with the pumped fluid or of multiple spring designs may be acceptable if fabricated of Hastelloy C or materials of equivalent or greater corrosion resistance.

3.2.6.5 Primary sealing faces shall either be of resin impregnated carbon graphite on silicon carbide or tungsten carbide, silicon carbide on silicon carbide, or material combinations with equivalent or better wearing properties, (these materials shall be evaluated on a case-by-case basis). The sealing surfaces shall be of such flatness as to allow pumps to remain leak-free at the seals through all phases of testing.

3.2.6.6 Secondary sealing elastomers shall be ethylene-propylene or fluorocarbon rubbers or of equivalent or better properties than these materials.

3.2.6.7 Mechanical seal integrity shall be evaluated during the 24-hour endurance test, which is run under conditions of maximum radial thrust. Seals shall not leak, increase noise level, nor otherwise fail during this test.

3.2.6.7.1 The seal shall be flushed using circulation from the pump discharge to facilitate heat removal, venting, and to prevent solids accumulation.

3.2.7 Bearings

Suitable bearings shall be provided to ensure smooth, low friction rotation of the rotor shafts. When anti-friction bearings are used, they shall be designed to withstand the maximum radial and thrust loads encountered during maximum load conditions. Water slingers and dust caps or other suitable means of preventing fluid or other foreign matter from entering the bearings shall be provided.

To provide adequate durability, anti-friction bearings shall have the following features:

- A minimum calculated life rating of not less than 5000 hours at maximum load.
- Grease lubrication, with a grease fitting and relief hole if lubrication is necessary.

3.2.8 Baseplate

The pump baseplates shall be suitably designed to support the pump and motor without excessive vibration or visible distortion.

3.2.9 Relief Valve

Relief valves shall be certified per the requirements of Standard 1359, and selected to provide relieving capacity and relief pressure appropriate to the pump's requirements. The manufacturer shall identify a minimum of one such valve for each pump model and rated capacity. Valves adjustments shall be preset at factory and shall be tamper resistant.

3.2.10 Unloader Valve

Pumps certified for water mist service shall be provided with an unloader valve certified per the requirements of Standard 5560 and selected to provide relieving capacity and relief pressure appropriate to the pump's requirements. The manufacturer shall identify a minimum of one such valve for each pump model and rated capacity. Valve adjustments shall be preset at the factory and shall be tamper resistant.

3.2.11 Electric Motor

3.2.11.1 The electric motor shall be provided as an integral part of the pumping unit. Drivers shall be electric motors designed per NEMA MG 1 or IEC 60034-1.

3.2.11.2 The motor shall be sized (in horsepower or kilowatts) such that the maximum motor current in any phase under any anticipated condition of pump load and voltage unbalance does not exceed the motor rated full-load current multiplied by the motor service factor.

3.2.11.3 Electric motors for fire pump service require a winding insulation temperature rating of NEMA/IEC Class B 266°F (130°C) or greater.

3.2.11.4 To protect against water ingress, electric motors for fire pump service require minimum rating equivalent to a NEMA open drip poof type or have a minimum IEC rating of IP22.

3.2.11.5 Eyebolts or equivalent lifting points shall be provided on the electric motor to lift the motor safely. Strength calculations for lifting mechanism shall be provided.

3.3 PUMP PACKAGE

The pump manufacturer shall assemble and supply the complete pump package (as detailed in Appendix D).

Certified fire pumps shall be manufactured or packaged at the location(s) audited by the certification agency and as specified in the certification report.

3.4 MATERIALS

All materials used in these pumps shall be suitable for the intended application. At minimum, the rotors, housings, housing wear liners, seals, shafts, and interior bolts or screws shall be constructed of materials offering corrosion resistance equivalent to or greater than that of 316 stainless steel.

3.5 MARKINGS

3.5.1 A permanently marked, legible, corrosion-resistant nameplate shall be securely attached to the pump or bedplate where it shall be easily visible. The nameplate shall include the following information:

- manufacturer's name and address;
- country of manufacture (if different than above)
- model or type designation;
- rated capacity;
- rated total head;
- rated speed;
- maximum power required;
- pump serial number;
- manufacturer and serial number of the driver;

- manufacturer and serial number of the controller; and;
- certification agency's mark of conformity.

3.5.2 Pumps that are produced at more than one location shall be identified as the product of a particular location.

3.5.3 An arrow indicating the direction of pump rotation shall be cast, permanently engraved, or stamped into the pump housing, cover, or end plate. A corrosion resistant metal nameplate bearing the arrow shall be considered acceptable if permanently fastened to the pump.

3.5.4 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency's mark of conformity.

3.5.5 The certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

3.5.6 All markings shall be legible and durable.

3.6 MANUFACTURER'S INSTALLATION AND OPERATION INSTRUCTIONS

Maintenance, operation and installation instructions, including any special dimension or installation requirements, shall be furnished by the manufacturer. Instructions shall be provided with each pump.

3.7 CALIBRATION

3.7.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage of the equipment. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard by an accredited ISO 17025 calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory is required.

3.7.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

4. PERFORMANCE REQUIREMENTS

4.1 HYDRAULIC PERFORMANCE TESTS

4.1.1 The pump shall develop its design pressure when delivering its rated capacity at the rated speed and maximum specified suction lift.

4.1.2 The maximum power required shall be determined.

4.1.3 A minimum of one sample pump of each rated capacity shall be tested at each rated speed over the full range of flows and pressures submitted for certification. If one or more rotors are used to obtain the desired head range for the pump, each shall be tested. Maximum and minimum displacement rotors of each type shall be tested. Intermediate displacement rotors may be tested as needed to ensure the certification agency's understanding of the intermediate displacement rotor's performance.

4.1.4 The pump shall be operated at various flow rates and speeds to generate total head, power, and efficiency curves. Test fluid temperature shall be continuously monitored. At each rated speed, the suction and discharge pressures, power required, and speed shall be measured. A minimum of four flow readings shall be taken to generate the curve. All test speeds must be within ± 4 percent of the rated speed. Test data shall be corrected to rated speed in order to develop characteristic curves.

4.1.5 If a pump is submitted for certification for pumping of foam concentrates, this test shall be repeated using a minimum of one of the pumps tested with water, but with a concentrate representing worst case conditions of specific gravity and viscosity. The relative performance achieved with the two fluids shall be used to predict performance of pumps used for foam concentrates. If the various pumps submitted differ significantly in design, additional performance tests using foam test concentrates may be required for their evaluation.

4.1.6 Pumped volume is directly proportional to rotor length, so it may not be necessary to test all rotor lengths to verify pump performance for all models. Any such reductions in required testing shall be at the sole discretion of the certification agency.

4.1.7 Tests, correction calculations to rated speeds, and net positive inlet pressure requirements (NPIPR) determination shall be conducted in conformance to ANSI/HI Standard 3.6, *American National Standard for Rotary Pump Tests*. Alternatively, another national or internationally recognized standard appropriate to the intended market for these pumps may be used at the sole discretion of the certification agency.

4.2 DRY OPERATION AND SELF-PRIMING

4.2.1 The same pump samples used for the performance tests shall demonstrate their ability for limited dry operation and to self-prime from a dry condition.

4.2.2 Inlet and outlet piping shall be drained of all liquid. The sample pumps shall be operated with a closed suction valve for a minimum of 10 minutes. The pump shall then be shut down.

4.2.3 The inlet shall then be immersed into a container of test foam concentrate with the liquid surface approximately 2 ft (0.6 m) below the pump's centerline. Inlet and outlet valves shall be fully open. The pump shall then be started and shall draw in the concentrate and fully evacuate all air.

4.3 ENDURANCE TEST

4.3.1 The pump shall be capable of continuous operation for 24 hours under the conditions stated in Section 4.3.2, without excessive vibration, loosening of parts (fasteners, et cetera), visible distortion of the baseplate, excessive generation of heat in the bearings, or rubbing of the rotor. If a pump is submitted for certification for pumping of foam concentrates, this test shall be conducted with a concentrate representing worst case conditions of specific gravity and viscosity.

4.3.2 A sample pump shall be operated continuously for 24 hours at maximum speed and maximum capacity. No loosening, distortion, overheating, or degradation of performance shall be allowed. Following the test, the pump shall be disassembled and examined for signs of rubbing. A method of ensuring that the pump runs continuously for 24 hours must be provided. All test speeds must be within ± 4 percent of the rated speed.

4.4 FLANGE AND GASKET TIGHTNESS

4.4.1 No leakage shall be observed in a 5 minute observation period when the pump is hydrostatically tested at the required pressure.

4.4.2 A sample assembly of each model and material shall be hydrostatically tested to a pressure equal to, or greater than, the sum of the maximum rated differential pressure of the pump plus a maximum allowable suction pressure specified by the pump manufacturer (P_{max} + $P_{max.\ Suction}$). The maximum rated differential pressure, P_{max}, is the highest relief valve setting specified for certification. The test pressure shall be held for five minutes. In no case shall the maximum allowable suction pressure, $P_{max.\ Suction}$, be less than 75 psi (5.15 bar), or the leakage test be run at less than 250 psi (17.25 bar). Housing bolts normally provided shall be used for this test.

4.5 HYDROSTATIC STRENGTH

4.5.1 No rupture, cracking or permanent distortion of any part of the pump shall be observed in a 5 minute test when hydrostatically tested at the required pressure.

4.5.2 A sample assembly of each model and material shall be hydrostatically tested to a pressure equal to, or greater than, twice the sum of the maximum rated differential pressure of the pump plus a maximum allowable suction pressure specified by the pump manufacturer, 2 x (Pmax + Pmax. Suction). The maximum rated differential pressure, Pmax, is the highest relief valve setting submitted for certification. The test pressure shall be held for five minutes. In no case shall the maximum allowable suction pressure, Pmax. Suction, be less than 75 psi (5.15 bar), or the test be run at a pressure less than 400 psi (27.60 bar).

4.6 TEST PROCEDURES

Pump testing is normally performed by the manufacturer at its facility. The certification agency shall witness the testing and obtain copies of the data and calibration certificates. The specific tests to be conducted shall be in accordance with the certification agency's test plan. Test procedures shall be in accordance with recommendations of the latest edition of the Hydraulic Institute Standards, *Standard for Centrifugal, Rotary and Reciprocating Pumps*.

5. OPERATIONS REQUIREMENTS

5.1 DEMONSTRATED QUALITY CONTROL PROGRAM

5.1.1 A quality control program is required to assure that subsequent pumps produced by the manufacturer shall present the same quality and reliability as the specific pumps examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests, and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2 The manufacturer shall demonstrate a quality assurance program which specifies controls for the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping;
- handling and disposition of non-conformance materials.

5.1.3 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.4 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.5 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2 SURVEILLANCE AUDIT

5.2.1 An audit of the manufacturing facility may be part of the certification agency's surveillance requirements to verify implementation of the quality control program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.2.3 The fire pump manufacturer shall maintain design/documentation control, and manufacture certified fire pumps only at the location(s) audited by the certification agency and as specified in the certification report.

5.2.4 The OEM is responsible to rectify any non-conformances discovered at the Alternate Manufacturing and/or the Fire Pump Packager facility to the satisfaction of the certification agency.

5.3 MANUFACTURER'S RESPONSIBILITIES

The manufacturer shall notify the certification agency of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

5.4 MANUFACTURING AND PRODUCTION TESTS

The manufacturer shall test each pump to be labeled with the certification agency's mark of conformity to the following minimum criteria:

5.4.1 Test Requirement No. 1 – Performance Test

The pump shall be performance tested at the rated flow and deliver the rated pressure, or greater. Inlet and outlet pressures, flow, rotational speed, and power supplied shall be measured and recorded. A minimum of two additional points shall be recorded, one a minimum of 10 psi (0.7 bar) higher and one a minimum of 10 psi (0.7 bar) lower than the rated point. These three points shall be speed corrected and plotted on the standard curve for that pump. Reasonable conformance with regard to values and especially slope of the capacity and power curves shall be demonstrated. Where inability to test at other than motor synchronous speeds or test stand power limitations would render it impossible to test at the as-sold rating, a pump may be tested at a minimum of three points at another speed or lesser output to demonstrate reasonable conformance to its standard performance curve for that condition.

5.4.2 Test Requirement No. 2 – Relief Valve Setting

The relief valve supplied shall be tested to verify set point. Set point shall be no higher than 1.25 times the pump's rated maximum pressure. Set point may be lower if requested by the customer to protect downstream components in the fire extinguishing system.

5.4.3 Test Requirement No. 2 - Leakage Test

The manufacturer shall test 100 percent of production fire pumps for body leakage to the maximum design working pressure, but not less than 250 psi (17.25 bar). The pressure shall be held for a minimum of five minutes with no objectionable leakage at any joint. Pump housing, end plate, or cover distortion or leakage is not allowed.

5.4.4 Records of these tests and other relevant data shall be available for review by the certification agency's auditor during any surveillance audit.

APPENDIX A:

Appendix A is intentionally blank

APPENDIX B:

Appendix B is intentionally blank

APPENDIX C: Test Procedures

There are several acceptable methods of obtaining the test data needed. In order to establish uniformity in method selection, the following techniques, based on recommendations by the Hydraulic Institute, are listed below. For more specific information such as test set-ups and the equations needed to compute results from raw data, reference should be made to the "Hydraulic Institute Standards", latest edition.

C.1 CAPACITY MEASUREMENTS

C.1.1 Weight

Scale measurements with accuracy of 0.25 percent of full scale shall be obtainable.

C.1.2 Volume

Reservoir measurements with accuracy of 0.5 percent of the reading shall be obtainable.

C.1.3 Venturi

A certified curve showing the calibration of the meter shall be provided. Machined tubes shall be accurate within ± 0.75 percent of the rate of flow. The size of the venturi needed shall be determined by the throat velocity. A minimum of 20 ft/sec (6.1 m/sec) shall be affected at the venturi throat at the rated capacity of the pump.

The accuracy of the venturi meter depends upon its installation within the hydraulic system. The meter shall not be adversely affected by improper flow conditions immediately preceding the venturi tube. Non-uniform velocity distribution or swirling or pulsating flow will affect the value of the coefficient. Table C.1.3 shows the length of straight pipe required ahead of the venturi tube expressed in terms of equivalent diameters.

Table C.1.3. Straight Pipe Required After Any Fitting Before the Venturi Meter in diameters of Pipe

Meter Ratio (Throat to Inlet Diameter)	0.4	0.5	0.6	0.7	0.8
One standard short radius elbow	1	2	3	4	6
Two elbows in same plane	2	3	4	6	8
Two elbows in planes at 90° and with straightening vanes	2	3	4	5	7
Standard cast iron flanged reducer	2	5	7.5	10	13
Standard cast iron flanged increaser	1	2	3	4.5	6
Globe valve with straightening vanes	2	4	6	9	12
Gate valve - 0.2 open	2	4	6	9	12
Gate valve - 0.5 open	2	3	4	6	8
Gate valve - full open	0	0.5	1	2	3

Note: A centrifugal pump pumping directly into a venturi meter should have a minimum of 10 pipe diameters of straight pipe between it and the meter. This distance can be reduced if straightening vanes are properly used between the pump and venturi.

C.1.4 Nozzles

A certified curve showing the calibration of the nozzle shall be provided. When ASME long radius flow nozzles are used with an outlet to inlet diameter ratio from 0.2 to 0.7, the tolerance in the rate of flow should not exceed ± 0.75 percent for 3 in. pipe and over. When other nozzles are used with the same specifications listed above, the error should not exceed ± 1 percent of the rated flow. The nozzle size shall be selected to provide a minimum velocity of 20 ft/s (6.1 m/s) at the nozzle throat.

C.1.5 Orifice Plate

A certified curve showing the calibration of a square edged concentric orifice plate shall be provided. The error should not exceed ± 1.5 percent of the reading when using an orifice-to-pipe diameter ratio from 0.10 to 0.80. Ratios outside of these limits should not be used. Preferred orifice to pipe diameter ratios are from 0.20 to 0.60.

To ensure accurate flow measurements, a sufficient length of straight pipe is required preceding and following the orifice plate. The values required expressed in terms of equivalent diameters, are shown in Tables C.1.5 (a) and (b). When "pipe taps" are used, the values shown in Tables C.1.5 (a) and (b) should be increased by 2 diameters.

Table C.1.5 (a) Straight Pipe Required After Any Fitting before Meter in Diameters of Pipe

Meter Ratio (Throat to Inlet Diameter)	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Tee or wye within line flow	6	6	6.5	7	8.5	10.5	14
One elbow, branch flow thru tee or wye, or flow from drum or separator	6	6	6.5	7	9	13	20.5
Globe valve - wide open	9	9	9.5	10.5	13	15	21
Gate valve - wide open	6	6	6	6	7.5	9.5	13.5
Two or more short radius elbows or bends in the same plane	7.5	7.5	8.5	10.5	13.5	18	25
Two or more long radius elbows or bends in the same plane	6	6	6.5	8	11	16	23
Two short radius elbows or bends in different planes	14.5	16	17.5	20.5	24.5	30	40
Two long radius elbows or bends in different planes	7	8	10	12	16	22	33

Note: A centrifugal pump pumping directly into a nozzle or orifice should have a minimum of 10 pipe diameters of straight pipe between it and the meter. This distance can be reduced if straightening vanes are properly used between the pump and nozzle or orifice.

Table C.1.5 (b) Straight Pipe Required After Meter Before Any Fitting in Diameters of Pipe

Meter Ratio (Throat to Inlet Diameter)	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Gate valve - wide open	0	0	0	0	0	0	0
Wye	0	0	0	0	0	0	4
Tee	0	0	0	0	0	3.5	4
Expansion joint	0	0	0	0	0	3.5	4
45° Elbow	0	0	0	0	3.5	3.5	4
Long radius elbow or bend	2	2.5	2.5	3	3.5	3.5	4
Regulators, control valves, and partly throttled gate valves	6	6	6	6	6	6	6

C.1.6 Weir

A rectangular sharp crested weir with a smooth vertical crest wall, complete crest contraction, free overfall and with the end contraction suppressed, is a suitable capacity measuring device. The weir should be calibrated in place with the water circuit.

When rectangular suppressed weirs are used, the error shall not exceed ∀2 percent of the flow under the following limitations of flow:

- The head is not smaller than 0.2 ft (61 mm).
- The head is not larger than one-half the height of the weir.
- The head is not larger than one-half the length of the weir.

C.2 HEAD MEASUREMENTS

C.2.1 Instruments to measure head shall, when practical, be water columns or manometers and for high pressures shall be mercury manometers, bourdon gauges, electrical pressure transducers or dead weight gauge testers. If water gauges are used, errors due to water temperature difference within the gauge and pump shall be avoided. Measuring instrumentation shall have records of calibration traceable to national standards. Tolerances shall not exceed ± 1.0 percent of the full scale.

C.2.2 It is important that steady flow conditions exist at the point of instrument connection. For this reason, it is necessary that pressure or head measurement be taken on a section of pipe where the cross-section is constant and straight. Five to ten diameters of straight pipe of unvarying cross-section following any elbow or curved member, valve, or other obstruction, are usually necessary to ensure steady flow conditions.

C.2.3 Special care shall be taken in the drilling of orifice or tap openings for gauges. The following precautions shall be taken:

- The orifice in the pipe shall be flush with and normal to the wall of the water passage.
- The wall of the water passage shall be smooth and of unvarying cross-section. For a distance of a minimum of 12 in. (305 mm) preceding the orifice, all tubercles and roughness shall be removed with a file or emery cloth, if necessary.
- The orifice shall be of a diameter from 1/8 in. to 1/4 in. (3.2 mm to 6.4 mm) and of a length equal to twice the diameter.
- The edges of the orifice shall be provided with a suitable radius tangential to the wall of the water passage, and shall be free from burrs or irregularities.

C.2.4 The datum shall be taken as the centerline of the pump.

C.3 POWER MEASUREMENTS

C.3.1 Pump input power shall be determined by either transmission dynamometers, torsion dynamometers, strain gauge type torque measuring devices, or by the use of calibrated drivers.

C.3.2 When pump input power is to be determined by transmission dynamometers, the unloaded and unlocked dynamometer must be properly balanced, prior to the test, at the same speed at which the test is to be run. The scales should be checked against standard weights.

C.3.3 When pump input power is to be determined by torsion dynamometers, the unloaded dynamometer shall be statically calibrated prior to the test by measuring the angular deflection for a given torque; the tare reading on the dynamometer scale is taken at rated speed with the pump disconnected.

C.3.4 When strain gauge type torque measuring devices are used to measure pump input power, they shall be calibrated, with their accompanying instrumentation, at regular intervals.

C.3.5 When pump input power is to be determined by the use of a calibrated motor, measurements of power input shall be made at the terminals of the motor to exclude any line losses that may occur between the switchboard and the driver itself. Certified calibration curves of the motor must be provided. The calibration shall be conducted on the specific motor in question, and not on a similar machine. Such calibrations must indicate the true input-output value of the motor efficiency and not some conventional method of determining an arbitrary efficiency.

C.3.6 After the completion of any of the above tests, recalibration or rebalancing shall be checked to assure that no change has taken place. In the event of appreciable change, the test shall be rerun.

C.3.7 Calibrated laboratory type electric meters and transformers shall be used to measure power input to all electric motors.

C.4 SPEED MEASUREMENT

C.4.1 Measurement of speed shall be made by means of revolution counters, tachometers, or stroboscopic devices.

C.4.2 For speed measurements taken by means of a revolution counter, the timing period shall be of sufficient length to obtain a true average speed. The stopwatch shall be checked against a standard timer. If electric/electronic speed sensing element with electronic counter is used, it shall be checked against a suitable secondary frequency standard.

C.4.3 When a tachometer is used, it shall be calibrated against a revolution counter before and after the test. Tachometer readings shall be made at frequent intervals during the period each test reading is taken to determine an accurate measurement of average speed over that reading period.

C.4.4 When a stroboscopic device is used, the comparison frequency source shall be either line frequency, where stable, or a stable independent frequency. The speed shall be determined by the observation and deduction of slip from the synchronous speed.

C.5 TIME MEASUREMENT

Time measurement with accuracy of 1/100 of a second shall be obtainable.

APPENDIX D: Fire Pump Unit (Packages)

The fire pump package consists of the following components which are furnished by the pump manufacturer, alternate manufacturer, or a fire pump packager. Where marked (*) certified components shall be supplied.

1. Fire pump*
2. Driver - diesel engine* or electric motor
3. Pump controller* (electric motor or diesel engine)
4. Flexible coupling (not all elastomeric) or drive shaft
5. Suction and discharge pressure gauges*
6. Pressure-relief valve* and waste cone, when required
7. Automatic air release valve*
8. Circulation-relief valve*
9. Substantial bedplate for pump and driver
10. Diesel engine accessories:
    i. starting batteries
    ii. rigid cooling water and fuel lines (May have short flexible elements in close proximity to engine to minimize vibration)
    iii. exhaust piping and muffler
    iv. fuel tank
11. Instruction, operation and maintenance manual in local language
12. Spare mechanical seals (optional, for pumps certified with mechanical seal)