NFPA®

1906

Standard for Wildland Fire Apparatus

2016

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NFPA® 1906

Standard for

Wildland Fire Apparatus

2016 Edition

This edition of NFPA 1906, *Standard for Wildland Fire Apparatus*, was prepared by the Technical Committee on Fire Department Apparatus. It was issued by the Standards Council on May 26, 2015, with an effective date of June 15, 2015, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 1906 was approved as an American National Standard on June 15, 2015.

Origin and Development of NFPA 1906

The first edition of NFPA 1906, *Standard for Wildland Fire Apparatus*, was published in 1995 to provide a standard for apparatus that are basically designed and deployed to combat fires in wildland. The document covered apparatus with pumps ranging in size from 20 gpm to 250 gpm (76 L/min to 950 L/min) and water tanks with a capacity of 125 gal (473 L) or more.

Requirements were also provided for the first time for foam proportioning systems using Class A foam as a fire suppressant agent and for compressed air foam systems (CAFS). The apparatus covered in the standard included built-to-specification apparatus and fire-fighting packages designed to be slipped onto a vehicle chassis.

In the 2001 edition, the requirements for low-voltage electrical systems, including the emergency warning systems, were brought in line with the requirements in NFPA 1901, *Standard for Automotive Fire Apparatus*. The chapter on pumps was reorganized to provide requirements for four types of pumps, with the range of sizes changed to include pumps from 10 gpm (38 L/min) to 500 gpm (1900 L/min). The allowable minimum size on water tanks was lowered to 50 gal (190 L), and the chapter on line-voltage systems was removed. The document was also updated in other areas where appropriate to make the requirements consistent with those in NFPA 1901.

The 2006 edition was a general updating of the document, including making requirements consistent with those in NFPA 1901 where appropriate. It added requirements for what the manufacturer certification of test results must include and for better illumination and signage for controls, switches, instruction plates, gauges, and instruments. This edition also introduced the concept of estimated in-service weight as a basis for measuring certain stability requirements and linked the maximum top speed of the apparatus to the tire manufacturer's ratings. It also required more head height at seating positions and the use of red seat belts if available.

The 2006 edition also reorganized the requirements for water pumps installed on the wildland fire apparatus into seven categories and updated the requirements for baffling water tanks to better address smaller water tanks. The standard required type testing of foam systems followed by individualized testing of each installation. Two annexes were added, one to provide an equipment size and weight chart, the other to provide guidelines for first-line and reserve fire apparatus. Finally, the document was reorganized according to the *Manual of Style for NFPA Technical Committee Documents*.

The 2012 edition was a complete reorganization of the document, to follow the same format and style as NFPA 1901, *Standard for Automotive Fire Apparatus*. It included a new category of wildland fire apparatus titled Wildland Mobile Water Supply Apparatus, giving specific requirements for vehicles equipped with a minimum of 1000 gal (4000 L) water tanks designed to operate off-road. This revision also included appropriate updates consistent with those requirements in NFPA 1901.

The 2016 edition of NFPA 1906 includes a new chapter on the design of wildland fire crew carriers specifically for the purpose of transporting wildland fire crews. It also includes a new chapter

on ultra-high pressure (UHP) fire pumps and associated equipment due to the increased use of UHP fire pumps. This edition provides guidance to manufacturers and purchasers as to the design, testing, and performance of UHP fire pumps with a rated discharge pressure of 1100 psi (7600 kPa) or greater. The 2016 edition of NFPA 1906 also introduces a new design concept of the on-board pump-and-roll firefighting position in Chapter 14. This is a seated, belted, and protected position that allows for safe and effective use of pump-and-roll operations in situations where walk along-side pump-and-roll operations are not practical. The Committee also has clarified the requirements within Chapter 16 for pump controls and has added updated tables to the chapter for the engine speed advancement interlock test. Additional changes have been made throughout the document to remove redundant language and to clarify requirements.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the design and performance of fire apparatus for use by the fire service.

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NFPA 1906

Standard for

Wildland Fire Apparatus

2016 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex E. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

1.1* Scope. This standard shall define the minimum requirements for the design, performance, and testing of new automotive fire apparatus that are designed primarily to support wildland fire suppression operations.

1.2 Purpose. The purpose of this standard shall be to establish the minimum requirements for new automotive wildland fire apparatus that will be safe and reliable when properly maintained and used within design parameters.

1.3 Application.

1.3.1* This standard shall apply to new fire apparatus that meet the following criteria:

(1) Rated at minimum 10,001 lb (4501 kg) gross vehicle weight rating (GVWR)
(2) Designed specifically for supporting wildland fire suppression operations
(3) Contracted for on or after January 1, 2016

1.3.2 Nothing shall prevent the use of the standard prior to January 1, 2016, if the purchaser and the contractor agree.

1.3.3 This standard shall not apply to fire apparatus designed to support structural fire fighting or associated fire department operations, which are covered by the requirements of NFPA 1901.

1.4* Retroactivity. The standard is not intended to be applied retroactively.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units of Measure.

1.6.1* In this standard, values for measurement in U.S. customary units shall be followed by an equivalent in SI units.

1.6.2 Either set of values can be used, but the same set of values (either U.S. customary units or SI units) shall be used consistently.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 2014 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, 25 West 43rd Street, 4th floor, New York, NY 10036.

ANSI/NEMA Z535.4, *Product Safety Signs and Labels*, 2011.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ANSI/ASME B1.20.7, *Hose Coupling Screw Threads, Inch*, 1991 (R2003).

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2005.

Boiler and Pressure Vessel Code, Section VIII, Division 1, 2013.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, 2013.

2.3.4 FAMA Publications. Fire Apparatus Manufacturers Association, P.O. Box 397, Lynnfield, MA 01940-0397.

FAMA TC008, *Graphical Symbols for Automotive Fire Apparatus*, 2013.

FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus,* 2014.

2.3.5 ISEA Publications. International Safety Equipment Association, 1901 North Moore Street, Arlington, VA 22209-1762, www.safetyequipment.org.

ANSI/ISEA 207, *Standard for High-Visibility Public Safety Vests*, 2011.

2.3.6 ISO Publications. International Standards Organization, 1 rue de Varembé, Case Postale 56, CH-1211 Genéve 20, Switzerland.

ISO 9244, *Earth-moving machinery — Machine safety labels — General principles,* 2008.

ISO/IEC 17020, *General criteria for the operation of various types of bodies performing inspection*, 1998.

ISO/IEC 17065, *Conformity Assessment: Requirements for bodies certifying products, processes and services,* 2012.

2.3.7 Parker Hannifin, Racor Division Publication. Parker Hannifin, Racor Division, Attn: Dan Haggard, 805 West Street, Holly Springs, MS 38634.

LF 1093-90, *Ember Separation Test Procedure*, January 2003.

2.3.8 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J156, *Fusible Links*, 2012.

SAE J541, *Voltage Drop for Starting Motor Circuits*, 1996.

SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, 2010.

SAE J553, *Circuit Breakers*, 2004.

SAE J554, *Electric Fuses (Cartridge Type)*, 1987.

SAE J575, *Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less Than 2032 mm in Overall Width*, 2012.

SAE J578, *Color Specification*, 2012.

SAE J595, *Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, 2008.

SAE J683, *Tire Chain Clearance — Trucks, Buses (Except Suburban, Intercity, and Transit Buses), and Combinations of Vehicles*, 2011.

SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, 2007.

SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*, 2009.

SAE J1127, *Low Voltage Battery Cable*, 2012.

SAE J1128, *Low Voltage Primary Cable*, 2012.

SAE J1194, *Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors*, 2009.

SAE J1330, *Photometry Laboratory Accuracy Guidelines*, 2007.

SAE J1690, *Flashers*, 1996.

SAE J1849, *Emergency Vehicle Sirens*, 2012.

SAE J1888, *High Current Time Lag Electric Fuses*, 1990.

SAE J1889, *L.E.D. Signal and Marking Lighting Devices*, 2011.

SAE J2077, *Miniature Blade Type Electrical Fuses*, 1990.

SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, 2011.

SAE J2202, *Heavy-Duty Wiring Systems for On-Highway Trucks*, 2008.

SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*, 1998, reaffirmed 2003.

SAE J2420, *COE Frontal Strength Evaluation — Dynamic Loading Heavy Trucks*, 2010.

SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*, 2010.

2.3.9 TRA Publications. Tire and Rim Association, Inc., 175 Montrose West Ave., Suite 150, Copley, OH 44321.

Tire and Rim Association — Year Book, 2015.

2.3.10 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 969, *Standard for Marking and Labeling Systems*, 1995, with revisions through November 24, 2008.

2.3.11 UNECE Publications. UN Economic Commission for Europe, Palais des Nations, CH – 1211, Geneva 10 Switzerland, www.UNECE.org.

ECE Regulation number 29, *Uniform Provisions Concerning the Approval of Vehicles with Regard to the Protection of the Occupants of the Cab of a Commercial Vehicle,*2011.

2.3.12 U.S. Department of Agriculture Publications. USDA Forest Service, San Dimas Technology and Development Center, 444 East Bonita Avenue, San Dimas, CA 91773.

USDA - Forest Service Standard 5100-1.

2.3.13 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Public Law 89-563.

Title 29, Code of Federal Regulations, Part 1910.169, "Air receivers." 29 CFR 1910.169.

Title 49, Code of Federal Regulations, Part 178.37, "Specification 3AA and 3AAX seamless steel cylinders." 49 CFR 178.37.

Title 49, Code of Federal Regulations, Part 393.94(c), "Interior noise levels in power units." 49 CFR 393.94(c).

2.3.14 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2013 edition.
NFPA 70® , *National Electrical Code®*, 2014 edition.

NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles,* 2012 edition.

NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels,* 2010 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.

NFPA 1917, *Standard for Automotive Ambulances,* 2016 edition.

NFPA 1961, *Standard on Fire Hose,* 2013 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary,* 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Acceptance. An agreement between the purchasing authority and the contractor that the terms and conditions of the contract have been met. [**1901,** 2016]

3.3.2 Acceptance Tests. Tests performed on behalf of or by the purchaser at the time of delivery to determine compliance with the specifications for the fire apparatus. [**1901,** 2016]

3.3.3 Access Ladder. One or more rungs (of any shape) for climbing that have a degree of inclination between 60 and 90 degrees. [**1901,** 2016]

3.3.4 Active Horizontal Angles of Light Emission. The angles, measured in a horizontal plane passing through the optical center of the optical source, as specified by the manufacturer of the optical device, between which the optical source contributes optical power. [**1901,** 2016]

3.3.5 Angle of Approach. The smallest angle made between the road surface and a line drawn from the front point of ground contact of the front tire to any projection of the apparatus in front of the front axle. [**1901,** 2016]

3.3.6 Angle of Departure. The smallest angle made between the road surface and a line drawn from the rear point of ground contact of the rear tire to any projection of the apparatus behind the rear axle. [**1901,** 2016]

3.3.7 ASME Pressure Vessel. A pressure vessel used for the storage or accumulation of air or gas under pressure that is constructed and tested in accordance with the ASME *Boiler and Pressure Vessel Code.* [**1901,** 2016]

3.3.8 Automatic Electrical Load Management System. A device that continuously monitors the electrical system voltage and automatically sheds predetermined loads in a selected order to prevent overdischarging of the apparatus' batteries. [**1901,** 2016]

3.3.9* Automatic Regulating Foam Proportioning System. A foam proportioning system that automatically adjusts the flow of foam concentrate into the water stream to maintain the desired proportioning ratio.

3.3.10 Auxiliary Braking System. A braking system in addition to the service brakes, such as an engine retarder, transmission retarder, driveline retarder, or exhaust retarder. [**1901,** 2016]

3.3.11 Auxiliary Engine–Driven Pumps. Pumps whose power is provided by engines that are independent of the vehicle engine.

3.3.12 Back-Up Alarm. An audible device designed to warn that the fire apparatus is in reverse gear. [**1901,** 2016]

3.3.13 Battery Disconnect Switch. A switch that disconnects the battery from all of the vehicle's wiring.

3.3.14 Bubble (Foam). A thin-walled, roughly spherical film of liquid inflated with air. [**1901,** 2016]

3.3.15 Center of Gravity. The point at which the entire weight of the fire apparatus is considered to be concentrated so that, if supported at this point, the apparatus would remain in equilibrium in any position. [**1901,** 2016]

3.3.16 Chassis. The basic operating motor vehicle including the engine, frame, and other essential structural and mechanical parts, but exclusive of the body and all appurtenances for

the accommodation of driver, property, passengers, appliances, or equipment related to other than control. Common usage might, but need not, include a cab (or cowl). [**1901,** 2016]

3.3.17 Class A Fires. Class A fires are fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. [**10,** 2013]

3.3.18 Class A Foam. Foam for use on fires in Class A fuels. [**1150,** 2010]

3.3.19 Class A Fuel. Materials such as vegetation, wood, cloth, paper, rubber, and some plastics in which combustion can occur at or below the surface of the material. [**1150,** 2010]

3.3.20* Compound Gauge. A gauge that indicates pressure both above and below atmospheric pressure. [**1901,** 2016]

3.3.21* Compressed Air Foam System (CAFS). A foam system that combines air under pressure with foam solution to create foam. [**1901,** 2016]

3.3.22 Continuous Duty. Operation at a substantially constant load for an indefinitely long time. [**70:**100]

3.3.23* Contractor. The person or company responsible for fulfilling an agreed-upon contract. [**1901,** 2016]

3.3.24 Convenient Reach. The ability of the operator to manipulate the controls from a driving/riding position without excessive movement away from the seat back or without excessive loss of eye contact with the roadway. [**1901,** 2016]

3.3.25 Curb Weight. The total weight of the complete vehicle less the payload. [**1901,** 2016]

3.3.26 Defect. A discontinuity in a part or a failure to function that interferes with the service or reliability for which the part was intended. [**1901,** 2016]

3.3.27 Discharge Outlet Size. The nominal size of the first fire hose connection from the pump on a discharge. [**1901,** 2016]

3.3.28 Documentation. Any data or information supplied by the manufacturer or contractor relative to the apparatus, including information on its operation, service, and maintenance. [**1901,** 2016]

3.3.29 DOT Cylinder. A pressure vessel constructed and tested in accordance with Title 49 CFR 178.37 that is used for the storage and transportation of air under pressure. [**1901,** 2016]

3.3.30 Dry Location. A location not normally exposed to moisture such as in the interior of the driving or crew compartment, the interior of a fully enclosed walk-in fire apparatus body, or a watertight compartment opened only for maintenance operations. [**1901,** 2016]

3.3.31* Eductor. A device placed in a hose line or a discharge pipe that incorporates a venturi and proportions foam concentrate or other fire fighting agents into the water stream. [**1901,** 2016]

3.3.32* Ejector. An appliance used to fill a fire engine's tank when the water source is below or beyond the engine's drafting capability.

3.3.33* Electric Siren (Electromechanical). An audible warning device that produces sound by the use of an electric motor with an attached rotating slotted or perforated disc. [**1901,** 2016]

3.3.34* Electronic Siren. An audible warning device that produces sound electronically through the use of amplifiers and electromagnetic speakers. [**1901,** 2016]

3.3.35 Emergency Vehicle. A fire apparatus or other vehicle that is permitted by law to call for the right of way while responding to an incident affecting the public safety and to block the public road while at the scene of such an incident.

3.3.36 Enclosed Compartment. An area designed to protect stored items from environmental damage (weather resistant) that is confined on six sides and equipped with an access opening(s) that can be closed and latched. [**1901,** 2016]

3.3.37 Estimated In-Service Weight. The amount that the fire apparatus manufacturer estimates the apparatus will weigh when it is placed in service with all fixed and portable equipment installed, all tanks full, and all personnel seating positions occupied.

3.3.38 Expansion Ratio. The ratio of the volume of foam in its aerated state to the original volume of nonaerated foam solution. [**1901,** 2016]

3.3.39 Final-Stage Manufacturer. An entity that performs such manufacturing operations on an incomplete vehicle that it becomes a complete vehicle.

3.3.40 Fire Pump. A water pump with a rated capacity of at least 250 gpm (1000 L/min) but less than 3000 gpm (12,000 L/min) at 150 psi (1000 kPa) net pump pressure, or a water pump with a rated capacity over 3000 gpm (12,000 L/min) or greater at 100 psi (700 kPa) net pump pressure that is mounted on a fire apparatus and used for fire fighting.

3.3.41 FMVSS. Abbreviation for Federal Motor Vehicle Safety Standards. Regulations promulgated by the National Highway Transportation Safety Administration (NHTSA) of the United States under Public Law 89-563, which are mandatory and must be complied with when motor vehicles or items of motor vehicle equipment are manufactured and certified thereto. [**1901,** 2016]

3.3.42 Foam. An aerated fire-extinguishing solution created by mixing air into foam solution to form bubbles. [**1901,** 2016]

3.3.43 Foam Concentrate. Foam fire-fighting agent as received from the manufacturer that must be diluted with water to make foam solution. [**1901,** 2016]

3.3.44 Foam Proportioner. A device or method to add foam concentrate to water to make foam solution. [**1901,** 2016]

3.3.45 Foam Proportioning System. The apparatus and techniques used to mix concentrate with water to make foam solution. [**1901,** 2016]

3.3.46 Foam Solution. A homogeneous mixture of water and foam concentrate in the proper proportions. [**1901,** 2016]

3.3.47 Fully Enclosed Personnel Area. A driver or passenger compartment on the fire apparatus that provides total enclosure on all sides, top, and bottom and has positive latching on all access doors. [**1901,** 2016]

3.3.48 Gallon. United States gallon [231 $in.^3$ (3.785 L)].

3.3.49 Gauge. A visual device that indicates a measurement.

3.3.50 Gauge Pressure. Pressure measured by an instrument where the pressure indicated is relative to atmospheric pressure. [**1901,** 2016]

3.3.51* GAWR (Gross Axle Weight Rating). The final-stage manufacturer's specified maximum load-carrying capacity of an axle system, as measured at the tire-ground interfaces. [**1901,** 2016]

3.3.52* Grade. A measurement of the angle used in road design and expressed as a percentage of elevation change over distance. [**1901,** 2016]

3.3.53 Ground Clearance. The verticle distance from the vehicle component to the ground. [**1901,** 2016]

3.3.54* GVWR (Gross Vehicle Weight Rating). The final-stage manufacturer's specified maximum load-carrying capacity of a single vehicle. [**1901,**2016]

3.3.55 Instruction Plate. A visual indication whether in pictorial or word format that provides instruction to the operator in the use of a component on the apparatus. [**1901,**2016]

3.3.56 Intake Connection Size. The nominal size of the first fire hose connection from the pump on an intake. [**1901,** 2016]

3.3.57 Intake Relief Valve. A relief valve piped to the intake manifold of a pump and designed to automatically relieve excessive pressure from the incoming flow of water by discharging water to the environment. [**1901,** 2016]

3.3.58 Interior. A sheltered location not exposed to the environment. [**1901,** 2016]

3.3.59 Interlock. A device or arrangement by means of which the functioning of one part is controlled by the functioning of another. [**1901,** 2016]

3.3.60 ISO. Insurance Services Office.

3.3.61 Label. A visual indication whether in pictorial or word format that provides for the identification of a control, switch, indicator, or gauge, or the display of information useful to the operator. [**1901,** 2016]

3.3.62 Lift. Pump lift is the vertical distance from the water surface to the centerline or eye of the impeller of the pump.

3.3.63 Line Voltage Circuit, Equipment, or System. An ac or dc electrical circuit, equipment, or system where the voltage to ground or from line to line is greater than 30 V rms (ac), 42.4 V peak (ac), or 60 V dc.

3.3.64 Low-Voltage Circuit, Equipment, or System. An electrical circuit, equipment, or system where the voltage does not exceed 30 V rms (ac), 42.4 peak (ac), or 60 V dc; usually 12 V dc in fire apparatus. [**1901,** 2016]

3.3.65 Manually Regulated Foam Proportioning System. A foam proportioning system that requires manual adjustment to maintain the proportioning ratio when there is a change of flow or pressure through the foam proportioner.

3.3.66 Manufacturer. The person or persons, company, firm, corporation, partnership, or other organization responsible for turning raw materials or components into a finished product. [**1901,** 2016]

3.3.67* Maximum Pump Close-Off Pressure. The maximum pump discharge pressure obtained with all discharge outlets closed, with the pump primed and running, with the pump drive engine operating at maximum obtainable speed, and with the pump intake pressure at atmospheric pressure or less. [**1901,** 2016]

3.3.68 Minimum Continuous Electrical Load. The electrical current required to continuously operate a defined set of electrical devices. [**1901,** 2016]

3.3.69 Miscellaneous Equipment. Portable tools and equipment carried on a fire apparatus not including suction hose, fire hose, ground ladders, fixed power sources, hose reels, cord reels, breathing air systems, or other major equipment or components permanently mounted on the apparatus. [**1901,** 2016]

3.3.70 Miscellaneous Equipment Allowance. That portion of the GVWR allocated for the weight of miscellaneous equipment and its mounting brackets, boards, or trays.

3.3.71 Momentary Switch. A switch that returns to the neutral position (off) when released. [**1901,** 2016]

3.3.72 National Hose Thread (NH). A standard screw thread that has dimensions for inside (female) and outside (male) fire hose connections as defined in NFPA 1963. [**1901,** 2016]

3.3.73* Net Pump Pressure. The sum of the discharge pressure and the suction lift converted to psi or kPa when pumping at draft, or the difference between the discharge pressure and the intake pressure when pumping from a hydrant or other source of water under positive pressure. [**1901,** 2016]

3.3.74 Nozzle Reaction. Force that occurs when a water stream is discharged from the nozzle. [**1901,** 2016]

3.3.75 NPSH (National Pipe Straight Hose Thread). National pipe straight hose coupling thread as specified in ASME B1.20.7, *Hose Coupling Screw Threads, Inch.*

3.3.76 NWCG. National Wildfire Coordinating Group.

3.3.77* Off-Road Use Vehicle. A vehicle designed to be used on other than paved or improved roads, especially in areas where no roads, poor roads, and steep grades exist and where natural hazards, such as rocks, stumps, and logs, protrude from the ground.

3.3.78 Operator's Panel. A panel containing gauges, switches, instruments, or controls where an operator can visually monitor the applicable functions. [**1901,** 2016]

3.3.79 Optical Center. The point specified by the optical warning device manufacturer of highest intensity when measuring the output of an optical warning device. [**1901,** 2016]

3.3.80 Optical Element. Any individual lamp or other light emitter within an optical source. [**1901,** 2016]

3.3.81 Optical Power. A unit of measure designated as candela-seconds/minute that combines the flash energy and flash rate of an optical source into one power measurement representing the true visual effectiveness of the emitted light. [**1901,** 2016]

3.3.82* Optical Source. Any single, independently mounted, light-emitting component in a lighting system. [**1901,** 2016]

3.3.83 Optical Warning Device. A manufactured assembly of one or more optical sources. [**1901,** 2016]

3.3.84 Personal Equipment Weight. A weight allowance for personal gear that is carried on the apparatus by each fire-fighting crew member.

3.3.85 Powered Equipment Rack. A power-operated device that is intended to provide storage of suction hoses, ground ladders, or other equipment, generally in a location above apparatus compartments. [**1901,** 2016]

3.3.86* Preconnected Hose Line. A hose line that is stored on the apparatus already connected to an outlet on a pump and that can be charged by the activation of one discharge valve. [**1901,** 2016]

3.3.87 Proper(ly). In accordance with the manufacturer's specifications or as recommended by the manufacturer. [**1901,** 2016]

3.3.88 psi. Pounds per square inch. [**1901,** 2016]

3.3.89 PTO. Power takeoff. [**1901,** 2016]

3.3.90 Pump Discharge Pressure Classification.

3.3.90.1 ***High Pressure.*** Pump discharge pressure from 500 psi (3500 kPa) to less than 1100 psi (7600 kPa). [**1901,** 2016]

3.3.90.2 ***Normal Pressure.*** Pump discharge pressure less than 500 psi (3500 kPa). [**1901,** 2016]

3.3.90.3 ***Ultra-High Pressure.*** Pump discharge pressure of 1100 psi (7600 kPa) or greater. [**1901,** 2016]

3.3.91 Pump and Roll. Process of discharging water while the vehicle is in motion.

3.3.92 Pump Operator's Panel. The area on a fire apparatus that contains the gauges, controls, and other instruments used for operating the pump. [**1901,** 2016]

3.3.93 Pump Operator's Position. The location from which the pump operator operates the pump. [**1901,** 2016]

3.3.94 Purchaser. The authority having responsibility for the specification and acceptance of the apparatus. [**1901,** 2016]

3.3.95 Purchasing Authority. The agency that has the sole responsibility and authority for negotiating, placing, and, where necessary, modifying each and every solicitation, purchase order, or other award issued by a governing body. [**1901,** 2016]

3.3.96 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by virtue of education, training, experience, or other special attributes possesses expertise regarding a particular subject matter, work, or project.

3.3.97 Ramp Breakover Angle. The angle measured between two lines tangent to the front and rear tire static loaded radius, and intersecting at a point on the underside of the vehicle that defines the largest ramp over which the vehicle can roll.

3.3.98 Rated Capacity (Water Pump). The flow rate to which the pump manufacturer certifies compliance of the pump when it is new. [**1901,** 2016]

3.3.99 Readily Accessible. Able to be located, reached, serviced, or removed without removing other components or parts of the apparatus and without the need to use special tools to open enclosures. [**1901,** 2016]

3.3.100 Rear Axle Track Width. The lateral distance between the centerlines of the tires at ground; if there are dual rear wheels, the lateral distance from the midway points between the inner and outer tires at ground. [**1901,** 2016]

3.3.101 Removable Winch. A winch with quick disconnects for power and controls that can be temporarily mounted on the apparatus at a permanently installed mounting receiver. [**1901,** 2016]

3.3.102 Reserve Capacity. The ability of a battery to sustain a minimum electrical load in the event of a charging system failure or a prolonged charging system deficit. [**1901,** 2016]

3.3.103 Reserved. The contents that would go in this section are not applicable to this document, but for consistency with other NFPA documents, the chapter, section, or subsection number is maintained.

3.3.104 Road Spray Location. Any underbody or underchassis location that is subject to road spray. [**1901,** 2016]

3.3.105 Sign. A visual indication whether in pictorial or word format that provides a warning to the operator or other persons near the apparatus. [**1901,** 2016]

3.3.106* Slip-On Fire-Fighting Module. A self-contained unit that includes an auxiliary-driven pump, piping, a tank, and hose storage and that is designed to be placed on a truck chassis, utility bed, flatbed, or trailer of sufficient carrying capacity.

3.3.107 Slow-Operating Valve. A valve that has a mechanism to prevent movement of the flow-regulating element from the fully closed position to the fully opened position or vice versa in less than 3 seconds. [**1901,** 2016]

3.3.108 Split Shaft PTO. A power takeoff (PTO) drive system that is inserted between the chassis transmission and the chassis drive axle and that has the shift mechanism necessary to direct the chassis engine power either to the drive axle or to a fire pump or other accessory. [**1901,** 2016]

3.3.109 Standard Cubic Feet per Minute (SCFM). An expression of airflow rate in which the airflow rate is corrected to standard temperature and pressure. Standard temperature is 60°F (15°C) and standard pressure is 14.696 psi (101.33 kPa) or 29.92 in. Hg (760 mm Hg).

3.3.110 Suction Hose. A hose that is designed to prevent collapse under vacuum conditions so that it can be used for drafting water from below the pump (lakes, rivers, wells, etc.). [**1961,** 2013]

3.3.111 Suction Lift. The sum of the vertical lift and the friction and entrance loss caused by the flow through the intake strainers and hose expressed in feet of water (meters of water) head. [**1901,** 2016]

3.3.112 Sump. A recessed area of a tank assembly designed primarily to entrap sludge or debris for removal and to serve as a central liquid collection point. [**1901,** 2016]

3.3.113 Supply Hose. Hose designed for the purpose of moving water between a pressurized water source and a pump that is supplying attack lines. [**1961,** 2013]

3.3.114 Swash Partition. A vertical wall within a tank structure designed to control the unwanted movement of the fluid within that tank. [**1901,** 2016]

3.3.115 Switch. Any set of contacts that interrupts or controls current flow through an electrical circuit. [**1901,** 2016]

3.3.116 Total Continuous Electrical Load. The total current required to operate all of the devices permanently connected to the apparatus that can be simultaneously energized excluding intermittent-type loads such as primers and booster reel rewind motors. [**1901,** 2016]

3.3.117 Tow Vehicle. A motor vehicle used to tow a trailer under emergency response conditions whether the tow vehicle–trailer combination is designed to remain together as a single unit or to be separated at the incident to allow the trailer to be used independently of the tow vehicle. [**1901,** 2016]

3.3.118 Trailer. A vehicle designed to be pulled by a tow vehicle and used to transport equipment or other vehicles under emergency response conditions. [**1901,** 2016]

3.3.119 Turning Clearance Radius. One-half the larger of the left or right full circle wall-to-wall turning diameter. [**1901,** 2016]

3.3.120 Ultimate Strength. The strength of a material in tension, compression, or shear, respectively, that is the maximum tensile, compressive, or shear stress that the material can sustain, calculated on the basis of the ultimate load and the original or unrestrained dimensions. [**1901,** 2016]

3.3.121 Unequipped Fire Apparatus. The completed fire apparatus excluding personnel, agent(s), and any equipment removable without the use of tools. [**1901,** 2016]

3.3.122 Vibration Isolation. Isolation materials used to prevent structure-borne vibrations from reaching attached surfaces. [**1901,** 2016]

3.3.123 Wet Location. A location on fire apparatus subject to saturation with water or other liquids and in unprotected locations exposed to the weather. *(See also 3.3.104, Road Spray Location.)* [**1901,** 2016]

3.3.124 Wildland Fire Crew Carrier Apparatus. Fire apparatus designed for transporting 10 or fewer personnel in the cab and crew compartment for the purpose of wildand fire suppression.

3.3.125 Wildland Fire Pump. A water pump that meets the requirements of Section 16.2 of NFPA 1906.

3.3.126 Wildland Fire Suppression Apparatus. Afire apparatus designed for fighting wildland fires that is equipped with a pump, a water tank, limited hose and equipment, and pump-and-roll capability.

3.3.127 Wildland Mobile Water Supply Apparatus (Wildland Water Tender). A fire apparatus designed for transporting water (pickup, transporting, and delivering) and fighting wildland fires on and off road that is equipped with a wildland fire pump, a water tank with minimum capacity of 1000 gal (4000 L), limited hose and equipment, and pump-and-roll capability.

Chapter 4 General Requirements

4.1 General.

4.1.1 All wildland fire apparatus shall meet the requirements of Chapters 1 through 4 and 12 through 15.

4.1.2 If a tow vehicle is to respond while calling for right-of-way under emergency conditions, it shall meet the requirements of 4.1.1. [**1901:**4.1.2]

4.2 Requirements by Apparatus Type. Certain chapters of this standard shall apply to the construction of each listed type of wildland apparatus, as shown in Table 4.2.

4.3 Responsibility of the Purchaser.

4.3.1* It shall be the responsibility of the purchaser to specify the details of the apparatus in addition to the requirements in NFPA 1906 needed by the manufacturer to build the apparatus, including:

(1) Requirements not uniquely specified in NFPA 1906, such as the type of apparatus desired.
(2) Any features of the apparatus desired in addition to, or in excess of, the requirements in NFPA 1906.

[**1901:**4.3.1]

4.4 Reserved.

4.5 Reserved.

4.6 Legal Requirements. The apparatus shall comply with all applicable federal and state or provincial laws and regulations. [**1901:**4.6]

4.7 Third-Party Certification of Test Results. Where this standard requires the results of tests to be certified by an independent third-party certification organization, that organization shall meet the requirements of this section. [**1901:**4.7]

4.7.1 All certification shall be performed by a certification organization that is accredited for inspection and testing systems on fire apparatus in accordance with ISO/IEC 17020, *General criteria for the operation of various types of bodies performing inspection*, or ISO/IEC 17065, *Conformity Assessment: Requirements for bodies certifying products, processes and services.* [**1901:**4.7.1]

4.7.2 The certification organization shall not be owned or controlled by manufacturers or vendors of the product that is being tested. [**1901:**4.7.2]

4.7.3 The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability. [**1901:**4.7.3]

4.7.4* The independent third-party organization shall witness all required tests by an in-person representative(s) at the test site or by use of verifiable automated data collection and image recording equipment. The third-party organization shall refuse to certify any test results for a system if all components of that system requiring testing do not pass the testing required by this standard. [**1901:**4.7.4]

4.7.5 There shall be no conditional, temporary, or partial certification of test results. [**1901:**4.7.5]

4.7.6* Forms or data sheets shall be provided and used during the testing. [**1901:**4.7.6]

Table 4.2 Chapter Requirements by Wildland Apparatus

Chapter	Wildland Fire Suppression Apparatus	Wildland Mobile Water Supply Fire Apparatus	Wildland Fire Crew Carrier Apparatus
1. Administration	Required	Required	Required
2. Referenced Publications	Required	Required	Required
3. Definitions	Required	Required	Required
4. General Requirements	Required	Required	Required
5. Wildland Fire Suppression Apparatus	Required	N/A	N/A
6. Reserved	N/A	N/A	N/A
7. Wildland Mobile Water Supply Fire Apparatus	N/A	Required	N/A
8. Reserved	N/A	N/A	N/A
9. Reserved	N/A	N/A	N/A
10. Wildland Fire Crew Carrier Apparatus	N/A	N/A	Required
11. Reserved	N/A	N/A	N/A
12. Chassis and Vehicle Components	Required	Required	Required
13. Low Voltage Electrical Systems and Warning Devices	Required	Required	Required
14. Driving and Crew Areas	Required	Required	Required
15. Body, Compartments, and Equipment Mounting	Required	Required	Required
16. Pumps for Wildland Fire Fighting and Associated Equipment	Required	Required	N/A
17. Reserved	N/A	N/A	N/A
18. Water Tanks	Required	Required	N/A
19. Reserved	N/A	N/A	N/A
20. Foam Proportioning Systems for Class A Foam Concentrate	If specified	If specified	N/A
21. Compressed Air Foam Systems (CAFS)	If specified	If specified	N/A
22. Line Voltage Electrical Systems	If specified	If specified	If specified
23. Reserved	N/A	N/A	N/A
24. Reserved	N/A	N/A	N/A
25. Winches	If specified	If specified	If specified
26. Reserved	N/A	N/A	N/A
27. Vehicle Protection Systems	If specified	If specified	If specified
28. Ultra-High Pressure	If specified	If specified	N/A

4.7.7 Programs shall be in place for training, proficiency testing, and performance verification of any staff involved with certification. [**1901:**4.7.7]

4.7.8 The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include provisions for the presentation of information from representatives of both sides of a controversy to a designated appeals panel. [**1901:**4.7.8]

4.8 Manufacturer Certification of Test Results. Where this standard requires the results of tests or the performance of a component to be certified by the manufacturer, the manufacturer shall meet the requirements of this section. [**1901:**4.8]

4.8.1 A representative of the manufacturer shall witness all tests and shall refuse to certify any test results for a system unless all components of that system requiring testing pass the testing required by this standard. [**1901:**4.8.1]

4.8.2 There shall be no conditional, temporary, or partial certification of test results. [**1901:**4.8.2]

4.8.3 The manufacturer shall have the facilities and equipment necessary to conduct the required testing, a program for the calibration of all instruments, and procedures to ensure the proper control of all testing. [**1901:**4.8.3]

4.8.4* Forms or data sheets shall be provided and used during the testing. [**1901:**4.8.4]

4.8.5 Programs shall be in place for training, proficiency testing, and performance verification of any personnel involved with certification. [**1901:**4.8.5]

4.8.6 An official of the company that manufactures or installs the product shall designate in writing who is qualified to witness tests and certify results. [**1901:**4.8.6]

4.8.7 Certification documentation shall be delivered with the apparatus, including results of the certification tests. [**1901:**4.8.7]

4.9 Personnel Protection.

4.9.1* Guards, shields, or other protection shall be provided where necessary in order to prevent injury of personnel by hot, moving, or rotating parts during nonmaintenance operations. [**1901:**4.9.1]

4.9.2 Electrical insulation or isolation shall be provided where necessary in order to prevent electrical shock from onboard electrical systems. [**1901:**4.9.2]

4.9.3 Vehicular workmanship shall ensure an operating environment free of accessible sharp projections and edges. [**1901:**4.9.3]

4.9.4* Safety signs with text shall conform to the general principles of ANSI/NEMA Z535.4, *Product Safety Signs and Labels*. Safety signs without text shall conform to the general principles for two-panel safety signs of ISO 9244, *Earth-moving machinery — Machine safety labels — General principles*. [**1901:**4.9.4]

4.9.4.1 Apparatus built for sale in the United States shall employ safety signage that complies with ANSI/NEMA Z535.4. [**1901:**4.9.4.1]

4.9.4.2 Apparatus built for sale outside the United States shall employ safety signage that complies with either ANSI/NEMA Z535.4 or ISO 9244. [**1901:**4.9.4.2]

4.9.4.3* Safety signs referenced in this standard beginning with the letters FAMA shall conform to the text and graphics of the referenced safety sign number found in FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*. [**1901:**4.9.4.3]

4.10 Controls and Instructions.

4.10.1 Illumination shall be provided for controls, switches, instruction plates, labels, gauges, and instruments necessary for the operation of the apparatus and the equipment provided on it. [**1901:**4.10.1]

4.10.1.1 If external illumination is provided, it shall be a minimum of 5 fc (50 lx) on the face of the device. [**1901:**4.10.1.1]

4.10.1.2 If internal illumination is provided, it shall be a minimum of 4 footlamberts (14 candela/m^2). [**1901:**4.10.1.2]

4.10.2* All required signs, instruction plates, and labels shall be permanent in nature and securely attached and shall meet the requirements of 4.9.4 and ANSI/UL 969, *Standard for Marking and Labeling Systems*. [**1901:**4.10.2]

4.10.2.1 The signs, instruction plates, and labels shall have resistance to damage from temperatures between –30°F and 176°F (–35°C and 80°C) and exposure to oil, fuel, water, hydraulic fluids, or other fluids used on the apparatus. [**1901:**4.10.2.1]

4.10.2.2 The exterior mounted labels relating to safety or critical operational instructions shall be reflective or illuminated as required by 4.10.1. [**1901:**4.10.2.2]

4.10.3 The centerline of any gauge or visual display required by this standard shall be no more than 84 in. (2130 mm) above the level where the operator stands to read the instrument. [**1901:**4.10.3]

4.10.4 The central midpoint or centerline of any control shall be no more than 72 in. (1830 mm) vertically above the ground (with vehicle at estimated in-service weight) or the platform that is designed to serve as the operator's standing position. [**1901:**4.10.4]

4.10.5 Controls Labeling. Where controls will be labeled using graphical symbols, they shall conform to the common graphical symbols found in FAMA TC008, *Graphical Symbols for Automotive Fire Apparatus*. [**1901:**4.10.5]

4.11 Reserved.

4.12 Component Protection.

4.12.1* Hydraulic hose lines, air system tubing, control cords, and electrical harnesses shall be mechanically attached to the frame or body structure of the apparatus. [**1901:**4.12.1]

4.12.2 The type of equipment described in 4.12.1 shall be furnished with protective looms, grommets, or other devices at each point where they pass through body panels or structural members or wherever they lie against a sharp metal edge. [**1901:**4.12.2]

4.12.3 A through-the-frame connector shall be permitted to be used in place of metal protective looms or grommets. [**1901:**4.12.3]

4.13 Vehicle Stability.

4.13.1* Rollover Stability. The apparatus shall meet the criteria defined in 4.13.1.1.

4.13.1.1 The apparatus shall meet the criterion defined in either of the following:

(1)* The apparatus shall remain stable in both directions in accordance with Table 4.13.1.1 when tested on a tilt table in accordance with SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*.

(2) The calculated or measured vertical center of gravity (VCG) divided by the rear axle track width shall not exceed the applicable criterion in Table 4.13.1.1.

4.13.1.1.1 Compliance shall be certified by testing, calculating, or measuring the apparatus or by comparing the apparatus to a compliant, substantially similar example apparatus, and the certification shall be delivered with the fire apparatus. [**1901:**4.13.1.1.1]

4.13.1.1.2 The example apparatus shall be considered substantially similar if it includes a chassis with the same or higher center of gravity (CG) height, the same or narrower rear axle track width, the same or greater water tank size and CG height, and the same type of front and rear suspension.

4.13.1.1.3 For purposes of 4.13.1.1, the apparatus shall be loaded with fuel, fire-fighting agents, hose, ladders, a weight of 250 lb (114 kg) in each seating position, and weight equivalent to the miscellaneous equipment allowance as defined in Table 12.1.2. [**1901:**4.13.1.1.3]

4.13.1.1.3.1 If the apparatus is designed to meet a specified higher equipment loading (e.g., a larger hose bed capacity) or to carry ground ladders or additional equipment, these greater loads shall be included in the testing, calculating, or measuring.

4.13.1.1.3.2 The weight added to the fire apparatus for the purpose of test, calculation, or measurement shall be distributed to approximate typical in-service use of the fire apparatus

Table 4.13.1.1 Vehicle GVWR

Vehicle GVWR	Tilt Criteria (degrees)	VCG/Track (percentage)
≤33,000 lb (15,000 kg)	30	75
>33,000 lb (15,000 kg)	27	80

while not exceeding the manufacturer's published individual compartment weight ratings. [**1901:**4.13.1.1.3.2]

4.13.2 Weight Distribution.

4.13.2.1* When the fire apparatus is loaded to its estimated in-service weight, the front-to-rear weight distribution shall be within the limits set by the chassis manufacturer. [**1901:**4.13.2.1]

4.13.2.2 The front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer, under full load and all other loading conditions. [**1901:**4.13.2.2]

4.13.3 Load Distribution.

4.13.3.1* The apparatus manufacturer shall calculate the load distribution for the apparatus and that load distribution plan shall be delivered with the fire apparatus. [**1901:**4.13.3.1]

4.13.3.2 The manufacturer shall engineer the fire apparatus to comply with the gross axle weight ratings (GAWR), the overall gross vehicle weight rating (GVWR), and the chassis manufacturer's load balance guidelines. [**1901:**4.13.3.2]

4.13.3.3* The fire apparatus, when loaded to its estimated in-service weight, shall have a side-to-side tire load variation of no more than 7 percent of the total tire load for that axle. [**1901:**4.13.3.3]

4.13.4* Each tire shall be equipped with a visual indicator or monitoring system that indicates tire pressure. [**1901:**4.13.4]

4.14 Fire Apparatus Performance.

4.14.1* The fire apparatus shall meet the requirements of this standard at elevations of 2000 ft (600 m) above sea level. [**1901:**4.14.1]

4.14.2* The fire apparatus shall meet all the requirements of this standard while stationary on a grade of 10 percent in any direction.

4.14.3* The fire apparatus shall meet the requirements of this standard in ambient temperature conditions between 32°F (0°C) and 110°F (43°C). [**1901:**4.14.3]

4.15 Highway Performance.

4.15.1 The apparatus, when loaded to its estimated in-service weight, shall be capable of the following performance while on dry, paved roads that are in good condition:

(1) Accelerating from 0 to 35 mph (55 km/hr) within 25 seconds on a 0 percent grade
(2)* Attaining a speed of 50 mph (80 km/hr) on a 0 percent grade
(3)* Maintaining a speed of at least 20 mph (32 km/hr) on any grade up to and including 6 percent.

[**1901:**4.15.1]

4.15.2* The maximum top speed of fire apparatus with a GVWR over 33,000 lb (11,800 kg) shall not exceed 68 mph (105 km/hr) or the manufacturer's maximum fire service speed rating for the tires installed on the apparatus, whichever is lower.

4.15.3 If the combined water tank and foam agent tank capacities on the fire apparatus exceed 1250 gal (4732 L), or the GVWR of the vehicle is over 50,000 lb (22,680 kg), the maximum top speed of the apparatus shall not exceed either 60 mph (85 km/hr) or the manufacturer's maximum fire service speed rating for the tires installed on the apparatus, whichever is lower. [**1901:**4.15.3]

4.15.4* The vehicle shall be capable of maneuvering across a 20 percent grade and up and down a 25 percent grade.

4.16 Serviceability.

4.16.1* The fire apparatus shall be designed so that all the manufacturer's recommended routine maintenance checks of lubricant and fluid levels can be performed by the operator without lifting the cab of a tilt-cab apparatus and without the need for hand tools. [**1901:**4.16.1]

4.16.2 Where special tools are required for routine service on any component of the apparatus, such tools shall be provided with the apparatus. [**1901:**4.16.2]

4.16.3 Apparatus components that interfere with repair or removal of other major components shall be attached with fasteners, such as cap screws and nuts, so that the components can be removed and installed with ordinary hand tools. These components shall not be welded or otherwise permanently secured into place. [**1901:**4.16.3]

4.17 General Pre-Delivery Tests.

4.17.1 Each apparatus shall be tested before delivery to verify that it meets the criteria in this section. [**1901:**4.17.1]

4.17.1.1 The tests shall be conducted at a location and in a manner that does not violate local, state or provincial, or federal traffic laws. [**1901:**4.17.1.1]

4.17.1.2 Tests shall be conducted on a dry, level, paved surface that is free of loose material, oil, or grease. [**1901:**4.17.1.2]

4.17.1.3 Tests shall be conducted with the water and foam tanks full (water or product). [**1901:**4.17.1.3]

4.17.2 The apparatus shall accelerate from 0 to 35 mph (55 km/hr) within 25 seconds. [**1901:**4.17.2]

4.17.3 The apparatus shall attain a speed of 50 mph (80 km/hr). [**1901:**4.17.3]

4.17.4 The auxiliary braking system, if so equipped, shall function as intended by the auxiliary braking system manufacturer. [**1901:**4.17.4]

4.17.5* The air service brakes shall bring the apparatus to a complete stop from a speed of 20 mph (32.2 km/hr) in a distance not exceeding 35 ft (10.7 m). [**1901:**4.17.5]

4.17.6 The hydraulic service brakes shall bring the apparatus to a complete stop from a speed of 30 mph (48.2 km/hr) in a distance not exceeding 88 ft (26.8 m). [**1901:**4.17.6]

4.18* Tests on Delivery. If acceptance tests are performed at the point of delivery, the tests shall not be performed in a manner that requires the apparatus or a component to operate outside its designed operating range.

4.19* Documentation. Any documentation delivered with the apparatus shall be permitted to be in printed format, electronic format, audiovisual format, or a combination thereof. [**1901:**4.19]

4.20 Data Required of the Contractor.

4.20.1 Fire Apparatus Documentation. The contractor shall supply, at the time of delivery, at least one copy of the following documents:

(1) The manufacturer's record of apparatus construction details, including the following information:
   (a) Owner's name and address
   (b) Apparatus manufacturer, model, and serial number
   (c) Chassis make, model, and serial number
   (d) GAWR of front and rear axles and GVWR
   (e) Front tire size and total rated capacity in pounds (kilograms)
   (f) Rear tire size and total rated capacity in pounds (kilograms)
   (g) Chassis weight distribution in pounds (kilograms) with water and manufacturer-mounted equipment (front and rear)
   (h) For each engine: make, model, serial number, rated horsepower and related speed, and governed speed; and if so equipped, engine transmission PTO(s) make, model, and gear ratio
   (i) Type of fuel and fuel tank capacity
   (j) Electrical system voltage and alternator output in amps
   (k) Battery make, model, and capacity in cold cranking amps (CCA)
   (l) Chassis transmission make, model, and serial number; and if so equipped, chassis transmission PTO(s) make, model, and gear ratio
   (m) Ratios of all driving axles
   (n) Maximum governed road speed
   (o) For each pump: make, model, rated capacity in gallons per minute (liters per minute where applicable), and serial number
   (p) For each pump transmission: make, model, serial number, and gear ratio
   (q) Reserved
   (r) Water tank certified capacity in gallons or liters
   (s) Reserved
   (t) Paint manufacturer and paint number(s)
   (u) Company name and signature of responsible company representative
   (v) Weight documents from a certified scale showing actual loading on the front axle, rear axle(s), and overall fire apparatus (with water tank full but without personnel, equipment, and hose)
(2) Reserved
(3) Certification of compliance of the optical warning system *(see 13.8.16*)
(4) Siren manufacturer's certification of siren (*see 13.9.1.1)*
(5) Written load analysis and results of the electrical system performance tests (*see 13.14.1 and Section 13.15*)
(6) Certification of slip resistance of all stepping, standing, and walking surfaces *(see 15.7.4.5)*
(7) The wildland fire pump manufacturer's certification of suction capability *(see 16.2.4.1)*
(8) If special conditions are specified by the purchaser of the wildland fire pump, the pump manufacturer's certification of suction capacity under the special conditions *(see 16.2.4.2)*
(9) A copy of the apparatus manufacturer's approval for stationary pumping applications of the wildland fire pump *(see 16.3.1)*
(10) Reserved
(11) For each pump, the pump manufacturer's certification of the hydrostatic test *(see 16.5.2.2)*
(12) For each pump, the certification of inspection and test for the pump *(see 16.13.1.2.4)*
(13) Reserved
(14) The certification of water tank capacity *(see Section 18.6)*
(15) Reserved
(16) Reserved
(17) If the apparatus has a foam proportioning system, the foam proportioning system manufacturer's certification of accuracy *(see 20.10.4.2)* and the final installer's certification that the foam proportioning system meets this standard *(see 20.11.2)*
(18) If the system has a CAFS, the documentation of the manufacturer's predelivery tests *(see Section 21.9)*
(19) If the apparatus has a line voltage power source, the certification of the test for the power source *(see NFPA 1901)*
(20) If the apparatus is equipped with an air system, air tank certificates *(see NFPA 1901, 24.5.1.2)*, the SCBA fill station certification *(see NFPA 1901, 24.9.7)*, and the results of the testing of the air system installation *(see NFPA 1901, 24.14.5 and NFPA 1901, 24.15.4)*
(21) Certification of vehicle side slope stability, including the weight distribution assumed for the calculations or as loaded on the vehicle for the tilt table test *(see 4.9.1)*
(22) Any other required manufacturer test data or reports

4.20.2 Operations and Service Documentation.

4.20.2.1 The contractor shall deliver with the fire apparatus at least two sets of complete operation and service documentation covering the completed apparatus as delivered and accepted. [**1901:**4.20.2.1]

4.20.2.2 The documentation shall address at least the inspection, service, and operations of the fire apparatus and all major components thereof. [**1901:**4.20.2.2]

4.20.2.3 The contractor shall also provide the following documentation for the entire apparatus and each major operating system or major component of the apparatus:

(1) Manufacturer's name and address
(2) Country of manufacture
(3) Source for service and technical information
(4) Parts replacement information
(5) Descriptions, specifications, and ratings of the chassis and pump
(6) Wiring diagrams for low-voltage and line voltage systems to include the following information:
   (a) Pictorial representations of circuit logic for all electrical components and wiring
   (b) Circuit identification
   (c) Connector pin identification
   (d) Zone location of electrical components
   (e) Safety interlocks
   (f) Alternator-battery power distribution circuits
   (g)* Input/output assignment sheets or equivalent circuit logic implemented in multiplexing systems
(7) Lubrication charts

(8) Operating instructions for the chassis and any major components such as the pump, and any auxiliary systems
(9) Reserved
(10) Instructions regarding the frequency and procedure for recommended maintenance
(11) Overall apparatus operating instructions
(12) Safety considerations
(13) Limitations of use
(14) Inspection procedures
(15) Recommended service procedures
(16) Troubleshooting guide
(17) Apparatus body, chassis, and other component manufacturer's warranties
(18) Special data required by this standard
(19) A material safety data sheet (MSDS) for any fluid that is specified for use on the apparatus

4.20.2.4* The contractor shall deliver with the apparatus all manufacturers' operations and service documents supplied with components and equipment that are installed or supplied by the contractor. [**1901:**4.20.2.4]

4.21 Statement of Exceptions. The entity responsible for final assembly of the apparatus shall deliver with the fire apparatus either a certification that the apparatus fully complies with all requirements of this standard or, alternatively, a Statement of Exceptions specifically describing each aspect of the completed apparatus that is not fully compliant with the requirements of this standard at the time of delivery. [**1901:**4.21]

4.21.1 The Statement of Exceptions shall contain, for each noncompliant aspect of the apparatus or missing required item, the following information:

(1) A separate specification of the section of the applicable standard for which compliance is lacking
(2) A description of the particular aspect of the apparatus that is not in compliance therewith or required equipment that is missing
(3) A description of the further changes or modifications to the delivered apparatus that must be completed to achieve full compliance
(4) Identification of the entity that will be responsible for making the necessary postdelivery changes or modifications or for supplying and installing any missing required equipment to the apparatus to achieve full compliance with this standard

[**1901:**4.21.1]

4.21.2 Prior to, or at the time of, delivery of the apparatus, the Statement of Exceptions shall be signed by an authorized agent of the entity responsible for final assembly of the apparatus and by an authorized agent of the purchasing entity, indicating mutual understanding and agreement between the parties regarding the substance thereof. [**1901:**4.21.2]

4.21.3* An apparatus that is delivered subject to a Statement of Exceptions shall be recognized as noncompliant by the purchaser. The purchaser either accepts the vehicle as noncompliant or accepts responsibility that the apparatus will not be placed in emergency service until the apparatus has been modified as necessary to be in full compliance with this standard.

Chapter 5 Wildland Fire Suppression Apparatus

5.1 General. If the apparatus is to function as a wildland fire suppression apparatus, it shall meet the requirements of this chapter.

5.2 Pump. The apparatus shall be equipped with a pump for wildland fire fighting that meets the requirements of Chapter 16 or a fire pump that meets the requirements of NFPA 1901.

5.3 Reserved.

5.4 Water Tank. The apparatus shall be equipped with a water tank(s) that meets the requirements of Chapter 18 and that has a minimum certified capacity (combined, if applicable) of 150 gal (600 L).

5.5* Equipment Storage. A minimum volume as shown in Table 5.5 of enclosed weather-resistant compartmentation that meets the requirements of Section 15.1 shall be provided for the storage of equipment.

5.6* Hose Storage. If the apparatus is equipped with a dedicated hose storage area(s), such area(s) shall comply with Section 15.10.

5.7 Equipment.

5.7.1 The following equipment shall be furnished by the contractor:

(1)* Two solid bottom wheel chocks, mounted in readily accessible locations, each designed to hold the apparatus, when loaded to its GVWR, on a 15 percent grade with the transmission in neutral and the parking brake released
(2) One set of tire tools, including a jack and a lug wrench, if a spare tire is carried on the apparatus

5.7.2* The following additional equipment shall be carried on the apparatus:

(1) One of the following traffic warning devices:
  (a) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retroreflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retroreflective white band 2 in. (51 mm) below the 6 in. (152 mm) band
  (b) One reflective triangle kit
(2) Five illuminated warning devices such as highway flares, unless the traffic cones or reflective triangles specified in 5.7.2(1) have illuminating capabilities
(3) One traffic vest for each seating position, each vest to comply with ANSI/ISEA 207, *Standard for High-Visibility Public Safety Vests*, and to have a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front

Table 5.5 Equipment Storage Requirements

Chassis GVWR		Storage Area	
lb	kg	ft^3	m^3
10,001–15,000	4,501–7,000	20	0.56
15,001–20,000	7,001–9,000	50	1.42
20,001–26,000	9,001–12,000	50	1.42
>26,000	>12,000	75	2.12

(4) One approved, dry chemical portable fire extinguisher with a minimum capacity in accordance with the following:
   (a) For a GVWR below 33,000 lb (15,000 kg), a 2A-10-B:C extinguisher
   (b) For a GVWR 33,000 lb (15,000 kg) and above, a 3A-40-B:C extinguisher
(5) One first-aid kit

5.7.3 A detailed list of who is to furnish the items and the method for orgainizing and mounting these items shall be supplied by the purchasing authority.

Chapter 6 Reserved

Chapter 7 Wildland Mobile Water Supply Fire Apparatus

7.1* General. If the apparatus is to function as a wildland mobile water supply apparatus, it shall meet the requirements of this chapter.

7.2 Pump. The apparatus shall be equipped with a pump for wildland fire fighting that meets the requirements of Chapter 16 or a fire pump that meets the requirements of NFPA 1901.

7.3 Reserved.

7.4 Water Tank. The apparatus shall be equipped with a water tank(s) that meets the requirements of Chapter 18 and that has a minimum certified capacity (combined, if applicable) of 1000 gal (4000 L).

7.5* Equipment Storage. A minimum of 20 ft^3 (0.57 m^3) of enclosed weather-resistant compartmentation that meets the requirements of Section 15.1 shall be provided for the storage of equipment.

7.6* Hose Storage.

7.6.1* The apparatus shall be equipped with a hose storage area that complies with Section 15.10.

7.6.2 Storage shall be provided to accommodate a minimum of 20 ft (6 m) of suction hose and 15 ft (4.5 m) of supply hose.

7.7 Equipment.

7.7.1 The following equipment shall be furnished by the contractor:

(1)* Two solid bottom wheel chocks, mounted in readily accessible locations, each designed to hold the apparatus, when loaded to its GVWR, on a 15 percent grade with the transmission in neutral and the parking brake released
(2) One set of tire tools, including a jack and a lug wrench, if a spare tire is carried on the apparatus

7.7.2* The following additional equipment shall be carried on the apparatus:

(1) One of the following traffic warning devices:
   (a) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retroreflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retroreflective white band 2 in. (51 mm) below the 6 in. (152 mm) band
   (b) One reflective triangle kit
(2) Five illuminated warning devices such as highway flares, unless the traffic cones or reflective triangles specified in 7.7.2(1) have illuminating capabilities
(3) One traffic vest for each seating position, each vest to comply with ANSI/ISEA 207, *Standard for High-Visibility Public Safety Vests*, and to have a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front
(4) One approved, dry chemical portable fire extinguisher with a minimum capacity in accordance with the following:
   (a) For a GVWR below 33,000 lb (15,000 kg), a 2A-10-B:C extinguisher
   (b) For a GVWR 33,000 lb (15,000 kg) and above, a 3A-40-B:C extinguisher
(5) One first-aid kit

7.7.3 A detailed list of who is to furnish the items and the method for organizing and mounting these items shall be supplied by the purchasing authority.

Chapter 8 Reserved

Chapter 9 Reserved

Chapter 10 Wildland Fire Crew Carrier Apparatus

10.1 General.

10.1.1 If the apparatus is to function as a wildand fire crew carrier apparatus, it shall meet the requirements of this chapter.

10.2 Equipment.

10.2.1 The following equipment shall be furnished by the contractor:

(1)* Two solid-bottom wheel chocks, mounted in readily accessible locations, each designed to hold the apparatus loaded to its GVWR, on a 15 percent grade, with the transmission in neutral, and the parking brake released
(2) One set of tire tools, including a jack and a lug wrench, if a spare tire is carried on the apparatus

10.2.2 The following additional equipment shall be carried on the apparatus:

(1) One of the following traffic warning devices:
   (a) Five fluorescent orange traffic cones not less than 28 in. (711 mm) in height, each equipped with a 6 in. (152 mm) retroreflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retroreflective white band 2 in. (51 mm) below the 6 in. (152 mm) band
   (b) One reflective triangle kit
(2) Five illuminated warning devices, such as highway flares, unless the traffic cones or reflective triangles specified in 10.2.2(1)have illuminating capabilities
(3) For each seating position, a traffic vest that complies with ANSI/ISEA 207, *Standard for High-Visibility Public Safety Vests,* and has a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front

(4) One approved, dry-chemical portable fire extinguisher with a minimum capacity in accordance with the following:
   (a) For a GVWR less than 33,000 lb (15,000 kg), a 2A-10-B:C extinguisher
   (b) For a GVWR of 33,000 lb (15,000 kg) or more, a 3A-40-B:C extinguisher
(5) One first-aid kit

10.2.3 A detailed list of who is to furnish the items and the method for organizing and mounting these items shall be supplied by the purchasing authority.

10.3* Crew Compartment. A crew compartment body separate from the main cab shall be utilized for transportation of wildland fire fighters.

10.3.1 Body Mounting. The crew compartment body shall be mounted per the allowed and/or recommended methods of the chassis manufacturer for off-highway use.

10.3.1.1 Body mounting shall allow independent movement between the body and the chassis frame.

10.3.1.2 An independent secondary retention system shall be furnished to prevent the crew compartment body from completely separating from the chassis frame if the primary retention system fails.

10.3.2 A minimum of 12 in. (300 mm) width of clear aisle walkway shall be provided.

10.3.3 Each internal storage compartment shall be permanently labeled with the load capacity. [**414:**4.13.10]

10.3.4 If separated, the cab and the crew compartment body bulkheads shall have an aligned opening of at least 150 in.^{2} (96,780 mm^2).

10.3.5 The body interior shall be free of all sharp projections and sharp corners.

10.4 Crew Compartment Body Structural Integrity.

10.4.1 Structural Integrity — Roof Loading.

10.4.1.1 The crew compartment body shall withstand a force equal to 2.5 times the curb weight of the vehicle applied to the roof of the vehicle's body structure, validated by testing a substantially similar crew compartment in accordance with 10.4.2.

10.4.1.2 The downward vertical movement at any point on the roof application plate shall not exceed 5.12 in. (130 mm). [**1917:**6.3.4]

10.4.1.3 Each exterior door of the vehicle and emergency escape windows shall be capable of opening and closing during the full application of the force and after release of the force.

10.4.1.4 No structural damage to any load bearing or supporting members (e.g., torn or broken material, broken welds, popped or sheared body rivets, bolts, and/or fasteners) shall be evident during the application of the force and after the release of the force. [**1917:**6.3.6]

10.4.2 Test Method – Roof Loading.

10.4.2.1 The following steps shall be performed during the roof crush test:

(1) Support the crew compartment on a rigid fixture independent of the vehicle suspension.
(2) Remove any components that extend upward from the vehicle roof.
(3) Measure and record the distance from the mounting surface to each of the four corners of the roof.
(4) Employ a rectangular force application plate fitted as near as possible to the contour of the crew compartment roof.
(5) Position the force application plate so that it is centered on the roof.
(6) Close all crew compartment doors.
(7) Load the application plate to 500 lb (227 kg) at a deflection rate less than 0.5 in. (13 mm) per second.
(8) Record elevation readings of all four corners of the roof.
(9) Load the application plate to 50 percent of the final load at a deflection rate less than 0.5 in. (13 mm) per second.
(10) Record elevation readings of all four corners of the roof.
(11) Load the application plate to 100 percent of the final load at a deflection rate less than 0.5 in. (13 mm) per second.
(12) Record elevation readings of all four corners of the roof.
(13) Verify that crew compartment doors and any emergency escape windows remain closed during the application of the load and are capable of being opened and closed.
(14) Remove load.
(15) Verify that crew compartment doors and any emergency escape windows remain closed after the application of the load and are capable of being opened and closed.

10.4.2.2 The application plate required in 10.4.2.1(4) shall be a minimum of 5 in. (127 mm) longer and 5 in. (127 mm) wider than the vehicle roof of the crew's compartment.

10.4.2.3 For the purposes of the measurements in 10.4.2.2, the crew compartment roof shall be that structure, seen in the top projected view, that coincides with the crew riding area, as shown in Figure 10.4.2.3.

10.4.3 Structural Integrity — Side Loading.

10.4.3.1 The crew compartment body shall withstand a force equal to 2.5 times the curb weight of the vehicle applied to either the driver or passenger side of the vehicle's body structure, validated by testing a substantially similar crew compartment in accordance with 10.4.4.

10.4.3.2 If so equipped, rear exterior doors and roof emergency escape hatches shall be capable of opening and closing during the full application of the force and after release of the force.

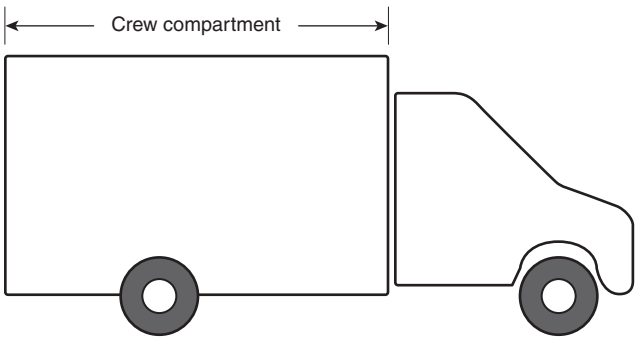


FIGURE 10.4.2.3 Crew Compartment Roof Measurement.

10.4.3.3 No structural damage to any load bearing or supporting members (e.g., torn or broken material, broken welds, popped or sheared body rivets, bolts, and/or fasteners) shall be evident during the application of the force and after the release of the force. [**1917:**6.3.6]

10.4.4 Test Method — Side Loading.

10.4.4.1 The following steps shall be performed during the side crush test:

(1) Place either side of the body of the crew carrier on a rigid horizontal surface so that the body of the crew compartment is entirely supported.
(2) Measure and record the distance from the mounting surface to each of the four top corners of the body side.
(3) Employ a rigid, rectangular force application plate fitted as near as possible to the contour of the crew compartment side.
(4) Position the force application plate so that it is centered on the crew compartment side.
(5) Close all crew compartment doors.
(6) Load the application plate to 500 lb (227 kg) at a deflection rate less than 0.5 in. (13 mm) per second.
(7) Record elevation readings of all four corners of the body side.
(8) Load the application plate to 50 percent of the final load at a deflection rate less than 0.5 in. (13 mm) per second.
(9) Record elevation readings of all four corners of the body side.
(10) Load the application plate to 100 percent of the final load at a deflection rate less than 0.5 in. (13 mm) per second.
(11) Record elevation readings of all four corners of the body side.
(12) Verify that rear exterior doors and any emergency roof escape hatches remain closed during the application of the load and are capable of being opened and closed.
(13) Remove load.
(14) Verify that rear exterior doors and any emergency roof escape hatches remain closed after the application of the load and are capable of being opened and closed.

10.4.4.2 The application plate required in 10.4.4.1(3) shall be a minimum of 5 in. (127 mm) longer and 5 in. (127 mm) wider than the vehicle side of the crew's compartment.

10.5 Crew Compartment Entry Doors.

10.5.1 The crew compartment shall be equipped with at least one primary access door opening with minimum dimensions of 28. in (710 mm) wide by 60 in.(1500 mm) high.

10.5.2 Door handles shall be designed and installed to protect against accidental or inadvertent opening. [**1917:**6.9.2]

10.5.3 Entry doors and door openings shall be designed to minimize inadvertent snagging of apparel. **[1917:**6.9.3]

10.5.4 When doors are open, the hinges and latches shall not protrude into the access area. [**1917:**6.9.5]

10.5.5 Doors shall be equipped with a hold-open device. [**1917:**6.9.6]

10.5.6 One externally operated lock for each door opening shall be provided. [**1917:**6.9.7]

10.5.7 An internal lock on each crew compartment primary entry door shall be provided.

10.5.8 All crew compartment entry door locks shall be identically keyed.

10.5.9 Doors shall be equipped with not less than 250 in.^{2} (160,000 mm^2) of safety glass area per door.

10.5.10 Doors and windows shall be designed to prevent leakage of exhaust fumes, dust, water, and air into the crew compartment.

10.6 Crew Compartment Body Means of Escape.

10.6.1 The crew compartment area shall have a minimum of four means of escape with at least one on the left side, right side, roof, and rear of the crew compartment.

10.7 Crew Compartment Seats.

10.7.1* All seats shall face fore or aft.

10.7.2 SCBA Storage. SCBA packs shall not be stored in the seat backs of seats in the crew compartment.

10.8 Crew Compartment Seat Head Height. The minimum vertical dimension from the seat H-point shall be 40 in. (1016 mm) to the ceiling for each belted seating position.

Chapter 11 Reserved

Chapter 12 Chassis and Vehicle Components

12.1* Carrying Capacity. The GAWR or GVWR of the chassis shall be adequate to carry the weight of the fire apparatus when loaded to its estimated in-service weight as defined in 12.1.2.

12.1.1 The manufacturer shall establish the estimated in-service weight during the design of the fire apparatus. [**1901:**12.1.1]

12.1.2 The estimated in-service weight shall include the following:

(1) Chassis, body, and tank(s)
(2) Full fuel, lubricant, and other chassis or component fluid tanks or reservoirs
(3) Full water and other agent tanks, if equipped
(4)* 250 lb (114 kg) in each seating position
(5)* Fixed equipment such as pumps, generators, reels, and air systems as installed
(6) Ground ladders, suction hose, designed hose load in their hose beds and on their reels
(7)* An allowance for miscellaneous equipment that is at least as great as the values shown in Table 12.1.2
(8)* If the apparatus is designed to accommodate SCBA, an additional 25 lb (11.4 kg) per seating position to the miscellaneous equipment allowance.

12.1.3 The manufacturer shall engineer and design the fire apparatus such that the completed apparatus, when loaded to its estimated in-service weight, with all movable weights distributed as close as is practical to their intended in-service configuration, does not exceed the GVWR. [**1901:**12.1.3]

12.1.4* A final manufacturer's certification of the GVWR or GCWR, along with a certification of the GAWR, shall be supplied on a label affixed to the vehicle. [**1901:**12.1.4]

Table 12.1.2 Minimum Miscellaneous Equipment Allowance

	Chassis GVWR		Equipment Weight	
	lb	kg	lb	kg
Wildland fire suppression apparatus	10,001–15,000	4,501– 7,000	200	90
	15,001–20,000	7,001–9,000	500	225
	20,001–26,000	9,001–12,000	500	225
	>26,000	>12,000	750	340
Wildland mobile water supply fire apparatus	All	All	200	90
Wildland fire crew carrier apparatus	≤19,500	≤8,845	500	225
	>19,500	>8,845	750	340

12.1.5 The fire apparatus manufacturer shall permanently affix a high-visibility label in a location visible to the driver while seated. [**1901:**12.1.5]

12.1.5.1* The label shall show the unladen height of the completed unequipped fire apparatus in feet and inches or in meters, the length of the completed fire apparatus in feet and inches or in meters, and the GVWR in tons or metric tons. [**1901:**12.1.5.1]

12.1.5.2 Wording on the label shall indicate that the information shown was current when the apparatus was manufactured and that, if the overall height changes while the vehicle is in service, the fire department must revise that dimension on the label.

12.2 Engine and Engine System Design.

12.2.1 Chassis Engine.

12.2.1.1* An engine governor or electronic fuel control system shall be installed that will limit the speed of the engine under all conditions of operation to that speed established by the engine manufacturer, which shall be the maximum governed speed. [**1901:**12.2.1.1]

12.2.1.2 Audible and visual warning devices that are visible from the driver's position shall be provided to alert the driver to high engine temperature or low oil pressure conditions. [**1901:**12.2.1.2]

12.2.1.3* Automatic engine shutdown systems shall not be permitted unless they are an integral part of the standard engine management system. [**1901:**12.2.1.3]

12.2.1.4 Engine derate programming shall be permitted to be used to protect the engine. [**1901:**12.2.1.4]

12.2.1.5 Engine Speed Auxiliary Control Device.

12.2.1.5.1* If the apparatus is equipped with an engine speed auxiliary control device, it shall comply with 12.2.1.5.2 and 12.2.1.5.3.

12.2.1.5.2* An interlock shall prevent the operation of the engine speed auxiliary control device unless the parking brake is engaged and the transmission is in neutral or park, or the parking brake is engaged and the engine is disengaged from the drive wheels. [**1901:**12.2.1.5.2]

12.2.1.5.3 The engine shall be prevented from regulating its own engine speed during times when engine rpm control is critical for consistent apparatus functions such as a generator or a water pump.

12.2.1.6 The installation of the engine, transmission, and engine- and transmission-driven accessories [power takeoffs (PTOs), etc.] shall meet the engine and transmission manufacturers' installation recommendations for the service intended. [**1901:**12.2.1.6]

12.2.2 Cooling System.

12.2.2.1* The engine's cooling system shall maintain a temperature in the engine at or below the engine manufacturer's maximum temperature rating under all conditions for which the apparatus is designed. [**1901:**12.2.2.1]

12.2.2.2 Drain Valves.

12.2.2.2.1 Readily accessible drain valves shall be installed at the lowest point of the cooling system and at such other points as are necessary to permit complete removal of the coolant from the system. [**1901:**12.2.2.2.1]

12.2.2.2.2* Drain valves shall be designed or positioned such that they will not open accidentally. [**1901:**12.2.2.2.2]

12.2.2.3 The radiator shall be mounted to prevent the development of leaks caused by twisting or straining where the apparatus operates over uneven ground. [**1901:**12.2.2.3]

12.2.3 Lubrication System.

12.2.3.1* The engine shall be provided with an oil filter of the type approved by the engine manufacturer. [**1901:**12.2.3.1]

12.2.3.2 The engine oil fill pipe shall be large enough and located so as to allow easy filling. [**1901:**12.2.3.2]

12.2.3.3 A permanent label in the driving compartment shall specify the quantity and type of the following fluids used in the vehicle and tire information:

(1) Engine oil
(2) Engine coolant
(3) Chassis transmission fluid
(4) Pump transmission lubrication fluid
(5) Pump priming system fluid, if applicable
(6) Drive axle(s) lubrication fluid
(7) Air-conditioning refrigerant

(8) Air-conditioning lubrication oil
(9) Power steering fluid
(10) Cab tilt mechanism fluid
(11) Transfer case fluid
(12) Equipment rack fluid
(13) CAFS air compressor system lubricant
(14) Generator system lubricant
(15)* Front tire cold pressure
(16)* Rear tire cold pressure
(17) Maximum tire speed ratings
[**1901:**12.2.3.3]

12.2.4* Air Intake System.

12.2.4.1* An air filter shall be provided in the engine's air intake system. [**1901:**12.2.4.1]

12.2.4.2 Air inlet restrictions shall not exceed the engine manufacturer's recommendations. [**1901:**12.2.4.2]

12.2.4.3* The air inlet shall be equipped with a means of separating water and burning embers from the air intake system. [**1901:**12.2.4.3]

12.2.4.4 The requirement in 12.2.4.3 shall be permitted to be achieved by either of the following methods:

(1) Provision of a device such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element
(2) Provision of a multiscreen ember separator capable of meeting the test requirements defined in the Parker Hannafin, Racor Division, publication LF 1093-90, *Ember Separation Test Procedure*, or an equivalent test

[**1901:**12.2.4.4]

12.2.4.5 An air restriction indicator shall be mounted in the driving compartment and visible to the driver. [**1901:**12.2.4.5]

12.2.5 Fuel System.

12.2.5.1 Diesel Engines.

12.2.5.1.1* The fuel supply lines and fuel filters shall meet the engine manufacturer's recommendations. [**1901:**12.2.5.1.1]

12.2.5.1.2 The filters or strainers shall be of a serviceable type and mounted in an accessible location. [**1901:**12.2.5.1.2]

12.2.5.1.3 Where two or more fuel lines are installed, separate fuel pumps operating in parallel with check valves and filtering devices shall be provided. [**1901:**12.2.5.1.3]

12.2.5.1.4 The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of an exhaust system. [**1901:**12.2.5.1.4]

12.2.5.1.5 The line(s) shall be protected from mechanical damage. [**1901:**12.2.5.1.5]

12.2.5.1.6 Electric Fuel Priming System.

12.2.5.1.6.1* Where an electric fuel priming system is furnished, the valving and piping shall be arranged so that the priming system can be operated only to reprime the fuel system. [**1901:**12.2.5.1.6.1]

12.2.5.1.6.2 When the priming system is not being intentionally operated, it shall be isolated from the fuel system and inoperable. [**1901:**12.2.5.1.6.2]

12.2.5.1.6.3 The priming system shall be marked with a label to indicate proper operation. [**1901:**12.2.5.1.6.3]

12.2.5.2 Gasoline Engines.

12.2.5.2.1 Fuel lines and filters or strainers that meet the engine manufacturer's recommendations shall be provided. [**1901:**12.2.5.2.1]

12.2.5.2.2 The filters or strainers shall be of a serviceable type and mounted in an accessible location. [**1901:**12.2.5.2.2]

12.2.5.2.3 Where two or more fuel lines are installed, separate fuel pumps operating in parallel with check valves and filtering devices shall be provided. [**1901:**12.2.5.2.3]

12.2.5.2.4 The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of an exhaust system. [**1901:**12.2.5.2.4]

12.2.5.2.5 The line(s) shall be protected from mechanical damage. [**1901:**12.2.5.2.5]

12.2.5.2.6 A gasoline feed system shall include an electric-powered fuel pump located within or adjacent to the fuel tank. [**1901:**12.2.5.2.6]

12.2.6 Exhaust System.

12.2.6.1* The exhaust piping and discharge outlet shall be located or shielded so as not to expose any portion of the apparatus or equipment to excessive heating. [**1901:**12.2.6.1]

12.2.6.2 Exhaust pipe discharge shall be directed away from the pump operator's position. [**1901:**12.2.6.2]

12.2.6.3 Reserved.

12.2.6.4 Silencing devices shall be provided. [**1901:**12.2.6.4]

12.2.6.5 Exhaust backpressure shall not exceed the limits specified by the engine manufacturer. [**1901:**12.2.6.5]

12.2.6.6 Where parts of the exhaust system are exposed so that they are likely to cause injury to operating personnel, protective guards shall be provided. [**1901:**12.2.6.6]

12.2.6.7* Diesel Particulate Filter. If the apparatus is driven by a diesel engine equipped with a diesel particulate filter (DPF), the requirements of 12.2.6.7.1 through 12.2.6.7.6 shall apply. [**1901:**12.2.6.7]

12.2.6.7.1 The regeneration process shall be activated by two methods:

(1)* Automatically by the engine system but only when the transmission is in gear and the speedometer indicates a speed above 5 mph (8 km/hr), whether the apparatus is in motion or is operating in stationary pump mode with an engine rpm sufficient to register 5 mph (8 km/hr) on the speedometer
(2) Manually when initiated by activation of a switch located in the driver's area of the driving compartment

[**1901:**12.2.6.7.1]

12.2.6.7.2 Instructions for initiating the manual regeneration process shall be explained in the apparatus operator's manual. [**1901:**12.2.6.7.2]

12.2.6.7.3* A switch shall be provided at the driver's area that will inhibit DPF regeneration until the switch is reset or the engine is shut down and restarted. [**1901:**12.2.6.7.3]

12.2.6.7.4 A DPF icon visible to the driver when seated in the driver's seat shall be illuminated to indicate that the DPF requires active regeneration. [**1901:**12.2.6.7.4]

12.2.6.7.5 A high exhaust system temperature (HEST) icon visible to the driver when seated in the driver's seat shall be illuminated to indicate that an active regeneration process has been initiated. [**1901:**12.2.6.7.5]

12.2.6.7.6* Engine exhaust gas temperature shall not exceed 851°F (455°C) when measured at the exit of the exhaust pipe during normal DPF regeneration. [**1901:**12.2.6.7.6]

12.3 Vehicle Components.

12.3.1 Braking System.

12.3.1.1 All brakes shall be readily accessible for adjustment. [**1901:**12.3.1.1]

12.3.1.2* Where air-actuated braking systems are provided, they shall include the following:

(1) An automatic moisture ejector
(2) An air drier
(3) A pressure protection valve to prevent air-operated accessories from drawing air from the air brake system when the air system's pressure drops below 80 psi (550 kPa)

12.3.1.3* Parking Brakes.

12.3.1.3.1 Parking brakes shall control the rear wheels, or all wheels, and shall be of the positive, mechanically actuated type. [**1901:**12.3.1.3.1]

12.3.1.3.2 A lockup device to retain applied pressure on hydraulically actuated service brake systems or the use of the "park" position on an automatic transmission shall not be substituted for a separate parking brake system. [**1901:**12.3.1.3.2]

12.3.1.4* Auxiliary Brake.

12.3.1.4.1 All apparatus with a GVWR of 36,000 lb (16,330 kg) or greater shall be equipped with an auxiliary braking system. [**1901:**12.3.1.4.1]

12.3.1.4.2* Auxiliary brakes shall have a switch to turn them off during adverse road conditions. [**1901:**12.3.1.4.2]

12.3.1.4.3 The DOT brake lights shall illuminate when the auxiliary brake is applied. [**1901:**12.3.1.4.3]

12.3.2 Suspension and Wheels.

12.3.2.1* Each load-bearing tire and rim of the fire apparatus shall not carry a weight in excess of the recommended load for the operation of truck tires of the size used, as published in *Tire and Rim Association — Year Book*, or as recommended by the tire manufacturer, when the apparatus is loaded to its GVWR. [**1901:**12.3.2.1]

12.3.2.2* Axle housings and any components other than wheels, tires, automatic tire chains, and items designed to swing clear shall clear the road surface by at least the ground clearance specified in Table 12.3.2.2.

12.3.2.3* An angle of approach and an angle of departure of at least 20 degrees shall be maintained at the front and the rear of the vehicle when it is loaded to the estimated in-service weight.

Table 12.3.2.2 Under-Vehicle Clearance

Chassis GVWR		Ground Clearance	
lb	kg	in.	mm
10,001–15,000	4,501–7,000	12	300
15,001–20,000	7,001–9,000	13	330
>20,000	>9,000	15	380

12.3.2.4 Clearance for tire chains shall be provided in accordance with SAE J683, *Tire Chain Clearance — Trucks, Buses (Except Suburban, Intercity, and Transit Buses), and Combinations of Vehicles*. [**1901:**12.3.2.4]

12.3.2.5 Steering.

12.3.2.5.1 The steering mechanism shall be capable of turning the front wheels to an angle of at least 30 degrees to either the right or left for nondriving front axles and at least 28 degrees for driving front axles. [**1901:**12.3.2.5.1]

12.3.2.5.2 Power steering or power-assisted steering shall be provided. [**1901:**12.3.2.5.2]

12.3.2.6 Reserved.

12.3.3* Transmission.

12.3.3.1 The transmission shall be rated for heavy-duty service and shall be designed to match engine torque and speed to the load demand. [**1901:**12.3.3.1]

12.3.3.2 The transmission shall provide the driver with the selection of individual gears or ranges of gears necessary to meet the performance requirements of this standard. [**1901:**12.3.3.2]

12.3.3.3* The power train shall allow the vehicle to function and operate smoothly at 2 mph (3.2 km/hr).

12.3.3.4* Apparatus with a front drive axle (4 × 4 or 6 × 6 configuration) shall include a visual indicator that is illuminated whenever the front drive axle is engaged.

12.3.4 Fuel Tanks.

12.3.4.1* The fuel capacity shall allow the engine to operate at 60 percent of gross engine horsepower for 2½ hours.

12.3.4.2 The tank fill opening shall be marked with a label indicating the type of fuel to be used. [**1901:**12.3.4.2]

12.3.4.3 Reserved.

12.3.4.4 The tank fill piping shall be placed so it is protected from mechanical damage during the normal use of the fire apparatus. [**1901:**12.3.4.4]

12.3.4.5 The tank and the fill piping shall be located or shielded so that they are not exposed to heat from an exhaust system or other source of ignition on the fire apparatus. [**1901:**12.3.4.5]

12.3.4.6 The tank shall be placed so it is removable for repairs. [**1901:**12.3.4.6]

12.3.4.7 Reserved.

12.3.4.8 Gasoline-fueled chassis shall have fuel withdrawal fittings above the normal fuel level.

12.3.5* **Tow Hooks.** Front and rear tow hooks or tow eyes shall be attached to the frame structure to allow towing (not lifting) of the apparatus without damage. [**1901:**12.3.5]

12.3.6 Towing Capability. If the apparatus is equipped for towing a trailer, the provisions of 12.3.6.1 through 12.3.6.5 shall apply. [**1901:**12.3.6]

12.3.6.1 For hydraulic brake–equipped,electric brake–equipped,or non-brake-equipped trailer towing capability, a primary electrical receptacle shall be provided near the hitch point and shall match the umbilical cable specified in 26.10.4.5 of NFPA 1901. [**1901:**12.3.6.1]

12.3.6.2 For air brake–equipped trailer towing capability, the following shall apply:

(1) A primary electrical receptacle shall be provided near the hitch point and shall match the umbilical cable specified in 26.10.4.4 of NFPA 1901.
(2) Gladhands shall be provided for air brake connections.

[**1901:**12.3.6.2]

12.3.6.3 An auxiliary electrical receptacle shall be provided near the hitch point and shall match the umbilical cable specified in 26.10.4.6 of NFPA 1901. [**1901:**12.3.6.3]

12.3.6.4 A label shall be provided in a location in which it is visible to an operator making trailer connections. The label shall state the maximum GVWR and tongue weight of the trailer that can be safely towed with the hitch system. [**1901:**12.3.6.4]

12.3.6.5 Two safety chain attachment points shall be provided near the hitch point for hitches designed to use safety chains, each designed with an ultimate strength of not less than the maximum GVWR specified on the label required in 12.3.6.4. [**1901:**12.3.6.5]

Chapter 13 Low-Voltage Electrical Systems and Warning Devices

13.1* **General.** Any low-voltage electrical systems or warning devices installed on the fire apparatus shall be appropriate for the mounting location and intended electrical load and shall meet the specific requirements of Chapter 13. [**1901:**13.1]

13.2 Wiring. All electrical circuit feeder wiring supplied and installed by the fire apparatus manufacturer shall meet the requirements of 13.2.1 through 13.2.8. [**1901:**13.2]

13.2.1* The circuit feeder wire shall be stranded copper or copper alloy conductors of a gauge rated to carry 125 percent of the maximum current for which the circuit is protected. [**1901**:13.2.1]

13.2.1.1 Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent. [**1901**:13.2.1.1]

13.2.1.2 The use of star washers for circuit ground connections shall not be permitted. [**1901**:13.2.1.2]

13.2.1.3 All circuits shall otherwise be wired in conformance with SAE J2202, *Heavy-Duty Wiring Systems for On Highway Trucks.*

13.2.2 Wiring and Wire Harness Construction.

13.2.2.1 All insulated wire and cable shall conform to SAE J1127, *Low Voltage Battery Cable,* or SAE J1128, *Low Voltage Primary Cable,* type SXL, GXL, or TXL. [**1901**:13.2.2.1]

13.2.2.1.1 All conductors shall be constructed in accordance with SAE J1127 or SAE J1128, except where good engineering practice dictates special strand construction. [**1901**:13.2.2.1.1]

13.2.2.1.2 Conductor materials and stranding, other than copper, shall be permitted if all applicable requirements for physical, electrical, and environmental conditions are met as dictated by the end application. [**1901**:13.2.2.1.2]

13.2.2.1.3 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127 or SAE J1128, except where good engineering practice dictates special conductor insulation. [**1901**:13.2.2.1.3]

13.2.2.2 The overall covering of conductors shall be moisture-resistant loom or braid that has a minimum continuous rating of 194°F (90°C) except where good engineering practice dictates special consideration for loom installations exposed to higher temperatures. [**1901**:13.2.2.2]

13.2.3 The overall covering of jacketed cables shall be moisture resistant and have a minimum continuous temperature rating of 194°F (90°C), except where good engineering practice dictates special consideration for cable installations exposed to higher temperatures. [**1901**:13.2.3]

13.2.4 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection. [**1901**:13.2.4]

13.2.4.1 The wiring connections and terminations shall be installed in accordance with the device manufacturer's instructions. [**1901**:13.2.4.1]

13.2.4.2 All ungrounded electrical terminals shall have protective covers or be in enclosures. [**1901**:13.2.4.2]

13.2.4.3 Wire nut, insulation displacement, and insulation piercing connections shall not be used. [**1901**:13.2.4.3]

13.2.5 Wiring shall be restrained to prevent damage caused by chafing or ice buildup, and protected against heat, liquid contaminants, or other environmental factors. [**1901**:13.2.5]

13.2.6* Wiring shall be uniquely identified at least every 2 ft (0.6 m) by color coding or permanent marking with a circuit function code. The identification shall reference a wiring diagram. *[See 4.20.2.3(6).]* [**1901**:13.2.6]

13.2.7 Circuits shall be provided with properly rated low voltage overcurrent protective devices. [**1901**:13.2.7]

13.2.7.1 Such devices shall be readily accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray. [**1901**:13.2.7.1]

13.2.7.2 Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices. [**1901**:13.2.7.2]

13.2.7.3 If a mechanical-type device is used, it shall conform to one of the following SAE standards:

(1) SAE J156, *Fusible Links*
(2) SAE J553, *Circuit Breakers*
(3) SAE J554, *Electric Fuses (Cartridge Type)*
(4) SAE J1888, *High Current Time Lag Electric Fuses*
(5) SAE J2077, *Miniature Blade Type Electrical Fuses*

[**1901**:13.2.7.3]

13.2.8 Switches, relays, terminals, and connectors shall have a direct current (dc) rating of 125 percent of maximum current for which the circuit is protected. [**1901**:13.2.8]

13.3 Power Supply.

13.3.1 A 12 V or greater electrical alternator shall be provided. [**1901**:13.3.1]

13.3.2* The alternator shall have a minimum output at idle to meet the minimum continuous electrical load of the fire apparatus as defined in 13.3.3, at 200°F (93°C) ambient temperature within the engine compartment, and shall be provided with full automatic regulation. [**1901**:13.3.2]

13.3.3 Minimum Continuous Electrical Load. The minimum continuous electrical load shall consist of the total amperage required to simultaneously operate the following in a stationary mode during emergency operations:

(1) The propulsion engine and transmission
(2) All legally required clearance and marker lights, headlights, and other electrical devices except windshield wipers and four-way hazard flashers
(3) The radio(s) at a duty cycle of 10 percent transmit and 90 percent receive (for calculation and testing purposes, a default value of 5 A continuous)
(4) The lighting necessary to produce 5 fc (50 lx) of illumination on all control and instrument panels
(5) The minimum optical warning system required in Section 13.8, where the apparatus is designed to call for or block the right-of-way
(6) The continuous electrical current required to simultaneously operate any water pumps and hydraulic pumps
(7)* Other warning devices and electrical loads that are designated as critical to the mission of the apparatus

13.3.4* The condition of the low-voltage electrical system shall be monitored by a warning system that provides both an audible and a visual signal to persons on, in, or near the apparatus of an impending electrical system failure caused by the excessive discharge of the battery set. [**1901**:13.3.4]

13.3.4.1 The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the electrical system voltage. [**1901**:13.3.4.1]

13.3.4.2 If electrical system voltage is monitored, the alarm shall sound if the system voltage at the battery drops below 11.8 V for 12 V nominal systems, 23.6 V for 24 V nominal systems, or 35.4 V for 42 V nominal systems for more than 120 seconds.

13.3.5 A voltmeter shall be mounted on the driver's instrument panel to allow direct observation of the system voltage. [**1901**:13.3.5]

13.3.6 Load Management.

13.3.6.1* If the total continuous electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 13.3.2, an automatic electrical load management system shall be required. [**1901**:13.3.6.1]

13.3.6.2 The minimum continuous electrical loads defined in 13.3.3 shall not be subject to automatic load management. [**1901**:13.3.6.2]

13.4* Batteries.

13.4.1 Batteries shall be of the high-cycle type. [**1901**:13.4.1]

13.4.2 With the engine off, the battery system shall be able to provide the minimum continuous electrical load for 10 minutes without discharging more than 50 percent of the reserve capacity and then to restart the engine. [**1901**:13.4.2]

13.4.3 The battery system cold cranking amps (CCA) rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer. [**1901**:13.4.3]

13.4.4 The batteries shall be mounted to prevent movement during fire apparatus operation and shall be protected against accumulations of road spray, snow, and road debris. [**1901**:13.4.4]

13.4.4.1 The batteries shall be readily accessible for examination, testing, and maintenance. [**1901**:13.4.4.1]

13.4.4.2 A means shall be provided for jump-starting the engine if the batteries are not accessible without lifting the cab of a tilt-cab apparatus. [**1901**:13.4.4.2]

13.4.4.3 Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes. [**1901**:13.4.4.3]

13.4.4.4* The batteries shall be protected against vibration and temperatures that exceed the battery manufacturer's recommendation. [**1901**:13.4.4.4]

13.4.5* If an onboard conditioner or charger is supplied, the associated line voltage electrical power system shall be installed in accordance with Chapter 22 of NFPA 1901.

13.4.6* One of the following master disconnect switches shall be provided:

(1) A master body disconnect switch that disconnects all electrical loads not provided by the chassis manufacturer
(2) A master load disconnect switch that disconnects all electrical loads on the apparatus except the starter

[**1901:**13.4.6]

13.4.6.1 The starter solenoids shall be connected directly to the batteries. [**1901**:13.4.6.1]

13.4.6.2 Electronic control systems and similar devices shall be permitted to be otherwise connected if so specified by their manufacturer. [**1901**:13.4.6.2]

13.4.6.3 The alternator shall be wired directly to the batteries through the ammeter shunt(s), if one is provided, and not through the master disconnect switch. [**1901:**13.4.6.3]

13.4.6.4* A green "master disconnect on" indicator that is visible from the driver's position shall be provided. [**1901:**13.4.6.4]

13.4.6.5 Rechargeable handlights, radios, and other similar devices shall be permitted to be connected to the electrical system ahead of the master load disconnect switch. [**1901:**13.4.6.5]

13.4.7* A sequential switching device shall be permitted to energize the optical warning devices required in 13.3.3 and other high current devices, provided the switching device shall first energize the electrical devices required in 13.3.3 within 5 seconds. [**1901**:13.4.7]

13.5 Starting Device.

13.5.1 An electrical starting device shall be provided for the engine. [**1901**:13.5.1]

13.5.2 When the electrical starting device is operating under maximum load, the voltage drop of the conductors between the battery and the starting device shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits.* [**1901**:13.5.2]

13.6 Temperature Exposure. Any alternator, electrical starting device, ignition wiring, distributor, or ignition coil shall be moisture resistant and protected such that it is not exposed to a temperature that exceeds the component manufacturer's recommendations. [**1901**:13.6]

13.7* Electromagnetic Interference. Electromagnetic interference suppression shall be provided, as required, to satisfy the radiation limits specified in SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz).* [**1901**:13.7]

13.8* Optical Warning Devices. Each apparatus that responds on public roads as an emergency vehicle by calling for or blocking the right-of-way from other traffic shall have a system of optical warning devices that meets or exceeds the requirements of this section; if the vehicle is not equipped to call for or block the right-of-way on a public highway, a sign shall be affixed on the dashboard that reads as follows: "This apparatus is not equipped to call for or block right-of-way on public highways."

13.8.1* The optical warning system shall consist of an upper and a lower warning level. [**1901**:13.8.1]

13.8.2 The requirements for each level shall be met by the warning devices in that particular level without consideration of the warning devices in the other level. [**1901**:13.8.2]

13.8.3 For the purposes of defining and measuring the required optical performance, the upper and lower warning levels shall be divided into four warning zones. [**1901**:13.8.3]

13.8.3.1 The four zones shall be determined by lines drawn through the geometric center of the apparatus at 45 degrees to a line drawn lengthwise through the geometric center of the apparatus. [**1901**:13.8.3.1]

13.8.3.2 The four zones shall be designated A, B, C, and D in a clockwise direction, with zone A to the front of the apparatus. *(See Figure 13.8.3.2.)* [**1901**:13.8.3.2]

13.8.4 Each optical warning device shall be installed on the apparatus and connected to the apparatus's electrical system in accordance with the requirements of this standard and the requirements of the manufacturer of the device. [**1901**:13.8.4]

13.8.5 A master optical warning system switch that energizes all the optical warning devices shall be provided. [**1901**:13.8.5]

13.8.6 The optical warning system on the fire apparatus shall be capable of two separate signaling modes during emergency operations. [**1901**:13.8.6]

13.8.6.1 One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way. [**1901**:13.8.6.1]

13.8.6.2 One mode shall signal that the apparatus is stopped and is blocking the right-of-way. [**1901**:13.8.6.2]

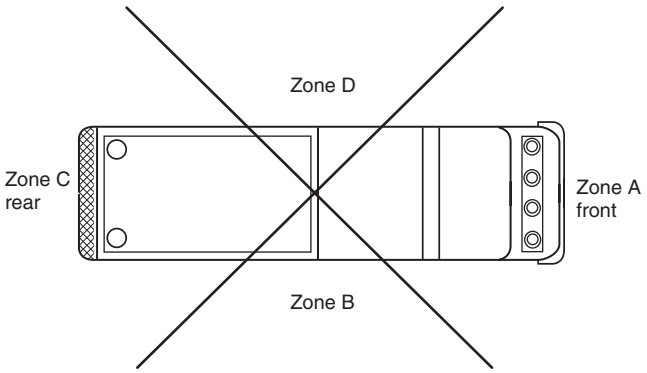


FIGURE 13.8.3.2 Warning Zones for Optical Warning Devices. [1901: Figure 13.8.3.2]

13.8.6.3 The use of some or all of the same warning lights shall be permitted for both modes, provided the other requirements of this chapter are met. [**1901**:13.8.6.3]

13.8.7 A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission. [**1901**:13.8.7]

13.8.7.1 When the master optical warning system switch is on and the parking brake is released or the automatic transmission is not in park, the warning devices signaling the call for the right-of-way shall be energized. [**1901:**13.8.7.1]

13.8.7.2 When the master optical warning system switch is on and the parking brake is on or the automatic transmission is in park, the warning devices signaling the blockage of the right-of-way shall be energized. [**1901:**13.8.7.2]

13.8.7.3* The system shall be permitted to have a method of modifying the two signaling modes. [**1901**:13.8.7.3]

13.8.8 The optical warning devices shall be constructed or arranged so as to avoid the projection of light, either directly or through mirrors, into any driving or crew compartment(s). [**1901**:13.8.8]

13.8.9 The front optical warning devices shall be placed so as to maintain the maximum possible separation from the headlights. [**1901:**13.8.9]

13.8.10 The optical sources on each level shall be of sufficient number and arranged so that failure of a single optical source does not create a measurement point in any zone on the same level as the failed optical source without a warning signal at a distance of 100 ft (30 m) from the geometric center of the apparatus. [**1901:**13.8.10]

13.8.11 Flash Rate.

13.8.11.1 The minimum flash rate of any optical source shall be 75 flashes per minute, and the minimum number of flashes at any measurement point shall be 150 flashes per minute. [**1901:**13.8.11.1]

13.8.11.1.1 Steadily burning, nonflashing optical sources shall be permitted to be used. [**1901:**13.8.11.1.1]

13.8.11.1.2 The optical energy provided by nonflashing optical sources shall not be included in the calculations of the zone's total optical power. [**1901**:13.8.11.1.2]

13.8.11.2 The flasher of any current-interrupted flashing device shall otherwise meet the requirements of SAE J1690, *Flashers*. [**1901**:13.8.11.2]

13.8.12* Color of Warning Lights.

13.8.12.1 Permissible colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 13.8.12.1. [**1901**:13.8.12.1]

13.8.12.2 All colors shall be as specified in SAE J578, *Color Specification*, for red, blue, yellow, or white. [**1901**:13.8.12.2]

13.8.13* Requirements for Large Apparatus.

13.8.13.1 If the apparatus has a bumper-to-bumper length of 25 ft (7.6 m) or more or has an optical center on any optical warning device greater than 8 ft (2.4 m) above level ground, the requirements of 13.8.13.2 through 13.8.13.6 shall apply. [**1901**:13.8.13.1]

13.8.13.2 Upper-Level Optical Warning Devices.

13.8.13.2.1 The upper-level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practical to define the clearance lines of the apparatus. [**1901**:13.8.13.2.1]

13.8.13.2.2 The upper-level optical warning devices shall not be mounted above the maximum height, specified by the device manufacturer, that gives an intensity value at 4 ft (1.2 m) above level ground and at 100 ft (30.5 m) from the optical warning device of less than 50 percent of that required at the optical center. [**1901:**13.8.13.2.2]

13.8.13.3 Lower-Level Optical Warning Devices.

13.8.13.3.1 To define the clearance lines of the apparatus, the optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted on or forward of the front axle centerline and as close to the front corner points of the apparatus as is practical. [**1901:**13.8.13.3.1]

13.8.13.3.2 The optical center of the lower-level optical warning devices at the rear of the vehicle shall be mounted on or behind the rear axle centerline and as close to the rear corners of the apparatus as is practical. [**1901:**13.8.13.3.2]

13.8.13.3.3 The optical center of any lower-level device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground. [**1901:**13.8.13.3.3]

13.8.13.4 Midship Optical Warning Devices.

13.8.13.4.1 A midship optical warning device shall be mounted on both the right and left sides of the apparatus if the distance between the front and rear lower-level optical devices exceeds 25 ft (7.6 m) at the optical center. [**1901:**13.8.13.4.1]

Table 13.8.12.1 Zone Colors

Color	Calling for Right-of-Way	Blocking Right-of-Way
Red	Any zone	Any zone
Blue	Any zone	Any zone
Yellow	Any zone except A	Any zone
White	Any zone except C	Not permitted

[**1901**: Table 13.8.12.1]

13.8.13.4.2 Additional midship optical warning devices shall be required, where necessary, to maintain a horizontal distance between the centers of adjacent lower-level optical warning devices of 25 ft (7.6 m) or less. [**1901:**13.8.13.4.2]

13.8.13.4.3 The optical center of any midship mounted optical warning device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground. [**1901:**13.8.13.4.3]

13.8.13.5* For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirements shown in Table 13.8.13.5. [**1901:**13.8.13.5]

13.8.13.6 No individual measurement point shall be less than that shown in Table 13.8.13.5. [**1901:**13.8.13.6]

13.8.14* Requirements for Small Apparatus.

13.8.14.1 If the apparatus has a bumper-to-bumper length of less than 25 ft (7.6 m) and has the optical center of all optical warning devices at 8 ft (2.4 m) or less above level ground, the requirements of 13.8.14.2 through 13.8.14.5 shall apply. [**1901:**13.8.14.1]

13.8.14.2 Upper-Level Optical Warning Devices.

13.8.14.2.1 The upper-level optical warning devices shall be mounted as high as practical, but not over 8 ft (2.4 m), at the optical center. [**1901:**13.8.14.2.1]

13.8.14.2.2 The upper-level optical warning devices shall be permitted to be combined in one or more enclosures and shall be permitted to be mounted on the cab roof or any other convenient point. [**1901**:13.8.14.2.2]

13.8.14.3 Lower-Level Optical Warning Devices.

13.8.14.3.1 One or more lower-level optical warning devices shall be visible from the front and the side of the apparatus. [**1901:**13.8.14.3.1]

13.8.14.3.2 The optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted on or forward of the front wheel centerline and as close to the front corner points of the apparatus as is practical. [**1901:**13.8.14.3.2]

13.8.14.3.3 The optical center of the device(s) shall be between 18 in. and 48 in. (460 mm and 1220 mm) above level ground. [**1901:**13.8.14.3.3]

13.8.14.4 For each operating mode, the combined optical power of all the optical sources mounted on both the upper and lower levels shall meet or exceed the zone's total optical power requirements shown in Table 13.8.14.4. [**1901:**13.8.14.4]

13.8.14.5 No individual measurement point shall be less than that shown in Table 13.8.14.4. [**1901:**13.8.14.5]

13.8.15 Tests of Optical Warning Devices.

13.8.15.1 Mechanical and Environmental Tests.

13.8.15.1.1 All optical warning devices shall be tested to the requirements of SAE J595, *Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*; SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*; or SAE J1889, *L.E.D. Signal and Marking Lighting Devices*. [**1901:**13.8.15.1.1]

Table 13.8.13.5 Minimum Optical Power Requirements for Large Apparatus

		Mode of Operation					
		Calling for Right-of-Way			Blocking Right-of-Way		
Zone	Level	*H* Total	At any *H* Point	At any Point 5 Degrees Up or 5 Degrees Down from *H*	*H* Total	At any *H* Point	At any Point 5 Degrees Up or 5 Degrees Down from *H*
A	Upper	1,000,000	10,000	3,500	400,000	10,000	3,500
B	Upper	400,000	10,000	3,500	400,000	10,000	3,500
C	Upper	400,000	10,000	3,500	800,000	10,000	3,500
D	Upper	400,000	10,000	3,500	400,000	10,000	3,500
A	Lower	150,000	3,750	1,300	150,000	3,750	1,300
B	Lower	150,000	3,750	1,300	150,000	3,750	1,300
C	Lower	150,000	3,750	1,300	150,000	3,750	1,300
D	Lower	150,000	3,750	1,300	150,000	3,750	1,300

Notes:
(1) All values are in candela-seconds/minute.
(2) *H* = Horizontal plane passing through the optical center.
(3) The values in the *H* Total columns are the total 19 data point values for each light, with data points on the boundary between zones counted in both zones.
[**1901:**Table 13.8.13.5]

Table 13.8.14.4 Minimum Optical Power Requirements for Small Apparatus

	Mode of Operation					
	Calling for Right-of-Way			Blocking Right-of-Way		
Zone	*H* Total	At any *H* Point	At Any Point 5 Degrees Up or 5 Degrees Down from *H*	*H* Total	At any *H* Point	At any Point 5 Degrees Up or 5 Degrees Down from *H*
A	1,000,000	10,000	3,500	400,000	10,000	3,500
B	200,000	8,000	3,500	200,000	8,000	3,500
C	400,000	10,000	3,500	800,000	10,000	3,500
D	200,000	8,000	3,500	200,000	8,000	3,500

Notes:
(1) All values are in candela-seconds/minute.
(2) *H* = horizontal plane passing through the optical center.
(3) The values in the *H* Total columns are the total 19 data point values for each light, with data points on the boundary between zones counted in both zones.
[**1901:**Table 13.8.14.4]

13.8.15.1.2 Optical devices and components designed for mounting only in weatherproof, interior spaces shall be tested in conformance with the applicable SAE standard listed in 13.8.15.1.1 and shall comply with the vibration test and the warpage test for plastic components. [**1901:**13.8.15.1.2]

13.8.15.1.3 Optical devices and components designed for mounting on the exterior of the apparatus or in nonweatherproof interior spaces shall be tested in conformance with SAE J845 and shall comply with the following performance requirements of that standard:

(1) Vibration
(2) Moisture
(3) Dust
(4) Corrosion
(5) High temperature
(6) Low temperature
(7) Durability
(8) Warpage

[**1901:**13.8.15.1.3]

13.8.15.2 Photometric Test Procedures for Optical Devices.

13.8.15.2.1 Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 13.8.15.2.2 through 13.8.15.2.5.2. [**1901:**13.8.15.2.1]

13.8.15.2.1.1 The results of the testing, and all required photometric data shall be available, upon request, from the optical warning device manufacturer.

13.8.15.2.1.2 The goniometer, integrating photometer, and other equipment used to take the test measurements shall meet the requirements of SAE J1330, *Photometry Laboratory Accuracy Guidelines*. [**1901:**13.8.15.2.1.2]

13.8.15.2.2 The optical source shall be mounted in a goniometer and operated as it would be in a normal system application. [**1901:**13.8.15.2.2]

13.8.15.2.2.1 The minimum distance between the light-emitting surface of the source being tested and the front face of the photometer detector shall be 59 ft (18 m). [**1901:**13.8.15.2.2.1]

13.8.15.2.2.2 The goniometer shall be oriented and the integrating photometer shall be set to integrate light pulses from the source for 20 seconds. [**1901:**13.8.15.2.2.2]

13.8.15.2.3 For all tests performed with the power applied, the lighting system, or component thereof, shall be operated at 12.8 V ± 0.1 V for 12 V nominal equipment, 25.6 V ± 0.2 V for 24 V nominal equipment, and 38.4 V ± 0.3 V for 42 V nominal equipment. [**1901:**13.8.15.2.3]

13.8.15.2.3.1 If the equipment is rated for operation on multiple voltages, the tests shall be performed at each of the rated voltages used by the equipment. [**1901:**13.8.15.2.3.1]

13.8.15.2.3.2 Voltage shall be measured at a point 12 in. ± 1 in. (300 mm ± 25 mm) from the entry into the component. [**1901:**13.8.15.2.3.2]

13.8.15.2.4 The technique described in 13.8.15.2.2 through 13.8.15.2.2.2 shall be performed along the horizontal plane that passes through the optical center, beginning at the optical center and repeated at 5-degree intervals to the left and to the right of the optical center throughout the active horizontal angle of light emission of the optical source. [**1901:**13.8.15.2.4]

13.8.15.2.5 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane that passes through the optical center, beginning at a point on the vertical plane passing through the optical center. [**1901:**13.8.15.2.5]

13.8.15.2.5.1 The measurements shall be repeated at 5 degree intervals to the left and to the right of this vertical plane throughout the active horizontal angle of light emission of the optical source. [**1901:**13.8.15.2.5.1]

13.8.15.2.5.2 If the optical warning device contains more than one optical source, the test shall be repeated for each optical source. [**1901:**13.8.15.2.5.2]

13.8.16* Compliance Documentation. The apparatus manufacturer shall demonstrate compliance of the warning system by one of the following methods:

(1) Certification that the system was installed within the geometric parameters specified by the manufacturer of the system, referencing the optical source test reports provided by the manufacturer of the system
(2) Certification that a mathematical calculation based on test reports for individual optical sources provided by the manufacturer of the devices and performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements of this standard
(3) Actual measurement of the lighting system after installation on the apparatus

[**1901:**13.8.16]

13.9 Audible Warning Devices.

13.9.1 Audible warning devices shall be provided.

13.9.1.1 At least one automotive traffic horn shall be provided.

13.9.1.2 If the apparatus responds as an emergency vehicle on public roads, one electric or electronic siren shall be provided.

13.9.1.2.1 The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*. [**1901:**13.9.1.1]

13.9.1.2.2* A means shall be provided to allow the activation of the siren within convenient reach of the driver. [**1901:**13.9.1.2]

13.9.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as is practical. [**1901:**13.9.2]

13.9.3 Audible warning equipment shall not be mounted on the roof of the apparatus. [**1901:**13.9.3]

13.10* Work Lighting. Any ground lighting, hose bed lighting, surface lighting, interior lighting, and compartment lighting shall meet the requirements of this section.

13.10.1 Reserved.

13.10.2 Reserved.

13.10.3 Reserved.

13.10.4 Reserved.

13.10.5 Reserved.

13.10.6 Reserved.

13.10.7 Reserved.

13.10.8 Testing. All work lights mounted in wet locations shall be tested in conformance with SAE J575, *Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less Than 2032 mm in Overall Width*, and shall comply with the following performance requirements of that standard:

(1) Vibration
(2) Moisture
(3) Dust
(4) Corrosion
(5) High temperature
(6) Low temperature
(7) Durability
(8) Warpage

[**1901:**13.10.8]

13.11 Reserved.

13.12* **Backup Alarm.** An electric or electronic backup alarm shall be provided that meets the Type D (87 dBA) requirements of SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*. [**1901:**13.12]

13.13 Stop, Tail, and Directional Lights.

13.13.1 The apparatus shall be equipped with all legally required stop, tail, and directional lights. [**1901:**13.13.1]

13.13.2 Directional lights shall be visible from the front, sides, and rear of the apparatus. [**1901:**13.13.2]

13.13.3 On apparatus 30 ft (10 m) or longer in length, a turn signal shall be mounted approximately midway along the apparatus at approximately running board height. [**1901:**13.13.3]

13.13.4 Equipment shall not be mounted in a manner that obscures the stop, tail, or directional lights. [**1901:**13.13.4]

13.14 Electrical System Performance Tests.

13.14.1* The fire apparatus low-voltage electrical system shall be tested as required by Section 13.14 and its subsections.

13.14.1.1 The test results shall be certified by the apparatus manufacturer.

13.14.1.2 The certification shall be delivered with the apparatus.

13.14.2 Tests shall be performed when the air temperature is between 0°F and 110°F (-18°C and 43°C). [**1901:**13.14.2]

13.14.3 Test Sequence.

13.14.3.1 The three tests defined in 13.14.3.2 through 13.14.3.4 shall be performed in the order in which they appear. [**1901:**13.14.3.1]

13.14.3.1.1 Before each test, the batteries shall be fully charged until the voltage stabilizes at the voltage regulator set point and the lowest charge current is maintained for 10 minutes. [**1901:**13.14.3.1.1]

13.14.3.1.2 Failure of any of these tests shall require a repeat of the sequence. [**1901:**13.14.3.1.2]

13.14.3.2 Reserve Capacity Test.

13.14.3.2.1 The engine shall be started and kept running until the engine and engine compartment temperatures are stabilized at normal operating temperatures and the battery system is fully charged. [**1901:**13.14.3.2.1]

13.14.3.2.2 The engine shall be shut off, and the minimum continuous electrical load shall be activated for 10 minutes. [**1901:**13.14.3.2.2]

13.14.3.2.3 All electrical loads shall be turned off prior to attempting to restart the engine. [**1901:**13.14.3.2.3]

13.14.3.2.4 The battery system shall then be capable of restarting the engine. [**1901:**13.14.3.2.4]

13.14.3.2.5 Failure to restart the engine shall be considered a test failure of the battery system. [**1901:**13.14.3.2.5]

13.14.3.3 Alternator Performance Test at Idle.

13.14.3.3.1 The minimum continuous electrical load shall be activated with the engine running at idle speed. [**1901:**13.14.3.3.1]

13.14.3.3.2 The engine temperature shall be stabilized at normal operating temperature. [**1901:**13.14.3.3.2]

13.14.3.3.3 The battery system shall be tested to detect the presence of battery discharge current. [**1901:**13.14.3.3.3]

13.14.3.3.4 The detection of battery discharge current shall be considered a test failure. [**1901:**13.14.3.3.4]

13.14.3.4 Alternator Performance Test at Full Load.

13.14.3.4.1 The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed. [**1901:**13.14.3.4.1]

13.14.3.4.2 The test duration shall be a minimum of 2 hours. [**1901:**13.14.3.4.2]

13.14.3.4.3 Activation of the load management system shall be permitted during this test. [**1901:**13.14.3.4.3]

13.14.3.4.4 An alarm sounded by excessive battery discharge as detected by the warning system required in 13.3.4, or a system voltage of less than 11.8 V dc for a 12 V nominal system, 23.6 V dc for a 24 V nominal system, or 35.4 V dc for a 42 V nominal system for more than 120 seconds, shall be considered a test failure. [**1901:**13.14.3.4.4]

13.14.4 Low-Voltage Alarm Test.

13.14.4.1 The following test shall be started with the engine off and the battery voltage at or above 12 V for a 12 V nominal system, 24 V for a 24 V nominal system, or 36 V for a 42 V nominal system. [**1901:**13.14.4.1]

13.14.4.2 With the engine shut off, the total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates. [**1901:**13.14.4.2]

13.14.4.3 The battery voltage shall be measured at the battery terminals. [**1901:**13.14.4.3]

13.14.4.4 The test shall be considered a failure if the alarm does not sound in less than 140 seconds after the voltage drops to 11.70 V for a 12 V nominal system, 23.4 V for a 24 V nominal system, or 35.1 V for a 42 V nominal system. [**1901:**13.14.4.4]

13.14.4.5 The battery system shall then be able to restart the engine. [**1901:**13.14.4.5]

13.14.4.6 Failure to restart the engine shall be considered a test failure. [**1901:**13.14.4.6]

13.15 Documentation. The manufacturer shall deliver the following with the fire apparatus:

(1) Documentation of the electrical system performance tests
(2) A written electrical load analysis, including the following:
    (a) The nameplate rating of the alternator
    (b) The alternator rating under the conditions specified in 13.3.2
    (c) Each of the component loads specified in 13.3.3 that make up the minimum continuous electrical load
    (d) Additional electrical loads that, when added to the minimum continuous electrical load, determine the total continuous electrical load
    (e) Each individual intermittent electrical load

[**1901:**13.15]

Chapter 14 Driving and Crew Areas

14.1 General.

14.1.1 Each crew riding position shall be within a fully enclosed personnel area except as provided in Section 14.4.

14.1.2 A label that states the number of personnel the vehicle is designed to carry shall be located in an area visible to the driver. [**1901**:14.1.2]

14.1.3* Each crew riding position shall be provided with a seat and an approved seat belt designed to accommodate a person with and without heavy clothing. [**1901**:14.1.3]

14.1.3.1* The effective seat belt web length for a Type 1 lap belt for pelvic restraint shall be a minimum of 60 in. (1525 mm) with the seat adjusted all the way back and down when measured using the following procedure:

(1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 14.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
(2) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
(3) Locate point C on line 1 at the outside of the seat on the receiver buckle side of the seat.
(4) Locate point D at the tip of thebuckle.
(5) Pull the seat belt webbing entirely out of the retractor and measure along the webbing between point A and the seat belt bucklelatch plate (tongue). Record this length as AD.
(6) Measure from point C to point D and record this length as CD.
(7) The effective seat belt web length equals AD + CD.

[**1901**:14.1.3.1]

14.1.3.2* A Type 2 seat belt shall have either a single retractor or dual retractors. A single retractor Type 2 pelvic and upper torso restraint-style seat belt assembly shall have a minimum effective seat belt web length of 110 in. (2800 mm) with the seat adjusted all the way back and down and when measured in accordance with 14.1.3.2.1. A dual retractor Type 2 pelvic and upper torso restraint-style seat belt assembly shall have a minimum effective shoulder belt web length of 50 in. (1270 mm) and a minimum effective lap belt web length of 60 in. (1530 mm) with the seat all the way back and down and as measured in 14.1.3.2.2. [**1901:**14.1.3.2]

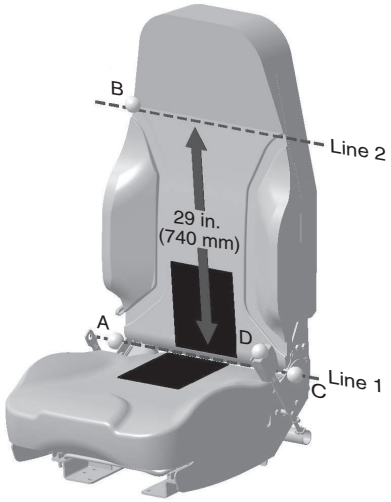


FIGURE 14.1.3.1 Dimension Lines for Measuring Seat Belt Effective Length. [1901: Figure 14.1.3.2]

14.1.3.2.1 Effective seat belt web length for a single retractor Type 2 seat belt shall be measured according to the following procedure:

(1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 14.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
(2) Locate an imaginary line parallel with line 1 and lying on the center of the seat back surface 29 in. (740 mm) from line 1 (line 2 in Figure 14.1.3.1).
(3) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
(4) Locate point B on line 2 at the shoulder strap edge of the seat back.
(5) Locate point C on line 1 at the outside of the seat on the buckle side of the seat.
(6) Locate point D at the tip of the buckle.
(7) Pull the seat belt webbing entirely out of the retractor and measure along the webbing between points A and B. Record this length as AB.
(8) Measure from point C to point D and record this length as CD.
(9) The effective seat belt web length equals AB + 2CD.

[**1901:**14.1.3.2.1]

14.1.3.2.2 Effective seat belt web length for a dual retractor Type 2 seat belt shall be measured according to the following procedure:

(1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 14.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
(2) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
(3) Locate point C on line 1 at the outside of the seat on the buckle side of the seat.
(4) Locate point D at the tip of the buckle.
(5) Pull the lap belt webbing entirely out of the lap belt retractor and measure along the webbing between point A and the seat belt latch plate (tongue). Record this length as AD.
(6) Locate an imaginary line parallel with line 1 and lying on the center of the seat back surface 29 in. (740 mm) from line 1 (line 2 in Figure 14.1.3.1).
(7) Locate point B on line 2 at the shoulder strap edge of the seat back.
(8) Pull the shoulder belt webbing entirely out of the shoulder belt retractor and measure along the webbing between point B and the seat belt latch plate (tongue). Record this length as BD.
(9) Measure from point C to Point D and record this length as CD.
(10) The effective lap belt web length equals AD + CD

(11) The effective shoulder belt web length equals BD + CD [**1901:**14.1.3.2.2]

14.1.3.2.3* In the case of a Type 2 seat belt, the distance from the buckle anchorage (point E in Figure 14.1.3.2.3) to the buckle tip (point D in Figure 14.1.3.2.3) shall be no more than 4 in. (102 mm) longer than the perpendicular distance from the buckle anchorage to a lateral axis through the H-point of the seat (line 3 in Figure 14.1.3.2.3) when the seat is adjusted to its lowest and most rearward position. [**1901:**14.1.3.2.3]

14.1.3.3 The seat belt webbing shall be bright red or bright orange in color, and the buckle portion of the seat belt shall be mounted on a rigid or semirigid stalk such that the buckle remains positioned in an accessible location. [**1901**:14.1.3.3]

14.1.3.4* The seat belt webbing color requirement of 14.1.3.3 shall not apply to vehicles with a GVWR of 19,500 lb (8,845 kg) or less. [**1901:**14.1.3.4]

14.1.3.5 All forward-facing seats adjacent to a side wall shall be provided with a Type 2 pelvic and upper torso restraint-style seat belt assembly. [**1901**:14.1.3.5]

14.1.3.6 Reserved.

14.1.3.7 Safety sign FAMA07, which warns of the importance of seat belt use shall be visible from each seat that is intended to be occupied while the vehicle is in motion. [**1901**:14.1.3.7]

14.1.3.8 Safety sign FAMA06 shall be visible from each seat that is not equipped with occupant restraint and therefore not intended to be occupied while the vehicle is in motion. [**1901:**14.1.3.8]

14.1.4 All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening. [**1901**:14.1.4]

14.1.5 Any door of the apparatus designed to allow persons to enter or exit the apparatus shall have at least 96 in.^{2} (62,000 mm^2) of retroreflective material affixed to the inside of the door. [**1901**:14.1.5]

14.1.6 At any seat location, the maximum noise level shall be 90 dBA without any warning devices in operation, as measured by the test procedure defined in 49 CFR 393.94(c), "Interior noise levels in power units test procedure," except that the test shall be performed with the vehicle traveling at a steady speed of 45 mph (72 km/hr) on a level, paved, smooth-surface road. [**1901:**14.1.6]

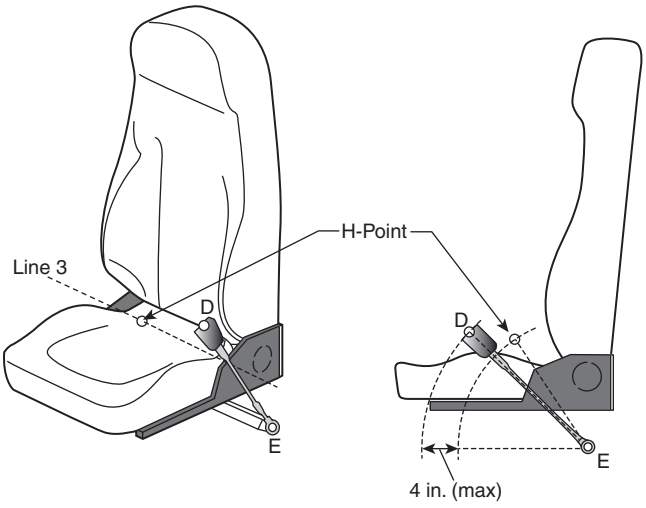


FIGURE 14.1.3.2.3 Dimension Lines for Measuring Buckle Length. [1901: Figure 14.1.3.2.3]

14.1.7 Seat Head Height.

14.1.7.1* The minimum vertical dimension from the seat H-point to the ceiling for each belted seating position shall be as follows:

(1) For suspension-style seats with independent height adjustment, the minimum vertical dimension shall be 37 in. (940 mm) measured with the height adjustment in its lowest position and the suspension inflated and/or raised to the upper limit of its travel.
(2) For suspension-style seats without independent height adjustment, the minimum vertical dimension shall be 37 in. (940 mm) measured with the suspension inflated and/or raised to the upper limit of its travel.
(3) For nonsuspension-style seats, the minimum vertical dimension shall be 35 in. (889 mm) measured with the seat adjusted to its lowest position.

[**1901**:14.1.8.1]

14.1.7.2 When independent vertical and/or horizontal seat adjustment is provided, it shall be fully adjustable within 10 seconds. [**1901:**14.1.8.2]

14.1.7.3 The seat-to-ceiling height shall be measured at the lowest surface in the area immediately above the projected area of the seat as it is moved through its horizontal travel with any soft headliner material depressed by hand. [**1901:**14.1.8.3]

14.1.7.4* The following statement shall be included in the operator's manual: "Warning: Serious head/neck injury can result from helmet use in cab. Do not wear helmet while seated unless necessary during suppression operations. Fire helmets are not designed for crash protection and they will interfere with the protection provided by head rests. Reduction of head clearance can increase the risk of spinal compression injury from roof contact. The use of seat belts is essential to protecting fire fighters during driving."

14.1.7.5 Safety sign FAMA43, which warns not to wear helmets while the vehicle is in motion, shall be visible from each seat that is intended to be occupied while the vehicle is in motion.

14.1.8 Seat Arrangement.

14.1.8.1 Each seating space shall have a minimum width of 22 in. (560 mm) at the shoulder level. [**1901**:14.1.9.1]

14.1.8.2 Seat cushions shall be a minimum of 18 in. (460 mm) in width and 15 in. (380 mm) from the front of the cushion to the face of the seat back. [**1901:**14.1.9.2]

14.1.8.3 A back cushion that extends from the face of the seat vertically at least 18 in. (460 mm) and that is a minimum of 18 in. (460 mm) wide at the base shall be provided. [**1901:**14.1.9.3]

14.1.8.3.1 The back cushion shall be permitted to be split to accommodate a fully recessed SCBA and bracket. [**1901:**14.1.9.3.1]

14.1.8.3.2 Where the back cushion is split to accommodate an SCBA, a headrest shall be supplied. [**1901:**14.1.9.3.2]

14.1.9 SCBA Mounting.

14.1.9.1* Where SCBA holders are mounted within a driving or crew compartment, they shall comply with the following:

(1) The SCBA holder shall retain a pack and bottle combination for the published weight rating of the holder when subjected to the dynamic force pulse per SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*.
(2) If the SCBA unit is mounted in a seatback, the release mechanism shall be accessible to the user while seated.
(3) Brackets that lock automatically either in the event of impact or when the parking brake is released, but are not locked at other times, shall be permitted.
(4)* The SCBA holder shall retain the bottle when subjected to the deceleration pulse at 0, 30, 90, and 180 degrees with respect to the direction of bottle extraction and in the horizontal plane.
(5) The SCBA holder shall retain the bottle when subjected to a deceleration pulse that exceeds 2 *g* for at least 60 ms in the vertical direction.
(6) The deceleration pulse shall meet the SAE J2418 deceleration profile with an accuracy of ±10% within the 35 to 95 ms range.
(7) The deceleration pulse shall be measured on a rigid portion of the base of the test fixture.
(8) The test component shall be retained in the holder during and after the dynamic test.
(9) The force required to extract the bottle after each test shall be no more than 125 percent of the initial extraction force.
(10) The SCBA holder shall be attached to the fixture in the same manner that it will be fastened to the seat or vehicle.
(11) The test bottle shall not move more than 3 in. relative to the frame of the holder during each test.
(12) The test fixture shall not allow the holder frame to move more than 3 in. relative to the base of the test sled.
(13) Each holder shall bear a label affixed by the holder manufacturer certifying compliance to these specifications.

[**1901:**14.1.9.1]

14.1.10 Equipment Mounting.

14.1.10.1 All equipment required to be used during an emergency response shall be securely fastened. [**1901:**14.1.11.1]

14.1.10.2 All equipment not required to be used during an emergency response, with the exception of SCBA units, shall not be mounted in a driving or crew area unless it is contained in an area capable of containing all contents when a 9 *g* force is applied in the longitudinal axis of the vehicle or a 3 *g* force is applied in any other direction, or the equipment is mounted in a bracket(s) that can contain the equipment when the equipment is subjected to those same forces.

14.1.10.3 Cab Equipment Mounting. Safety sign FAMA10, which warns of the need to secure items in the cab, shall be visible inside the cab. [**1901:**14.1.10.3]

14.1.11 Steps and access handrails that comply with 15.7.1 through 15.7.4.6, and Section 15.8 shall be provided as necessary for access to all driving and crew compartments. [**1901:**14.1.12]

14.1.12 Where the crew compartment and the driving compartment are separated, prohibiting direct voice communication, a two-way buzzer or two-way voice intercom system shall be provided. [**1901:**14.1.13]

14.1.13 Means of Escape.

14.1.13.1 Any interior area to be occupied by personnel shall have a minimum of two means of escape. [**1901:**14.1.14.1]

14.1.13.2 Each opening shall be a minimum of 24 in. × 24 in. (610 mm × 610 mm). [**1901:**14.1.14.2]

14.1.14 Fresh Air Intake. Fresh air intake for the HVAC system of an enclosed crew compartment shall be equipped with a means of separating burning embers from the air intake system such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the inside of the crew compartment.

14.2 Cab Tilt Systems. If the fire apparatus has a cab tilt system, the system shall meet the requirements of 14.2.1 through 14.2.3.2. [**1901:**14.2]

14.2.1 If the operation of the cab tilt system is accomplished by hydraulic means, the system shall be equipped with devices to prevent the motion of the cab in the event of any hydraulic hose failure. [**1901:**14.2.1]

14.2.2 If the cab has a powered tilting system, the system shall be interlocked to operate only when the parking brake is engaged and shall be configured so that the failure of a single component will not result in unintentional tilting of the cab. [**1901:**14.2.2]

14.2.3 The control of the cab tilt mechanism shall be accomplished clear of the cab travel area while still having the travel area in clear view. [**1901:**14.2.3]

14.2.3.1 A mechanical means shall be provided to hold the cab in a fully raised position. [**1901:**14.2.3.1]

14.2.3.2 If the cab is able to be raised to a defined intermediate position, a mechanical means shall also be provided to hold the cab in that intermediate position. [**1901:**14.2.3.2]

14.3 Driving Compartment.

14.3.1* A fully enclosed driving compartment with seating capacity for not fewer than two persons shall be provided.

14.3.2* Cabs on apparatus with a GVWR greater than 26,000 lb (11,800 kg) shall meet the requirements of one of the following sets of standards:

(1) SAE J2420, *COE Frontal Strength Evaluation —— Dynamic Loading Heavy Trucks,* and SAE J2422, *Cab Roof Strength Evaluation —— Quasi-Static Loading Heavy Trucks*
(2) ECE Regulation number 29, *Uniform Provisions Concerning the Approval of Vehicles with Regard to the Protection of the Occupants of the Cab of a Commercial Vehicle*

[**1901:**14.3.2]

14.3.3 Driver's Seat.

14.3.3.1 The driver's seat shall be readily adjustable by the driver. [**1901:**14.3.3.1]

14.3.4* The passenger side mirror shall be so mounted that the driver has a clear view of the mirror when the passengers are in their normal seated positions. [**1901:**14.3.4]

14.3.5 All primary rearview mirrors used by the driver shall be adjustable from the driver's position. [**1901:**14.3.5]

14.3.6 Instrumentation and Controls.

14.3.6.1 The following instrumentation and controls shall be mounted in the driving compartment and shall be identified and visible to the driver while seated:

(1) Speedometer
(2) Tachometer
(3) Odometer
(4) Oil pressure indicator or gauge
(5) Coolant temperature indicator or gauge
(6) Automatic transmission temperature indicator or gauge, if applicable and available
(7) Voltmeter
(8) Reserved
(9) Air pressure gauge(s), if applicable
(10) Turn signal control and indicator lights
(11) Headlight/DOT light switch
(12) High-beam headlight switch and indicator
(13) Fuel level gauge(s)
(14) Master ignition switch
(15) Heater/defroster controls
(16) Warning lights and siren switches
(17) Master disconnect switch
(18) "Master disconnect on" indicator light
(19) Windshield wipers and windshield washer control
(20) PTO-engaged indicator, if applicable
(21) Pump engagement controls, if applicable

14.3.6.2 Controls and switches that are expected to be operated by the driver while the apparatus is in motion shall be within convenient reach for the driver. [**1901:**14.3.6.2]

14.4* On-Board Pump-and-Roll Fire-Fighting Position.

14.4.1 If an on-board pump-and-roll fire fighting position as described in this section is provided it shall be on a wildland fire apparatus with a GVWR of no more than 19,500 lbs.

14.4.2 If an on-board pump-and-roll fire fighting position is provided, it shall include the following:

(1) A seat with an approved Type 1 seat belt for each fire-fighting position
(2) Controls required by the operator within reach without removing the seat belt
(3) A means of communication with the driver
(4) Safety sign FAMA44, which warns of riding safety procedures, and the maximum speed of 10 mph visible from the pump-and-roll fire-fighting position
(5) Safety sign FAMA45, which warns of driving safety procedures, and the maximum speed of 10 mph visible from the driver's position or visible to the driver while entering the cab

14.4.3 If the seating position is located outside the cab, it shall meet the:requirements in 14.4.3.1 through 14.4.3.6.

14.4.3.1 The seating position shall be located behind the cab and ahead of the rear axle.

14.4.3.2 A protective structure shall be provided in compliance with the side impact and crush criteria from SAE J1194,*Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors.*

14.4.3.3 A protective structure shall be designed to allow exit out of either side of the vehicle.

14.4.3.4* The protective structure shall include a perforated plate or mesh with openings no larger than 1.5 in. (3.8 cm) × 1.5 in. (3.8 cm) or other solid guard to protect from brush hazards at the front, the back, and the roof.

14.4.3.5 A door or gate with a latching mechanism shall be provided on each side of the vehicle designed to allow exit out of either side of the vehicle.

14.4.3.5.1 The door or gate shall be designed to prevent outward swing even in the event of failure of the latching mechanism.

14.4.3.5.2 The door or gate shall be at least 48 in. (1200 mm) high from the walking surface below the firefighter's feet.

14.4.3.5.3 The door or gate shall be constructed so there are no horizontal or vertical openings below the 48 in. (1200 mm) minimum height greater than 24 in. (610 mm) in either direction.

14.4.3.6 Equipment located within the protective structure shall meet the requirements of 14.1.10.

Chapter 15 Body, Compartments, and Equipment Mounting

15.1* Compartmentation.

15.1.1* Any enclosed external compartments shall be weather resistant and ventilated and have provisions for drainage.

15.1.2 All electrical junctions or wiring within compartments shall be protected from mechanical damage resulting from equipment stored in the compartment. [**1901:**15.1.2]

15.2 Reserved.

15.3 Equipment Containment.

15.3.1* Equipment holders or compartments shall be provided for all tools, equipment, and other items that are on the fire apparatus. [**1901:**15.3.1]

15.3.2* Equipment holders shall be attached and shall be designed so that equipment remains in place under all vehicle operating conditions. [**1901:**15.3.2]

15.3.3 All tools and equipment shall be readily accessible. [**1901:**15.3.3]

15.4 Powered Equipment Racks. When a powered equipment rack is provided, it shall meet the requirements of this section. [**1901:**15.4]

15.4.1 The equipment rack shall be constructed of materials that are capable of carrying the equipment that is intended to be mounted on the equipment rack. [**1901:**15.4.1]

15.4.2 A lock shall be provided that will retain the equipment rack in the road travel position when the vehicle is in motion.

15.4.3 An interlock shall be provided to prevent operation of the equipment rack unless the apparatus parking brake has been activated. [**1901:**15.4.3]

15.4.4 Controls shall be provided in a position where the operator can visually follow the travel of the equipment rack. [**1901:**15.4.4]

15.4.5 A visual signal shall be provided at the driver's position to indicate that the equipment rack is in motion, or in the down position, and that the parking brake is not engaged. [**1901:**15.4.5]

15.4.6 Flashing lights facing the front and rear of the apparatus shall be provided on the equipment rack and shall be illuminated whenever the equipment rack is in the down position. [**1901:**15.4.6]

15.4.7 The outward ends of the equipment rack that protrude beyond the body of the apparatus shall have retroreflective material to indicate a hazard or obstruction. [**1901:**15.4.7]

15.5* SCBA Storage. Storage of complete SCBA units or SCBA cylinders shall be arranged so as to prevent damage, injury, or abrasion to the SCBA from other equipment stored in the general area. [**1901:**15.5]

15.5.1 If an SCBA unit or cylinder is stored within a driving or crew compartment, the mounting shall comply with the requirements of Section 15.5 and 14.1.9. [**1901:**15.5.1]

15.5.2 If an SCBA cylinder is mounted in a vertical position with the valve down, it shall be supported with a brace or yoke under the cylinder or valve area to prevent downward movement. [**1901:**15.5.2]

15.5.3 The holding or clamping device shall not injure, wear, scrape, or otherwise affect the SCBA unit or cylinder, including damage to the paint or reflective finish, while the cylinder is being placed in, stored in, or removed from the holder. [**1901:**15.5.3]

15.5.4 The SCBA storage area shall be a ventilated, dry area away from all heat sources that could damage the SCBA (e.g., mufflers, engines). [**1901:**15.5.4]

15.5.5* Vertical Storage of SCBA Cylinders in Tubes.

15.5.5.1 The base of the storage tube shall have a rubber, plastic, or similar device to prevent wear on the cylinder and to prevent damage if the cylinder is accidentally dropped into the storage position. [**1901:**15.5.5.1]

15.5.5.2 Each storage tube shall have a drain to prevent accumulation of moisture. [**1901:**15.5.5.2]

15.5.6* Horizontal Storage of SCBA Cylinders.

15.5.6.1 The storage rack or tube assembly shall be designed to prevent the cylinder from accidentally sliding out of the storage rack or tube and shall be installed so as to keep the cylinder from hitting or rubbing on compartment doors, by preventing movement or shifting when in transit. [**1901:**15.5.6.1]

15.5.6.2 The rear wall of each SCBA storage area or tube shall be covered with a rubber, plastic, or similar material to prevent wear on cylinders. [**1901:**15.5.6.2]

15.6 Pump and Plumbing Access. If the water pump on the wildland fire apparatus is in an enclosed space, the requirements of 15.6.4 shall apply.

15.6.1 Reserved.

15.6.2 Reserved.

15.6.3 Reserved.

15.6.4 All valves, gauges, controls, pump, and other plumbing equipment shall be accessible for service and replacement.

15.7 Stepping, Standing, and Walking Surfaces.

15.7.1* Steps, platforms, or permanently attached access ladders shall be provided so that fire fighters have access to all working and storage areas of the fire apparatus. [**1901:**15.7.1]

15.7.1.1 The maximum stepping height shall not exceed 18 in. (460 mm), with the exception of the ground to first step, which shall not exceed 24 in. (610 mm) when the vehicle is loaded to its estimated in-service weight. [**1901:**15.7.1.1]

15.7.1.1.1 The maximum horizontal offset between steps shall not exceed 18 in. (460 mm). [**1901:**15.7.1.1.1]

15.7.1.1.2 Any step that decreases the specified approach or departure angle shall be designed to be movable so as not to be damaged when the vehicle traverses terrain that requires the full angle of approach or departure.

15.7.1.1.3 Reserved.

15.7.1.1.4 The ground-to-first-step height shall be determined with the apparatus on level ground. [**1901:**15.7.1.1.4]

15.7.1.2* All steps shall have a minimum area of 35 in.^{2} (22,580 mm^2), shall be of such a shape that a 5 in. (125 mm) diameter disk does not overlap any side when placed on the step, and shall be arranged to provide at least 6 in. (150 mm) of clearance between the leading edge of the step and any obstruction. [**1901:**15.7.1.2]

15.7.1.3 All platforms shall have a minimum depth of 8 in. (200 mm) from the leading edge of the platform to any obstruction. [**1901:**15.7.1.3]

15.7.1.4 All access ladders shall have at least 8 in. (200 mm) of clearance between the leading edge of any rung and the body of the fire apparatus or other obstruction. [**1901:**15.7.1.4]

15.7.1.5 Climbing Method Instruction. Safety sign FAMA23, which warns of the proper climbing method, shall be visible to personnel entering the cab and at each designated climbing location on the body. [**1901:**15.7.1.5]

15.7.1.6 Designated horizontal standing or walking surfaces higher than 48 in. (1220 mm) from the ground and not guarded by a railing or structure at least 12 in. (300 mm) high when measured with the apparatus at curb weight, shall have at least a 1 in. (25 mm) wide safety yellow or orange line delineation that contrasts with the background to mark the outside perimeter of the designated standing or walking surface area, excluding steps and ladders. [**1901:**15.7.1.6]

15.7.2 All steps, platforms, or access ladders shall be designed and installed to sustain a minimum static load of 500 lb (227 kg) without deformation. [**1901:**15.7.2]

15.7.3 Ladder rungs on access ladders shall have a skid-resistant surface or covering, but that surface or covering shall not be required to meet the slip resistance performance requirements of 15.7.4. [**1901:**15.7.3]

15.7.4* Slip Resistance.

15.7.4.1* All materials used for exterior surfaces designated as stepping, standing, and walking areas and all interior steps shall have a minimum slip resistance in any orientation of 0.68 when tested wet using the English XL tester in accordance with the manufacturer's instructions, or 0.52 when tested wet using the Brungraber Mark II tester in accordance with the manufacturer's instructions. [**1901:**15.7.4.1]

15.7.4.2 All materials used for interior floors shall have a minimum slip resistance in any orientation of 0.58 when tested dry using the English XL tester in accordance with the manufacturer's instructions or 0.47 when tested dry using the Brungraber Mark II tester in accordance with the manufacturer's instructions. [**1901:**15.7.4.2]

15.7.4.3 A standard Neolite® test sensor shall be used with both the English XL tester and the Brungraber Mark II tester. [**1901:**15.7.4.3]

15.7.4.4 Sampling Strategy.

15.7.4.4.1 For uniformly patterned materials, at least 16 readings shall be taken on each sample. [**1901:**15.7.4.4.1]

15.7.4.4.1.1 Each reading shall be taken 90 degrees clockwise from the previous orientation, resulting in at least four readings in each orientation. [**1901:**15.7.4.4.1.1]

15.7.4.4.1.2 The readings shall be averaged and reported as the slip resistance for the material. [**1901:**15.7.4.4.1.2]

15.7.4.4.2 For directionally patterned materials, at least 32 readings shall be taken on each sample. [**1901:**15.7.4.4.2]

15.7.4.4.2.1 Each reading shall be taken 45 degrees clockwise from the previous orientation, resulting in at least four readings in each orientation. [**1901:**15.7.4.4.2.1]

15.7.4.4.2.2 The four readings in each direction shall be averaged and reported as the slip resistance for the material in that orientation. [**1901:**15.7.4.4.2.2]

15.7.4.5 The contractor shall deliver with the fire apparatus a certification that all materials used for exterior surfaces designated as stepping, standing, and walking areas, all interior steps, and all interior floors meet the requirements of 15.7.4. [**1901:**15.7.4.5]

15.7.4.6 Where the fuel fill is located at or near a stepping surface, the surface shall be constructed of an open grate–type material to facilitate draining of accidentally spilled fuel to lessen any slipping hazard. [**1901:**15.7.4.6]

15.7.5 Safety sign FAMA24, which warns personnel not to ride on the vehicle, shall be located at the rear step areas and at any cross walkways. [**1901:**15.7.5]

15.8 Access Handrails or Handholds.

15.8.1 Access handrails or handholds shall be provided at each entrance to a driving or crew compartment and at each position where steps or ladders for climbing are located. [**1901:**15.8.1]

15.8.2 Exterior access handrails shall be constructed of or covered with a slip-resistant, noncorrosive material. [**1901:**15.8.2]

15.8.3 Exterior access handrails shall be between 1 in. and 1⅝ in. (25 mm and 42 mm) in diameter and have a minimum clearance between the handrails and any surface of at least 2 in. (50 mm). [**1901:**15.8.3]

15.8.4* All exterior access handrails shall be designed and mounted to reduce the possibility of hand slippage and to avoid snagging of hose, equipment, or clothing. [**1901:**15.8.4]

15.8.5 Handrails and handholds shall be constructed so that three points of contact (two hands and one foot, or one hand and two feet) can be maintained at all times while ascending and descending. [**1901:**15.8.5]

15.8.6* Access handrails supplied by the chassis manufacturer on a commercial chassis shall be permitted to be used to meet the requirements of this section. [**1901:**15.8.6]

15.9 Metal Finish.

15.9.1 Where dissimilar metals that pose a galvanic corrosion or reactive threat are to be mounted together, the mounting base material shall have an isolation barrier prior to assembly to prevent dissimilar metal reaction. [**1901:**15.9.1]

15.9.2* Painting.

15.9.2.1* All exposed ferrous metal surfaces that are not plated or stainless steel shall be cleaned and prepared and shall be painted or coated. [**1901:**15.9.2.1]

15.9.2.2 The paint or coating, including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendation. [**1901:**15.9.2.2]

15.9.3* Reflective Striping.

15.9.3.1* A retroreflective stripe(s) shall be affixed to all of the following:

(1) The side of the apparatus covering at least 50 percent of the cab and 50 percent of the body on each side, excluding the pump panel areas
(2) At least 25 percent of the width of the front of the apparatus (measured at the front of the vehicle, not including mirrors or other protrusions)
(3) At least 50 percent of the width of the rear-facing vertical surface of the apparatus calculated by considering any vertical surface within 36 in. (91 cm) forward of the rear bumper, visible from the rear of the apparatus, excluding any pump panel areas not covered by a door

15.9.3.1.1* The stripe or combination of stripes shall be a minimum of 4 in. (100 mm) in total width or as wide as possible if 4 inches (100 mm) of flat surface is not available.

15.9.3.1.2 The 4 in. (100 mm) wide stripe or combination of stripes shall be permitted to be interrupted by objects (e.g., receptacles, cracks between slats in roll-up doors) provided the full stripe is seen as conspicuous when the apparatus is being approached.

15.9.3.1.3 A graphic design shall be permitted to replace all or part of the required striping material if the design or combination thereof covers at least the same perimeter length(s) required by 15.9.3.1. [**1901:**15.9.3.1.3]

15.9.3.2 Reserved.

15.9.3.3 All retroreflective materials required by 15.9.3.1 shall conform to the requirements of ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1, for Type I Sheeting.

15.9.3.3.1 All retroreflective materials used to satisfy the requirements of 15.9.3.1 that are colors not listed in ASTM D4956, Section 6.1.1, shall have a minimum coefficient of retroreflection of 10 with observation angle of 0.2 degrees and entrance angle of -4 degrees. [**1901:**15.9.3.3.1]

15.9.3.3.2 Reserved.

15.9.3.3.3 Any printed or processed retroreflective film construction used to meet the requirements of 15.9.3.1 shall conform to the standards required of an integral colored film as specified in ASTM D4956, Section 6.1.1.

15.10* Hose Storage. If a hose storage area(s) is provided, it shall comply with this section. [**1901:**15.10]

15.10.1 The hose storage area shall be made from noncorrosive materials.

15.10.2* The bottom shall be constructed to prevent the accumulation of water and allow for ventilation to aid in drying hose. [**1901:**15.10.1]

15.10.3 The interior shall be smooth and free from all projections, such as nuts, sharp angles, or brackets, that might cause damage to the hose. [**1901:**15.10.2]

15.10.4 The interior of a hose storage area shall not be required to meet the slip resistance requirements given in 15.7.4. [**1901:**15.10.3]

15.10.5 Reels, handrails, ladders, and equipment holders shall be placed so as not to obstruct the laying or removal of hose from the storage area. [**1901:**15.10.4]

15.10.6* Any hose storage area shall be equipped with a positive means to prevent unintentional deployment of the hose from the top, sides, front, and rear of the hose storage area while the apparatus is underway in normal operations. [**1901:**15.10.5]

15.10.7 Hose Restraint Safety Sign. Safety sign FAMA22, which warns of the need to secure hose, shall be visible to personnel at each hose storage area. [**1901:**15.10.6]

15.10.8* If a hose reel is provided, it shall be equipped with a brake.

15.10.8.1 The hose reel shall have a capacity of not less than 100 ft (30 m) of ¾ in. (19 mm) booster hose.

15.10.8.2 When the reel is equipped with over 100 ft (30 m) of hose, the reel shall have power rewind capability.

15.11 Requirements for Mounting of Ground Ladders. If the apparatus is equipped with ground ladders, the mounting shall meet the requirements of 15.11.1 through 15.11.4.

15.11.1 Ground ladders shall be mounted and protected to prevent movement, abrasion, or other damage to the ground ladder while they are on the fire apparatus. [**1901:**15.11.1]

15.11.2 When mounted on the apparatus, ground ladders shall not be subject to exposure to heat sources (such as engine heat) of 212°F (100°C) or greater. [**1901:**15.11.2]

15.11.3 Ground ladders shall be supported to prevent any sagging or distortion while they are mounted on the fire apparatus. [**1901:**15.11.3]

15.11.4 The rollers and other moving parts of the frame holding the ground ladders on the apparatus shall be readily accessible to permit lubrication. [**1901:**15.11.4]

15.12* Receivers and Anchors for Rope and Removable Winches.

15.12.1 Receivers or anchors installed at any location on the apparatus for use as removable winch anchors shall be designed and affixed to provide at least a 2.0-to-1 straight line pull no-yield safety factor over the load rating of the removable winch. [**1901:**15.12.1]

15.12.2 Receivers or anchors installed at any location on the apparatus for use with rope operations shall be designed and affixed to the apparatus to provide at least a 9000 lbf (40,000 N) no-yield condition with a straight line pull. [**1901:**15.12.2]

15.12.3 Safety sign FAMA28 shall be located on or near each receiver or anchor stating the maximum straight line pull rating. [**1901:**15.12.3]

15.13 Slip-On Fire-Fighting Module. If the pump, piping, and tank are built as a slip-on, self-contained unit, it shall meet the requirements of 15.13.1 through 15.13.3 and shall be mounted on the fire apparatus in accordance with 15.13.4. [**1901:**15.13]

15.13.1 The major components of the slip-on module, including the pump, pumping engine, water and agent tank(s), plumbing system, and electrical system, shall meet the requirements of the applicable chapters of this standard covering those components. [**1901:**15.13.1]

15.13.2 Intake and discharge piping shall not interfere with the routine maintenance of the pump, engine, or auxiliary systems and shall not unduly restrict the servicing of these components. [**1901:**15.13.2]

15.13.3 The manufacturer of a slip-on fire-fighting module shall provide the following data with the module:

(1) Weight without water but with all other tanks or reservoirs for liquids full
(2) Weight full with water and other liquids, including foam concentrate, fuel, and lubricants
(3) Horizontal center of gravity when full with water and other liquids
(4) Overall dimensions

[**1901:**15.13.3]

15.13.4 Mounting.

15.13.4.1 The slip-on module shall be mounted in a manner that allows access to the engine, pump, and auxiliary systems for routine maintenance. [**1901:**15.13.4.1]

15.13.4.2 The slip-on module shall be removable using common hand tools. [**1901:**15.13.4.2]

15.13.4.3 The slip-on module shall be mounted in a manner that prevents damage by vibration. [**1901:**15.13.4.3]

15.13.4.4* Special anchorage shall be provided on the vehicle chassis and on the slip-on fire-fighting module to secure the fire-fighting module to the vehicle chassis. [**1901:**15.13.4.4]

15.13.4.5 The anchorage described in 15.13.4.4 shall be designed to prevent movement of the slip-on module during rapid acceleration, deceleration, or side-hill operations. [**1901:**15.13.4.5]

15.13.4.6 Drilling on chassis frame flanges or welding to chassis frame shall not be permitted. [**1901:**15.13.4.6]

Chapter 16 Pumps for Wildland Fire Fighting and Associated Equipment

16.1 Application.

16.1.1 If the apparatus is equipped witha pump, the wildland fire apparatus shall include a wildland fire pump as defined in Section 16.2 through 16.13.11.4.4 or a fire pump as defined in NFPA 1901.

16.1.2 The purchaser shall refer to the standards applicable to the pump selected.

16.2 Design and Performance Requirements.

16.2.1* One or more wildland fire pumps shall be mounted on the apparatus and rated at one or more of the ratings in Table 16.2.1.

16.2.2 The apparatus shall be designed for pump and roll operations.

16.2.2.1* The vehicle drive engine and drive train shall be arranged so that the pump can deliver at least 20 gpm (80 L/min) at a gauge pressure of 80 psi (550 kPa), while the fire apparatus is moving at 2 mph (3.2 km/hr) or less.

16.2.3 Pumping System Capability.

16.2.3.1 Reserved.

16.2.3.2 Reserved.

16.2.3.3* When dry, the pump system in both parallel and series operation where pumps are of the parallel/series type shall be capable of taking suction under the conditions specified in 16.2.4.1 through 20 ft (6 m) of suction hose of the size specified in Table 16.2.4.1(a) and a strainer and discharging water in not more than 30 seconds.

Table 16.2.1 Wildland Fire Apparatus Pump Rating Chart

Minimum Pump Pressure		Minimum Rated Capacity or Flow Rate	
psi	kPa	gpm	L/min
100	700	50	200
		150	600
150	1000	50	200
		250	1000
250	1700	50	200
		150	600
300	2000	200	800
400	2800	30	120

16.2.3.4 Vacuum.

16.2.3.4.1 The completed pumping system shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) at altitudes up to 2000 ft (600 m) by means of the pump priming system and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (34 kPa).

16.2.3.4.2 The requirement in 16.2.3.4.1 shall be met with all intake valves open, with all intakes capped or plugged, with all discharge caps removed and valves closed, and without the use of the pump primer during the 5-minute period. [**1901**:16.2.3.4.2]

16.2.3.4.3 The requirement in 16.2.3.4.1 shall also be met with the intake valves closed and caps or plugs removed.

16.2.3.4.4 An automatic method shall be provided to prevent the loss of vacuum through the priming system when the priming device is not being operated.

16.2.3.4.4.1 A manual method shall be provided to shut off the priming system to prevent loss of vacuum, to prevent backflow, and to prevent outflow when the priming device is not in use.

16.2.3.4.4.2 If the automatic method to shut off the priming system prevents flow in both directions, a separate manual method shall not be required.

16.2.3.4.4.3 The method used to shut off the priming device shall be permitted to be a separate device controlled by the primary control.

16.2.3.4.5 Pump intake plumbing shall be capable of withstanding a minimum vacuum of 30 in. Hg (101.6 kPa) without becoming deformed.

16.2.4 Pumping Suction Capability.

16.2.4.1 The pump manufacturer shall certify that the pump can deliver its rated capacity at rated net pump pressure from draft, under the following conditions:

(1) At an altitude of 2000 ft (600 m) above sea level
(2) Through a single intake with 20 ft (6 m) of suction hose of the size specified in Table 16.2.4.1(a) and equipped with a suction hose strainer
(3) With a lift of 10 ft (3 m)
(4) At 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level)
(5) At a water temperature of 60°F (16°C)
(6) At the entrance and friction loss for the 20 ft (6 m) of suction hose and strainer listed in Table 16.2.4.1(b) or at the entrance and friction loss for the 6 m of suction hose and strainer listed in Table 16.2.4.1(c).

Table 16.2.4.1(a) Suction Hose Size by Pump Capacity Rating

Flow Rate		Suction Hose Size	
gpm	L/min	in.	mm
30	120	1½	38
50	200	2	52
150	600	2½	65
200	800	2½	65
250	1000	3	75

Table 16.2.4.1(b) Entrance and Friction Loss in 20 ft of Suction Hose, Including Strainer (inch-pound units)

	Suction Hose Size (in.)									
	1½		2		2½		3		4	
Flow Rate (gpm)	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
30	2.7	2.38	0.75	0.66						
50			1.7	1.50	0.5	0.44				
150					4.5	3.97	1.9	1.64		
200					8.0	7.06	3.3	2.91	0.8	0.71
250					13.0	11.47	5.2	4.59	1.3	1.1

Table 16.2.4.1(c) Entrance and Friction Loss in 6 m of Suction Hose, Including Strainer (SI Units)

	Suction Hose Size (mm)									
	38		52		65		75		100	
Flow Rate (L/min)	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
120	0.82	8.1	0.23	2.2						
200			0.52	5.1	0.15	1.5				
600			2.83	27.8	0.91	9.0				
800					2.44	23.9	1.01	9.9	0.24	2.4
1000					3.96	38.9	1.58	15.5	0.4	4

16.2.4.2* The pump manufacturer shall certify that the pump is capable of pumping rated capacity at rated net pump pressure from draft at any of the following special conditions when these conditions are specified by the purchaser:

(1) At an elevation above 2000 ft (600 m)
(2) At lifts higher than 10 ft (3 m), through more than 20 ft (6 m) of suction hose, or both

16.3 Pump Engine Requirements.

16.3.1 The apparatus manufacturer shall approve the use of the pumping engine for stationary pumping applications based on the size of the fire apparatus and the rating of the pump being furnished. [**1901**:16.3.1]

16.3.2 Reserved.

16.3.3 Reserved.

16.3.4 Reserved.

16.3.5 Reserved.

16.3.6 Reserved.

16.3.7 Engine and Engine System Design. If a separate pump engine drives the pump, that engine shall meet the requirements of 16.3.7.1 through 16.3.7.3.

16.3.7.1* An engine governor or electronic fuel control system shall be installed that will limit the speed of the engine under all conditions of operation to that speed established by the engine manufacturer, which shall be the maximum governed speed.

16.3.7.2* Automatic engine shutdown systems shall be permitted if they are an integral part of the standard engine management system.

16.3.7.3 Automatic engine shutdown systems shall be permitted to automatically shut down the pump drive engine when the pump is out of water, provided the system is manually armed.

16.3.8 Cooling System.

16.3.8.1 The engine shall be air cooled or liquid cooled with a self-contained cooling system.

16.3.8.2 The engine's cooling system shall maintain a temperature in the engine at or below the engine manufacturer's maximum temperature rating under all conditions for which the fire apparatus is designed.

16.3.8.3 If the engine is liquid cooled, the cooling system shall meet the requirements of 16.3.8.3.1 through 16.3.8.3.4.

16.3.8.3.1 If the cooling system is equipped with drain valves, they shall be installed at the lowest point of the cooling system.

16.3.8.3.2* Drain valves shall be designed or positioned such that they will not open accidentally.

16.3.8.3.3 The radiator shall be mounted to prevent the development of leaks caused by twisting or straining where the apparatus operates over uneven ground.

16.3.8.3.4 A coolant temperature gauge or high-temperature indicator light shall be provided.

16.3.9 Lubrication System.

16.3.9.1 The engine oil fill-pipe shall be large enough and located so as to allow easy filling.

16.3.9.2 If the pump drive engine has a positive pressure lubrication system, a low–oil pressure indicator or oil pressure

gauge shall be provided that is visible from the pump operator's position.

16.3.9.3 Clearance or an extension shall be provided so the engine oil can be drained and captured.

16.3.10 Fuel and Air System.

16.3.10.1 Diesel Engines.

16.3.10.1.1 Air Intake System.

16.3.10.1.1.1* An air filter shall be provided in the engine's air intake system.

16.3.10.1.1.2 Air inlet restrictions shall not exceed the engine manufacturer's recommendations.

16.3.10.1.1.3 For engines greater than 35 hp (26 kW), if approved by the engine manufacturer, the air inlet shall be equipped with a means of separating water and burning embers from the air intake system such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element.

16.3.10.1.2* The fuel supply lines and fuel filters shall meet the engine manufacturer's recommendations.

16.3.10.1.3 Electric Fuel Priming System.

16.3.10.1.3.1* Where an electric fuel priming system is furnished, the valving and piping shall be arranged and marked with a label so that it can be operated only to reprime the fuel system.

16.3.10.1.3.2 When the electric fuel priming system is not being intentionally operated, it shall be isolated from the fuel system and inoperable.

16.3.10.1.3.3 The priming system shall be marked with a label to indicate proper operation.

16.3.10.2 Gasoline Engines.

16.3.10.2.1 Air Intake System.

16.3.10.2.1.1* An air filter shall be provided in the engine's intake air system.

16.3.10.2.1.2 Air inlet restrictions shall not exceed the engine manufacturer's recommendations.

16.3.10.2.1.3 For engines greater than 35 hp (26 kW), if approved by the engine manufacturer, the air inlet shall be equipped with a means of separating water and burning embers from the air intake system such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element.

16.3.10.2.2 Fuel System.

16.3.10.2.2.1 All fuel lines and all filters or strainers shall meet the engine manufacturer's recommendations.

16.3.10.2.2.2 The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of a vehicle exhaust system.

16.3.10.2.2.3 The line(s) shall be protected from mechanical damage.

16.3.11 Exhaust System.

16.3.11.1 The exhaust piping and its discharge shall be located so as not to expose any portion of the apparatus to excessive heating.

16.3.11.2* Exhaust pipe discharge shall be directed away from the pump operator's position.

16.3.11.3 The exhaust system shall meet the requirements of USDA Forest Service specifications 5100-1 unless 100 percent of the exhaust gases pass through a turbo charger.

16.3.11.4 Exhaust backpressure shall not exceed the limits specified by the engine manufacturer.

16.3.12 Engine Controls.

16.3.12.1* A nonkeyed switch to start or stop the pump engine shall be furnished and shall be located at the pump operator's position.

16.3.12.2 The engine speed shall be permitted to be controlled by an automatic speed controller or a manually adjustable throttle.

16.3.12.2.1 A hand throttle of a type that holds its set position shall be provided where the pump drive engine is not equipped with an automatic throttle control system to control the engine speed.

16.3.12.2.2 Where provided, the throttle shall be located so that it can be manipulated from the pump operator's position with all instrumentation in full view.

16.3.13 Electrical System and Devices.

16.3.13.1 The electrical system on the pump engine shall meet the requirements of Section 13.2.

16.3.13.2 Where a separate battery(s) is provided, the requirements of 16.3.13.2.1 through 16.3.13.2.4 shall apply.

16.3.13.2.1 A built-in means to charge the battery(s) shall be provided.

16.3.13.2.2 The charging system shall have an output adequate to meet the continuous anticipated electrical load of the engine and starting system as manufactured, at 200°F (93°C) operating temperature (within any engine enclosure, if applicable).

16.3.13.2.3 The charging system shall be provided with full automatic regulation.

16.3.13.2.4 The batteries shall meet the requirements of 13.4.4 through 13.4.4.4.

16.3.13.3* Battery power for the separate engine-driven pump shall be permitted to be supplied from the chassis battery(ies).

16.3.14 Starting Device.

16.3.14.1 An electrical starting device shall be provided.

16.3.14.2 The characteristics of the electrical starting device shall be such that, when operating under maximum load, the voltage drop of the conductors shall be in accordance with SAE J541.

16.3.15* Fuel Tanks.

16.3.15.1 The fuel tank(s) shall be of sufficient size to permit operation of the pump at its rated capacity and pressure for at least 1 hour without refilling.

16.3.15.2* The pump engine shall be permitted to draw fuel from the chassis fuel tank, when done in accordance with the chassis manufacturer's recommendation.

16.3.15.3 Each fuel tank shall be labeled near the fill opening to indicate the type of fuel.

16.4 Power Train Capability.

16.4.1 All components in the power train from the engine to the wildland fire pump shall be capable of transmitting the torque necessary to power the pump, as installed in the apparatus, for the pump-rated capacity without exceeding the component manufacturer's continuous-duty torque rating.

16.4.2 When pumping continuously at rated capacity, lubricant temperatures in any power train component installed in the apparatus from the engine to the pump shall not exceed the component manufacturer's recommendation for maximum temperature.

16.4.3* A means shall be provided to limit the nominal net engine output during pumping operation to a torque level equal to the nominal continuous-duty torque rating of the weakest component or, if there are multiple devices to be driven simultaneously, to a level equal to the sum of the nominal continuous-duty torque ratings of multiple components. [**1901:**16.4.3]

16.5* Construction Requirements.

16.5.1* Wetted moving parts shall be constructed of a corrosion-resistant material. [**1901**:16.5.1]

16.5.1.1 Where more than one pump is provided, and where the pumps are interconnected so that pressure from one pump can be transmitted to the other pump, check valves, intake or discharge relief valves, pump drive gear ratios, or other automatic means shall be provided to avoid pressurizing either pump beyond the hydrostatic pressure referenced in 16.5.2.1.

16.5.2 Hydrostatic Test.

16.5.2.1 The pump body shall be subjected to a hydrostatic test pressure of 100 psi (700 kPa) above the maximum close-off pressure or to a gauge pressure of 300 psi (2000 kPa), whichever is higher, for 10 minutes.

16.5.2.2 The pump manufacturer shall provide a certificate of completion for the hydrostatic test. [**1901:**16.5.2.2]

16.5.3 The entire discharge and intake piping system, valves, drain cocks and lines, and intake and outlet closures, excluding the tank-to-pump lines on the tank side of the valve in those lines, shall be subjected to a hydrostatic test pressure of 100 psi (700 kPa) above the maximum close-off pressure or to a gauge pressure of 300 psi (2000 kPa), whichever is higher, for 5 minutes.

16.5.4 The pump shall allow a positive pressure water source to directly add to the pump's discharge pressure. [**1901:**16.5.5]

16.6* Pump Intake.

16.6.1* Intakes of the same or larger size as specified in Table 16.2.4.1(a) for suction hose size shall be provided.

16.6.1.1* Any intake shall have male threads and any 2½ in. (65 mm) intake or larger shall have National Hose Thread (NH).

16.6.1.2 If the couplings on the suction hose carried on the apparatus are of a different size from that of the pump intake(s) or have means of hose attachment other than that provided on the intake(s), an adapter(s) shall be provided to allow connection of the suction hose to the pump intake(s). [**1901:**16.6.1.2]

16.6.1.3* Safety sign FAMA25, which warns of the need for training prior to operating the apparatus, shall be located on the pump operator's panel. [**1901:**16.6.1.3]

16.6.2 Intake Strainer.

16.6.2.1 Each intake shall have a removable or accessible strainer inside the connection. [**1901:**16.6.2.1]

16.6.2.2* The strainer(s) shall restrict spherical debris that is too large to pass through the pump. [**1901:**16.6.2.2]

16.6.3 Reserved.

16.6.4 Any 3 in. (76 mm) or larger intake valve except the tank-to-pump valve shall be a slow-operating valve. [**1901:**16.6.4]

16.6.5 Reserved.

16.6.6 Each valved intake having a connection size larger than 3 in. (75 mm) shall be equipped with an adjustable automatic pressure relief device installed on the supply side of the valve to bleed off pressure from a hose connected to the valved intake. [**1901:**16.6.6]

16.6.6.1 The pressure relief device shall discharge to atmosphere, and the discharge shall be piped or directed away from the pump operator's position. [**1901:**16.6.6.1]

16.6.6.2 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa). [**1901:**16.6.6.2]

16.6.6.3 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min). [**1901:**16.6.6.3]

16.6.7 If the pump is equipped with one or more intakes larger than 3 in. (75 mm) that are not valved, an adjustable automatic pressure relief device shall be installed on the pump system to bleed off excess pressure from a hose connected to the pump intake. [**1901:**16.6.7]

16.6.7.1 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa). [**1901:**16.6.7.1]

16.6.7.2 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min). [**1901:**16.6.7.2]

16.6.7.3 The pressure relief device shall discharge to atmosphere. [**1901:**16.6.7.3]

16.6.8 Intake Covers. All intakes shall be provided with caps, plugs, or closures.

16.6.8.1 Intakes having male threads shall be equipped with caps. [**1901:**16.6.8.1]

16.6.8.2 Intakes having female threads shall be equipped with plugs. [**1901:**16.6.8.2]

16.6.8.3 Where adapters for special threads or other means for hose attachment are provided on the intakes, closures shall be provided for the adapters in lieu of caps or plugs. [**1901:**16.6.8.3]

16.6.8.4 Caps, plugs, or closures for 3½ in. (90 mm) and smaller intakes shall remain secured to the apparatus or pumping unit when removed from the intakes. [**1901:**16.6.8.4]

16.6.9 Reserved.

16.6.10* If the manufacturer or contractor provides a valve, siamese, or adapter on a suction inlet(s) that will remain in place while the apparatus is in motion, that valve, siamese, or adapter shall not project beyond the apparatus running board.

16.7 Pump Discharge Outlets.

16.7.1* Sufficient discharge outlets, including any discharge outlets located in hose storage areas, shall be provided to discharge the rated capacity of the pump at the flow rates as shown in Table 16.7.1.

16.7.2 Discharge Outlet Connections.

16.7.2.1* Each 1½ in. (38 mm) or larger discharge outlet shall be equipped with male National Hose Thread (NH).

16.7.2.2* Adapters with special threads or other means for hose attachment shall be permitted to be furnished on any outlets. [**1901:**16.7.2.2]

16.7.3 Reserved.

16.7.4 Each discharge outlet, except an outlet to which a hose is to be preconnected, shall be equipped with a cap or closure that is capable of withstanding 100 psi (700 kPa) over the maximum rated pump close-off pressure or 300 psi (2000 kPa) gauge pressure, whichever is higher.

16.7.4.1 Where adapters are provided on the discharge outlet connections, the closures shall fit on the adapters. [**1901:**16.7.4.1]

16.7.4.2 If a cap or closure is provided, it shall be secured to the pumping unit with a chain or cable.

16.7.4.3 Caps shall automatically release pressure in the discharge outlet before the threads are completely disengaged unless outlet and cap are equipped with drains or bleeder valves. [**1901:**16.7.4.3]

Table 16.7.1 Flow Rates for Various Outlet Sizes

Outlet Size		Flow Rates	
in.	mm	gpm	L/min
1	25	50	200
1½	38	125	500
2½	65	250	1000

16.7.4.4 The pressure relief shall discharge to atmosphere, and the discharge shall direct away from the operator's position. [**1901:**16.7.4.4]

16.7.5* Each discharge outlet shall be equipped with a valve that can be opened and closed smoothly at the flows shown in Table 16.7.1 at pump discharge gauge pressures of 250 psi (1700 kPa) or of 100 psi (700 kPa) over the pump rated pressure, whichever is greater.

16.7.5.1 The flow-regulating element of each valve shall not change its position under any condition of operation that involves discharge pressures to the maximum pressure of the pump.

16.7.5.2 The means to prevent a change in position shall be incorporated in the operating mechanism and shall be permitted to be manually or automatically controlled.

16.7.5.3* Any 3 in. (76 mm) or larger discharge valve shall be a slow-operating valve. [**1901:**16.7.5.2]

16.7.6 Reserved.

16.7.7 Any 2½ in. (65 mm) or larger discharge outlet that is located more than 42 in. (1070 mm) above the ground and to which a hose is to be connected, but that is not in a hose storage area, shall be equipped with a sweep elbow of at least 30 degrees downward.

16.7.8* Valves.

16.7.8.1 Reserved.

16.7.8.2 Reserved.

16.7.8.3* A pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open shall be provided between the pump discharge and the water tank.

16.7.8.4 All discharge valves 1 in. (25 mm) or over in size shall be quarter-turn types.

16.7.8.5 Where the valve operating mechanism does not indicate the position of the valve, an indicator shall be provided to show when the valve is closed. [**1901**:16.7.10]

16.7.8.6 Visible quarter-turn valves shall be installed so they are open when the handle is parallel with the run of the pipe and are closed when the handle is perpendicular to the run of the pipe.

16.7.8.7 Blind valves, which are valves behind panels, shall have their open and closed positions marked "Open" and "Closed."

16.7.8.8 Operating mechanisms for valves used on the fireground shall be marked as to their function, such as "Intake," "Tank to Pump," "Pump to Tank," and "Discharge."

16.7.8.9 If the apparatus is equipped with a booster reel, the piping, valves, and swivel between the pump and booster reel shall be nominally the same size as or larger than the nominal inside diameter of the hose to be carried on the reel.

16.7.8.9.1 A shutoff valve shall be provided between the pump and the reel.

16.7.8.9.2 High-pressure booster hose of the same nominal size shall be permitted in place of piping.

16.7.9* Location of Discharge Outlets.

16.7.9.1 No discharge outlet larger than 2½ in. (65 mm) shall be located at the pump operator's panel. [**1901:**16.7.9.1]

16.7.9.2 If the apparatus has a top console–type pump operator's panel, vertical discharge outlets larger than 2½ in. (65 mm) shall be permitted at the top midship position of apparatus where the outlets are used for directly connected deck guns or monitors and no fire hose is used for coupling the components. [**1901:**16.7.9.2]

16.8 Pump Drains.

16.8.1 A readily accessible drain valve(s) that is marked with a label as to its function shall be provided to allow for draining of the pump and all water-carrying lines and accessories. [**1901:**16.8.1]

16.8.2 The drain valve(s) shall be operational without the operator having to get under the apparatus, or a label at the operator's location shall indicate the location of drains that need to be operated from under the apparatus.

16.9 Pump Operator's Location.

16.9.1* The pump controls, gauges, and instruments shall be accessed from ground level, a working platform, or a driver's compartment.

16.9.2 All gauges, discharge outlets, pump intakes, and controls shall be illuminated in compliance with 4.10.1. [**1901:**16.9.2]

16.9.3 Each control, gauge, and instrument shall be marked with a label as to its function.

16.10* Pump Controls.

16.10.1 General Provisions. Provisions shall be made for placing the pump drive system in operation using controls and switches that are identified and within convenient reach of the operator. [**1901:**16.10.1]

16.10.1.1 Where the pump is driven by the chassis engine and engine compression brakes or engine exhaust brakes are furnished, these engine brakes shall be automatically disengaged for pumping operations. [**1901:**16.10.1.1]

16.10.1.2* Any control device used in the pumping system power train between the engine and the pump, except a manual pump shift override device if provided, shall be equipped with a means to prevent unintentional movement of the control device from its set position in the pumping mode. [**1901:**16.10.1.2]

16.10.1.3 Where the pump is driven by the chassis engine, a label indicating the chassis transmission shift selector position to be used for pumping shall be provided in the driving compartment and located so that it can be read from the driver's position. [**1901:**16.10.1.3]

16.10.1.4 Where the pump is driven by the chassis engine and automatic transmission through a split shaft PTO, an interlock system shall be provided to prevent the pump drive system from being shifted out of the "pump engaged" pumping mode of operation when the chassis transmission is in pump gear. [**1901:**16.10.1.4]

16.10.1.5 Where the power train from engine to pump includes retarders or other auxiliary braking devices, they shall be automatically disengaged for pumping operations.

16.10.2* Interlocks and Indicators. Where the water pump is driven by the chassis engine, an interlock system shall be provided to ensure that the pump drive system components are engaged in the pumping mode of operation so that the pumping system can be operated from the pump operator's position, with indicators to inform the operators of the status of the controls. [**1901:**16.10.2]

16.10.2.1 Required Indicators.

16.10.2.1.1 All apparatus shall have "Pump Engaged" and "OK to Pump" indicators in the driver compartment. [**1901:**16.10.2.1.1]

16.10.2.1.2 All apparatus shall have "Throttle Ready" and "OK to Pump" indicators on the pump operator's panel. [**1901:**16.10.2.1.2]

16.10.2.1.3 If the apparatus is designed to do pump-and-roll, an "OK to Pump-and-Roll" indicator shall also be in the driver compartment. [**1901:**16.10.2.1.3]

16.10.2.2* Pump Engaged. A "Pump Engaged" indicator shall be provided in the driving compartment to indicate the pump shift process has been successfully completed. [**1901:**16.10.2.1]

16.10.2.3 OK to Pump. An "OK to Pump" indicator shall be provided in the driving compartment and on the pump operator's panel to indicate that all of the following conditions have been met to safely operate the pump in stationary mode:

(1) The pump shift is engaged.
(2) The parking brake is engaged.
(3) If the pump is driven from a transfer case PTO or auxiliary transmission PTO, the drive to the wheels is in neutral.
(4) If the apparatus is equipped with an automatic transmission, the chassis transmission is in the correct pump gear as identified in 16.10.1.3 as follows:
    (a) If the pump is driven by a PTO after the chassis transmission gearing (e.g., split shaft PTO, transfer case PTO, etc.) the transmission is in the correct forward drive gear.
    (b) If the pump is driven by a PTO ahead of the chassis transmission gearing (e.g., flywheel PTO, crankshaft PTO, etc.) the transmission is in neutral.
(5) If the apparatus is equipped with a manual transmission, any gear, including neutral, will allow an "OK to Pump" indicator to come on provided all other conditions are met.

[**1901:**16.10.2.3]

16.10.2.4* OK to Pump and Roll. If the apparatus is designed to be used in both stationary pumping mode and "pump-and-roll" pumping mode, an "OK to Pump and Roll" indicator shall be provided in the driving compartment to indicate that all of the following conditions have been met to safely operate the pump in pump-and-roll mode.

(1) The pump shift is engaged.
(2) The parking brake is released.

[**1901:**16.10.2.4]

16.10.2.5 Throttle Ready.

16.10.2.5.1 A "Throttle Ready" indicator shall be provided on the pump operator's panel. [**1901:**16.10.2.5.1]

16.10.2.5.2 The "Throttle Ready" indicator shall indicate when the pump is in "OK to Pump" mode. [**1901:**16.10.2.5.2]

16.10.2.5.3* The "Throttle Ready" indicator at the pump operator's panel shall be permitted to indicate when the parking brake is engaged and, if the apparatus is equipped with an automatic transmission, when the chassis transmission is in neutral. [**1901:**16.10.2.5.3]

16.10.2.6 Engine Speed Control.

16.10.2.6.1 An engine speed control shall be provided at the pump operator's panel. [**1901:**16.10.2.6.1]

16.10.2.6.2 An interlock system shall be provided to prevent advancement of the engine speed at the pump operator's panel unless the apparatus has a "Throttle Ready" indication. [**1901:**16.10.2.6.2]

16.10.2.6.3 Loss of power to the interlock system shall return the engine speed to idle and prevent advancement from the pump operator's panel. [**1901:**16.10.2.6.3]

16.10.2.7 Manual Override. If a pump shift manual override device is provided, the "Pump Engaged," "OK to Pump," "OK to Pump and Roll," and "Throttle Ready" indicators and the pump operator's panel engine speed advancement interlock system shall be operationally functional when the manual override device is used to shift the pump. [**1901:**16.10.2.7]

16.10.3 Parallel/Series Control.

16.10.3.1 With parallel/series centrifugal pumps, the control positions for parallel operation (volume) and series operation (pressure) shall be indicated. [**1901:**16.10.13.1]

16.10.3.2 The control for changing the pump from series to parallel, and vice versa, shall be operable at the pump operator's position. [**1901:**16.10.13.2]

16.10.4* Pressure Control System.

16.10.4.1* On pumps with a rated capacity of 200 gpm or 250 gpm (800 L/min or 1000 L/min) a means shall be provided that, when set in accordance with the manufacturer's instructions, will automatically control the discharge pressure to a maximum of 60 psi (400 kPa) pressure rise above the set pressure(s) when all discharge valves are closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds during the following conditions:

(1) Over a range of pressures from 70 psi to 300 psi (500 kPa to 2000 kPa) net pump pressure with intake gauge pressure between -10 psi and 185 psi (-70 kPa and 1300 kPa) and discharge gauge pressure between 90 psi and 300 psi (620 kPa and 2000 kPa)
(2) With initial engine and pump controls set to produce a range of flows from 150 gpm (600 L/min) to the rated capacity of the pump

16.10.4.2 If the pump is equipped with a relief valve system where the system does not control engine speed, the system shall be equipped with a means to indicate when the system is in control of the pressure. [**1901:**16.10.14.2]

16.10.4.2.1 If the pump is equipped with a governor system that controls engine speed, an indicator shall show when the system is turned on and whether it is controlling the engine speed or pump pressure. [**1901:**16.10.14.2.1]

16.10.4.2.2 Either system shall be controllable by one person at the pump operator position. [**1901:**16.10.14.2.2]

16.10.4.2.3 If the system discharges water to the atmosphere, the discharge shall be in a manner that will not expose personnel to high-pressure water streams. [**1901:**16.10.14.3]

16.10.5* Priming System. A priming system shall be provided and controlled from the pump operator's position. [**1901:**16.10.15]

16.10.5.1 The priming system shall be capable of meeting the requirements of 16.2.3.3 and 16.2.3.4.

16.10.5.2 The priming system shall be capable of operating with no lubricant or with a biodegradable nontoxic lubricant. [**1901:**16.10.15.2]

16.10.5.3* The priming system shall use one of the following priming methods:

(1) Prime from the intake with the pump running
(2) Prime from the discharge with the pump not running

16.10.6 Protection of Pump Controls. All pump controls and devices shall be installed so as to be protected against mechanical damage and the effects of adverse weather conditions on their operation. [**1901:**16.10.16]

16.11 Pump Engine Controls.

16.11.1* A throttle control that holds its set position shall be provided to control the pump engine speed. [**1901:**16.11.1]

16.11.2 The throttle control on vertically (greater than 45 degrees) arranged pump panels shall be located not higher than 72 in. (1680 mm) nor lower than 42 in. (1070 mm) from the operator's standing position with all instruments in full view.

16.11.3 The throttle control on horizontally (less than 45 degrees) arranged pump panels shall be located not higher than 50 in. (1270 mm) nor lower than 32 in. (810 mm) from the operator's standing position with all instruments in full view. [**1901:**16.11.3]

16.12 Instrumentation.

16.12.1 Pump Operator's Panel.

16.12.1.1* The following controls and instruments shall be provided and installed as a group on the pump operator's panel:

(1) Master pump intake pressure gauge (if applicable)
(2) Master pump discharge pressure gauge
(3) Pumping engine tachometer [if engine is over 35 hp (26 kW)]
(4) Pumping engine coolant temperature gauge [if engine is over 35 hp (26 kW)]
(5) Pumping engine oil pressure gauge [if engine is over 35 hp (26 kW)]
(6) Voltmeter [if engine is over 35 hp (26 kW)]
(7) Pump pressure control(s) (if applicable)
(8) Pumping engine throttle
(9) Primer control

(10) Water tank–to–pump valve control
(11) Water tank fill valve control
(12) Water tank level gauge

16.12.1.2 Reserved.

16.12.1.3 Any instrumentation exposed to the elements shall be weatherproof. [**1901:**16.12.1.3]

16.12.1.4 Where provided, pumping engine oil pressure and engine coolant temperature gauges shall be equipped with audible and visual warnings.

16.12.1.5 Any engine operation gauge on the pump operator's panel shall be in addition to those on the vehicle's instrument panel.

16.12.2* Master Pump Intake and Discharge Pressure Gauges.

16.12.2.1 The following shall be provided:

(1) A master pump discharge gauge
(2) A master intake compound gauge [if one or more 3 in. (75 mm) or larger external pump intakes are provided]

16.12.2.1.1 The intake pressure gauge shall read from 30 in. Hg (100 kPa) vacuum to at least a gauge pressure of 300 psi (2000 kPa). [**1901:**16.12.2.1.1]

16.12.2.1.2 A master discharge pressure gauge shall read from 30 in. Hg (100 kPa) vacuum to at least a gauge pressure of 300 psi (2000 kPa) or 100 psi (500 kPa) over maximum pump pressure, whichever is greater.

16.12.2.1.3 Pressure gauges shall not be damaged by a 30 in. Hg (100 kPa) vacuum. [**1901:**16.12.2.1.3]

16.12.2.1.4 Pressure gauges shall be marked with labels that read "Pump Intake" for the intake pressure gauge and "Pump Discharge" for the discharge pressure gauge. [**1901:**16.12.2.1.4]

16.12.2.1.5* The master discharge gauge shall be connected directly at the pump discharge, before any check valves.

16.12.2.2* If analog gauges are used, they shall meet the requirements of 16.12.2.2.1 through 16.12.2.2.7. [**1901:**16.12.2.2]

16.12.2.2.1 There shall be at least a 1 in. (25 mm) diameter differential in viewing area between the master gauges and individual discharge gauges, with the master gauges being the larger. [**1901:**16.12.2.2.1]

16.12.2.2.2 Analog gauges displaying the vacuum portion in 120 degrees of arc or less shall have an accuracy complying with Grade B as defined by ASME B40.100, *Pressure Gauges and Gauge Attachments*.

16.12.2.2.3 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have an accuracy of 3½ percent or better on vacuum and 3½ percent or better on pressure over their entire respective scale. [**1901:**16.12.2.2.3]

16.12.2.2.4 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have graduation lines on the vacuum side every 1 in. Hg (5 kPa) with major and immediate graduation lines emphasized and figures at least every 10 in. Hg (50 kPa). [**1901:**16.12.2.2.4]

16.12.2.2.5 Numerals for master gauges shall be a minimum of 0.25 in. (6.4 mm) high. [**1901:**16.12.2.2.5]

16.12.2.2.6 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa). [**1901:**16.12.2.2.6]

16.12.2.2.7 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge. [**1901:**16.12.2.2.7]

16.12.2.3 Digital Gauges. If digital master pressure gauges are used, they shall meet the requirements of 16.12.2.3.1 through 16.12.2.3.3. [**1901:**16.12.2.3]

16.12.2.3.1 The digits shall be at least ½ in. (12.7 mm) high. [**1901:**16.12.2.3.1]

16.12.2.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa). [**1901:**16.12.2.3.2]

16.12.2.3.3 Digital master pressure gauges shall have an accuracy of ±3 percent over the full scale. [**1901:**16.12.2.3.3]

16.12.2.4* Cab Gauges. If the pump on the apparatus is driven by the chassis engine through a PTO, and the apparatus is designed for pump-and-roll operations using that chassis engine–driven pump, a second gauge that meets the same requirements as the discharge pressure gauge required by 16.12.2.1.2 shall be mounted in the driving compartment in view of the driver.

16.12.2.4.1 The gauge shall read from 30 in. Hg (100 kPa) vacuum to at least 300 psi (2000 kPa) or 100 psi (500 kPa) over maximum pump pressure, whichever is greater.

16.12.2.4.2 If both an intake gauge and a master discharge gauge are provided, a label at the intake gauge shall read "Pump Intake" and a label at the master discharge gauge shall read "Pump Discharge."

16.12.2.5 Gauge Mounting. Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

16.12.3 Discharge Outlet Instrumentation.

16.12.3.1 Reserved.

16.12.3.2* Any discharge outlet that is equipped with a flowmeter shall also be provided with a pressure gauge. [**1901:**16.12.3.2]

16.12.3.3 The pressure gauge display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure gauge bezel and the valve control midpoint or centerline.

16.12.3.4 If both a flowmeter and a pressure gauge are provided for an individual discharge outlet, the pressure gauges shall be located within 6 in. (150 mm) of the valve control midpoint or centerline, and the flowmeter display shall be adjacent to and within 2 in. (51 mm) of the pressure gauge bezel.

16.12.3.5 Pressure gauges shall be connected to the outlet side of the valve. [**1901:**16.12.3.5]

16.12.3.6 Flowmeters shall display flow in increments no greater than 10 gpm (50 L/min). [**1901:**16.12.3.6]

16.12.3.7 Where analog pressure gauges are used, they shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*. [**1901:**16.12.3.7]

16.12.3.7.1 Numerals for gauges shall be a minimum 5/32 in. (4 mm) high. [**1901:**16.12.3.7.1]

16.12.3.7.2 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized, and figures at least every 100 psi (500 kPa). [**1901:**16.12.3.7.2]

16.12.3.7.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; be freeze protected; and have internal mechanisms that are factory lubricated for the life of the gauge.

16.12.3.8 If a digital pressure gauge is used, it shall meet the requirements of 16.12.3.8.1 through 16.12.3.8.3.

16.12.3.8.1 The digits shall be at least ½ in. (12.7 mm) high.

16.12.3.8.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa). [**1901:**16.12.3.8.2]

16.12.3.8.3 Digital pressure gauges shall have an accuracy of ±3 percent over the full scale. [**1901:**16.12.3.8.3]

16.12.3.9 Each flowmeter shall be calibrated to an accuracy of ±5 percent when flowing the amount of water shown in Table 16.12.3.9 for the pipe size in which it is mounted. [**1901:**16.12.3.9]

16.12.4 Reserved.

16.12.5 Connections for test gauges shall be provided.

16.13 Required Testing.

16.13.1 Apparatus Pump System Certification.

16.13.1.1 General. The pump shall be tested after the pump and all its associated piping and equipment have been installed on the fire apparatus.

16.13.1.1.1 The testing shall include at least the pumping tests in 16.13.2, the priming system test in 16.13.5, the vacuum test in 16.13.6, the water tank–to–pump flow test in 16.13.7, the gauge and flowmeter test in 16.13.9, the piping integrity test in 16.13.10, and the water tank capacity test in 16.13.11.

16.13.1.1.2 Reserved.

16.13.1.1.3 If the fire pump is driven by the chassis engine, the engine speed advancement interlock test shall be included *(see 16.13.8)*.

Table 16.12.3.9 Flowmeter Calibration Flow for Each Pipe Size

Pipe Size		Flow	
in.	mm	gpm	L/min
1	25	40	150
1½	40	90	340
2	50	160	600
2½	65	250	950
3	80	375	1400

16.13.1.1.4 Reserved.

16.13.1.1.5 Reserved.

16.13.1.1.6 On pumps with a rated flow of 200 gpm (750 L/min) or more and 2 or more discharges of 1½ in. (38 mm) or larger, the pressure control test shall be included *(see 16.13.4)*.

16.13.1.2 Reserved.

16.13.1.2.1 Reserved.

16.13.1.2.2 Reserved.

16.13.1.2.3 Reserved.

16.13.1.2.4 The test results shall be certified by the apparatus manufacturer. [**1901:**16.13.1.2.4]

16.13.1.3* Test Label.

16.13.1.3.1 A test label shall be provided at the pump operator's panel that gives the rated discharges and pressures together with the speed of the engine as determined by the certification test for each unit, the position of the parallel/series pump as used, and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve. [**1901:**16.13.1.3.1]

16.13.1.3.2 The label shall be completely stamped with all information at the factory and attached to the vehicle prior to shipping. [**1901:**16.13.1.3.2]

16.13.2 Pumping Tests.

16.13.2.1 Conditions for Tests.

16.13.2.1.1 The test site shall be adjacent to a supply of clear water, with the water level not more than 10 ft (3 m), or less than 3 ft (0.91 m) below the center of the pump intake, and close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water, when connected to the pump by 20 ft (6 m) of suction hose.

16.13.2.1.2* Tests shall be performed when conditions are as follows:

(1) Air temperature: 0°F to 110°F (-18°C to 43°C)
(2) Water temperature: 35°F to 90°F (2°C to 32°C)
(3) Barometric pressure: 29 in. Hg (98.2 kPa), minimum (corrected to sea level)
(4)* Minimum lift: 3 ft (1 m) from center of pump intake to the surface of the water

[**1901:**16.13.2.1.2]

16.13.2.1.3 If it is necessary to perform the test outside the air or water temperature ranges stated in 16.13.2.1.2 and the pump passes the certification test, the test results shall be acceptable. [**1901:**16.13.2.1.3]

16.13.2.1.4 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests. [**1901:**16.13.2.1.4]

16.13.2.1.4.1 If the chassis engine drives the pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 16.13.2.1.4.3, shall be applied for the entire pumping portion of this test. [**1901:**16.13.2.1.4.1]

16.13.2.1.4.2 If the vehicle is equipped with a fixed power source driven by the same engine that drives the wildland fire pump, the fixed power source shall be running at a minimum

of 50 percent of its rated capacity throughout the pumping portion of the pump test.

16.13.2.1.4.3 The following devices shall be permitted to be turned off or not operating during the pump test:

(1) Reserved
(2) Foam pump
(3) Hydraulically driven equipment (other than hydraulically driven line voltage generator)
(4) Winch
(5) Windshield wipers
(6) Four-way hazard flashers
(7) Compressed air foam system (CAFS) compressor

16.13.2.1.5 All structural enclosures, such as floorboards, gratings, grilles, and heat shields, not furnished with a means for opening them in service shall be kept in place during the tests. [**1901:**16.13.2.1.5]

16.13.2.2 Equipment.

16.13.2.2.1 Suction Hose.

16.13.2.2.1.1 Suction hose shall be of the size specified in Table 16.2.4.1(a) for the rated capacity of the pump.

16.13.2.2.1.2 A suction hose and strainer that will allow flow with total entrance and friction loss not greater than that specified in Table 16.2.4.1(b) or Table 16.2.4.1(c) shall be used.

16.13.2.2.2 One or more lines of fire hose of sufficient diameter shall be provided to allow discharge of the rated capacity of the pump to the nozzle(s) or other flow-measuring equipment, without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) [approximately 193 gpm (730 L/min) for 1½ in. (38 mm) hose or 500 gpm (2000 L/min) for 2½ in. (65 mm) hose].

16.13.2.2.3* Discharge shall be measured using a smoothbore nozzle and pitot tube, a square-edged round orifice and pressure gauge, or other equipment such as flowmeters, volumetric tanks, or weigh tanks.

16.13.2.2.4 Test Gauges.

16.13.2.2.4.1 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100, and shall be at least size 3½ per ASME B40.100. [**1901:**16.13.2.2.4.1]

16.13.2.2.4.2 The pump intake gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to a gauge pressure of 150 psi (1000 kPa) for a compound gauge. [**1901:**16.13.2.2.4.3]

16.13.2.2.4.3 The discharge pressure gauge shall have a gauge pressure range of 0 psi to 400 psi (0 kPa to 2800 kPa) or be at least 100 psi (700 kPa) over the maximum pump close-off pressure.

16.13.2.2.4.4 Pitot gauges shall have a gauge pressure range of at least 0 psi to 160 psi (0 kPa to 1100 kPa). [**1901:**16.13.2.2.4.5]

16.13.2.2.4.5 All gauges shall be calibrated in the month preceding the tests using a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year. [**1901:**16.13.2.2.4.6]

16.13.2.2.5 Each test gauge connection shall include a means for "snubbing," such as a needle valve to damp out rapid needle movements. [**1901:**16.13.2.2.5]

16.13.2.2.6 Speed-measuring equipment shall consist of a tachometer or other device for measuring revolutions per minute.

16.13.2.3 Procedure.

16.13.2.3.1* The ambient air temperature, water temperature, vertical lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to and after each pump test. [**1901:**16.13.2.3.1]

16.13.2.3.2* The engine, pump, transmission, and all parts of the apparatus shall exhibit no undue heating, loss of power, or other defect during the entire test. [**1901:**16.13.2.3.2]

16.13.2.3.3 The pump shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated net pump pressure.

16.13.2.3.4 If the pump is stopped before the test is completed, the entire pump test shall be repeated.

16.13.2.3.5 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence. [**1901:**16.13.2.3.4.3]

16.13.2.3.6 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure. [**1901:**16.13.2.3.4.4]

16.13.3 Reserved.

16.13.4 Pressure Control Test. The pump system shall be tested for pressure rise as follows:

(1) The pump shall be operated at draft, delivering rated capacity at a discharge gauge pressure of 150 psi (1000 kPa).
(2) If a pressure control system is supplied, it shall be set in accordance with the manufacturer's instructions to maintain the discharge gauge pressure at 150 psi (1000 kPa) ± 5 percent.
(3) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
(4) The rise in discharge pressure shall not exceed 60 psi (400 kPa) and shall be recorded.

16.13.5 Priming System Test. With the apparatus or pumping unit set up for the pumping test, the priming system shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

16.13.5.1 This test shall be permitted to be performed in connection with priming the pump for the pumping test. [**1901:**16.13.5.1]

16.13.5.2 The interval from the time the primer is started until the time the pump is discharging water shall be noted. [**1901:**16.13.5.2]

16.13.5.3 The time required to prime the pump shall not exceed 30 seconds.

16.13.5.4 Only biodegradable products shall be permitted to be discharged onto the ground.

16.13.6 Vacuum Test. The vacuum test shall consist of subjecting the interior of the pump, with all intake valves open, all intakes capped or plugged, and all discharge caps removed and valves closed, to a vacuum of 17 in. Hg (57.6 kPa) by means of the pump priming system.

16.13.6.1 At altitudes above 2000 ft (600 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.6 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (300 m) of altitude above 2000 ft (600 m).

16.13.6.2 The primer shall not be used after the 5-minute test period has begun. [**1901:**16.13.6.2]

16.13.6.3 The engine shall not be operated at any speed greater than the governed speed during this test. [**1901:**16.13.6.3]

16.13.6.4 The vacuum shall not drop more than 10 in. Hg (34 kPa) in 5 minutes. [**1901:**16.13.6.4]

16.13.6.5* The vacuum test shall then be repeated with all intake valves closed and the caps or plugs on all gated intakes removed. [**1901:**16.13.6.5]

16.13.7 Water Tank–to–Pump Flow Test.

16.13.7.1 A water tank–to–pump flow test shall be conducted as follows:

(1) The apparatus shall be placed on level ground and the water tank filled until it overflows.
(2) All intakes to the pump shall be closed.
(3) The tank fill line and bypass cooling line, if supplied, shall be closed.
(4) A hose line(s) and nozzle(s) for discharging water at the rated tank-to-pump flow rate shall be connected to one or more discharge outlets.
(5) The tank-to-pump valve(s) and the discharge valve(s) leading to the hose line(s) and nozzle(s) shall be fully opened.
(6) The engine throttle shall be adjusted until the required flow rate, -0 +5 percent, is established.
(7) The discharge pressure shall be recorded.
(8) The discharge valves shall be closed and the water tank refilled.
(9) The bypass cooling line shall be permitted to be opened temporarily, if needed, to keep the water temperature in the pump within acceptable limits.
(10) The discharge valves shall be fully reopened and the time noted.
(11) If necessary, the engine throttle shall be adjusted to maintain the discharge pressure recorded as noted in 16.13.7.1(7).
(12) When the discharge pressure drops by 10 psi (70 kPa) or more, the time shall be noted and the elapsed time from the opening of the discharge valves shall be calculated and recorded.

16.13.7.2 Volume Discharge Calculation.

16.13.7.2.1 The volume discharged shall be calculated by multiplying the rate of discharge in gallons per minute (liters per minute) by the time in minutes elapsed from the opening of the discharge valves until the discharge pressure drops by at least 10 psi (70 kPa). [**1901:**16.13.7.2.1]

16.13.7.2.2 Other means shall be permitted to be used to determine the volume of water pumped from the tank such as a totalizing flowmeter, weighing the fire apparatus before and after, or refilling the tank using a totalizing flowmeter. [**1901:**16.13.7.2.2]

16.13.7.2.3 The rated tank-to-pump flow rate as defined in 18.3.1shall be maintained until 80 percent of the rated capacity of the tank has been discharged. [**1901:**16.13.7.3]

16.13.8* Engine Speed Advancement Interlock Test. If the pump is driven by the chassis engine, the engine speed advancement interlock system shall be tested to verify that engine speed cannot be increased at the pump operator's panel unless the proper conditions are met.

16.13.8.1 If the apparatus is equipped with a pump driven through split-shaft PTO, the test shall verify that for each of the conditions specified in the first four columns of Table 16.13.8.1, the indicators and engine speed controls operate as specified in the last four columns. [**1901:**16.13.8.1]

16.13.8.2 If the apparatus is equipped with a pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, that is designed for stationary pumping only the test shall verify that for each of the conditions specified in the first four columns of Table 16.13.8.2, the indicators and engine speed controls operate as specified in the last four columns. [**1901:**16.13.8.2]

16.13.8.3 If the apparatus is equipped with a pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that for each of the conditions specified in the first four columns of Table 16.13.8.3, the indicators and engine speed controls operate as specified in the last four columns. [**1901:**16.13.8.3]

16.13.8.4 If the apparatus is equipped with a pump driven through transfer case PTO or auxiliary transmission PTO designed for stationary pumping only, the test shall verify that for each of the conditions specified in the first five columns of Table 16.13.8.4, the indicators and engine speed controls operate as specified in the last four columns. [**1901:**16.13.8.4]

16.13.9 Gauge and Flowmeter Test.

16.13.9.1 Pump intake and discharge pressure gauges shall be checked for accuracy while water is pumping at rated capacity at pump rated pressure.

16.13.9.2 Any gauge that is off by more than 10 psi (70 kPa) from the calibrated test gauge shall be recalibrated, repaired, or replaced. [**1901:**16.13.9.2]

16.13.9.3 Each flowmeter shall be checked for accuracy while water is being pumped at the flow rate listed in Table 16.13.9.3 at 100 psi (700 kPa).

16.13.9.4 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced. [**1901:**16.13.9.4]

16.13.10* Manufacturer's Predelivery Test.

16.13.10.1 Piping Integrity Test. The pump and its connected piping system shall be hydrostatically tested to a gauge pressure of 250 psi (1700 kPa) or 100 psi (700 kPa) above the maximum pump close-off pressure, whichever is greater, up to 500 psi (3400 kPa).

Table 16.13.8.1 Pump Driven Through Split- Shaft PTO

Test Conditions				Verifications			
Transmission Type	**Chassis Transmission Gear Selected**	**Parking Brake Status**	**Pump Shift Control Action Status (Driving Compartment)[a]**	**Pump Indicator Status (Driving Compartment)**	**Pump Indicator Status (Pump Operator's Panel)**	**Engine Speed Control in Cab**	**Engine Speed Control at Pump Operator's Panel**
Either	Neutral b	On	Road	None	None[c]	Yes	No[c]
Either	Neutral[b]	On	Road	None	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Either	Neutral[b]	Off	Road	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged"[e]	None[c]	Yes	No[c]
Automatic	Neutral	On	Engaged	"Pump Engaged"[e]	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Automatic	Neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Pump gear[f]	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump	Yes or No[d]	Yes
Automatic	Pump gear[f]	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Pump gear[f]	On	Road	None	None	Yes	No
Automatic	Pump gear[f]	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	On	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	On	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[d]	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No

[a]Refers to the physical position of the pump shift control, (or status of an electrical control action), in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]A manual transmission can be in any gear or neutral.
[c]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[d]Some apparatus may be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[e]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.
[f]The chassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.
[g]The chassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

Table 16.13.8.2 Pump Driven Through Transmission-Mounted PTO, Front-of-Engine Crankshaft PTO, or Engine Flywheel PTO Designed for Stationary Pumping Only

Test Conditions				Verifications			
Transmission Type	**Chassis Transmission Gear Selected**	**Parking Brake Status**	**Pump Shift Control Action Status (Driving Compartment)[a]**	**Indicator Status (Driving Compartment)**	**Indicator Status (Pump Operator's Panel)**	**Engine Speed Control in Cab**	**Engine Speed Control at Pump Operator's Panel**
Either	Neutral[b]	On	Disengaged	None	None[c]	Yes	No[c]
Either	Neutral[b]	On	Disengaged	None	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Either	Neutral[b]	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[d]	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[d]	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]A manual transmission can be in any gear or neutral.
[c]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[d]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[e]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

Table 16.13.8.3 Stationary Pumping and Pump-and-Roll

Test Conditions				Verifications			
Transmission Type	**Chassis Transmission Gear Selected**	**Parking Brake Status**	**Pump Shift Control Action Status (Driving Compartment)[a]**	**Indicator Status (Driving Compartment)[b]**	**Indicator Status (Pump Operator's Panel)**	**Engine Speed Control in Cab**	**Engine Speed Control at Pump Operator's Panel**
Either	Neutral[c]	On	Disengaged	None	None[d]	Yes	No[d]
Either	Neutral[c]	On	Disengaged	None	"Throttle Ready"[d]	Yes or No[e]	Yes[d]
Either	Neutral[c]	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[e]	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll"[f]	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged"[b]	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll"	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump	Yes or No[e]	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll"	None	Yes	No

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

[b]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

[c]A manual transmission can be in any gear or neutral.

[d]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

[e]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

[f]"OK to Pump and Roll" stays on in neutral to allow shifting to neutral when temporarily stopped with the foot brake applied. This allows additional throttle to be applied for greater pump speed. Do not shift to neutral while the vehicle is moving; this is a prohibited operation in at least 17 states.

Table 16.13.8.4 Pump Driven Through Transfer Case PTO or Auxiliary Transmission PTO Designed for Stationary Pumping Only

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment)[a]	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral[b]	Neutral	On	Disengaged	None	None[c]	Yes	No[c]
Either	Neutral[b]	Engaged	On	Disengaged	None	None[c]	Yes	No[c]
Either	Neutral[b]	Neutral	On	Disengaged	None	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Either	Neutral[b]	Engaged	On	Disengaged	None	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Either	Neutral[b]	Neutral	Off	Disengaged	None	None	Yes	No
Either	Neutral[b]	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	Neutral	On	Engaged	"Pump Engaged"[e]	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Automatic	Neutral	Engaged	On	Engaged	"Pump Engaged"[e]	"Throttle Ready"[c]	Yes or No[d]	Yes[c]
Automatic	Neutral	Neutral	Off	Engaged	"Pump Engaged"[e]	None[c]	Yes	No[c]
Automatic	Neutral	Engaged	Off	Engaged	"Pump Engaged"[e]	None[c]	Yes	No[c]
Automatic	Pump gear[f]	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[d]	Yes
Automatic	Pump gear[f]	Engaged	On	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Pump gear[f]	Neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Pump gear[f]	Engaged	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Pump gear[f]	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Pump gear[f]	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Pump gear[f]	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Pump gear[f]	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Neutral	On	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Engaged	On	Engaged	"Pump Engaged"[e]	None	Yes	No
Automatic	Any gear other than neutral and pump gear[g]	Engaged	Off	Engaged	"Pump Engaged"[e]	None	Yes	No

(continues)

Table 16.13.8.4 *Continued*

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment)[a]	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Manual	Any gear or neutral	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No[d]	Yes
Manual	Any gear or neutral	Engaged	On	Engaged	"Pump Engaged"[e]	"Throttle Ready" c	Yes or No[d]	Yes[c]
Manual	Any gear or neutral	Neutral	Off	Engaged	"Pump Engaged"[e]	None	Yes	No
Manual	Any gear or neutral	Engaged	Off	Engaged	"Pump Engaged"[e]	None	Yes	No

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]A manual transmission can be in any gear or neutral.
[c]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[d]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[e]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.
[f]Chassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.
[g]Chassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

16.13.10.2 The hydrostatic test shall be conducted with the tank fill line valve closed, the tank-to-pump valve closed, and the pump bypass line return to the water tank valve closed, if equipped, or the line disconnected and capped.

16.13.10.3 All discharge valves shall be open and the outlets capped.

16.13.10.4 All intake valves shall be closed, and nonvalved intakes shall be capped.

16.13.10.5 The pressure shall be maintained for 3 minutes.

16.13.11 Water Tank Capacity Test. The water tank shall be tested for usable water capacity by either a totalizing flowmeter method or a truck weight method.

16.13.11.1 The water tank shall be filled until it overflows.

16.13.11.2 If the unit is equipped with an automatic shutdown due to a low-pressure feature, the feature shall be engaged.

16.13.11.3 If a totalizing flowmeter is used, the meter shall be connected to a discharge valve and set to zero.

16.13.11.3.1 The discharge valve to which the totalizing flowmeter is connected shall be opened and the unit run at between 25 and 35 percent of the pump's rated flow at 100 psi (700 kPa) until it automatically shuts down or the pressure drops below 30 psi (200 kPa).

16.13.11.3.2 The total volume that was discharged shall be recorded.

Table 16.13.9.3 Flowmeter Test Flows

Discharge Size		Test Flow	
in.	mm	gpm	L/min
1	25	40	160
1½	40	90	360
2½	65	250	1000

16.13.11.4 If the truck weight method is used, the truck shall be weighed and the weight recorded.

16.13.11.4.1 The pump shall be started and brought up to a flow rate of between 25 and 35 percent of the pump's rated flow at 100 psi (700 kPa) by partly opening a discharge valve.

16.13.11.4.2 The discharge valve shall be closed when the unit automatically shuts down or the pump pressure drops below 30 psi (200 kPa).

16.13.11.4.3 The truck shall be reweighed.

16.13.11.4.4 The water tank empty weight shall be subtracted from water tank full weight, and the result divided by 8.33 lb/gal to obtain the usable water volume in gallons.

Chapter 17 Reserved

Chapter 18 Water Tanks

18.1 General. If the fire apparatus is equipped with a water tank,the apparatus shall meet the requirements of this chapter.

18.2 Tank Construction.

18.2.1* All water tanks shall be constructed of noncorrosive material or other materials that are protected against corrosion and deterioration. [**1901:**18.2.1]

18.2.2 Water tanks exposed to sunlight shall be opaque to prevent light from entering, with the exception of the water level visual indicator panel, if equipped. [**1901:**18.2.2]

18.2.3* The water tank shall have a means to permit cleaning of the tank.

18.2.4* If the water tank is independent of the body and compartments, it shall be equipped with a method for removing the tank(s) fromthe chassis. [**1901:**18.2.4]

18.2.5 Tanks shall be cradled, cushioned, spring mounted, or otherwise protected from undue stress resulting from travel on uneven terrain in accordance with the tank manufacturer's requirements. [**1901:**18.2.4]

18.2.6* All water tanks shall be provided with baffles or swash partitions to form containment cells or dynamic water movement control. [**1901:**18.2.5]

18.2.6.1 If a containment method of baffling is used, the baffles shall meet the requirements of 18.2.6.1.1 through 18.2.6.1.4. [**1901:**18.2.5.1]

18.2.6.1.1 At least one baffle running longitudinal to the axis of the apparatus shall be provided in all water tanks. [**1901:**18.2.5.1.1]

18.2.6.1.2 At least one transverse baffle shall be provided in tanks of 100 gal (380 L) or more. [**1901:**18.2.5.1.2]

18.2.6.1.3 There shall be a maximum distance of 51 in. (1295 mm) between any combination of tank vertical walls and baffles, or between parallel baffles. [**1901:**8.2.6.1.3]

18.2.6.1.4 Each baffle shall cover at least 75 percent of the area of the plane that contains the baffle. [**1901:**18.2.5.1.4]

18.2.6.2 If a dynamic method of partitioning is used, the baffles shall meet the requirements of 18.2.6.2.1 through 18.2.6.2.4. [**1901:**18.2.5.2]

18.2.6.2.1 The tank shall contain vertical transverse and longitudinal partitions. [**1901:**18.2.5.2.1]

18.2.6.2.2 The vertical partitions shall be secured to the top and bottom of the tank. [**1901:**18.2.5.2.2]

18.2.6.2.3 The longitudinal partitions shall extend a minimum of 75 percent of the tank length. [**1901:**18.2.5.2.3]

18.2.6.2.4 The partitions shall be arranged in such a manner that the vertical plane of each partition shall create cells no dimension of which shall exceed 48 in. (1220 mm). [**1901:**18.2.6.2.4]

18.2.7 Cleanout Sumps.

18.2.7.1 If the water tank is greater than 500 gal (2000 L), one or more cleanout sumps shall be provided.

18.2.7.2 A means of access 3 in. (75 mm) diameter or larger shall be furnished for each sump to facilitate cleaning. [**1901:**18.2.7.2]

18.2.7.3 If the sump is used for the tank-to-pump line connection, the design shall prevent sludge or debris in the sump from entering the pump. [**1901:**18.2.7.3]

18.2.8 Water Level Indicator.

18.2.8.1 An indicator shall be provided that shows the level or amount of water in the tank(s). [**1901:**18.2.7.1]

18.3 Tank-to-Pump Intake Line.

18.3.1 A valved tank-to-pump connection shall be provided and shall be capable of flowing water from the tank at the rated capacity of the pump up to 250 gpm (1000 L/min).

18.3.1.1 The valve control shall be located at the pump operator's position.

18.3.2 The flow required in 18.3.1 shall be sustainable while pumping a minimum of 80 percent of the certified tank capacity with the fire apparatus on level ground.

18.3.3* If the pump rating is greater than 500 gpm (2000 L/min), an automatic means shall be provided in the tank-to-pump line that prevents unintentional backfilling of the water tank through that line.

18.3.4 Connections or outlets from the tank(s) to the pump shall be designed to prevent air from being entrained while pumping water from the tank. [**1901:**18.3.4]

18.4 Filling and Venting.

18.4.1 Fill Opening. A readily accessible, covered fill opening designed to prevent spillage shall be provided. [**1901:**18.4.1]

18.4.1.1* The fill opening shall have a minimum inside diameter of 3¼ in. (83 mm). [**1901:**18.4.1.1]

18.4.1.2 The cover shall be marked with a label that reads "Water Fill." [**1901:**18.4.1.2]

18.4.1.3 A screen that is easily removed and cleaned shall be installed in the opening. [**1901:**18.4.1.3]

18.4.1.4* The cover, or another device, shall open as a vent to release pressure buildup in the tank. [**1901:**18.4.1.4]

18.4.2 Vent/Overflow Outlet.

18.4.2.1* A vent/overflow outlet that is sized to allow water to be drawn from the tank at a rate at least equal to the rated capacity of the pump or 250 gpm (1000 L/min), whichever is lower, shall be provided.

18.4.2.2* The tank vent/overflow pipeshall be positioned to discharge any liquid overflow not less than 12 in. (30.5 cm) behind the centerline of the rear axle.

18.4.3 Tank Fill Line.

18.4.3.1* A valved tank fill line, sized in accordance with Table 18.4.3.1, shall be provided.

Table 18.4.3.1 Size of Tank Fill Line (Pump to Tank)

Pump Size		Tank Size					
		250 gal or less (950 L or less)		251 gal to 999 gal (951 L to 3784 L)		1000 gal or more (3785 L or more)	
gpm	L/min	in.	mm	in.	mm	in.	mm
50 or less	190 or less	¾	20	1	25	1	25
51–199	191–753	1	25	1½	40	1½	40
200 or greater	754 or greater	1½	40	1½	40	2	50

18.4.3.2 Reserved.

18.4.3.3* The valve shall be capable of regulating flow and shall be controllable from the pump operator's position. [**1901:**18.4.3.3]

18.5 Reserved.

18.6 Water Tank Capacity Certification.

18.6.1* The manufacturer shall certify the capacity of the water tank prior to delivery of the apparatus. [**1901:**18.6.1]

18.6.2 The certified capacity shall be recorded on the manufacturer's record of construction *(see 4.17.1)*, and the certification shall be delivered with the apparatus.

Chapter 19 Reserved

Chapter 20 Foam Proportioning Systems for Class A Foam Concentrate

20.1* Application.

20.1.1 If the wildland fire apparatus is equipped with a foam proportioning system for Class A foam concentrate, the foam proportioning system shall comply with the applicable sections of this chapter.

20.1.2 References in this chapter to foam proportioning systems shall include systems to proportion all water additives. [**1901:**20.1.2]

20.2* Requirements by Type of Foam Proportioning System.

20.2.1* Eductor System. An eductor foam proportioning system shall meet the requirements of 20.3.1 through 20.3.7, 20.3.9, Sections 20.4 through 20.6, and Sections 20.9 through 20.11. [**1901:**20.2.1]

20.2.2* Self-Educting Master Stream Nozzle. A self-educting master stream nozzle shall meet the requirements of Sections 20.3, 20.4, 20.6, and 20.9 through 20.11. [**1901:**20.2.2]

20.2.3* Intake-Side System. An intake-side foam proportioning system shall meet the requirements of Sections 20.3 through 20.6 and Sections 20.9 through 20.11. [**1901:**20.2.3]

20.2.4* Around-the-Pump System. An around-the-pump foam proportioning system shall meet the requirements of Sections 20.3 through 20.6 and Sections 20.9 through 20.11. [**1901:**20.2.4]

20.2.5* Balanced Pressure System. A balanced pressure foam proportioning system shall meet the requirements of Sections 20.3 through 20.11. [**1901:**20.2.5]

20.2.6* Direct Injection System. A direct injection foam proportioning system shall meet the requirements of Sections 20.3 through 20.7 and Sections 20.9 through 20.11. [**1901**:20.2.6]

20.2.7* Water-Powered Direct Injection Foam Proportioning System. A water motor or water turbine foam proportioning system shall meet the requirements of Sections 20.3 through 20.7 and Sections 20.9 through 20.11. [**1901**:20.2.7]

20.3 Design and Performance Requirements of a Foam Proportioning System.

20.3.1* The foam proportioning system shall be capable of proportioning foam concentrate(s) in accordance with the foam concentrate manufacturer's recommendations for the type of foam concentrate used in the system over the system's design range of flow and pressures. [**1901:**20.3.1]

20.3.2 The purchaser shall specify the following:

(1) Range of waterflows and pressures
(2) Proportioning rates
(3) Types of concentrate(s) (Class A, Class B, etc.)
(4) Brand and viscosity of concentrate

[**1901:**20.3.2]

20.3.3 The fire apparatus shall be capable of supplying the power required by the foam proportioning system in addition to the requirements of the other power-dependent systems installed on the apparatus. [**1901:**20.3.3]

20.3.4* Components of the foam proportioning system that are continuously wetted with foam concentrate shall be constructed of materials that will not be damaged in form, fit, or function when exposed to foam concentrates, including the adverse effects of corrosion, formation of harmful solids, deterioration of gaskets and seals, binding of moving parts, and deterioration of the foam concentrate caused by contact with incompatible materials. [**1901:**20.3.4]

20.3.5 The foam proportioning system components that can be flushed with water after use shall be constructed of materials that do not corrode after being flushed with water and allowed to dry. These components shall also be constructed of materials resistant to deterioration by foam concentrates. [**1901:**20.3.5]

20.3.6 The foam concentrate supply line shall not collapse under any operating conditions specified by the manufacturer of the foam proportioning system. [**1901:**20.3.6]

20.3.7 Backflow.

20.3.7.1 A means shall be provided to prevent water backflow into the foam proportioning system and the foam concentrate storage tank.

20.3.7.2 A means shall be provided to prevent foam solution backflow through the foam proportioning system into the water source.

20.3.8 A device that consists of a removable element that does not restrict the full flow capacity of the foam concentrate supply line shall be provided on the foam concentrate supply side of the foam proportioning system to prevent any debris that might affect the operation of the foam proportioning system from entering the system. [**1901:**20.3.8]

20.3.9 Flush Lines.

20.3.9.1 A flush line(s) shall be provided as required by the foam proportioning system manufacturer to flush foam concentrate from the system. [**1901:**20.3.9.1]

20.3.9.2 A means shall be provided in the flush line(s) to prevent water backflow into the foam concentrate tank or water tank during the flushing operation. [**1901:**20.3.9.2]

20.3.9.3 Where the foam proportioning system is connected to more than one foam concentrate storage tank, provisions shall be made to flush all common lines to avoid contamination of dissimilar foam concentrates. [**1901:**20.3.9.3]

20.4 Controls for Foam Proportioning Systems.

20.4.1* The foam proportioning system operating controls shall be located at the pump operator's position and shall be identified as required by 20.9.2. [**1901:**20.4.1]

20.4.2 Foam proportioning systems that require flushing after use shall be provided with controls accessible to the operator to completely flush the system with water according to the manufacturer's instructions. [**1901:**20.4.2]

20.4.3 Foam proportioning systems that incorporate foam concentrate metering valves shall have each metering valve calibrated and marked with a label to indicate the rate(s) of the foam concentrate proportioning available as determined by the design of the system. [**1901:**20.4.3]

20.4.4 Foam proportioning systems that incorporate automatic proportioning features shall be equipped with controls that enable the operator to isolate the automatic feature and operate the system. [**1901:**20.4.4]

20.5 Foam Proportioning System Pressure Gauges, Flowmeters, and Indicators.

20.5.1 The displays of all pressure gauges or flowmeters, and other indicators (e.g., fluid-level indicators) shall be located so that they are visible from the pump operator's position and shall meet the requirements of 4.10.3. [**1901:**20.5.1]

20.5.2 If an analog pressure gauge is used, it shall meet the requirements of 20.5.2.1 through 20.5.4. [**1901:**20.5.2]

20.5.2.1 The gauge shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*. [**1901:**20.5.2.1]

20.5.2.2 Numerals for master gauges shall be a minimum of $^{5}/_{32}$ in. (4 mm) high. [**1901:**20.5.2.2]

20.5.2.3 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa). [**1901:**20.5.2.3]

20.5.2.4 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; be freeze protected; and have internal mechanisms that are factory lubricated for the life of the gauge.

20.5.3 If digital pressure gauges are used, they shall meet the requirements of 20.5.3.1 through 20.5.3.3. [**1901:**20.5.3]

20.5.3.1 The digits shall be at least ¼ in. (6.4 mm) high. [**1901:**20.5.3.1]

20.5.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa). [**1901:**20.5.3.2]

20.5.3.3 Digital pressure gauges shall have an accuracy of ±3 percent over the full scale. [**1901:**20.5.3.3]

20.5.4 Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration. [**1901:**20.5.4]

20.5.5 A gauge(s) shall be provided for balanced pressure foam proportioning systems that simultaneously indicates water pressure and foam concentrate pressure. [**1901:**20.5.5]

20.6 Atmospheric Foam Concentrate Tank. If the foam proportioning system incorporates an atmospheric foam concentrate tank, the requirements of 20.6.1 through 20.6.12 shall apply. [**1901:**20.6]

20.6.1 The foam concentrate tank(s) shall be constructed of noncorrosive materials or other materials that are protected against corrosion or deterioration and that will not be adversely affected by the foam concentrate to be stored in the tank. [**1901:**20.6.1]

20.6.2 Swash Partitions.

20.6.2.1 All foam concentrate tanks shall be provided with swash partitions arranged such that the maximum dimension perpendicular to the plane of any partition shall not exceed 36 in. (900 mm). [**1901:**20.6.2.1]

20.6.2.2 The swash partition(s) shall extend from wall to wall and cover at least 75 percent of the area of the plane of the partition. [**1901:**20.6.2.2]

20.6.3 The foam concentrate tank shall be provided with a fill tower or expansion compartment having a minimum area of 12 $in.^2$ (7500 mm^2) and having a volume of not less than 1 percent of the total tank volume. [**1901:**20.6.3]

20.6.3.1 The fill tower opening shall be protected by a completely sealed airtight cover. [**1901:**20.6.3.1]

20.6.3.2* The cover shall be attached to the fill tower by mechanical means. [**1901:**20.6.3.2]

20.6.3.3 The fill opening shall incorporate a removable screen with a mesh not to exceed ¼ in. (6 mm).

20.6.3.4* The fill tower shall be arranged so that foam concentrate from a standard container (5 gal, or up to 25 L) can be poured directly into the tank without the use of funnels or other special devices.

20.6.4 The fill tower shall be equipped with a pressure/vacuum vent that enables the tank to compensate for changes in pressure or vacuum when filling or withdrawing foam concentrate from the tank. [**1901:**20.6.4]

20.6.4.1 The pressure/vacuum vent shall not allow atmospheric air to enter the foam tank except during operation or to compensate for thermal fluctuations. [**1901:**20.6.4.1]

20.6.4.2 The vent shall be protected to prevent foam concentrate from escaping or directly contacting the vent at any time. [**1901:**20.6.4.2]

20.6.4.3 The vent shall be of sufficient size to prevent tank damage during filling or foam withdrawal. [**1901:**20.6.4.3]

20.6.5 The foam concentrate tank shall not be equipped with an overflow pipe or any direct opening to the atmosphere. [**1901:**20.6.5]

20.6.6* The foam concentrate tank(s) shall be designed and constructed to facilitate complete interior flushing and cleaning as required. [**1901:**20.6.6]

20.6.7 Tank Drain.

20.6.7.1 A minimum ½ in. (13 mm) inside diameter full flow drain valve and piping shall be provided at the lowest point of any foam concentrate tank.

20.6.7.2 The drain shall be piped to drain directly to the surface beneath the apparatus without contacting other body or chassis components. [**1901:**20.6.7.2]

20.6.8* The foam concentrate tank shall be constructed and installed to be independent of the apparatus body. [**1901:**20.6.8]

20.6.9 The foam concentrate discharge system design shall prevent the siphoning of foam concentrate. [**1901:**20.6.9]

20.6.10 Labels.

20.6.10.1 A label that reads "Foam Tank Fill" shall be placed at or near any foam concentrate tank fill opening. [**1901:**20.6.10.1]

20.6.10.2* A label that specifies the following shall be placed at or near any foam concentrate tank fill opening:

(1) Type(s) of foam concentrate the system is designed to use
(2) Any restrictions on the types of foam concentrate that can be used with the system
(3) A warning message that reads "Warning: Do Not Mix Brands and Types of Foam"

[**1901:**20.6.10.2]

20.6.11 The foam concentrate tank outlet connection shall be designed and located to prevent aeration of the foam concentrate and shall allow withdrawal of 80 percent of the foam concentrate tank storage capacity under all operating conditions with the fire apparatus on level ground. [**1901:**20.6.11]

20.6.12 The foam concentrate tank inlet connection, if provided, shall prevent aeration of the foam concentrate under all operating conditions. [**1901:**20.6.12]

20.7* Foam Concentrate Pump. If the foam proportioning system is equipped with a foam concentrate pump, the requirements of 20.7.1 through 20.7.5 shall apply. [**1901:**20.7]

20.7.1 The foam concentrate pump shall operate without cavitation when delivering maximum rated flow. [**1901:**20.7.1]

20.7.2* The materials of construction for the foam concentrate pump shall be corrosion resistant and compatible with the type of foam concentrate(s) listed on the label required in 20.9.3. [**1901:**20.7.2]

20.7.3 Drivetrain components that transmit power to the foam concentrate pump shall be in accordance with the fire apparatus manufacturer's design performance provided on the label required in 20.9.3. [**1901:**20.7.3]

20.7.4 A means to relieve excess pressure in the foam concentrate pumping system shall be provided to protect the foam concentrate pump from damage. [**1901:**20.7.4]

20.7.5 Foam concentrate pumps that are intended to be supplied from an external source of foam concentrate shall be provided with an external valved intake connection. [**1901:**20.7.5]

20.8 Pressure Vessel Foam Concentrate or Foam Solution Tanks. If the foam proportioning system incorporates a pressure vessel foam concentrate tank, or the foam solution is contained in a pressure vessel, the requirements of 20.8.1 through 20.8.8 shall apply. [**1901:**20.8]

20.8.1 If the tank is charged with a compressed gas or a pressurized liquid, and it falls within the scope of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, it shall be designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the rated pressure. [**1901:**20.8.1]

20.8.2 Foam proportioning system piping and components shall be designed to withstand a minimum of 1½ times the maximum working pressure of the pressure vessel and shall be tested to the working pressure of the pressure vessel after installation. [**1901:**20.8.2]

20.8.3 The pressure vessel tank shall be protected against corrosion from the foam concentrate or water stored in the tank. [**1901:**20.8.3]

20.8.4 If the tank is equipped with a gravity fill (i.e., has a fill cap), the fill opening shall be a minimum of 2 in. (51 mm) inside diameter. [**1901:**20.8.4]

20.8.4.1 The fill cap shall be equipped with nontapered threads and a compressible gasket. [**1901:**20.8.4.1]

20.8.4.2 Special wrenches or tools required to tighten the fill cap shall be supplied by the manufacturer and shall be mounted adjacent to the fill cap. [**1901:**20.8.4.2]

20.8.4.3 A safety vent hole shall be located in the fill cap so that it vents the tank pressure while at least 3½ threads remain engaged. [**1901:**20.8.4.3]

20.8.5 A minimum ½ in. (13 mm), manually operated, valved vent shall be provided on all pressure vessel tanks. [**1901:**20.8.5]

20.8.6 If the pressure vessel is charged with a compressed gas or a pressurized liquid, a relief valve that meets the applicable requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, shall be installed on the pressure vessel and set to prevent the vessel pressure from exceeding 110 percent of the maximum allowable working pressure. [**1901:**20.8.6]

20.8.7 A minimum ½ in. (13 mm), manually operated, valved drain connection shall be provided on all pressure vessel tanks.

20.8.8 A device indicating the internal pressure of the pressure vessel shall be located at the operator's position. [**1901:**20.8.8]

20.9 Labels and Instruction Plates.

20.9.1 An instruction plate shall be provided for the foam proportioning system that includes, at a minimum, a piping schematic of the system and basic operating instructions.

20.9.2 Each control, gauge, and indicator necessary to operate the foam proportioning system shall be marked with a label as to its function.

20.9.3 A label, located at the operator's position, shall provide the following information pertaining to the performance operating specifications of the foam proportioning system:

(1) Foam classification type
(2) Maximum and minimum proportioning rates (percent)
(3) Maximum and minimum waterflow [gpm (L/min)]
(4) Maximum and minimum operating pressures
(5)* The statement "Use only concentrates that are compatible with this foam proportioning system. Refer to the foam proportioning system manufacturer's operating manual."

[**1901:**20.9.3]

20.9.3.1 If an in-line eductor system is provided on the apparatus, the following information shall also be provided on the plate:

(1) Maximum hose length using 1½ in., 1¾ in., and 2 in. (38 mm, 44 mm, and 51 mm) hose
(2) Allowable elevation changes
(3) The statement: "The flow rate of the nozzle must match the flow rate of the system."

[**1901:**20.9.3.1]

20.9.3.2 If an around-the-pump system is provided on the apparatus, the following information shall also be provided on the plate:

(1) Maximum intake pressure or required intake to discharge pressure differential
(2) A table to indicate flow rate and the corresponding metering valve setting

[**1901:**20.9.3.2]

20.9.4 Operations and Maintenance Manual.

20.9.4.1 Two copies of an operations and maintenance manual shall be provided. [**1901:**20.9.4.1]

20.9.4.2 The manual shall include a complete diagram of the system, operating instructions, system foam concentrate capabilities, original system calibration, and details outlining all recommended maintenance procedures. [**1901:**20.9.4.2]

20.10 Foam Proportioning System Accuracy.

20.10.1* The foam proportioning system shall be type tested and certified by the foam proportioning system manufacturer to be accurate throughout the foam proportioning system's declared range of waterflow, water pressure, foam percentage (or foam proportioning system capacity), and concentrate viscosity. [**1901:**20.10.1]

20.10.1.1 At a minimum, this declaration shall include the test points listed in Table 20.10.1.1. [**1901**:20.10.1.1]

Table 20.10.1.1 Test Points for Certification of Foam Proportioning System Performance

Waterflow	Water Pressure	Foam Percentage or Foam Proportioning System Capacity
Minimum	Minimum	Minimum
Maximum	Maximum	Maximum*
Minimum	Maximum	Minimum
Maximum	Minimum	Maximum
Midrange	Midrange	Midrange†

*See 20.10.1.3.
†See 20.10.1.2.
[**1901**:Table 20.10.1.1]

20.10.1.2* Calibration at midrange shall be established by the foam proportioning system manufacturer. [**1901:**20.10.1.2]

20.10.1.3 When testing to the maximum for waterflow and foam percentage or foam proportioning system capacity, the test shall be at the limits of the foam proportioning system or the water pump, whichever is more restrictive. [**1901:**20.10.1.3]

20.10.2 Systems designed to produce foam solution at ratios of less than 1 percent shall proportion foam concentrate to an accuracy of -0/+40 percent. [**1901:**20.10.2]

20.10.3 Systems designed to produce foam solution at ratios of 1 percent or greater shall proportion foam concentrate to an accuracy of -0/+30 percent or 1 percentage point, whichever is less. [**1901:**20.10.3]

20.10.4 The foam proportioning system manufacturer shall provide the certification required by Section 20.10 to the final-stage apparatus manufacturer. [**1901:**20.10.4]

20.10.4.1 The certification shall include the foam proportioning system manufacturer's viscosity performance specifications. [**1901:**20.10.4.1]

20.10.4.2 The final-stage apparatus manufacturer shall deliver a copy of the certification with the fire apparatus. [**1901:**20.10.4.2]

20.11 Testing and Documentation.

20.11.1 The final installer shall test and certify the following:

(1) The foam proportioning system, as installed, complies with the foam equipment manufacturer's installation recommendations.
(2)* The foam proportioning system has been calibrated and tested to meet the foam equipment manufacturer's and the purchaser's performance specifications.
(3)* At a minimum, the foam proportioning system has been tested at the points defined in Table 20.11.1 for each foam system injection point.

[**1901:**20.11.1]

Table 20.11.1 Test Points for Installation Testing of Foam Proportioning System Performance

Waterflow	Water Pressure	Foam Percentage or Foam Proportioning System Capacity
Minimum	Minimum	Minimum
Maximum	Maximum	Maximum*
Midrange	Midrange	Midrange†

*See 20.10.1.3.
†See 20.10.1.2.
[**1901:** Table 20.11.1]

20.11.2 The final installer shall deliver documentation with the fire apparatus declaring the foam proportioning system as installed meets the requirements of 20.10.2 or 20.10.3 across the foam proportioning system manufacturer's declared range of waterflow, water pressure, foam percentage (or foam proportioning system capacity), and concentrate viscosity at the test points defined in Table 20.11.1. [**1901:**20.11.2]

Chapter 21 Compressed Air Foam Systems (CAFS)

21.1* Application. If the wildland fire apparatus is equipped with a compressed air foam system (CAFS), it shall comply with the applicable sections of this chapter.

21.2 General Requirements.

21.2.1 An automatic regulating foam proportioning system shall be used and shall comply with the applicable requirements of Chapter 20.

21.2.2 The total CAFS rating shall be expressed in terms of airflow and waterflow. [**1901:**21.2.2]

21.2.2.1* The airflow shall be expressed in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] and shall be based on the continuous flow capacity of the compressed air source(s) at a minimum gauge pressure of 125 psi (862 kPa). [**1901:**21.2.2.1]

21.2.2.2 The waterflow shall be expressed in gallons per minute (gpm) [liters per minute (L/min)] at a gauge pressure of 125 psi (862 kPa). [**1901:**21.2.2.2]

21.2.3 The fire apparatus shall be capable of supplying power for operating the CAFS at its rated capacity while simultaneously providing power to all other power-dependent systems installed on the apparatus. [**1901:**21.2.3]

21.2.4* On a CAFS, the air pressures shall be automatically balanced to the water pressure to within −0/+10 percent throughout the operational range of the CAFS. [**1901:**21.2.4]

21.2.5* A means shall be provided on the CAFS for the operator to relieve all pressure from the system after the system has been deactivated. [**1901:**21.2.5]

21.3 Compressed Air System.

21.3.1 The compressed air system operating in clean environmental conditions shall be designed to provide a continuous rated air supply for a duration of 6 hours without needing adjustment, additional lubrication, or air filters changed. [**1901:**21.3.1]

21.3.2 Relief Valve.

21.3.2.1 The compressed air system shall be equipped with a relief valve that is set to prevent the compressed air system from exceeding 110 percent of the maximum allowable working pressure of the system. [**1901:**21.3.2.1]

21.3.2.2 The outlet of the relief valve shall be routed to an area that does not expose personnel to air blasts or cause the creation of dust. [**1901:**21.3.2.2]

21.3.3 If the possibility exists for moisture to build up in the compressed air system, the system shall be equipped with moisture traps and drains. [**1901:**21.3.3]

21.3.4 If an air receiveror holding, surge, or separator tank is provided and is 6 in. nominal pipe size or less, the tank shall be subjected to a hydrostatic test to a gauge pressure of 500 psi (3400kPa) for a minimum of 10 minutes. [**1901:**21.3.4]

21.3.4.1 The tank manufacturer shall provide a certificate of completion for the hydrostatic test. [**1901:**21.3.4.1]

21.3.4.2 For air receiver or holding, surge, or separator tanks larger than 6 in. nominal pipe size, the tank shall be designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the maximum working pressure. [**1901:**21.3.4.2]

21.3.4.3 Transportable air tanks shall comply with 49 CFR 178.37, "Specification 3AA and 3AAX seamless steel cylinders," or 29 CFR 1910.169, "Air receivers." [**1901:**21.3.4.3]

21.3.4.4 Relief valves on transportable air tanks shall be of the ASME type on ASME cylinders and of the DOT type on DOT cylinders or equal for the rated pressure. [**1901:**21.3.4.4]

21.3.4.5 Valves installed on air tanks shall meet the requirements of the Compressed Gas Association or equivalent standards regarding pressure and usage with compressed air. [**1901:**21.3.4.3]

21.3.4.6 If the installation utilizes cylinders that require periodic testing, a label shall be placed on the operator's panel indicating the test date stamped on the cylinders and the date the cylinders will next require testing. [**1901:**21.3.4.4]

21.4* Air Mixing.

21.4.1 An automatic means shall be provided to prevent the backflow of water or foam solution into the compressed air system or air into the water pump or the foam proportioning equipment. [**1901:**21.4.1]

21.4.2 A means of mixing air and foam solution that provides for a homogeneous mixture of compressed air and foam solution shall be provided on CAFS. [**1901:**21.4.2]

21.5* Compressed Air System Piping. The discharge plumbing shall be configured to minimize the use of elbows or abrupt turns. [**1901:**21.5]

21.6 Air System Controls.

21.6.1 All compressed air system controls shall be located such that they can be reached from the pump operator's position and shall be identified with an instruction plate in accordance with the requirements of 21.8.1.

21.6.2 Compressed air systems that require flushing after use shall be provided with controls that are accessible to the operator and enable the operator to completely flush the system with water according to the manufacturer's instructions. [**1901:**21.6.2]

21.7 Foam System Pressure Gauges, Flowmeters, and Indicators.

21.7.1 The displays of all pressure gauges, flowmeters, and indicators (e.g., fluid level indicators) shall be located so they are visible from the pump operator's position and shall meet the requirements of 4.10.3. [**1901:**21.7.1]

21.7.2 Where analog pressure gauges are used, they shall meet the requirements of 21.7.2.1 through 21.7.2.4. [**1901:**21.7.2]

21.7.2.1 Analog pressure gauges shall have a minimum accuracy of Grade B as defined in ASME B40.100. [**1901:**21.7.2.1]

21.7.2.2 Numerals for master gauges shall be a minimum of $\frac{5}{32}$ in. (4 mm) high. [**1901:**21.7.2.2]

21.7.2.3 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa). [**1901:**21.7.2.3]

21.7.2.4 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge. [**1901:**21.7.2.4]

21.7.3 If digital pressure gauges are used, they shall meet the requirements of 21.7.3.1 through 21.7.3.3. [**1901:**21.7.3]

21.7.3.1 The digits shall be at least $\frac{1}{4}$ in. (6.4 mm) high. [**1901:**21.7.3.1]

21.7.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa). [**1901:**21.7.3.2]

21.7.3.3 Digital pressure gauges shall have an accuracy of ±3 percent over the full scale. [**1901:**21.7.3.3]

21.7.4 Each pressure gauge and flowmeter, and its respective display, shall be mounted and attached so it is protected from accidental damage and excessive vibration. [**1901:**21.7.4]

21.7.5 If flowmeters are provided, they shall meet the requirements of 21.7.5.1 and 21.7.5.2. [**1901:**21.7.5]

21.7.5.1 Flowmeter displays shall be located at the pump operator's panel and shall indicate the airflow in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] and indicate the waterflow in gallons per minute (gpm) [liters per minute (L/min)]. [**1901:**21.7.5.1]

21.7.5.2 Flowmeters shall be rated to a hydrostatic burst gauge pressure of 500 psi (3400 kPa) if located on the pressure side of the system. [**1901:**21.7.5.2]

21.7.6* A pressure gauge shall be provided for the compressed air system. [**1901:**21.7.6]

21.8 Labels and Instruction Plates. [**1901:**21.8]

21.8.1 An instruction plate indicating the identification, function, and operation shall be provided for each control, gauge, and indicator required to operate the CAFS. [**1901:**21.8.1]

21.8.2 A label shall be provided that is visible from the pump operator's position that gives the rated continuous flow capacity of the compressed air system at a gauge pressure of 125 psi (862 kPa). [**1901:**21.8.2]

21.8.3 An instruction plate shall be provided that is visible from the pump operator's position that states the following:

(1) Open and close valves slowly.
(2) Do not run with just air and water.
(3) Shut off air when foam tank is empty.
(4) Be prepared for high nozzle reactions — open nozzle slowly.

[**1901:**21.8.3]

21.8.4 Operations and Maintenance Manual.

21.8.4.1 Two copies of an operations and maintenance manual shall be provided. [**1901:**21.8.4.1]

21.8.4.2 The manual shall include a complete diagram of the CAFS, operating instructions, the system rating, and details outlining all recommended maintenance procedures. [**1901:**21.8.4.2]

21.9* Manufacturer's Predelivery Tests. The manufacturer shall conduct the tests in 21.9.1 and 21.9.2 prior to delivery of the fire apparatus and deliver documentation of the test results with the fire apparatus. [**1901:**21.9]

21.9.1 CAFS Capacity Rating Test.

21.9.1.1 The operation of the water pump and the compressed air source shall be tested simultaneously to determine the integrity of the system and to ensure that the power available is capable of operating these components of the CAFS simultaneously. [**1901:**21.9.1.1]

21.9.1.1.1* The compressed air system shall be operated at its flow capacity at a minimum gauge pressure of 125 psi (862 kPa), and the water pump shall discharge a minimum of 2 gpm of water at 125 psi net pump pressure for every 1 SCFM (250 L/min of water at 862 kPa net pump pressure for every 1 SCMM) of compressed air discharge. [**1901:**21.9.1.1.1]

21.9.1.1.2 The discharge shall be through at least two separate discharge openings, one discharging air only and the other discharging water only. [**1901:**21.9.1.1.2]

21.9.1.2 One or more lines of fire hose of sufficient diameter shall be provided to allow discharge of the required amount of water from the pump to a nozzle or other flow-measuring equipment without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) [approximately 500 gpm (2000 L/min) for $2\frac{1}{2}$ in. (65 mm) hose]. [**1901:**21.9.1.2]

21.9.1.2.1 The discharge shall be measured using a smooth-bore nozzle and pitot tube or other equipment such as flowmeters, volumetric tanks, or weigh tanks. [**1901:**21.9.1.2.1]

21.9.1.2.2 Test gauges shall meet the requirements of 16.13.2.2.4 and 16.13.2.2.5. [**1901:**21.9.1.2.2]

21.9.1.3 The airflow rate shall be measured using a pressure and temperature compensated flow-measuring device. [**1901:**21.9.1.3]

21.9.1.3.1 The airflow shall be measured in SCFM [L/min at standard temperature and pressure] at a minimum gauge pressure of 125 psi (862 kPa). [**1901:**21.9.1.3.1]

21.9.1.3.2 The airflow-measuring device shall have been calibrated for accuracy within the previous 3 months. [**1901:**21.9.1.3.2]

21.9.1.3.3* The air discharge outlet shall have nothing attached directly to it except the test device(s). [**1901:**21.9.1.3.3]

21.9.1.4 The water pump and the compressed air system shall be started, and the rated flows and pressures as specified in 21.9.1.1.1 shall be established and maintained. [**1901:**21.9.1.4]

21.9.1.4.1 The system shall be run for 1 hour. [**1901:**21.9.1.4.1]

21.9.1.4.2 Readings of the airflow rate and pressure, and the water pump pressure and discharge rate, shall be taken at least every 10 minutes. [**1901:**21.9.1.4.2]

21.9.1.5 Failure of any component of the CAFS to maintain air and water pressures and discharge volumes at or above the system rating shall constitute failure of the test. [**1901:**21.9.1.5]

21.9.2 Standby Run Test.

21.9.2.1 One 200 ft (60 m) line of 1½ in. (38 mm) hose shall be connected to the discharge of the CAFS and shall be stretched out on level ground. [**1901:**21.9.2.1]

21.9.2.2 A quarter-turn valve of the same nominal size as the hose shall be installed at the discharge end. [**1901:**21.9.2.2]

21.9.2.3 The hose shall be restrained immediately behind the valve at the discharge end to prevent uncontrollable movement when the valve is opened. [**1901:**21.9.2.3]

21.9.2.4 Operating as a CAFS, with a gauge pressure air output at 125 psi (862 kPa), a foam flow shall be established in the hose line. [**1901:**21.9.2.4]

21.9.2.5 With the water tank at the half-full level, the valve at the discharge end of the hose shall be shut no faster than in 3 seconds and no slower than in 10 seconds. [**1901:**21.9.2.5]

21.9.2.6 The engine's speed shall be maintained for 10 minutes without discharging water, air, or foam solution from the CAFS and without operator intervention. [**1901:**21.9.2.6]

21.9.2.7 A bypass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits. [**1901:**21.9.2.7]

21.9.2.8 At the end of 10 minutes, the valve shall be reopened no faster than in 3 seconds and no slower than in 10 seconds. [**1901:**21.9.2.8]

21.9.2.9 Damage to the CAFS that affects its rated performance characteristics or the lack of a fire stream immediately upon opening the hose line shall constitute failure of this test. [**1901:**21.9.2.9]

Chapter 22 Line Voltage Electrical Systems

22.1 If the apparatus is equipped with a line voltage electrical system, the system shall meet the requirements of Chapter 22 of NFPA 1901.

Chapter 23 Reserved

Chapter 24 Reserved

Chapter 25 Winches

25.1 General. If a chassis-mounted winch is installed on the apparatus, it shall meet the requirements of this chapter. [**1901:**25.1]

25.1.1* The winch shall be designed for the intended use and shall be installed in accordance with the winch manufacturer's recommendations. [**1901:**25.1.1]

25.1.2 All winches shall be equipped with rollers, guides, or both to prevent damage to the winch wire or synthetic rope or the apparatus. [**1901:**25.1.2]

25.1.3 All rollers and guides shall be designed to match the winch capacity and rope size. [**1901:**25.1.3]

25.2 Winch Wire or Synthetic Rope.

25.2.1 The winch shall have a minimum wire rope or synthetic rope length of 75 ft (22 m). [**1901:**25.2.1]

25.2.2 The wire rope or synthetic rope shall be of a type and size recommended by the winch manufacturer. [**1901:**25.2.2]

25.2.3 The wire rope or synthetic rope assembly, including all hardware such as clevises, hooks, and snatch blocks provided for attachment to the winch, shall have a design load rating greater than the line pull capacity of the winch. [**1901:**25.2.3]

25.3 Clutch. The winch shall be equipped with a clutch assembly to permit free spooling and quick removal of wire or synthetic rope. [**1901:**25.3]

25.3.1 The free spooling clutch shall be accessible without reaching under the apparatus. [**1901:**25.3.1]

25.3.2 If the winch is installed under the apparatus or not visible to the operator, the free spooling clutch shall be remotely controlled. [**1901:**25.3.2]

25.4 Electric Powered Winches.

25.4.1* Controls. Operation of the winch shall be from a remote location at least 12 ft from the winch or within an enclosed area. [**1901:**25.4.1]

25.4.2 Power Supply.

25.4.2.1 Dedicated power and ground circuits shall be utilized. [**1901:**25.4.2.1]

25.4.2.2 Wiring shall be sized in accordance with the winch manufacturer's installation instructions and shall comply with Chapter 13.

25.4.3 Removable Electric Winches.

25.4.3.1 Electric winches that are temporarily attached to the apparatus (at sides, rear, or front) shall meet the same requirements as permanently mounted winches. [**1901:**25.4.3.1]

25.4.3.2 The attachment to the apparatus shall be with quick-release devices. [**1901:**25.4.3.2]

25.4.3.3 The attachment system on the apparatus shall meet the requirements of Section 15.12. [**1901:**25.4.3.3]

25.4.4 Electric Power for Removable Winches.

25.4.4.1 The electrical power supply(ies) from the apparatus to the removable winch shall terminate at a quick disconnect receptacle with a connector plug. [**1901:**25.4.4.1]

25.4.4.2 The receptacle shall have a label indicating its use. [**1901:**25.4.4.2]

25.4.4.3 The power cord from the receptacle to the winch shall be sized for the power requirements of the winch. [**1901:**25.4.4.3]

25.4.4.4 The power cord shall be highly flexible and shall be protected from mechanical damage. [**1901:**25.4.4.4]

25.5* Hydraulically Driven Winches.

25.5.1 Hydraulic Hose.

25.5.1.1 All hydraulic hose shall be designed for the hydraulic pressures expected to be encountered. [**1901:**25.5.1.1]

25.5.1.2 Hose shall be a wire-braided type with a female swivel on one end. [**1901:**25.5.1.2]

25.5.2 Operation of the hydraulic winch shall be from a remote location at least 12 ft from the winch or within an enclosed area. [**1901:**25.5.2]

25.5.3 Hydraulic Reservoir.

25.5.3.1 The hydraulic system components shall be capable of maintaining, under all operating conditions, oil cleanliness and temperature that comply with the manufacturer's recommendations. [**1901:**25.5.3.1]

25.5.3.2 A means for checking and filling the hydraulic reservoir shall be readily accessible. [**1901:**25.5.3.2]

25.5.3.3 The fill location shall be conspicuously marked with a label that reads "Hydraulic Oil Only." [**1901:**25.5.3.3]

25.5.3.4 The manufacturer shall provide instructions for checking and filling the hydraulic reservoir. [**1901:**25.5.3.4]

25.5.4 The hydraulic winch engagement controls shall be located in the driving compartment. [**1901:**25.5.4]

25.5.4.1* A "Hydraulic Winch Engaged" indicator shall be provided in the driving compartment to indicate that the hydraulic pump engagement has been successfully completed. [**1901:**25.5.4.1]

Chapter 26 Reserved

Chapter 27 Vehicle Protection Systems

27.1 Brush Rails. If brush rails are installed on the fire apparatus, they shall meet the requirements of 27.1.1 through 27.1.4.

27.1.1 Rails shall be supported directly by members attached to the vehicle chassis frame.

27.1.2 The rails shall be designed for replacement, if damaged, or for removal for servicing or repairing the vehicle chassis or body without the use of welding or cutting equipment.

27.1.3 The rails shall not impede the normal opening of engine enclosures, access to the driving and crew compartment(s), access to body storage compartments, or access to firefighting equipment.

27.1.4 The rails shall not block the full function of any of the vehicle lighting systems, including normal travel lights, warning lights, and work area lights on the vehicle.

27.2 Grille Guard. If a grille guard is installed on the fire apparatus, it shall meet the requirements of 27.2.1 through 27.2.6.

27.2.1 The grille guard shall protect the front of the cab, including the headlights and radiator air inlet.

27.2.2 The grille guard shall be supported directly by the bumper at the front of the cab or by members attached to the vehicle chassis frame.

27.2.3 The grille guard shall be designed for replacement, if damaged, or for removal for servicing or repairing the vehicle chassis without the use of welding or cutting equipment.

27.2.4 The guard shall not impede the normal opening of the engine enclosures.

27.2.5 The guard shall not block the full function of any of the vehicle lighting systems, including normal travel lights, warning lights, and work area lights on the vehicle.

27.2.6 Parts of the radiator that might be exposed and subjected to brush damage from behind and under the front bumper also shall be protected.

27.3* Skid Plates. If skid plates are installed on the fire apparatus, they shall meet the requirements of 27.3.1 through 27.3.5.

27.3.1 Skid plates shall be installed on nonmovable components that protrude below the normal truck chassis parts.

27.3.2 Skid plates shall be supported directly by the component they are protecting or the chassis frame.

27.3.3 Skid plates shall be removable without the use of welding or cutting equipment.

27.3.4 Skid plates shall not impede the normal function of the vehicle or any of its systems.

27.3.5 Skid plates shall be designed, located, and installed in a manner that minimizes the trapping of vegetative material between the plate and the component it guards or other components.

Chapter 28 Ultra-High Pressure Fire Pumps and Associated Equipment

28.1 Application. If the apparatus is equipped with an ultra-high pressure fire pump, the provisions of this chapter shall apply. [**1901:**28.1]

28.2 Pump Performance.

28.2.1 An ultra-high pressure fire pump shall have a minimum rated capacity of 6 gpm (25 L/min) and shall have a rated

discharge pressure greater than or equal to 1100 psi (7600 kPa). [**1901:**28.2.1]

28.2.2 The rating for ultra-high pressure fire pumps shall be based on the pump taking water from the apparatus water tank. [**1901:**28.2.2]

28.2.3 If the completed pumping system is capable of taking suction, it shall do so within 30 seconds under the following conditions:

(1) At an altitude of 2000 ft (600 m) above sea level
(2) Through 10 ft (3 m) of suction hose of the size specified in Table 28.2.3 and equipped with a suction hose strainer
(3) With a lift of 3 ft (1 m)
(4) At 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level)
(5) At a water temperature of 60°F (16°C)

[**1901:**28.2.3]

28.2.4* The pump manufacturer shall certify for each ultra-high pressure fire pump the rated capacity in gpm (L/min), rated discharge pressure in psi (kPa), and net positive suction head required (NPSHR) in ft (m) of water at 60°F (16°C) and 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level) for an elevation up to 2000 ft (600 m). [**1901:**28.2.4]

28.2.5 Vacuum.

28.2.5.1 If the completed pumping system is capable of taking suction per 28.2.3, it shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) at altitudes up to 2000 ft (600 m) by means of the pump priming system and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (34 kPa). [**1901:**28.2.5.1]

28.2.5.2 The requirements of 28.2.5.1 shall be met with all intake valves open, with all intakes capped or plugged, with all discharge caps removed and valves closed, and without the use of the pump primer during the 5-minute period. [**1901:**28.2.5.2]

28.3 Power Train Capability.

28.3.1 All components in the power train from the engine to the pump shall be capable of transmitting the continuous duty power required by the pump for at least 30 minutes at the pump's rated capacity and pressure. [**1901:**28.3.1]

28.3.2 When pumping rated capacity and pressure, lubricant temperatures in any power train component shall not exceed the component manufacturer's recommendation for maximum temperature. [**1901:**28.3.2]

Table 28.2.3 Suction Hose Size by Pump Capacity Rating

Flow Rate		Minimum Suction Hose Size	
gpm	L/min	in.	mm
20 and less	80 or less	1	25
30	120	1½	38
50	200	2	52
100	400	2½	65
150	600	2½	65
200	800	2½	65
250	1000	3	75
300	1200	3	75

[**1901:**Table 28.2.3]

28.4 Construction Requirements.

28.4.1 The pump body, the discharge piping, and valves, excluding the tank fill line, on the tank side of the valve, shall be capable of withstanding a minimum hydrostatic pressure of 1.4 times the rated discharge pressure. [**1901:**28.4.1]

28.4.2 The pump intake, tank fill line on the tank side of the valve, and associated plumbing and valves, excluding the tank-to-pump line on the tank side of the valve, shall be capable of withstanding a minimum hydrostatic pressure of 250 psi (1700 kPa). [**1901:**28.4.2]

28.4.3 The pump, piping, and valves shall be capable of delivering the rated capacity at the rated discharge pressure of the pump and withstanding closure of all discharges. [**1901:**28.4.2]

28.4.4 Pump Body Integrity Test. The pump body shall be subjected to either a hydrostatic test per 28.4.4.1 or a hydrodynamic test per 28.4.4.2. [**1901:**28.4.3]

28.4.4.1 If the pump body is subjected to a hydrostatic test, it shall be hydrostatically tested to a gauge pressure of 1.4 times the rated discharge pressure for a minimum of 10 minutes. [**1901:**28.4.3.1]

28.4.4.2 If the pump body is subjected to a hydrodynamic test, it shall be hydrodynamically tested to a gauge pressure of 1.4 times the rated discharge pressure for a minimum of 10 minutes. [**1901:**28.4.3.2]

28.4.4.3 The pump manufacturer shall provide a certificate of completion for the hydrostatic or hydrodynamic test. [**1901:**28.4.3.3]

28.5 Pump Intakes.

28.5.1 Each pump intake shall be sized to permit the full rated performance of the pump. [**1901:**28.5.1]

28.5.2* For any pump intake equipped with a valve, the valve shall be controlled from the pump operator's position. [**1901:**28.5.2]

28.5.3* Each external intake shall be equipped with National Hose (NH) threads on the connection with a removable or accessible strainer. [**1901:**28.5.3]

28.5.3.1 Adapters with special threads or other means for hose attachment shall be permitted on any intake connection. [**1901:**28.5.3.1]

28.5.3.2 Each external valved intake larger than 1½ in. shall be equipped with a bleeder valve to bleed off air or water from a hose connected to the intake. [**1901:**28.5.3.2]

28.5.3.3 All intake connections shall be provided with closures, caps, or plugs capable of withstanding a hydrostatic gauge pressure of 250 psi (1730 kPa). [**1901:**28.5.3.3]

28.5.3.3.1 Intake connections having male threads shall be equipped with caps. [**1901:**28.5.3.3.1]

28.5.3.3.2 Intake connections having female threads shall be equipped with plugs. [**1901:**28.5.3.3.2]

28.5.3.3.3 Where adapters for special threads or other means for hose attachment are provided on the intake connections, closures shall be provided for the adapters in lieu of caps or plugs. [**1901:**28.5.3.3.3]

28.5.3.4 Caps or closures for intake connections 3 in. (75 mm) and smaller shall remain secured to the apparatus when removed from the connection. [**1901:**28.5.3.4]

28.5.4 The pump shall have a means to restrict debris that is too large to pass through the pump. [**1901:**28.5.4]

28.6 Pump Discharges.

28.6.1* Each pump discharge shall be equipped with a valve that can be controlled from a pump operator's position. [**1901:**28.6.1]

28.6.2 Any discharge that can be supplied from another pump system on the apparatus shall have check valves in both supply lines to prevent backflow into either pump. [**1901:**28.6.2]

28.6.3 Discharge Outlet Connections.

28.6.3.1 All discharge outlets, except connections to which a hose will be preconnected, shall be equipped with connectors that permit hose attachment or removal within 30 seconds. [**1901:**28.6.3.1]

28.6.3.2 Adapters with special threads or other means for hose attachment shall be permitted to be attached to any discharge outlet connection. [**1901:**28.6.3.2]

28.6.3.3 Discharge outlet connections shall not be permitted to be equipped with NH threads. [**1901:**28.6.3.3]

28.6.4 All discharge outlet connections, except connections to which a hose will be preconnected, shall be equipped with caps or closures capable of withstanding a hydrostatic gauge pressure of 1.4 times the rated discharge pressure. [**1901:**28.6.4]

28.6.4.1 If the apparatus has more than one discharge, the caps or closures shall be capable of withstanding closure of all discharges when pump controls are set to deliver rated capacity at rated discharge pressure. [**1901:**28.6.4.1]

28.6.4.2 Where adapters are provided on the discharge outlet connection, the closures shall fit on the adapters. [**1901:**28.6.4.2]

28.6.4.3 Caps or closures for outlet connections 3 in. (75 mm) and smaller shall remain secured to the apparatus when removed from the connection. [**1901:**28.6.4.3]

28.6.5 All preconnected hose connections and preconnected hoses shall be capable of withstanding a hydrostatic gauge pressure of 1.4 times the maximum discharge pressure. [**1901:**28.6.5]

28.6.6 All preconnected hose connections and preconnected hoses shall be capable of withstanding closure of all discharges when pump controls are set to deliver rated capacity at rated discharge pressure. [**1901:**28.6.6]

28.6.7* If a water tank fill line is provided, the line shall be connected from the pump discharge manifold directly to the water tank. [**1901:**28.6.8]

28.6.8 If a water tank fill line is provided, the line shall include a valve that can be controlled from the pump operator's position. [**1901:**28.6.9]

28.7 Pump Operator's Panel.

28.7.1 Each pump control, gauge, and other instrument necessary to operate the ultra-high pressure fire pump shall be marked with a label as to its function. [**1901:**28.7.1]

28.7.2 All gauges, instruments, and controls located on the ultra-high pressure fire pump operator's panel shall be illuminated to a minimum lighting level of 5 fc (54 lx). [**1901:**28.7.2]

28.7.3 Safety sign FAMA25, which warns of the need for training prior to operating the apparatus, shall be located on the pump operator's panel. [**1901:**28.7.3]

28.7.4 Safety sign FAMA20, which warns of the hazards of ultra-high pressure, shall be located in a visible location adjacent to any discharge outlet. [**1901:**28.7.4]

28.8 Pump Controls.

28.8.1* Controls shall be provided for placing the pump in operation. [**1901:**28.8.1]

28.8.2 If the pump requires engagement to operate, the control for the pump engagement mechanism shall be marked with a label to indicate when the pump is properly engaged in pumping position. [**1901:**28.8.2]

28.8.3 Pressure Control System.

28.8.3.1 A system shall be provided or the pump shall have operating characteristics that are capable of limiting the increase of net pump pressure to a maximum pressure rise of 40 percent over the rated pump pressure when all discharges are closed when the engine and pump controls are set to produce the rated capacity at the rated net pump pressure of the pump. [**1901:**28.8.4.1]

28.8.3.2 If the pump is equipped with a governor system that controls engine speed, an indicator shall show when the system is turned on and whether it is controlling the engine speed or pump pressure. [**1901:**28.8.4.2]

28.8.3.3 If the pump is equipped with a governor system, it shall be controllable by one person at the pump operator position. [**1901:**28.8.4.3]

28.8.4 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions on their operation. [**1901:**28.8.5]

28.8.5 Drain Valve(s).

28.8.5.1* An accessible drain valve(s) that is marked with a label as to its function shall be provided to allow the pump and all water-carrying lines and accessories to be drained. [**1901:**28.8.6.1]

28.8.5.2 The drain valve(s) shall be operational without the operator having to get under the apparatus. [**1901:**28.8.6.2]

28.8.6 Pump Cooling.

28.8.6.1* A pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open shall be provided between the pump discharge and the water tank. [**1901:**28.8.6.1]

28.8.6.2 Where the pump is of a positive displacement type an automatic bypass relief valve shall be permitted to be provided in place of the recirculation line. [**1901:**28.8.6.2]

28.9 Pump Drive Systems.

28.9.1 Where the pump is driven by a split-shaft PTO transmission, chassis transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or flywheel PTO, the pertinent provisions of 16.10.2 through 16.10.7 shall apply as applicable. [**1901:**28.9.1]

28.9.2 Where the pump is driven by a chassis transmission-mounted (SAE) PTO and the pump system does not conform to 16.4.2, a visible or audible warning device shall be provided on the pump operator's panel that is actuated if the temperature of the lubricant in the chassis transmission exceeds the transmission manufacturer's recommended maximum temperature. [**1901:**28.9.2]

28.9.3 If a separate pumping engine is provided, it shall meet the requirements of 12.2.1.1, 12.2.1.2, 12.2.2, 12.2.3.1, 12.2.3.2, 12.2.4, 12.2.5, 12.2.6, Section 13.2, 13.4.3, 13.4.4, 13.4.4.1, 13.4.4.3, 13.4.4.4, 13.4.5, and Section 13.5. [**1901:**28.9.3]

28.10* Engine Controls.

28.10.1 A throttle control shall be provided to control the engine speed. [**1901:**28.10.1]

28.10.2 This throttle control shall be permitted to be the same throttle control that is used for the main fire pump. [**1901:**28.10.2]

28.11 Gauges and Instruments.

28.11.1 Master Pump Discharge Pressure Gauge. A master discharge pressure gauge shall be provided. [**1901:**28.11.1]

28.11.1.1 The master discharge pressure gauge shall read from a gauge pressure of 0 to not less than 500 psi (3500 kPa) higher than the maximum pressure that can be developed by the pump when it is operating with zero intake pressure. [**1901:**28.11.1.1]

28.11.1.2 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade 1A as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*. [**1901:**28.11.1.2]

28.11.1.2.1 Numerals for master gauges shall be a minimum 0.25 in. (6.4 mm) high. [**1901:**28.11.1.2.1]

28.11.1.2.2 There shall be graduation lines showing at least every 50 psi (200 kPa), with major and intermediate graduation lines emphasized and figures at least every 500 psi (2000 kPa). [**1901:**28.11.1.2.2]

28.11.1.2.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge. [**1901:**28.11.1.2.3]

28.11.1.3 If a digital pressure gauge is used, the digits shall be at least 0.25 in. (6.4 mm) high. [**1901:**28.11.1.3]

28.11.1.3.1 Digital pressure gauges shall display pressure in increments of not more than 50 psi (200 kPa). [**1901:**28.11.1.3.1]

28.11.1.3.2 Digital master pressure gauges shall have an accuracy of ±3 percent over the full scale. [**1901:**28.11.1.3.2]

28.11.2 Protection of Gauges and Instruments. Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration. [**1901:**28.11.2]

28.11.3* Cab Gauges. If the apparatus is designed for pump-and-roll operations, a second gauge that meets the same requirements as the discharge pressure gauge required by 28.11.1 shall be mounted in the driving compartment in view of the driver. [**1901:**28.11.3]

28.12 Required Testing.

28.12.1 Apparatus Pump System Certification.

28.12.1.1 General. The UHP pump shall be tested after the pump and all its associated piping and equipment have been installed on the fire apparatus. [**1901:**28.12.1.1]

28.12.1.1.1 The testing shall include at least the 30-minute pumping test in 28.12.5, the pressure control test in 28.12.7, the gauge and flowmeter test in 28.12.11, the manufacturer's predelivery test in 28.12.12, and the water tank capacity test in 28.12.13. [**1901:**28.12.1.1.1]

28.12.1.1.2 If the 30-minute pumping test is not performed from the apparatus water tank, the water tank–to–pump flow test in 28.12.6 shall be included. [**1901:**28.12.1.1.2]

28.12.1.1.3 If the pumping system is equipped with a priming system, the priming system test in 28.12.8, and the vacuum test in 28.12.9 shall be included. [**1901:**28.12.1.1.3]

28.12.1.1.4 If the UHP pump is driven by the chassis engine, the engine speed advancement interlock test in 28.12.10 shall be included. [**1901:**28.12.1.1.4]

28.12.1.1.5 The test results shall be certified by the manufacturer. [**1901:**28.12.1.1.5]

28.12.1.2* Test Label.

28.12.1.2.1 A test label shall be provided at the pump operator's position that gives the rated discharges and pressures. [**1901:**28.12.1.2.1]

28.12.1.2.2 If powered by an engine, the speed of the engine as determined by the certification test for each unit and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve shall be provided on the test label. [**1901:**28.12.1.2.2]

28.12.1.2.3 The label shall be stamped with all information at the factory and attached to the vehicle prior to shipping. [**1901:**28.12.1.2.3]

28.12.2 Conditions for Tests.

28.12.2.1 Tests shall be performed when conditions are as follows:

(1) Air temperature: 0°F to 110°F (–18°C to 43°C)
(2) Water temperature: 35°F to 90°F (2°C to 32°C)
(3) Barometric pressure: 29 in. Hg (98.2 kPa), minimum (corrected to sea level)

[**1901:**28.12.2.1]

28.12.2.2 If it is necessary to perform the test outside the air or water temperature ranges or the minimum barometric pressure stated in 28.12.2.1 and the pump passes the certification test, the test results shall be acceptable. [**1901:**28.12.2.2]

28.12.2.3 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests. [**1901:**28.12.2.3]

28.12.2.3.1 If the chassis engine drives the UHP pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 28.12.2.3.3, shall be applied for the entire pumping portion of this test. [**1901:**28.12.2.3.1]

28.12.2.3.2 If the vehicle is equipped with a fixed power source driven by the same engine that drives the ultra-high pressure fire pump, the fixed power source shall be running at a minimum of 50 percent of its rated capacity throughout the pumping portion of the pump test. [**1901:**28.12.2.3.2]

28.12.2.3.3 The following devices shall be permitted to be turned off or not operating during the pump test:

(1) Foam pump
(2) Hydraulically driven equipment (other than hydraulically driven line voltage generator)
(3) Winch
(4) Windshield wipers
(5) Four-way hazard flashers
(6) Compressed air foam system (CAFS) compressor

[**1901:**28.12.2.3.3]

28.12.2.3.4 All structural enclosures, such as floorboards, gratings, grilles, and heat shields, not furnished with a means for opening them in normal service shall be kept in place during the tests. [**1901:**28.12.2.3.4]

28.12.3 Equipment.

28.12.3.1 One or more lines of UHP hose of sufficient diameter shall be provided to allow discharge of the rated capacity of the pump without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) through the hose. [**1901:**28.12.3.1]

28.12.3.2 Discharge rate shall be measured using equipment such as flowmeters, volumetric tanks, or weigh tanks. [**1901:**28.12.3.2]

28.12.3.3 Test Gauges.

28.12.3.3.1 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100 and shall be at least size 3½ per ASME B40.100, *Pressure Gauges and Gauge Attachments*. [**1901:**28.12.3.3.1]

28.12.3.3.2 The pump intake gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to a gauge pressure of 150 psi (1000 kPa) for a compound gauge. [**1901:**28.12.3.3.2]

28.12.3.3.3 The discharge pressure gauge shall have a gauge pressure range of 0 psi (0 kPa) to not less than 500 psi (3500 kPa) over the rated pump discharge pressure. [**1901:**28.12.3.3.3]

28.12.3.3.4 All gauges shall have been calibrated in the year preceding the tests using a deadweight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year. [**1901:**28.12.3.3.4]

28.12.3.3.5 Each test gauge connection shall include a means for snubbing, such as a needle valve to damp out rapid needle movements. [**1901:**28.12.3.3.5]

28.12.3.4 Speed-measuring equipment shall consist of a tachometer or other device for measuring revolutions per minute. [**1901:**28.12.3.4]

28.12.4 Procedure.

28.12.4.1* The ambient air temperature, water temperature, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to the pump test. [**1901:**28.12.4.1]

28.12.4.2* The engine, pump, transmission, and all parts of the fire apparatus shall exhibit no undue heating, loss of power, overspeed, leaks, or other defect during the entire test. [**1901:**28.12.4.2]

28.12.5 Thirty-Minute Pumping Test.

28.12.5.1 The UHP pump shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated pump discharge pressure. [**1901:**28.12.5.1]

28.12.5.2 The 30-minute pumping test shall be permitted to be performed from the apparatus water tank with provisions to maintain tank level during the duration of the test. [**1901:**28.12.5.2]

28.12.5.3 The 30-minute pumping test shall be permitted to be performed with water supplied to the pump intake from a separate water supply that provides positive pressure to the pump intake. [**1901:**28.12.5.3]

28.12.5.4 If the 30-minute pumping test is performed with water supplied to the pump that provides positive pressure at the pump intake, the net pump pressure shall be equal to the rated pump discharge pressure. [**1901:**28.12.5.4]

28.12.5.5 The 30-minute pumping test shall be permitted to be run at a test site that provides a supply of clear water and is close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water, when connected to the pump by a minimum of 10 ft (3 m) of suction hose. [**1901:**28.12.5.5]

28.12.5.6 If the pump is stopped before the test is completed, the entire pump test shall be repeated. [**1901:**28.12.5.6]

28.12.5.7* The flow discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence. [**1901:**28.12.5.7]

28.12.5.8 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure. [**1901:**28.12.5.8]

28.12.6 Water Tank-to-Pump Flow Test

28.12.6.1 If the 30-minute pumping test in 28.12.5 is not performed from the apparatus water tank, a water tank–to–pump flow test shall be performed with water supplied from the apparatus water tank to verify the tank to pump flow capability. [**1901:**28.12.6.1]

28.12.6.2 The test shall consist of 5 minutes of continuous pumping at rated capacity at rated pump pressure taking water from the apparatus water tank. [**1901:**28.12.6.2]

28.12.6.3 The flow, discharge pressure, and engine speed shall be recorded at the beginning and end of the test. [**1901:**28.12.6.3]

28.12.7 Pressure Control Test. The pressure control system of an ultra-high pressure fire pump shall be tested for pressure rise as follows:

(1) The ultra-high pressure fire pump shall be operated to deliver rated capacity at rated discharge gauge pressure.
(2) If a pressure control system is supplied, it shall be set in accordance with the manufacturer's instructions.
(3) All discharge valves shall be closed.

(4) Any rise in discharge pressure shall not exceed 40 percent of the rated discharge pressure.
(5) The pump shall be operated with the discharge lines closed for 3 minutes without the temperature of the pump exceeding 140°F (60°C).
(6)* The final discharge pressure, any rise in discharge pressure, and the final pump temperature shall be recorded.
[**1901:**28.12.7]

28.12.8 Priming System Test. If the UHP pumping system is equipped with a priming system, it shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water. [**1901:**28.12.8]

28.12.8.1* This test shall be run at a test site that provides a supply of clear water and is close enough to allow 10 ft (3 m) of suction hose of the size specified in Table 28.2.3 and equipped with a suction hose strainer to be connected to the pump intake to be submerged at least 2 ft (0.6 m) below the surface of the water, with the water level at least 3 ft (0.91 m) below the center of the pump intake corrected for the following conditions:

(1) At an altitude of 2000 ft (600 m) above sea level
(2) At 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level)
(3) At a water temperature of 60°F (16°C)
[**1901:**28.12.8.1]

28.12.8.2 The interval from the time the priming system is started until the time the pump is discharging water shall be noted. [**1901:**28.12.8.2]

28.12.8.3 The time required to prime the pump shall not exceed 30 seconds. [**1901:**28.12.8.3]

28.12.8.4 Only biodegradable products shall be permitted to be discharged onto the ground. [**1901:**28.12.8.4]

28.12.9 Vacuum Test. If the UHP pumping system is equipped with a priming system, a vacuum test shall be performed that consists of subjecting the interior of the pump, with all intake valves open, with all intakes capped or plugged, and with all discharge caps removed, to a vacuum of 17 in. Hg (57.6 kPa) by means of the pump priming system. [**1901:**28.12.9]

28.12.9.1 At altitudes above 2000 ft (600 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.6 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (300 m) of altitude above 2000 ft (600 m). [**1901:**28.12.9.1]

28.12.9.2 The primer shall not be used after the 5-minute test period has begun. [**1901:**28.12.9.2]

28.12.9.3 The engine shall not be operated at any speed greater than the governed speed during this test. [**1901:**28.12.9.3]

28.12.9.4 The vacuum shall not drop more than 10 in. Hg (34 kPa) in 5 minutes. [**1901:**28.12.9.4]

28.12.9.5 The vacuum test shall then be repeated with all intake valves closed and the caps or plugs on all gated intakes removed. [**1901:**28.12.9.5]

28.12.10* Engine Speed Advancement Interlock Test. If the UHP pump is driven by the chassis engine, the engine speed advancement interlock system shall be tested to verify that engine speed cannot be increased at the pump operator's panel unless there is throttle-ready indication. [**1901:**28.12.10]

28.12.10.1 If the apparatus is equipped with a stationary UHP pump driven through a split-shaft PTO, the test shall verify that the engine speed control at the pump operator's panel cannot be advanced when either of the following conditions exists:

(1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
(2) The chassis transmission has been placed in the position for pumping as indicated on the label provided in the driving compartment, the parking brake is on, and the UHP pump shift in the driving compartment is in the road position.
[**1901:**28.12.10.1]

28.12.10.2 If the apparatus is equipped with a stationary UHP pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, the test shall verify that the engine speed control on the pump operator's panel cannot be advanced when either of the following conditions exists:

(1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift status in the driving compartment is disengaged.
(2) The chassis transmission is in any gear other than neutral, the parking brake is on, and the UHP pump shift in the driving compartment is in the "Pump Engaged" position.
[**1901:**28.12.10.2]

28.12.10.3 If the apparatus is equipped with a UHP pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that the engine speed control at the pump operator's panel cannot be advanced when any of the following conditions exists:

(1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift status in the driving compartment is disengaged.
(2) The chassis transmission is in any gear other than neutral, the parking brake is on, and the UHP pump shift in the driving compartment is in the "Pump Engaged" position.
(3) The chassis transmission is in any gear other than neutral, the parking brake is off, the UHP pump shift in the driving compartment is in the "Pump Engaged" position, and the "OK to Pump-and-Roll" indicator is on.
[**1901:**28.12.10.3]

28.12.10.4 If the apparatus is equipped with a stationary UHP pump driven through a transfer case PTO, the test shall verify that the engine speed control on the pump operator's panel cannot be advanced when one of the following conditions exists:

(1) The chassis transmission is in neutral, the transfer case is in neutral, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
(2) The chassis transmission is in neutral, the transfer case is engaged, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
(3) The chassis transmission has been placed in the position for pumping as indicated on the label provided in the driving compartment, the parking brake is on, and the UHP pump shift in the driving compartment is in the road position.
[**1901:**28.12.10.4]

28.12.11 Gauge and Flowmeter Test.

28.12.11.1 Pump intake and discharge pressure gauges shall be checked for accuracy while pumping at rated capacity at pump rated pressure. [**1901:**28.12.11.1]

28.12.11.2 Any gauge that does not meet Grade B ASME B40 requirements as compared to the calibrated test gauge shall be recalibrated, repaired, or replaced. [**1901:**28.12.11.2]

28.12.11.3 Each flowmeter shall be checked for accuracy while pumping at rated capacity at pump rated pressure. [**1901:**28.12.11.3]

28.12.11.4 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced. [**1901:**28.12.11.4]

28.12.12 Manufacturer's Predelivery Test.

28.12.12.1 Piping Integrity Test. The UHP pump and its connected piping system shall be subjected to both a hydrostatic test per 28.12.12.2and a hydrodynamic test per 28.12.12.3. [**1901:**28.12.12.1]

28.12.12.2 Hydrostatic Test. All system plumbing that will be exposed to rated pump discharge pressure shall be hydrostatically tested to at least 1.4 times the rated pump discharge pressure. [**1901:**28.12.12.2]

28.12.12.2.1 The following system components shall not be required to be hydrostatically tested under this section:

(1) Pump intake plumbing
(2) Portions of a discharge path that vent to atmosphere
(3) The pump body and any permanently mounted plumbing supplied by the pump manufacturer

[**1901:**28.12.12.2.1]

28.12.12.2.2 If the complete plumbing system is capable of withstanding the hydrostatic test pressure, or if the items listed in 28.12.12.2.1 can be isolated from hydrostatic test pressure through the use of permanently installed valves, the test procedure shall be as follows:

(1) Establish the system boundaries by shutting all valves to components listed in 28.12.12.2.1. All other valves must be open with the discharge outlet capped, plugged, flanged, or otherwise sealed.
(2) Fill the system with water and bleed all air from the system.
(3) Use a hydrostatic test pump to establish a test pressure of at least 1.4 times the rated pump discharge pressure.
(4) Maintain the hydrostatic test pressure for at least 3 minutes.

[**1901:**28.12.12.2.2]

28.12.12.2.3* If the design of the system will not allow the components listed in 28.12.12.2.1 to be isolated from hydrostatic test pressure when installed on the completed apparatus, and such components are not designed to withstand hydrostatic test pressure, the hydrostatic test shall be permitted to be performed on the discharge plumbing prior to installation on the apparatus. [**1901:**28.12.12.2.3]

28.12.12.2.3.1 The plumbing connections that connect to the components listed in 28.12.12.2.1 shall be capped or plugged during the hydrostatic test. [**1901:**28.12.12.2.3.1]

28.12.12.2.3.2 Once the section is isolated, the test procedure shall be as listed in 28.12.12.2.2(2) through 28.12.12.2.2(4). [**1901:**28.12.12.2.3.2]

28.12.12.3 As installed on the apparatus, all piping that will be exposed to rated pump discharge pressure shall be hydrodynamically tested. [**1901:**28.12.12.3]

28.12.12.3.1 The test procedure shall be as follows:

(1) Establish the system boundaries by shutting all discharge valves
(2) Establish a water supply to the UHP pump, either from the tank or from an external source
(3) Fill the system with water and bleed all air from the system
(4) Use the UHP pump to establish the maximum pump discharge pressure without disabling relief valves, governors, or automatic shutdown systems
(5)* Conduct the hydrodynamic test, which can be conducted with a bypass valve, relief valve, or discharge valve open as necessary to maintain pump temperature during the test
(6) Maintain the hydrodynamic test pressure for a minimum of 5 minutes
(7) Verify there is no leakage in any of the plumbing

[**1901:**28.12.12.3.1]

28.12.12.3.2 The hydrodynamic test in 28.12.12.3.1 shall be permitted to be performed in conjunction with the 30-minute pumping test in 28.12.5. [**1901:**28.12.12.3.2]

28.12.12.4 The hydrodynamic test pressure shall be maintained for 3 minutes. [**1901:**28.12.12.4]

28.12.13 Water Tank Capacity Test. The water tank shall be tested for usable water capacity by either a totalizing flowmeter method or a truck weight method. [**1901:**28.12.13]

28.12.13.1 The water tank shall be filled until it overflows. [**1901:**28.12.13.1]

28.12.13.2 If the unit is equipped with an automatic shutdown due to a low pressure feature, that feature shall be engaged. [**1901:**28.12.13.2]

28.12.13.3 If a totalizing flowmeter is used, the meter shall be connected to a discharge and set to zero. [**1901:**28.12.13.3]

28.12.13.3.1 If the totalizing flowmeter is connected to a discharge valve, the valve shall be opened and the unit run at between 50 and 100 percent of the pump's rated flow until it automatically shuts down or the pressure drops below 1000 psi (7000 kPa). [**1901:**28.12.13.3.1]

28.12.13.3.2 The total volume that was discharged shall be recorded. [**1901:**28.12.13.3.2]

28.12.13.4 If the truck weight method is used, the truck shall be weighed and the weight recorded. [**1901:**28.12.13.4]

28.12.13.4.1 The pump shall be started and brought up to a flow rate of between 25 and 35 percent of the pump's rated flow by partly opening a discharge valve or by reducing the speed of the pump. [**1901:**28.12.13.4.1]

28.12.13.4.2 The discharge valve shall be closed when the unit automatically shuts down or the pump pressure drops below 1000 psi (7000 kPa). [**1901:**28.12.13.4.2]

28.12.13.4.3 The truck shall be reweighed. [**1901:**28.12.13.4.3]

28.12.13.4.4 The water tank empty weight shall be subtracted from water tank full weight and the result divided by 8.33 lb/gal to obtain the usable water volume in gallons. [**1901:**28.12.13.4.4]

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 This standard is designed to cover new automotive fire apparatus primarily used to fight wildland fires at both on-road and off-road locations. To a limited degree, these apparatus can be used to protect exposures or fight structure fires from the exterior. The apparatus covered by this standard are not intended to replace or supersede the function of pumpers or initial attack fire apparatus.

A.1.3.1 The term *new* as applied in this standard is intended to refer to the original construction of a fire apparatus using all new materials and parts.

A.1.4 It is not intended that this standard be applied retroactively to existing apparatus. However, if major renovations are made to an existing apparatus, it is suggested that the apparatus be brought into line with this standard as closely as possible. NFPA 1912 covers the requirements for refurbishing a fire apparatus.

A.1.6.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, a unit that is outside of but recognized by SI, is commonly used in international fire protection. Table A.1.6.1(a) and Table A.1.6.1(b) provide conversion factors as an aid to the user. Table A. 1.6.1(c) provides other conversion factors that could be useful to the reader. Table A.1.6.1(d) provides a list of the abbreviations used in this standard and their meaning.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such

Table A.1.6.1(a) Conversion Factors: U.S. Units to SI Units

U.S. Units	SI Units
1 gallon per minute (gpm)	3.785 liters per minute (L/min)
1 pound per square inch (psi)	6.895 kilopascals (kPa)
1 inch of mercury (in. Hg) at 60°F (15.6°C)	3.376 kilopascals (kPa)
1 inch (in.)	25.40 millimeters (mm)
1 foot (ft)	0.3048 meter (m)
1 cubic foot (ft^3)	0.02832 cubic meter (m^3)
1 square inch ($in.^2$)	645.2 square millimeters (mm^2)
1 mile per hour (mph)	1.609 kilometers per hour (km/hr)
1 pound (lb)	0.4536 kilogram (kg)
1 horsepower (hp)	0.7457 kilowatt (kW)
1 candlepower	12.57 lumens
1 pound per cubic foot (lb/ft^3)	16.02 kilograms per cubic meter (kg/m^3)
1 footcandle (fc)	10.76 lux (lx)
1 footlambert (fl)	3.426 candela/m^2

Table A.1.6.1(b) Conversion Factors: SI Units to U.S. Units

SI Units	U.S. Units
1 liter per minute (L/min)	0.2642 gallon per minute (gpm)
1 kilopascal (kPa)	0.1450 pound per square inch (psi)
1 kilopascal (kPa)	0.2962 inch of mercury (in. Hg) at 60°F (15.6°C)
1 millimeter (mm)	0.03937 inch (in.)
1 meter (m)	3.281 feet (ft)
1 cubic meter (m^3)	35.31 cubic feet (ft^3)
1 square millimeter (mm^2)	0.001550 square inch ($in.^2$)
1 kilometer per hour (km/hr)	0.6214 mile per hour (mph)
1 kilogram (kg)	2.205 pounds (lb)
1 kilowatt (kW)	1.341 horsepower (hp)
1 lumen	0.07958 candlepower
1 kilogram per cubic meter (kg/m^3)	0.06243 pound per cubic foot (lb/ft^3)
1 lux (lx)	0.09290 footcandle (fc)
1 candela/m^2	0.2919 footlambert (fl)

Table A.1.6.1(c) Useful Conversion Factors

U.S. Units	=	SI Units
1 gallon per minute (gpm)	=	0.833 imperial gallon per minute (igpm)
1 imperial gallon per minute (igpm)	=	4.546 liters per minute (L/min)
1 imperial gallon per minute (igpm)	=	1.2 gallons per minute (gpm)
1 foot (ft) of water	=	0.433 pound per square inch (psi)
1 liter per minute (L/min)	=	0.2200 imperial gallon per minute (igpm)
1 pound per square inch (psi)	=	2.31 feet (ft) of water
1 metric ton (mton)	=	1000 kilograms (kg)
1 kilopascal (kPa)	=	0.01 bar
1 bar	=	100 kilopascals (kPa)

Table A.1.6.1(d) Abbreviations Used in This Standard

Abbreviation	Term	Abbreviation	Term
A	ampere	kPa	kilopascal
C	Celsius	kW	kilowatts
F	Fahrenheit	L	liters
fc	footcandle	L/min	liters per minute
ft	feet	lx	lux
gpm	gallons per minute	m	meter
hp	horsepower	mm	millimeter
in.	inch	mph	miles per hour
in. Hg	inches of mercury	psi	pounds per square inch
kg	kilograms	V	volt
km/hr	kilometers per hour		

standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.9 Automatic Regulating Foam Proportioning System. The automatic adjustments of the foam proportioning system are made based on changes in waterflow or conductivity.

A.3.3.20 Compound Gauge. On most gauges, zero equals atmospheric pressure. Gauges typically measure pressure above atmospheric pressure in pounds per square inch (psi) [kilopascals (kPa)] and below atmospheric pressure in inches of mercury (in. Hg) [kilopascals (kPa)]. [**1901,** 2016]

A.3.3.21 Compressed Air Foam System (CAFS). A CAFS consists of a compressed air source, pressurized source of foam solution, and discharge hardware. [**1901,** 2016]

A.3.3.23 Contractor. The contractor might not necessarily manufacture the fire apparatus or any portion of the fire apparatus but is responsible for the completion, delivery, and acceptance of the entire unit. [**1901,** 2016]

A.3.3.31 Eductor. The pressure at the throat of a venturi is below atmospheric pressure, allowing foam concentrate or other fire-fighting agent at atmospheric pressure in storage to flow into the water stream. [**1901,** 2016]

A.3.3.32 Ejector. An ejector operates on the same principle as a jet pump.

A.3.3.33 Electric Siren (Electromechanical). Only one type of warning sound can be produced by electric sirens, but the level or pitch can be varied by the speed of the motor. [**1901,** 2016]

A.3.3.34 Electronic Siren. Varied types of warning sounds can be produced by electronic sirens, such as a wail, yelp, or simulated air horn. [**1901,** 2016]

A.3.3.51 GAWR (Gross Axle Weight Rating). It is a requirement of the National Highway Traffic Safety Administration that the GAWR be posted in the vehicle on a permanently affixed label. The axle system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

A.3.3.52 Grade. A 45-degree slope is equal to a 100 percent grade. [**1901,** 2016]

A.3.3.54 GVWR (Gross Vehicle Weight Rating). It is a requirement of the National Highway Traffic Safety Administration that the GVWR of a vehicle be posted in the vehicle on a permanently affixed label. The GVWR can be equal to or less than the sum of the front GAWR and the rear GAWR. The in-service weight or gross vehicle weight should always be equal to or less than the GVWR.

A.3.3.67 Maximum Pump Close-Off Pressure. Multistage series/parallel pumps are measured with the pump in the pressure (series) setting. [**1901,** 2016]

A.3.3.73 Net Pump Pressure. When operating from a hydrant, the net pump pressure typically is less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psi (1034 kPa) and the intake (suction) gauge reads 20 psi (138 kPa), the net pump pressure equals 130 psi (896 kPa). When operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge reads 145 psi (1000 kPa) and the intake (suction) gauge reads 10 in. Hg (34 kPa) vacuum, the net pump pressure will be 150 psi (1034 kPa) (1 in. Hg = 0.5 psi = 3.4 kPa). [**1901,** 2016]

A.3.3.77 Off-Road Use Vehicle. An off-road use vehicle is not automatically an all-wheel-drive vehicle. Off-road vehicles are just as susceptible as on-road vehicles to becoming stuck if they are driven in areas where the ground does not support the vehicle weight.

A.3.3.82 Optical Source. An optical source can consist of a single optical element or a fixed array of any number of optical elements whose geometric positioning relative to each other is fixed by the manufacturer of the optical source and is not intended to be modified. A light bar is a typical example of an optical source that consists of multiple optical elements. [**1901,**2016]

A.3.3.86 Preconnected Hose Line. A preconnected hose line is commonly called a bucket line, cross lay, speed lay, or mattydale. [**1901,** 2016]

A.3.3.106 Slip-On Fire-Fighting Module. Slip-on fire-fighting modules typically can be placed on and removed from the vehicle with a minimum of time and effort.

A.4.3.1 Just specifying that an apparatus to be purchased must be compliant with NFPA 1906 is not enough information to purchase a specific vehicle. There are many items described in NFPA 1906 that must be specified by the purchaser. For example, does the purchaser want a fire suppression apparatus, mobile water supply apparatus, fire crew carrier apparatus, and so on. NFPA 1906 is a minimum standard and most purchasers want to include additional features.

Annex B contains detailed descriptions of considerations to include in the decision-making process for purchasing an apparatus. Figure B.2 can be used as a guide for collecting information. Many items in the figure are marked with an asterisk (*). These items should be specified for every apparatus. Those items without an asterisk should be specified if desired.

A.4.7.4 If the third-party certification of the pump test results uses verifiable automated data collection and image recording equipment, then the third-party organization should refuse to certify any test results for a system if all components of that system requiring testing do not pass the testing required by this standard. The process for acquiring test data should include the following:

(1) The equipment for securing verifiable automated data collection and image recording should be designed to monitor, collect, and transmit test data from the test site to a microprocessor and compatible software.
(2) Electronic components should record all pump test data.
(3) Hardware, software, and data output should be configured into a tamper-free design and operation.
(4) Date and time displays should be provided and recorded as part of the electronic data acquisition.
(5) Cameras and data recorders should record all sequences of pump testing and video snapshot clips can be provided for specific test points.
(6) The equipment should have provisions for manual entry to record information specific to the purchaser, chassis, OEM manufacturer, vertical suction lift distance, no-load governed speed, altitude, barometric pressure, and other required test documentation.
(7) Data acquisition should record the following at intervals required by the appropriate sections of this standard:
    (a) Master pump pressure
    (b) Master vacuum (in. of Hg)
    (c) Fire pump drive engine RPM — tachometer
    (d) Pitot pressure and/or flowmeter display(s)
    (e) Date and time (i.e., day, hour, minute, second)
    (f) Flow measurement
    (g) Water temperature of test pit and ambient temperature
    (h) Coolant temperature from the fire pump drive engine radiator
    (i) Oil pressure monitoring from the fire pump drive engine
    (j) Low-voltage monitoring during entire test sequence in addition to alarm to operator
    (k) If applicable, line voltage monitoring and recording (i.e., frequency, voltage, amps, and ambient temperature in the generator area)
(8) Following the OEM apparatus test, the test data and video/photo segments should be transmitted to a third-party accredited organization in compliance with the requirements of this standard as it pertains to review and certification of test results.

[**1901:**A.4.7.4]

A.4.7.6 Refer to typical forms, data sheets, and test protocols for pump and aerial testing in Section C.3 of NFPA 1911. Additional forms for testing foam, CAFS, air systems, and low and line voltage are provided if the authority having jurisdiction requires third-party testing of these systems. [**1901,** A.4.7.6]

A.4.8.4 Refer to typical forms, data sheets, and test protocols for pump and aerial testing in Section C.3 of NFPA 1911. Additional forms for testing foam, CAFS, air systems, and low and line voltage are provided if the authority having jurisdiction requires third-party testing of these systems. [**1901,** A.4.8.4]

A.4.9.1 The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation. [**1901**:A.4.9.1]

A.4.9.4 Uniformity of safety signage is a desirable objective. Examples of common safety signs solutions are depicted in FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, and should be considered where deemed applicable by the manufacturer. [**1901:**A.4.9.4]

A.4.9.4.3 Font size, scaling, and aspect ratio can be adjusted if required to fit the physical restrictions of the apparatus. [**1901:**A.4.9.4.3]

A.4.10.2 All required signs, instruction plates, and labels should be highly visible and placed on the vehicle where they are not subject to damage from wear and tear. [**1901**:A.4.10.2]

A.4.12.1 The attachment of electric, air, hydraulic, and other control lines and hoses should be with removable mechanically attached fastening devices. The attachment of such equipment with adhesive or glue-on clamps or clips has been found to be inadequate for long-term performance on fire apparatus. The use of plastic ties to bundle wire harnesses and hose is permissible, but ties should not be used to attach such items to a cab, body, frame, or other major structure. [**1901**:A.4.12.1]

A.4.13.1 Several features and factors affect vehicle safety in a rollover.

Custom Fire Apparatus Cab. The nature of the custom fire apparatus cab makes it much stronger in rollover than typical conventional commercial chassis cabs. There is much anecdotal evidence to indicate that the crashworthiness of a typical custom fire apparatus cab is significantly greater than a typical commercial cab, and most custom chassis manufacturers can provide test data on cab integrity. [**1901**:A.4.13.1]

Lateral Acceleration Alert Device. There are both mechanical and electronic devices available that will measure the lateral acceleration of a vehicle. Although these devices will not prevent rollover, they can be used effectively as a driver training tool to indicate when the vehicle is approaching the roll threshold and as a reminder to the driver that excessive lateral acceleration can lead to a rollover event. [**1901**:A.4.13.1]

Side Roll Protection. Many custom fire apparatus manufacturers offer side air bags or curtains that inflate during a roll event and that are usually combined with seat belt pretensioning devices and suspension seat pull-down devices. This option can reduce injury during a rollover as long as the occupants are seated and belted. [**1901**:A.4.13.1]

Roll Stability Control. This technology electronically senses the lateral acceleration of the vehicle and takes action by depowering the engine and applying the brakes if the vehicle approaches a roll threshold. The effectiveness of this product is limited to events on relatively flat pavement, since it cannot do much to help the situation once a vehicle is off the road and leaning into a ditch. [**1901**:A.4.13.1]

Electronic Stability Control (ESC). ESC uses a steering wheel position sensor, a vehicle yaw sensor, a lateral accelerometer, and individual wheel brake controls in conjunction with the antilock brake system (ABS). The system tracks the direction that the driver intends to steer and uses brake application at individual wheels to help straighten out the vehicle. [**1901**:A.4.13.1]

Driver Skill and Experience. While the design and features of the vehicle are important to safe driving, the most important aspect of crash prevention is the skill and experience of the operator. The operator's attitude, training, experience, qualifications, and the application of those qualities are the most important elements in crash prevention. The operator must ensure that the physical limits of the vehicle are not exceeded. Driver skill is developed only through training and practice. [**1901**:A.4.13.1]

A.4.13.1.1(1) When a vehicle is on a tilt table, the point of instability is when the vehicle is "balanced" on the verge of rollover, and very little constraining force, if any, is required to restrain the vehicle. This can occur with the front wheels still in contact with the surface of the tilt table or with other wheels in contact with the surface of the tilt table. [**1901**:A.4.13.1.1(1)]

A.4.13.2.1 The distribution of the weight between the front wheels and the rear wheels should be a major consideration, because improper design will seriously affect the handling characteristics of the fire apparatus. Too little weight on the front wheels can cause a front-end skid and, on bumpy roads, can cause the front of the fire apparatus to veer from side to side. At the very least, it will be difficult to keep the fire apparatus under control. Too much weight on the front wheels reduces the traction of the rear wheels and can result in a rear-end skid or difficulty in traveling over unpaved roads or in mud. [**1901**:A.4.13.2.1]

A.4.13.3.1 It is critical that the purchaser provide the manufacturer the equipment inventory and mounting locations for equipment on the apparatus. This information should include existing equipment and estimated future equipment to be carried. The projections of total equipment payload and mounting locations are essential for proper engineering of a new fire apparatus. It is the responsibility of the purchaser to properly load the fire apparatus and place equipment to comply with the GVWR, the front-to-rear weight distribution, and the right-to-left load balance requirements of this standard. [**1901**:A.4.13.3.1]

A.4.13.3.3 The projections of total equipment payload and mounting locations are essential for proper engineering of a new fire apparatus. The purchaser of the fire apparatus should maintain the side-to-side loading requirement in 4.13.3.3 as equipment is loaded or installed on the apparatus.

The percentage difference in side-to-side tire load should be calculated as shown in the following formula:

[A.4.13.3.3]

$$\frac{(\text{Heavier weight} - \text{Lighter weight})}{\text{Total weight}} \times 100 = \text{Percent difference}$$

[**1901**:A.4.13.3.3]

A.4.13.4 A frequent killer of fire fighters is apparatus rollover. Proper tire inflation improves the handling characteristics and minimizes rollover. [**1901**:A.4.13.4]

A.4.14.1 The power generated by internal combustion engines can decrease with an increase in altitude. The loss varies with the type of engine, the fuel it uses, and the amount of air inlet supercharging. If the apparatus is going to be regularly used at elevations above 2000 ft (600 m), the manufacturer needs to know the operating elevation to provide an engine that will deliver proper performance. [**1901**:A.4.14.1]

A.4.14.2 Although the purchaser needs to specify grades in excess of 6 percent, the fire department should evaluate where the apparatus will be expected to operate in a stationary position on such grades. The occasional exposure to excessive grades while moving over roadways is different from prolonged stationary operations. Apparatus might require special lubrication systems for engines and other modifications to ensure the apparatus will not be damaged by operation on the increased grades. [**1901**:A.4.14.2]

A.4.14.3 The temperature conditions, either hot or cold, where the fire apparatus will be used or stored should be considered in the design of the vehicle. If the vehicle is to be used in conditions that exceed 110°F (43°C), additional cooling of the engine, pump, and other components might be necessary. Likewise, if the apparatus is to be used or stored in subfreezing conditions, special system drains, engine heaters, pressure gauge protectors, or other components might be needed to prevent damage or to allow continued use. [**1901**:A.4.14.3]

A.4.15.1(2) Although this standard recognizes the need for the fire apparatus to be able to accelerate to a high speed while traveling on public roads, caution should be taken with regard to how fast the fire apparatus can travel. [**1901**:A.4.15.1(2)]

Where fire apparatus has to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission, an automatic transmission, or any combination of these might enhance the fire apparatus's off-road capability. [**1901**:A.4.15.1(2)]

A.4.15.1(3) The purchaser should specify the performance required on grades in excess of 6 percent. The occasional exposure to excessive grades is different from an everyday occurrence. A combination of steep grades and narrow, winding roads might require consultation with manufacturers prior to finalizing the apparatus specifications and then the designation of special road tests. If the apparatus will be subjected to a class of service not normally encountered, a manufacturer cannot be expected to anticipate the need without sufficient specification details. [**1901**:A.4.15.1(3)]

A.4.15.2 Special fire service tire ratings could apply that are different from the sidewall rating on the tire. The purchaser might want to consider requesting the tire manufacturer's rating documentation. Fire service ratings are based on the assumption that the truck will never drive at this speed for more than 50 mi (1 hour for some manufacturers) without stopping to cool the tires. If longer responses or trips are anticipated, the fire service ratings should not be used. [**1901**:A.4.15.2]

A.4.15.4 Where fire apparatus might have to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission, an automatic transmission, or any combination thereof, might enhance the fire apparatus's off-road capability.

A.4.16.1 Purchasers might want to specify that all routine lubricant and fluid level checks be performed from ground level to reduce the risks of injury from falling from apparatus. [**1901**:A.4.16.1]

A.4.17.5 The variations in the brake performance testing requirements reflect the differences between 49 CFR 571. 105,

"Hydraulic and Electric Brake Systems," and 49 CFR 571. 121, "Air Brake Systems." [**1901:** A.4.17.5]

A.4.18 Where the point of delivery is over 2000 ft (600 m) of elevation, it is important to test the pump and pumping engine performance to ensure that the engine can develop adequate power at the point of delivery. This test can be performed with the pump supplied from a fire hydrant or at draft, with the discharge and net pressure maintained at rating for the pump. The net pressure (P) when the pump is supplied from a hydrant with positive intake pressure is the discharge gauge pressure (D) minus the intake gauge pressure (S).

A.4.19 It is important for the purchaser and contractor to agree on the format in which the documentation is to be delivered. It is also important that the purchaser consider the long-term ramifications of changing media technology if electronic format is used for delivery of the documentation. Software and hardware will need to be maintained over the years to utilize electronic documentation. [**1901**:A.4.19]

A.4.20.2.3(6)(g) The equivalent circuit logic could be described in several ways. It might be shown as an equivalent schematic, a word-based description, or a table. In any case, it should define the relationship between input status and output status. [**1901**:A.4.20.2.3(6)(g)]

A.4.20.2.4 Suppliers of components and equipment installed or supplied by the contractor often supply operations and maintenance documents with those components or equipment. This standard requires that the contractor deliver these documents to the purchaser. The purchaser should specify if multiple copies of these documents are required. [**1901**:A.40.2.4]

A.4.21.3 The purchaser either accepts the vehicle as noncompliant or accepts responsibility that the apparatus will not be placed in emergency service until the apparatus has been modified as necessary to accomplish full compliance with this standard.

A.5.5 Additional compartmentation might be required to accommodate the size, shape, and weight of special equipment. Any special equipment to be carried on the apparatus should be identified in the specifications so the apparatus manufacturer can ensure the equipment will be properly accommodated within the design of the apparatus. [**1901**:A.5.5]

A.5.6 Hose storage areas are not required to be contiguous. The purchaser should consider arrangements for hose storage that will best support operational procedures. The purchaser should also consider specifying some type of cover for the hose compartment(s). Hinged or removable covers might be advantageous for wildland fire operations.

A.5.7.1(1) Parking brakes on FMVSS-certified apparatus are only designed to hold on a 20 percent grade. If departments intend to park on grades greater than 20 percent, they should consider specifying wheel chocks with higher performance. Chock performance criteria are not meant to encourage parking on a grade greater than 20 percent. The practice of parking on a grade greater than 20 percent should be performed by a two-person crew, with the driver staying in the cab with a foot on the service brake pedal and the second crew member setting or removing the chocks.

A.5.7.2 The equipment required by National Wildland Coordinating Group (NWCG) to be carried on wildland fire apparatus for national mobilization can be found in the *Interagency Standards for Fire and Fire Aviation Operations* or the National Interagency Fire Center website www.nifc.gov/policies/red_book.htm.

A.7.1 Mobile water supply fire apparatus are known as "tankers" in the eastern part of the United States and as "water tenders" in the western part of the United States.

In wildland fire fighting, two types of mobile water supply fire apparatus are used, "support" and "wildland." Wildland mobile water supply fire apparatus are used for fire suppression activities. Support mobile water supply fire apparatus are typically contractor-owned construction equipment and are not used for fire suppression.

This standard covers the wildland mobile water supply fire apparatus.

A.7.5 Additional compartmentation might be required to accommodate the size, shape, and weight of special equipment. Any special equipment to be carried on the apparatus should be identified in the specifications so that the apparatus manufacturer can ensure the equipment will be properly accommodated within the design of the apparatus. [**1901**:A.7.4]

A.7.6 Hose storage areas are not required to be contiguous. The purchaser should consider arrangements for hose storage that will best support operational procedures, particularly if hose is to be carried preconnected to the tank inlet or a pump discharge. The purchaser should also consider specifying some type of cover for the hose compartment(s). Hinged or removable covers might be advantageous for wildland fire operations. The purchaser should provide the apparatus manufacturer with details regarding the size and length of suction or supply hose and what arrangement for storage of the hose is desired so that the manufacturer can more accurately provide appropriate accommodations for the hose.

A.7.6.1 The purchaser should specify the location and the arrangement of the hose storage area to allow carrying of the hose preconnected to the tank inlet. The purchaser should also consider specifying some type of cover for the hose compartment. Hinged or removable covers might be desirable for wildland fire operations.

A.7.7.1(1) Parking brakes on FMVSS-certified apparatus are only designed to hold on a 20 percent grade. If departments intend to park on grades greater than 20 percent, they should consider specifying wheel chocks with higher performance. Chock performance criteria are not meant to encourage parking on a grade greater than 20 percent. The practice of parking on a gradegreater than 20 percent should only be performed by a two-person crew,with the driver staying in the cab with a foot on the service brake pedal and the second crew member setting or removing the chocks.

A.7.7.2 The equipment required by NWCG to be carried on wildland fire apparatus for national mobilization can be found in the *Interagency Standards for Fire and Fire Aviation Operations* or the National Interagency Fire Center website www.nifc.gov/policies/red_book.htm.

A.10.2.1(1) Parking brakes on FMVSS-certified apparatus, including those equipped with air brakes, are only designed to hold on a 20 percent grade. If departments intend to park on grades greater than 20 percent, they should consider specifying wheel chocks with higher performance. Chock performance criteria are not meant to encourage parking on a grade greater

than 20 percent. The practice of parking on a grade greater than 20 percent should be performed by a two-person crew, with the driver staying in the cab with a foot on the service brake pedal and the second crew member setting or removing the chocks.

A.10.3 Specification of vehicle air conditioning is a complex topic and cannot be accurately predicted by specifying a system with a particular Btu capacity. Btu capacity is often calculated for individual air-conditioning components, but will not reflect the actual output of the system nor guarantee a particular performance at the system level.

The performance of any vehicle air-conditioning system is dependent on many factors such as ambient temperature, humidity, solar load, duration of heat-soak, engine test rpm (i.e., refrigerant compressor speed), percent of fresh vs. recirculated air, and so on. The acceptability of a system has subjective criteria as well, such as the temperature and velocity of the vent air, whether the air can be directed at the occupant's face, and how quickly the system is able to attain the desired average temperature.

Purchasers who are particularly sensitive to air-conditioning performance might wish to consider specifying a system tested in accordance with SAE J2646, *Cab Air-Conditioning Test Procedure — Heavy Trucks with and without Sleepers*. Meeting a desired air-conditioning performance might require additional vehicle features, such as increased cab insulation or special window tinting.

A.10.7.1 If a seat belt–monitoring system is desired, it should be installed in accordance with the seat belt–monitoring requirements in NFPA 1901.

A.12.1 The carrying capacity of a vehicle is one of the least understood but one of the most important features of design. All vehicles are designed for a GVWR, which should not be exceeded by the purchaser after the vehicle has been placed in service.

Many factors make up the GVWR, including the design of the springs or suspension system, the rated axle capacity, the rated tire and wheel loading, and the distribution of the weight between the front and rear wheels.

Water Tank. One of the most critical factors is the size of the water tank. Water weighs approximately 8.3 lb/gal (1 kg/L). A value of 10 lb/gal (1.2 kg/L) can be used when estimating the weight of the tank and its water, making a 500 gal (2000 L) tank and its water about 5000 lb (2400 kg).

Miscellaneous Equipment. If the finished apparatus is not to be overloaded, the purchaser should provide the contractor with the weight of equipment to be carried if it is in excess of the allowance shown in Table 12.1.2.

Large Compartment Capacity. The manufacturer is required by the standard to provide a miscellaneous equipment allowance in compliance with the minimum allowance listed in Table 12.1.2. Purchasers who specify vehicles with large compartment capacity should work closely with the vehicle manufacturer to ensure that the GVWR is sufficient to carry the intended equipment. A vehicle with average compartment loading will have a miscellaneous equipment weight of about 8 lb/ft^3 (125 kg/m^3) of compartment space available for miscellaneous equipment. A very lightly loaded vehicle could have as little as 4 lb/ft^3 (65 kg/m^3). A heavily loaded vehicle can reach 12 lb/ft^3 (200 kg/m^3). This volume does not include space occupied by generators, reels, air systems, ladders, hose, and so forth, that are not in the miscellaneous equipment allowance. Total equipment weight varies significantly, depending on the density of the equipment and how tightly the fire department chooses to pack it.

Overloading. Overloading of the vehicle by the manufacturer through design or by the purchaser adding a great deal of equipment after the vehicle is in service will materially reduce the life of the vehicle and will undoubtedly result in increased maintenance costs, particularly with respect to the springs, tires, axles, transmissions, clutches, and brakes. Overloading can also seriously affect handling characteristics, making steering particularly difficult.

Underloading. Brake equipment on heavy vehicles can be sensitive to the weight distribution of the vehicle. Specifying a GVWR significantly greater than the estimated in-service weight can lead to poor brake performance, chatter, and squeal. Purchasers who specify configurations with limited compartment volume on a high-capacity chassis should consult the manufacturer to ensure that a vehicle with an underloaded condition will not result.

Purchaser Responsibility. The purchaser should specify the weight of the equipment to be carried if it is in excess of the allowance for miscellaneous equipment. This weight specification allows a chassis with an adequate GAWR and GVWR to be supplied. Specific additional equipment often necessary to meet the operational requirements of the department could include additional hose, chain saws, rations, tow chains, tire chains, drinking water containers, ice chests, additional hand tools, and additional containers of foam concentrate.

Severe Service. Fire apparatus have to be able to perform their intended service under adverse conditions. Wildland apparatus often are required to operate off paved roads. Chassis components should be selected with the rigors of service in mind.

Off-Road Use. If the apparatus is designed for off-road use, it is recommended that the apparatus, when loaded to its estimated in-service weight, should not exceed 80 percent of the chassis GVWR. In addition, the axle loads should not exceed 80 percent of the appropriate GAWR. If the vehicle chassis manufacturer certifies the GVWR and GAWR for 50 percent minimum off-road use, the full weight ratings can be utilized.

A.12.1.2(4) The 250 lb (114 kg) per person used here does not include the weight of SCBA and tools carried by a fire fighter, because the weight of this equipment is accounted for elsewhere. [**1901**:A.12.1.2(4)]

A.12.1.2(5) If the purchaser or dealer will be installing generators, reels, air systems, or other fixed equipment, the purchaser should notify the manufacturer, and allowance for this weight should be provided by the manufacturer in addition to the miscellaneous equipment allowance. **[1901**:A.12.1.2(5)]

A.12.1.2(7) The miscellaneous equipment allowances are minimum values based on the minimum compartment volume requirements. These values should be adequate for many volunteer departments responding to individual incidents that are suppressed in less than a 12-hour period. Those departments or agencies that send crews out for days or weeks at a time will likely need more carrying capacity both by weight and by volume. Apparatus that will be used in this manner should be specified accordingly. The ratio of 100 lb (45 kg) of weight

capacity for each 10 ft^3 (0.28 m^3) of compartment volume can be used as a conservative approach when configuring individual apparatus.

A.12.1.2(8) Wildland fire apparatus are not required to carry SCBA units. However, if the purchaser intends to carry SCBA units, accommodations need to be made for them and their weight included in the miscellaneous equipment allowance. The purchaser needs to work with the manufacturer on where the units will be carried, whether in seat backs or in compartments, and how they will be mounted.

A.12.1.4 A motor vehicle sold in the United States requires the affixing of a certification label or tag by the final-stage manufacturer of the motor vehicle stating that the vehicle meets all applicable Federal Motor Vehicle Safety Standards (49 CFR 571) and Federal Theft Prevention Standards (49 CFR 541). The location for affixing the certification label on the motor vehicle is a requirement of the federal standard requiring this label. See 49 CFR 567, "Certification," for more information. [**1901:**A.12.1.4]

A.12.1.5.1 It is important for fire apparatus drivers to understand the height, length, and weight of the vehicles compared to their personally owned vehicles. It is also important that this information be accurate. The height of the apparatus could change after delivery, depending on what equipment might be added; therefore, the fire department should note such changes on the label. Suggested wording for the label is shown in Figure A.12.1.5.1.

A.12.2.1.1 The maximum governed speed is established by the engine manufacturer as a safe limit of engine speed. The engine governor or electronic fuel control system should prevent the engine from exceeding the safe speed. Most engine manufacturers allow a plus tolerance of 2 percent for maximum governed speed. [**1901**:A.12.2.1.1]

A.12.2.1.3 A shutdown beyond the control of the pump operator during fire-fighting operations can result in loss of waterflow from the pump that could severely endanger personnel. Automatic fuel line safety shutoff as required by DOT regulations is not considered an automatic engine shutdown. [**1901**:A.12.2.1.3]

A.12.2.1.5.1 An increase in engine speed provides increased alternator output, increased engine cooling, increased air conditioner output, and increased output or performance from other devices that derive their power from the chassis engine. [**1901**:A.12.2.1.5.1]

A.12.2.1.5.2 The purpose of the interlock is to ensure that the chassis engine speed cannot be advanced without disengaging the driving wheels of the apparatus either at the transmission (having it in park or neutral) or by having a split shaft PTO fully engaged in the correct position to drive the component. [**1901**:A.12.2.1.5.2]

When manufactured, this vehicle was:
XX ft YY in. High
XX ft YY in. Long
ZZZZ tons GVWR

Changes in height since the apparatus was manufactured shall be noted on this label by the fire department.

FIGURE A.12.1.5.1 Suggested Label Showing Dimensions of Fire Apparatus.

A.12.2.2.1 Where a regular production model commercial chassis is used, it is recommended that the heavy-duty radiator option be included when such is available. [**1901**:A.12.2.2.1]

Where local environmental extremes exist — that is, high humidity and temperatures or extreme low temperatures — the purchaser should state specifically under what environmental conditions the apparatus is expected to operate. [**1901**:A.12.2.2.1]

A.12.2.2.2.2 It is important to have drain valves on the coolant systems of the apparatus for routine maintenance and repairs. The drain valve(s) should be located at low points in the system for complete drainage of the coolant. The design of the valve should be such that the valve will not inadvertently open from vehicle or engine vibration. It is also critical, especially on wildland vehicles or other vehicles subject to go off-road, that the drain valves are located out of the angle of approach or angle of departure or other areas where the valve could be subjected to damage. Accidental opening of or damage to the coolant drain valve could allow sudden loss of the engine coolant, causing severe or catastrophic damage to the engine. [**1901**:A.12.2.2.2.2]

A.12.2.3.1 Full-flow oil filters are mandatory with some diesel engines. [**1901**:A.12.2.3.1]

A.12.2.3.3(15) Tire cold pressure should be based on the tire manufacturer's load and inflation tables for the load to be carried and the rim pressure rating, not necessarily the maximum load at maximum pressure listed on the tire sidewall. [**1901:**A.12.2.3.3(15)]

A.12.2.3.3(16) Tire cold pressure should be based on the tire manufacturer's load and inflation tables for the load to be carried and the rim pressure rating, not necessarily the maximum load at maximum pressure listed on the tire sidewall. [**1901:**A.12.2.3.3(16)]

A.12.2.4 On a diesel engine, a manual emergency engine shutdown might be provided in addition to the normal engine shutoff switch. It could be of the type that will close off either the air supply or the exhaust gas flow of the engine. The activation mechanism should be provided with a guard and marked with a sign that reads "Emergency Shutdown." Provisions to prevent restarting of the engine without a special reset procedure should be included. [**1901**:A.12.2.4]

A.12.2.4.1 Caution needs to be used because air intake filters might affect the engine manufacturer's air restriction requirements. [**1901**:A.12.2.4.1]

A.12.2.4.3 The extent to which air inlet protection is required could depend on specific fire department operations. Departments operating in ember-rich environments, such as wildland fires, should consider specifying a multiscreen ember separator capable of meeting the test requirements defined in the Parker Hannafin, Racor Division, publication LF 1093–90, *Ember Separation Test Procedure*, or an equivalent test. Purchasers of apparatus utilizing commercial chassis should be aware that ember separators capable of meeting these test requirements may have a screen and housing externally mounted on or around the commercial chassis hood or bumper extension. [**1901**:A.12.2.4.3]

A.12.2.5.1.1 To prevent engine shutdown due to fuel contamination, dual filters in parallel, with proper valving so that each filter can be used separately, might be preferable. The purchaser should specify if dual filters are desired. Installation of two or more pumps should be designed so that failure of one pump will not nullify the performance of the other pump(s). It should be remembered that commercial vehicles are designed for over-the-road operation, and the fuel system and battery are at least partially cooled by the flow of air resulting from the motion. [**1901**:A.12.2.5.1.1]

A.12.2.5.1.6.1 With the use of diesel engines, the concern for vapor lock common with gasoline engines does not exist, and electric fuel pumps usually are not compatible for connection in series with a diesel engine fuel system. As a result, where an electric fuel pump is specified with a diesel engine, it is arranged as a fuel priming pump only. When not properly marked with a label or when the control valves are not properly set, the auxiliary priming system can cause the diesel engine to lose its prime. In addition, operation of a priming pump during diesel engine operation can boost fuel inlet pressure to the engine's fuel system. This could cause erratic engine behavior and loss of engine speed control. Control systems for priming pumps should allow only momentary operation and prevent the operation of the pump while the engine is operating. [**1901**:A.12.2.5.1.6.1]

A.12.2.6.1 Emissions from exhaust discharge pipes should be directed away from any fire-fighting tools, since such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use. [**1901**:A.12.2.6.1]

A.12.2.6.7 Exhaust temperature while the diesel particulate filter (DPF) is actively regenerating can reach 900°F to 1300°F (480°C to 704°C). The purchaser should be aware that these temperatures are much higher than normal engine idle exhaust temperatures. [**1901**:A.12.2.6.7]

Apparatus that make short runs with extended idle time might tend to build up soot in the DPF without giving the engine sufficient opportunity to passively regenerate. If the DPF light illuminates, the vehicle should be driven above 5 mph (8 km/hr) for a period of time to allow the DPF to regenerate either actively or passively, or it should be parked in a controlled area and a manual regeneration initiated. [**1901**:A.12.2.6.7]

Those fire departments that employ in-station exhaust venting equipment while performing DPF regeneration should consult their vent supplier to ensure that the vent system will handle any potential DPF active regeneration event or perform the regeneration outside while not connected to exhaust venting equipment. [**1901**:A.12.2.6.7]

A.12.2.6.7.1(1) The requirement for the DPF to automatically initiate only above 5 mph (8 km/hr) ensures that the exhaust gas temperatures will not change suddenly while the apparatus is parked. This will avoid situations where an apparatus is parked next to a curb and pedestrians are suddenly exposed to excessively hot exhaust gas. [**1901**:A.12.2.6.7.1(1)]

A.12.2.6.7.3 The DPF regeneration inhibit switch allows the operator to keep the DPF from regenerating during times when the apparatus is operating in an environment where extremely hot exhaust gas would be a hazard. [**1901**:A.12.2.6.7.3]

The inhibit function must be used carefully. Repeated use of the inhibit function can lead to soot buildup. Excessive buildup of soot can produce an uncontrolled burn inside the DPF, causing significant vehicle damage and dangerous exhaust temperatures. Watch the DPF indicator and provide opportunity to regenerate the DPF soon after using the inhibit function. [**1901**:A.12.2.6.7.3]

A.12.2.6.7.6 Exhaust system temperature mitigation devices might be required to meet the temperature requirement. Exhaust temperature mitigation devices might be affected by the addition of adapters commonly used to hook up to exhaust extraction equipment. The purchaser should ensure that this adaptation is certified by the manufacturer/installer of the adapter that it will not adversely affect the performance of the device. [**1901**:A.12.2.6.7.6]

Exhaust gas temperatures that meet this standard can ignite fine fuels, especially if a stationary DPF regeneration process is used. Exhaust system surface temperatures will exceed this requirement during a DPF regeneration and also can ignite fuels that are under the apparatus or caught on the underside of the apparatus. A site away from potential fuel sources should be selected for a stationary DPF regeneration.

A.12.3.1.2 Adequate braking capacity is essential for the safe operation of fire apparatus. This subject is normally covered in state highway regulations, but it should be noted that fire apparatus might have a special problem compared with normal vehicles of the same gross vehicle weight. Fire apparatus could have to make successive brake applications in a short period of time when attempting to respond to alarms with minimal loss of time. Thus, the problem of brake "fade" and braking capacity could be critical unless the brakes provided take into account the service requirements. Air-actuated brakes are recommended for fire service vehicles of over 25,000 lb (11,000 kg) GVWR.

Where air brakes are provided, it is important that they be of a quick buildup type with dual tanks and a pressure regulating valve. The rated compressor capacity should be not less than 12 ft^3/min (0.34 m^3/min) for this class of service. Air brakes require attention to guard against condensation in the air lines, such as might occur in areas subject to changes in climate that affect the moisture content of the air. Automatic moisture ejection of a nonfreezing type is recommended. Air pressure drop should be limited to normal air losses. The presence of either of the following conditions indicates the need for immediate service:

(1) Air brake pressure drop of more than 2 psi (14 kPa) in 1 minute with the engine stopped and service brakes released
(2) Air pressure drop of more than 3 psi (21 kPa) in 1 minute with the engine stopped and service brakes fully applied

A.12.3.1.3 There have been occurrences of a driver becoming disabled while driving a fire apparatus. The purchasers might want to specify the placement of the parking brake control to a location where it can be reached from the officer's seat or require a second control so the officer can stop the vehicle if the driver becomes disabled. Subsection 4.15.4 requires that the apparatus be able to maneuver up and down a 25 percent grade. If there is a need to park the apparatus on such grades and get out of the vehicles, the capability will have to be

designed into the parking brake system to park under these conditions.

A.12.3.1.4 Purchasers of fire apparatus with a GVWR less than 36,000 lb (16,330 kg) should also consider equipping the apparatus with an auxiliary braking system. Fire apparatus commonly make repeated stops from high speeds that cause rapid brake lining wear and brake fade, sometimes leading to accidents. [**1901:**A.12.3.1.4]

Auxiliary braking systems are recommended on apparatus that are exposed regularly to steep or long grades, operate in congested areas where repeated stops are normal, or respond to a high number of emergencies. [**1901:**A.12.3.1.4]

Examples of auxiliary braking systems include engine retarders, transmission retarders, exhaust retarders, and driveline retarders. These devices have various levels of effectiveness on braking. In addition, the systems can be activated by various means and settings, both automatic and manual in operation. The purchaser should carefully evaluate all auxiliary braking systems based on vehicle weight, terrain, duty cycle, and many other factors. [**1901:**A.12.3.1.4]

Some auxiliary braking devices should be disconnected when the apparatus is operated on slippery surfaces. Follow the auxiliary braking device manufacturer's recommendations for proper instructions. [**1901:**A.12.3.1.4]

A.12.3.1.4.2 Under poor traction and road conditions, the operator should turn off the secondary braking device to prevent the rear wheels from losing traction. This may not be needed on apparatus equipped with ABS, where the system will automatically disable the secondary braking device when it senses wheel slip.

A.12.3.2.1 Fire departments with vehicles that could be subject to continuous long-distance driving need to specify tire rating for continuous operation in place of intermittent operation. [**1901:**A.12.3.2.1]

A.12.3.2.2 Ground clearance dimensions are not intended to include the drive shaft(s) connections to an axle(s) that should meet the axle housing clearance requirements. All-wheel-drive or off-road vehicles normally require greater ground clearance. Also, the chassis manufacturer's ramp breakover angle should be maintained. When specifying the desired ground clearance, the purchaser should consider the terrain over which the vehicle is to be used.

For a wildland engine, ramp breakover angle is very important. No part of the fire package, such as the pump, should drag and become damaged when the apparatus is crossing water bars and other obstacles. Ramp breakover angle is not the same as ground clearance. The term *ground clearance* refers to the clearance all along the bottom of the vehicle, while the term *ramp breakover angle* is an inverted "V" between the front and rear axles. It is possible to add vertical exhaust pipes and skid plates without decreasing the ramp breakover angle.

A.12.3.2.3 The angle of approach or departure affects the road clearance of the vehicle going over short, steep grades such as would be found in a driveway entrance, crossing a high crowned road at a right angle, or in off-road service. Too low an angle of approach or departure will result in the apparatus scraping the ground. Figure A.12.3.2.3 shows the method of determining the angle of departure. The angle of approach (front of vehicle) is measured in the same fashion.

In Figure A.12.3.2.3, the line *AT* represents the circumstance in which the tailboard is the determining lowest point. The line *BT* represents a circumstance in which the tailboard is not the lowest point (in this case, the lowest point is a fuel tank). The angle of departure is shown as *XA* or *XB*. To determine the angle of departure, place a thin steel strip against the rear of the tires where they touch the ground or stretch a string tight from one rear tire to the other at the rear of where they touch the ground. Determine the lowest point (the tailboard, fuel tank, or other equipment or component) that would make the smallest angle of departure. Hang a plumb bob from the lowest point and mark the point on the ground where the point of the plumb bob touches. Measure the vertical distance from the ground to the point where the plumb bob was hung (*V*). Measure the horizontal distance from the plumb bob point to the front of the steel strip or to the string running from rear tire to rear tire (*H*). Divide the vertical distance (*V*) by the horizontal distance (*H*). The ratio *V/H* is the tangent of the angle of departure. If this ratio is known, the angle of departure can be determined from a table of trigonometric functions of angles or from a math calculator. The standard requires a minimum angle of departure of 20 degrees; since the tangent of 20 degrees is 0.3640, if *V* divided by *H* is 0.3640 or larger, the angle of departure is 20 degrees or greater.

A.12.3.3 Where automatic transmissions are used, the power takeoff (PTO) applications could present problems, especially where dual PTO drives are required. In some instances, the PTO drive can be engaged only in torque converter range, with resultant chances of overheating with prolonged use. If high engine rpm occurs, there is the possibility, if the vehicle is accidentally left in gear, of the output torque overcoming the parking brake and moving the vehicle. Proper operational instructions are essential with automatic transmissions.

A.12.3.3.3 If a 4 × 2, manual transmission–equipped chassis is to go 2 mph (3.2 km/hr), special gearing might have to be provided, such as a two-speed axle, an auxiliary transmission, or an extra low–geared transmission.

A.12.3.3.4 The purchaser can consider adding a device that will shift the transfer case from all-wheel drive back to standard 4 × 2 or 6 × 4 drive when the vehicle speed exceeds the manufacturer's recommended maximum speed for all-wheel drive operations.

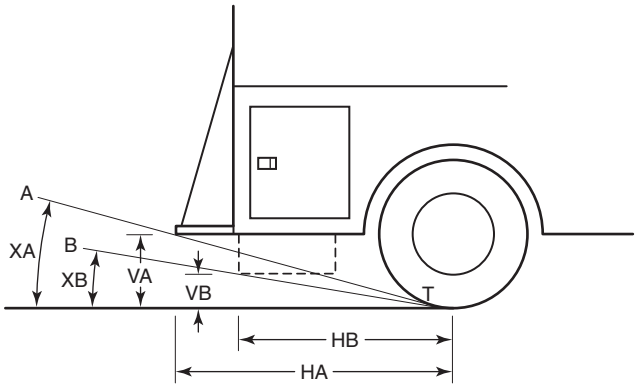


FIGURE A.12.3.2.3 Dimensions for Determining Angle of Departure.

A.12.3.4.1 Where a large-capacity fuel tank is desired, as in the case of apparatus designed for rural service, the capacity should be specified by the purchaser. [**1901:**A.12.3.4.1]

A.12.3.5 If the purchaser wants the hooks to be accessible without compartment doors having to be opened, the specification should state that fact.

A.13.1 This chapter defines the requirements for alternators, batteries, load management, and instrumentation to detect incipient electrical system failure. The intent is to require an electrical system that will operate the apparatus using power supplied by the alternator, shed nonessential electrical loads where necessary, and provide early warning of electrical failure in time to permit corrective action. [**1901:**A.13.1]

A.13.2.1 The 125 percent requirement for wiring and circuits is intended to provide reduced voltage drop over wire rated based on ampacity due to heating. In low voltage wiring, voltage drop becomes a problem before the thermal limit of current carrying capacity of a wire is reached. This requirement also ensures that the circuit protection will prevent damage to the wire in the event of a short or an overload. It is not the intent of this requirement to have the final-stage manufacturer replace the chassis manufacturer's original equipment wiring to meet the 125 percent requirement. It is also not the intent of this requirement to have electrical accessories purchased by the apparatus manufacturer rewired to meet the 125 percent requirement. Electrical device manufacturer–supplied wiring can be used to the point where it connects to the apparatus manufacturer's installed wiring. [**1901:**A.13.2.1]

A.13.2.6 It is the intent of 13.2.6 to provide a unique means of identifying a wire or circuit to prevent confusing it with another wire or circuit if electrical system repairs become necessary. If a color coding scheme is used instead of some other unique identification, that color should not be reused for a wire in any unrelated circuits within the same harness. However, 13.2.6 covers only low-voltage wiring and does not apply to shielded cables commonly used for communication purposes or wiring used in line-voltage circuits.

A.13.3.2 When the load specified in 13.3.2 is exceeded and larger alternators are not available, the purchaser and the manufacturer need to work together to determine how to reduce the minimum continuous electrical load to that which can be sustained under the conditions defined in 13.3.2.

The minimum alternator size is developed based on the loads required to meet the minimum continuous electrical load. Most apparatus will actually have loads exceeding the minimum requirements of this standard. The purchaser should review the maximum current output of the alternator versus the load study supplied for the apparatus from the manufacturer for on-scene and responding modes.

A.13.3.3(7) The purchaser should analyze the electrical loads that need to be maintained to fulfill the mission of the apparatus and define those loads for the manufacturer of the apparatus. The purchaser needs to understand, however, that there is a limit to the output capacity of an alternator system on the apparatus's engine and that this standard requires that the apparatus be capable of maintaining the minimum continuous electrical load under the conditions defined in A.13.3.2.

A.13.3.4 The unexpected shutdown of a fire apparatus at a fire can place fire fighters in mortal danger and seriously affect the fire attack. With computer-controlled engines and transmissions as well as electric valves and other controls, an electrical system failure could result in an immediate and total shutdown of the apparatus. The low-voltage monitoring system is intended to provide an early warning of an impending electrical failure and provide enough time to permit operator intervention. [**1901:**A.13.3.4]

A.13.3.6.1 Reduced crew sizes have forced the apparatus operator to assume many new fireground tasks in addition to that of operating an apparatus. Even if the operator is at the apparatus, he or she is too busy with higher priority tasks to pay much attention to monitoring the condition of the electrical system. [**1901:**A.13.3.6.1]

Electrical loads on modern fire apparatus frequently exceed the alternator capacity and can be supplied only by the deep discharge of the apparatus batteries. The high-cycle batteries that are designed to provide the large amount of amperage to crank modern diesel engines are severely damaged when deeply discharged. The automatic load management is intended to protect the electrical system from needless damage while maintaining the operation of essential devices. [**1901:**A.13.3.6.1]

It is important that the priority of all managed loads be specified by the purchaser so that, as electrical loads are disconnected from the apparatus's electrical systems, they are shed in an order least likely to affect emergency operations. The optical warning devices in excess of the minimum required in this standard can and should be load managed. [**1901:**A.13.3.6.1]

A.13.4 Batteries on fire apparatus should be larger than those used on commercial vehicles because, in addition to starting the vehicle, they need to provide the supplemental energy to power high-amperage, intermittent operation devices such as mechanical sirens and electric rewind hose reels. [**1901:**A.13.4]

Batteries usually have two ratings: “cold cranking amperes,” which determine the size engine that can be started, and “reserve capacity,” which provides a measure of the total power that can be provided at a much lower constant rate of discharge. Fire apparatus batteries should be sized to have enough cold cranking amperage and reserve capacity to restart the engine after being substantially discharged. [**1901:**A.13.4]

The purchaser might want to specify a battery disconnect switch for disconnecting the battery for maintenance or storage. This switch should be located where it cannot be operated from the driver's position. The chassis manufacturer should be consulted before such a switch is installed, because such an installation might affect the chassis warranty.

A.13.4.4.4 Overheating of a battery will cause rapid deterioration and early failure; evaporation of the water in the battery electrolyte can also be expected. Batteries in commercial chassis are often installed to take advantage of the cooling effect of the flow of air from motion in over-the-road operation and could be subject to overheating when the apparatus is operated in a stationary position, such as during pumping operations. [**1901:**A.13.4.4.4]

A.13.4.5 An onboard battery conditioner or charger or a polarized inlet should be provided for charging all batteries. The power cord from the onboard charger or battery conditioner should be plugged only into a receptacle protected by a ground-fault circuit interrupter (GFCI) at the shoreline origination point.

A.13.4.6 The purchaser might want to consider a second pilot light on the outside of the apparatus to warn that the master disconnect is on when the apparatus is parked in the fire station. [**1901:**A.13.4.6]

A.13.4.6.4 The purchaser might consider specifying that the indicator light dim automatically or be located in an area of the cab where it does not distract the driver when driving at night. The purchaser might consider a second "battery on" pilot light on the outside of the apparatus to warn that the batteries are on when the apparatus is parked in the fire station. [**1901:** A. 13.4.6.4]

A.13.4.7 Sequential switching devices are sometimes used to minimize the load placed on the electrical system during apparatus start-up for an emergency response. [**1901:**A.13.4.7]

A.13.7 SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz),* provides test procedures and recommended levels to assist engineers in the control of broadband electromagnetic radiation and in the control of radio interference resulting from equipment installed on the apparatus. Adherence to the recommended levels will minimize the degradation effects of potential interference sources on fireground communication equipment or other devices susceptible to electromagnetic interference.

Procedures are included to measure the radiation from a single device or the entire apparatus. Compliance could be determined through actual tests on the completed apparatus or predictions based on tests previously conducted on similarly equipped apparatus. If compliance certification is required, it should be so indicated in the apparatus specifications.

A.13.8 In general, most fire apparatus are considered to be emergency vehicles and, as such, should be equipped with the optical warning devices described in this standard. One exception might be an apparatus that responds over long distances (i.e., over 100 miles) to a wildland fire without the need to call for the right-of-way from other traffic. If the purchaser wants to specify an apparatus without emergency lighting, care first needs to be taken to make sure that no conflict exists with local, state, or federal laws for the purchaser's jurisdiction. Even if emergency lighting is not required by state or federal law, it is still recommended that the apparatus be equipped with a system of amber flashers or rotating beacons.

A.13.8.1 The upper-level optical warning devices provide warning at a distance from the apparatus, and the lower-level optical warning devices provide warning in close proximity to the apparatus. *(See Figure A.13.8.1.)* [**1901:**A.13.8.1]

A.13.8.7.3 Under typical conditions, the specified optical warning system provides effective, balanced warning. In some situations, however, the safety of the apparatus can be increased by turning off some warning devices. For example, if other vehicles need to pass within close proximity to the parked apparatus, the possibility of distracting other drivers can be reduced if the headlights and lower-level warning lights are turned off. In snow or fog, it might be desirable to turn off forward-facing strobes or oscillating lights to reduce visual disorientation of the apparatus driver. [**1901:**A.13.8.7.3]

The intent of the warning light system is to provide full coverage signals through the operation of a single master switch when the apparatus is either responding or blocking the right-of-way. There is no intent to prevent the use of lower levels of warning when the apparatus driver believes such reductions are appropriate, given the vehicle's mission, the weather, or other operational factors. Additional switches downstream of the master switch can be specified by the purchaser to control individual devices or groups of devices. [**1901:**A.13.8.7.3]

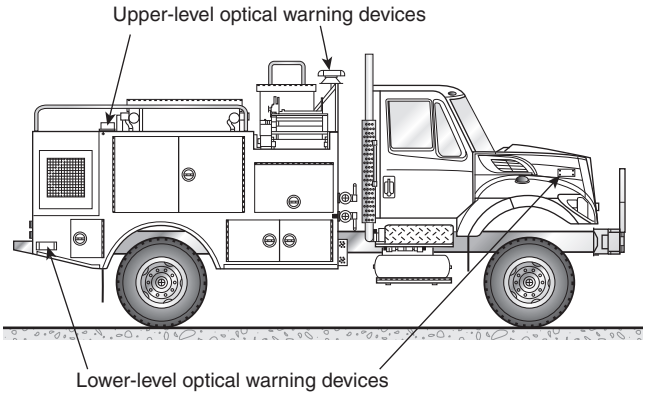


FIGURE A.13.8.1 Upper- and Lower-Level Optical Warning Devices.

Purchasers might want to specify traffic flow–type lighting such as amber directional indicators for use in alerting approaching motorists of blocked or partially blocked highways. [**1901:**A.13.8.7.3]

A.13.8.10 When a component such as a flasher or power supply is used to operate more than one optical source, the optical sources should be connected so that the failure of this component does not create a measurement point without a warning signal at any point in any zone on either the upper or lower level. Although a single optical source can be used to provide warning signals into more than one zone, the possibility of a total signal failure at a measurement point is increased when the same flasher or power supply is used to operate multiple optical sources, each providing signals into more than one zone. [**1901:**A.13.8.10]

A.13.8.12 Flashing headlights are used in many areas as warning lights and provide an inexpensive way to obtain additional warning to the front of the apparatus. Daylight flashing of the high-beam filaments is very effective and is generally considered safe. Nighttime flashing could affect the vision of oncoming drivers as well as make driving the apparatus more difficult. [**1901:**A.13.8.12]

In some jurisdictions, headlight flashing is prohibited or limited to certain types of emergency vehicles. If flashing headlights are employed on fire apparatus, they are to be turned off when the apparatus headlights are on. They should also be turned off along with all other white warning lights when the apparatus is in the blocking mode. [**1901:**A.13.8.12]

Steady burning headlights are not considered warning lights and can be illuminated in the blocking mode to light the area in front of the apparatus. Consideration should be given, however, to avoid shining lights into the eyes of oncoming drivers. [**1901:**A.13.8.12]

A.13.8.13 The minimum optical warning system should require no more than an average of 40 A for the operation of the upper-level and lower-level devices in the blocking mode.

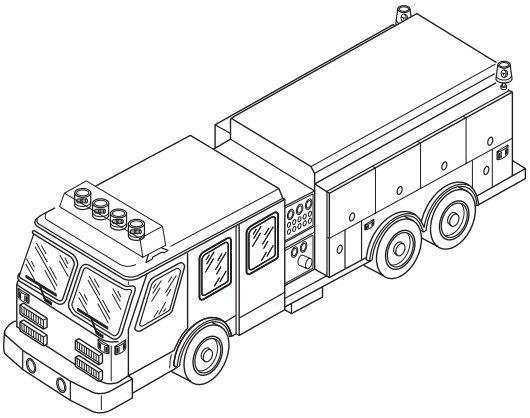


FIGURE A.13.8.13(a) Front and Left Side of Apparatus with Optical Warning System. [1901:Figure A.13.8.13(a)]

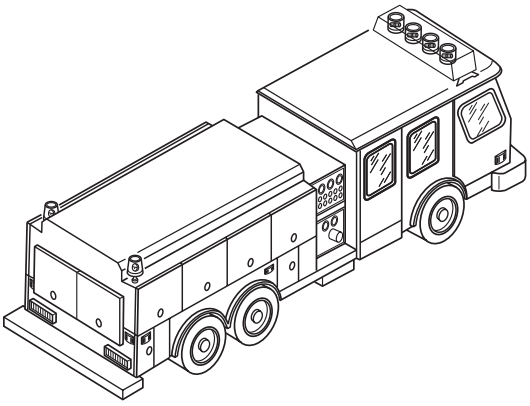


FIGURE A.13.8.13(b) Rear and Right Side of Apparatus with Optical Warning System. [1901:Figure A.13.8.13(b)]

On apparatus whose length requires midship lights, no more than 5 A of additional current should be required for the operation of each set of midship lights. Optical warning systems drawing more than 40 A might necessitate modification of the electrical system specified in Section 13.3 in order to supply the additional power required. [**1901:**A.13.8.13]

See Figure A.13.8.13(a) and Figure A.13.8.13(b) for illustrations of an optical warning system on a large fire apparatus. [**1901:**A.13.8.13]

A.13.8.13.5 The zone totals reflect the combined performance of the individual optical warning devices oriented as intended on the apparatus when viewed along the perimeter of a circle of 100 ft (30.5 m) radius from the geometric center of the apparatus. [**1901:**A.13.8.13.5]

The zone total is the sum of the optical power of all optical sources projecting signals of permissible color into the zone as measured at 5-degree increments along the horizontal plane passing through the optical center *H* throughout the 90 degrees included in the zone (19 data points). The calculation of zone totals assumes that all optical sources are mounted at the geometric center of the apparatus. With the optical center of each optical source oriented as installed, the optical power contributed by every optical source at a given point is taken from the test report, and they are added together to determine the total optical power at that point. The zone total is the sum of the optical power at the 19 measurement points in the zone. The upper- and lower-level optical sources are calculated independently. [**1901:**A.13.8.13.5]

The engineering basis of Section 13.8 permits both the design and the certification of an optical warning system by mathematical combination of the individual test reports for any number of optical warning devices of different color, flash rate, optical source, and manufacturer. [**1901:**A.13.8.13.5]

Using the test reports provided by the device manufacturer, the contribution of optical energy from each optical source is determined for every data point. The total candela-seconds per minute of optical energy is determined at each point, and then the zone totals are calculated and compared to Table 13.8.13.5. [**1901:**A.13.8.13.5]

A.13.8.14 The minimum optical warning system should require no more than an average of 35 A for the operation of the devices in the blocking mode. [**1901:**A.13.8.14]

A.13.8.16 In a few cases, a manufacturer might wish to type certify by actual measurement of the optical warning system on an apparatus. [**1901:**A.13.8.16]

Certification of the actual measurement of the performance of the optical warning system is made with each optical source either mounted on the apparatus or on a frame duplicating the mounting of the device on the apparatus. The performance of the system can be directly measured along the perimeter of a circle with a 100 ft (30.5 m) radius from the geometric center of the apparatus. Each optical warning device used should be certified by its manufacturer as conforming to all the requirements of this standard pertaining to mechanical and environmental testing. Photometric testing of the system should be performed by qualified personnel in a laboratory for such optical measurements. [**1901:**A.13.8.16]

The test voltages and other details should be as called for in this standard for the photometric testing of individual optical warning devices. The elevation of the photometer, however, could be set at the elevation that maximizes the performance of the upper-level devices and at a second, different elevation that maximizes the performance of the lower-level devices. [**1901:**A.13.8.16]

With the optical center of each device oriented as installed, the sum of the actual value of the optical power contributed by every optical source is then determined at each measurement point. The zone total is the sum of the optical power at the 19 measurement points in the zone. [**1901:**A.13.8.16]

Measurements are made to determine all the optical requirements of this standard, including the optical power at each of the required measurement points, the zone totals at the horizontal plane passing through the optical center, and the zone totals at 5 degrees above and 5 degrees below the horizontal plane passing through the optical center. Any upper-level warning devices mounted above the maximum height specified by the manufacturer(s) should be tested to demonstrate that at 4 ft (1.2 m) above level ground and 100 ft (30.5 m) from the mounted device, the optical energy exceeds 50 percent of the minimum required at the horizontal plane passing through the optical center. [**1901:**A.13.8.16]

A.13.9.1.2.2 If the purchaser wishes to have the siren controls within convenient reach of persons riding in both the right and

left front seat positions, that should be specified. In some apparatus, multiple control switches might be necessary to achieve convenient reach from the two positions. If other signal devices, such as an additional siren, bell, air horn(s), or buzzer are desired, the type of device and its control location also should be specified. [**1901:**A.13.9.1.2]

A.13.10 Depending on how the fire apparatus will be used, the purchaser may want to call for ground lighting, hose bed lighting, work surface and step lighting, interior lighting, or compartment lighting. The purchaser should specify where lights are desired and what level of performance is desired. For many of these lights, there is a problem with mounting them in a way that they will not be damaged by brush, equipment, or vibration.

A.13.12 The purchaser might wish to add camera(s) at the sides or rear of a vehicle with cab monitoring screens or automatic vehicle-stopping devices that sense an obstruction at the rear of the vehicle. In addition, angled backup lights mounted in the wheel well areas will provide additional scene lighting for personnel who might be at the side of the vehicle or lighting of folding tanks or other obstacles on the side of the apparatus. Any such devices will improve safety while vehicles are backing. [**1901:**A.13.12]

A.13.14.1 The purchaser might wish to have the entire low-voltage electrical system and warning device system certified by an independent third-party certification organization. [**1901:**A. 13.14.1]

A.14.1.3 The purchaser will need to define how many seating positions are required to carry personnel and might wish to specify the arrangement of the seating positions. Canopy cab extensions with patio door–type closures or separate telephone booth–type personnel enclosures are acceptable means for providing fully enclosed seating positions. The ultimate mission of wildland fire apparatus is dependent upon the apparatus responding to and arriving at incidents safely. To this end, it is essential that the wildland fire apparatus be driven in a safe manner and that all occupants are seated and belted while the apparatus is in motion. To encourage safe practices, fire department management should consider employing methods of monitoring driving and safety habits of the personnel onboard. Several methods of monitoring compliance of all safety precautions by personnel in the apparatus have been developed, including available live video monitoring, video recording, and vehicle data recording. Any monitoring method should include monitoring the use of seat belts and an indication of the characteristics of how carefully the apparatus is being driven. Purchasers may wish to consider specifying seat belt colors such as bright red or orange, which contrast with personnel clothing and thus are easier to observe for compliance. The purchaser may wish to consider specifying a Vehicle Data Record in accordance with NFPA 1901. This device can be used to keep track of seat belt use by personnel and monitor driving habits of the operator. This may be a useful tool for those departments struggling to enforce seat belt use policy.

A.14.1.3.1 The minimum effective belt length dimensions were determined from a survey of 300 fire fighters wearing bunker gear. For a lap belt only, the 95th percentile male fire fighter required 48 in. (1220 mm) of belt length, and the largest subject in the survey required 54 in. (1370 mm). The 60 in. (1525 mm) minimum will accommodate the largest subject and provide 12 in. (305 mm) spare for the 95th percentile subject. [**1901:**A.14.1.3.2]

A.14.1.3.2 For a lap and shoulder belt assembly, the 95th percentile fire fighter required 98 in. (2490 mm) of effective belt length, and the largest subject in the survey required 109 in. The 110 in. (2800 mm) minimum will accommodate the largest subject and provide 12 in. (305 mm) spare for the 95th percentile subject. [**1901:**A.14.1.3.2]

A.14.1.3.2.3 If the H-point of the seat is unknown, it can be estimated by the method outlined in A.14.1.7.1.

A.14.1.3.4 Some models of commercial vehicles with a GVWR of 19,500 lb (8,845 kg) or less do not have bright red or bright orange seat belts available. However, if seat belts meeting these requirements are commercially available on the required cab model, purchasers should consider specifying the bright red or bright orange color. Alternatively, a patch or slipcover might be available to make the seat belts more visible. [**1901:**14.1.3.4]

A.14.1.7.1 The H point is the mechanically hinged hip point of the torso and thigh on the devices used in defining and measuring vehicle seating accommodation in SAE J826, *Devices for Use in Defining and Measuring Vehicle Seating Accommodation*. It is an imaginary point located in two-dimensional space above the seat cushion. The H point is measured using a tool that simulates human hips and torso of a specific size and weight. The H point will vary with the size, shape, and material of the seat back, seat frame, and seat cushion. If the H point measurement is not available, it can be approximated by measuring 5 in. (130 mm) ahead of the seat back and 3 in. (75 mm) up from the nondepressed seat cushion surface. [**1901:**14.1.7.1]

Suspension-style seats have been developed for long-haul truck operations where the operator is driving for many hours at a time. Acceleration and braking are controlled, with an eye to fuel economy. The suspension-style seat in this duty profile provides a smoother ride and reduces fatigue from long hours in the seats. In contrast, the operator of a fire apparatus typically is making short runs with fast acceleration, quick maneuvers, and sudden braking. The bouncing motion of the suspension seat could hinder the driver's ability to maintain precise control of the throttle, brake, steering wheel, and other driving controls. [**1901:**14.1.7.1]

Selection of seating options should be made with consideration to the frequency of time that the driver will spend in the vehicle each day, and whether the fire department standard operating procedure (SOP) requires or encourages the occupant of the seat to be equipped with headgear during firefighting operations. The use of headgear reduces headroom and increases the chance of injury should the vehicle encounter unexpected road undulation or speed bumps. The effect of such road conditions during high-speed operation might be intensified by the action of a seat suspension. Potential for injury is greatly increased by failure to use or properly adjust the seat belt.

Proper seat adjustment is another issue that should be addressed by the fire department SOPs if apparatus are equipped with suspension seats. Too much pressure in a suspension seat air bag will reduce static headroom height and will negate the potential benefits of the suspension. Too little pressure will cause the seat to bounce excessively. The proper amount of pressure is dependent on the weight of the occupant. Departments where multiple drivers share an apparatus should recognize that adjustments need to be made between each shift. Seat adjustment should not be postponed until the driver is exiting the station on the way to a call. [**1901:**14.1.7.1]

A.14.1.7.4 The minimum seat head height values in this standard assume that the occupants are not wearing fire helmets. The use of a helmet puts the occupant at greater risk of neck or back injury during a rollover or a severe road event. [**1901:**A.14.1.8.4]

A.14.1.9.1 SCBA units and other equipment stored in the crew compartment can cause injuries to occupants of the compartment if they fly around the compartment as the result of an accident or other impact. Departments should check their pack and bottle weight to ensure that it does not exceed the published rating of the SCBA holder to be provided. [**1901:**A.14.1.9.1]

A.14.1.9.1(4) A new holder can be employed for each test. [**1901:**A.14.1.9.1(4)]

A.14.3.1 With the requirements for fully enclosed driving and crew compartments, the potential for heat buildup in these areas is greater. The purchaser should be aware of this condition and might wish to specify ventilation fans or air conditioning to keep the ambient temperature in the driving and crew compartment(s) lower. [**1901:**A.14.3.1]

A.14.3.2 The U.S. standards developed by SAE and the United Nations ECE regulation mirror each other except that SAE J2422 requires a roof preload impact prior to the roof crush. The ECE standard was established in 1958, while the SAE standards did not add performance criteria until 2003. Both the SAE and ECE standards are viable minimum measures of cab integrity. Manufacturers may test in excess of the standards. [**1901:**A.14.3.2]

A.14.3.4 The purchaser should realize that local conditions or operating procedures could cause the passenger to project into the sight pattern of the driver and therefore cause vision obstructions. Seats should be arranged so that SCBA and any passengers wearing protective clothing do not cause vision obstructions. Movement of the passenger should be considered when installing radios, computers, and other equipment so that forward movement or shifting is reduced to a minimum and does not block the driver's vision. [**1901:**A.14.3.4]

When specifying new apparatus, the purchaser should consider remotely controlled mirrors, especially on the passenger side. The location and mounting of the mirrors should not be placed where door pillars or other obstructions block their view. The location and mounting should be placed so warning lights do not reflect in the mirror to blind the driver's view. The location and mounting should not be placed so that the driver must look through the windshield area that is not wiped by the windshield wiper when viewing the passenger side mirror. Convex and other secondary mirrors should be considered to eliminate blind spots not covered by primary mirrors. Where necessary, heated mirrors should also be considered. [**1901:**A. 14.3.4]

The purchaser should consider specifying a style of mirror that swings when making contact with branches and trees.

A.14.4 Typically, while engaged in fire-fighting operations on structural fires, apparatus and personnel are positioned in a safe location and hose is extended as necessary to discharge water or suppressants on the combustible material.

In wildand fire suppression, mobile attack is often utilized in addition to stationary pumping. In mobile attack, sometimes referred to as pump-and-roll, water is discharged from the apparatus while the vehicle is in motion. Pump-and-roll operations are inherently more dangerous than stationary pumping because the apparatus and personnel are in close proximity to the fire combined with the additional exposure to hazards caused by a vehicle in motion. The personnel and/or apparatus could be subject to injury or damage due to accidental impact, rollover, and/or environmental hazards, including burn over.

To mitigate the increased risk inherent with pump-and-roll operations, the following tactics are recommended:

(1) Driver is located inside the apparatus in a seated, belted position within the enclosed cab. Fire fighter(s) located outside the cab, walking alongside the apparatus, in clear view of the driver, discharging water with a short hose line.
(2) Driver and fire fighter(s) are located inside the apparatus in a seated, belted position within the enclosed cab. Water is discharged via a monitor or turret that is controlled from within the apparatus.
(3) Driver is located inside the apparatus in a seated, belted position within the enclosed cab with one or more fire fighters seated and belted in the on-board pump-and-roll fire-fighting position as specified in Section 14.4.
(4) Driver and fire fighter(s) are located inside the apparatus in a seated, belted position within the enclosed cab, but water is discharged with a short hose line or hard line out an open cab window.
(5) And under no circumstances is it ever considered safe practice to ride standing or seated on the exterior of the apparatus for mobile attack other than seated and belted in an on-board pump-and-roll fire-fighting position. *(See Section 6.3 of NFPA 1500.)*

The on-board pump-and-roll fire-fighting position should only be used when the following conditions are met:

(1) The apparatus is actively engaged in mobile attack on the fire line.
(2) The fuel model is characterized as fine fuels.
(3) The ground is level, flat and free of obstacles.
(4) Driver visibility is unobstructed.
(5) Vehicle speeds are no greater than 10 mph.
(6) Fire fighter is wearing full protective NFPA 1977–compliant personal protective equipment and is equipped with a fire shelter.

A.14.4.3.4 This is to protect against objects such as limbs entering the seating enclosure. Woven wire cloth with ¼ in. (0.6 cm) diameter wire spaced at 1¾ in. (4.4 cm) on centers is commonly used in the forestry industry to provide this protection.

A.15.1 Compartmentation that is designed to meet the size, shape, and weight requirements of special equipment might be required. Any special equipment to be carried on the apparatus should be identified in the specifications. [**1901:**A.15.1]

A.15.1.1 A water tank can condense water on the outside. Ventilation and drainage should be provided in compartments sharing a common wall with a water tank.

A.15.3.1 Fire-fighter injuries resulting from climbing on apparatus to retrieve, store, and operate equipment can be minimized if specifications require that equipment be accessible from ground level. Examples of ways to reduce the need to climb on the apparatus include, but are not limited to, using

powered equipment racks, using remote control deck guns, lowering of storage areas for preconnected attack lines and using pull-out trays, using slide-out or pull-down storage trays, and providing for the checking of fluid levels from ground level. [**1901:**A.15.3.1]

A.15.3.2 Where equipment other than that originally mounted on the apparatus is to be carried, the fire department should ensure that the equipment is securely attached to the vehicle with appropriate holders. [**1901:**A.15.3.2]

A.15.5 SCBA units are typically stored in crew seats, behind bench seats, and on walls, doors, or shelves of storage compartments. [**1901:**A.15.5]

The area where the complete SCBA unit is to be mounted should be arranged to prevent damage to hose, straps, belts, facepiece, regulator, and other attachments. This arrangement should include prevention of wear and tear on the delicate facepiece due to vehicle movement. The facepiece should be stored in a nylon or plastic bag to prevent such abrasion. [**1901:**A.15.5]

Storage of spare hose assemblies, facepieces, regulators, and other SCBA pack accessories should be in a clean and dry area, away from heat-producing devices or mechanical damage. Preferably, the equipment should be stored individually in plastic or noncorrosive bins with dust-free covers. The contents of each bin should be noted on a label on the exterior. [**1901:**A. 15.5]

A.15.5.5 SCBA cylinders should always be stored with the valve assemblies at the top. [**1901:**A.15.5.5]

A.15.5.6 SCBA cylinders should be stored with valve assemblies exposed to the compartment opening or storage area to permit inspection of valves or gauges. [**1901:**A.15.5.6]

A.15.7.1 Ascending into and descending from certain types of driving and crew compartments is ergonomically difficult and sometimes results in falls and subsequent fire fighter injuries. When designing and specifying apparatus, it is strongly suggested that chassis and apparatus manufacturers be consulted concerning available alternatives to make driving and crew compartment access as ergonomically convenient and as safe as possible. [**1901:**A.15.7.1]

A.15.7.1.2 The intent of step size and placement requirements is to ensure that the fire fighter's foot is supported 7 in. to 8 in. (175 mm to 200 mm) from the toe when the foot is placed on the step in the normal climbing position. The leading edge is not necessarily the side opposite the fastening location. [**1901:**A.15.7.1.2]

A.15.7.4 Apparatus are constructed with surface areas that are not intended to be used as stepping, standing, and walking areas. These include cosmetic and protective coverings on horizontal surfaces. During the design stage of the vehicle, purchasers should designate which areas are stepping, standing, or walking areas. It is important that proper materials are selected for the application and local conditions. [**1901:**A.15.7.4]

When selecting stepping, standing, and walking surfaces, the purchaser should take into consideration the long-term use of the vehicle. The slip resistance of certain surfaces might deteriorate over time. It is also important for the fire department to properly maintain or replace slip-resistant materials as they deteriorate. [**1901:**A.15.7.4]

A.15.7.4.1 Slip Resistance. When selecting stepping, standing, and walking surfaces, the purchaser should take into consideration the long-term use. The slip resistance of certain surfaces might deteriorate over time. It is also important for the fire department to properly maintain or replace slip-resistant materials as they deteriorate. [**1901:**A.15.7.4.1]

A.15.8.4 Exterior access handrails should be mounted in a way so as to minimize the chances of damage or removal by brushing objects such as trees. [**1901:**A.15.8.4]

A.15.8.6 The intent is that the apparatus manufacturer does not need to remove and replace those grab handles designed and built into the chassis by a commercial chassis manufacturer. Grab handles inside the door are acceptable. [**1901:**A. 15.8.6]

A.15.9.2 Corrosion protection, commonly known as undercoating, might be advantageous in areas where climatic conditions or road treatment will corrode vehicle components. The material, its application method, and the areas to be protected should be carefully specified so the corrosion protection will adequately protect the vehicle's cab and body sheet metal components subject to corrosive conditions that might be encountered in the fire department's response area. [**1901:**A. 15.9.2]

A.15.9.2.1 The purchaser should give consideration to the choice of paint color(s) as it relates to the total vehicle conspicuousness. In addition, the purchaser needs to specify whether nonferrous body components are to be painted and whether any lettering, numbering, or decorative striping is to be furnished. **[1901:**A.15.9.2.1]

A.15.9.3 The purchaser should specify whether the striping required under this standard will be provided by the manufacturer on delivery of the apparatus or will be installed by the purchaser or its designee following delivery. In any event, the required striping must be installed before the unit is placed in emergency service. [**1901:**A.15.9.3]

A.15.9.3.1 If the purchaser specifies roll-up doors, consideration should be given to affixing a strip of reflective material to the rail area below the door. If the purchaser specifies vertically hinged compartment doors, consideration should be given to affixing 4 in. (100 mm) minimum width reflective stripes or chevron-type reflective stripes on the inside of the doors. [**1901:**A.15.9.3.1]

A.15.9.3.1.1 Purchaser may wish to consider adding the chevron requirement from NFPA 1901, if there is sufficient vertical surface at the rear of the apparatus.

A.15.10 Apparatus provided with booster hose and reel assemblies should have power rewind capability. However, if a manual rewind is provided, attention should be paid to the location of the hand crank. It should be placed in a location that allows the operator to rewind the hose onto the reel without having to climb onto the apparatus. [**1901:**A.15.10]

If the apparatus is to be used or stored in subfreezing conditions, the reel should be equipped with an air chuck mechanism to allow connection of an external source of compressed air to facilitate removal of water within the booster hose assembly. This mechanism should be located on the discharge side of the booster reel valve. [**1901:**A.15.10]

The purchaser should specify whether a single or split hose bed is desired and any special arrangements desired for preconnected hose lines. [**1901:**A.15.10.1]

A.15.10.2 It is also recommended that the purchaser consider specifying some type of cover for the hose compartment. Hinged or removable covers might be advantageous. [**1901:**A. 15.10.1]

A.15.10.6 Many fire departments have experienced fire hose inadvertently coming off apparatus while traveling to and from incidents. Several incidents have resulted in injuries, damage to property, and death. Fire departments and manufacturers have developed various methods of preventing inadvertent deployment, including fully enclosed hose bed covers, buckled straps, hook-and-loop straps, fabric covers, webbing mesh, wind deflectors, and other material restraints or combination of restraints. It is also important that fire departments develop methods of storing hose and appliances in a manner that does not promote the inadvertent deployment of the hose and appliances. [**1901:**A.15.10.5]

A.15.10.8 Apparatus provided with booster hose and reel assemblies should have power rewind capability. However, if a manual rewind is provided, attention should be paid to the location of the hand crank. It should be placed in a location that allows the operator to rewind the hose onto the reel without having to climb onto the apparatus.

If the apparatus is to be used or stored in subfreezing conditions, the reel should be equipped with an air chuck mechanism to allow connection of an external source of compressed air to facilitate removal of water within the booster hose assembly. This mechanism should be located on the discharge side of the booster reel valve.

A.15.12 Trailer hitch–type receivers are commonly used as anchor points for both removable winches and rope operations. Removable winches are intended for equipment recovery operations only. Rope operations could involve personnel rescue, which requires the receiver and its anchorage to be designed using higher safety factors. [**1901:**A.15.12]

A.15.13.4.4 If the unit is going to be moved onto and off a chassis periodically, the purchaser might wish to specify lifting eyes or forklift slots to facilitate the unit's movement. Provisions to prevent accidental breakaway from the chassis should be provided. [**1901:**A.15.13.4.4]

A.16.2.1 Some of the pump performance requirements listed in Table 16.2.1 are the same as the pump requirements of certain U.S. fire and insurance organizations. Table A.16.2.1 ties the performances required by Table 16.2.1 to those required by the National Wildfire Coordinating Group (NWCG), the Insurance Services Office (ISO), and the U.S. Forest Service for agency engines.

A.16.2.2.1 If the apparatus is equipped with an automatic transmission, it is acceptable to lightly apply throttle and brakes for short periods of time to maintain a maximum speed of 2 mph (3.2 km/hr). If the vehicle is to be used for simultaneous pump-and-roll and fire fighting while the vehicle is moving, remote controlled nozzle(s) or turret(s) should be considered. See also A.6.3.1 of NFPA 1500.

Heavy braking in combination with moderate to heavy throttle can create a large amount of heat in the automatic transmission converter and brakes that could lead to damage.

Table A.16.2.1 Water Pump Performance When Installed in Wildland Apparatus Engine

psi	kPa	gpm	L/min
100	700	50[a]	200
		150	600
150	1000	50[b]	200
		250[c]	1000
250	1700	50[d]	200
		150[e]	600
300	2000	200[f]	800
400	2800	30	120

[a] NWCG rating for type 4, 5, and 6 engines [50 gpm @ 100 psi (200 L/min @ 700 kPa)]
[b] ISO9 rating [50 gpm @ 150 psi (200 L/min @ 1000 kPa)]
[c] ISO8 rating [250 gpm @ 150 psi (1000 L/min @ 1000 kPa)] and also NWCG Tactical Water Tender T2
[d] U.S. Forest Service type 4, 5, and 6 engine [50 gpm @ 250 psi (200 L/min @ 1700 kPa)]
[e] NWCG rating for type 3 engine [150 gpm @ 250 psi (600 L/min @ 1700 kPa)]
[f] U.S. Forest Service type 3 agency engines [200 gpm @ 300 psi (800 L/min @ 2000 kPa)]

A.16.2.3.3 High points in the suction plumbing should be avoided. If there are high points in the intake plumbing, a prime or suction should also be taken at the top of the high point as well as at the top of the pump suction inlet. [**1901:**A. 16.2.3.3]

A.16.2.4.2 If the pump is expected to operate above 2000 ft (600 m) or at lifts of more than 10 ft (3 m) or through more than 20 ft (6 m) of suction hose, the apparatus manufacturer needs to be made aware of this fact in order to compensate for the fact that the power of a naturally aspirated internal combustion engine decreases with elevation above sea level or that additional head loss will be encountered on the intake side of the pump. At an altitude of 2000 ft (600 m), the actual (uncorrected) atmospheric pressure equivalent to the sea level reading of 29.9 in. Hg (101 kPa) is 27.8 in. Hg (94.1 kPa). The purchaser should seek certification from the pump manufacturer that the pump meets the necessary performance requirements under these more strenuous conditions.

Under some conditions, the engine-pump combination is not able to perform at higher elevations. When this occurs, it is necessary to either increase the engine horsepower or de-rate the pump.

The suction hose size shown in Table 16.2.4.1(a) is for pump rating purposes only, and other sizes of suction hose can be carried on the fire apparatus for use in the field. The performance of a fire pump can be adversely affected by the design of the suction piping or the addition of valves to the suction side of the pump. Losses due to additional piping or valves that are added to the fire pump suction reduce pump performance.

A.16.3.7.1 The maximum governed speed is established by the engine manufacturer as a safe limit of engine speed. The governor prevents the engine from exceeding the safe speed. Most engine manufacturers allow a plus tolerance of 2 percent for maximum governed speed.

A.16.3.7.2 A shutdown not controlled by the pump operator during the fire-fighting operations can result in loss of water-flow from the pump, which could severely endanger personnel.

A.16.3.8.3.2 It is important to have drain valves on the plumbing. The drain valve(s) should be located at low points in the system to completely drain the system. The design of the valve should be such that the valve will not inadvertently open from vibration. It is also critical, especially on wildland vehicles or other vehicles subject to go off-road, that the drain valves are located out of the angle of approach or angle of departure or other areas where the valve could be subjected to damage or contact with brush or other objects. Accidental opening of or damage to the drain valve could impact the operation of the system.

A.16.3.10.1.1.1 Caution needs to be used because air intake filters might affect the engine manufacturer's air restriction requirements. See A.12.2.4.1.

A.16.3.10.1.2 See A.12.2.5.1.1.

A.16.3.10.1.3.1 See A.12.2.5.1.6.1.

A.16.3.10.2.1.1 See A.12.2.4.1.

A.16.3.11.2 Emissions from exhaust discharge pipes should be directed away from any fire-fighting tools, since such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use.

A.16.3.12.1 If a switch to stop the engine is provided in the driving compartment, it should be a momentary switch and should be within convenient reach of the driver. A pumping engine running light might be desired in the driving compartment.

A.16.3.13.3 If the vehicle batteries are used, the electrical requirements of the pump engine need to be considered when sizing the vehicle's charging system. *(See 13.3.1 and 13.3.2.)*

A.16.3.15 The fuel tank(s) and systems that meet 49 CFR 393.65, "All Fuel Systems"; 49 CFR 393.67, "Liquid Fuel Tanks"; or 49 CFR 393.69, "Liquefied Petroleum Gas System," should be used when available. Among other requirements, these regulations do not allow gravity or siphon feeds for other than diesel fuel tanks. Fuel withdrawal fittings have to be above normal levels of fuel in the tank when the tank is full.

A.16.3.15.2 It is recommended that the pump engine use the same type of fuel as the chassis engine.

A.16.4.3 Each component in the driveline has a continuous-duty torque rating. At this level of usage, each component also has a design life expressed as hours of use at rated torque. The design life of some components can be substantially less than the remaining drive system components. An hourmeter activated by the pumping system and marked with a label should be provided to log the number of hours of drive system usage. [**1901:**A.16.4.3]

Programming the engine to use an alternate torque curve or sizing the pump and pump gear ratio to limit the torque required is an acceptable means of limiting the net engine output torque. [**1901:**A.16.4.3]

A.16.5 Figure A.16.5 shows a typical plumbing schematic for an apparatus with a centrifugal pump. The valves on the schematic are identified by numbers corresponding to a valve numbering system that is used by a number of federal wildland fire-fighting agencies. This numbering system is detailed in the schematic in Figure A.16.5.

A.16.5.1 When fire apparatus plumbing is being designed, galvanic corrosion protection for dissimilar metals should be provided. Pumps and piping frequently required to pump salt-water, water with additives, or other corrosive waters should be built of bronze or other corrosion-resistant materials. For occasional pumping of such water, pumps built of other materials are satisfactory if properly flushed out with freshwater after such use. Where corrosive water is being pumped and the pump and piping are not made of corrosion-resistant materials, the placement of anodes in the pump might minimize the corrosive effects.

The term *all bronze* indicates that the pump's main casing, impeller, intake and discharge manifolds, and other principal components that are exposed to the water to be pumped, with the exception of the shaft bearings and seals, are made of a high-copper-alloy material. Use of like materials for the pump and piping is recommended.

Corrosion effects are proportional to the mass relationship of bronze to iron. It is, therefore, preferable to use similar materials for the pump and piping. Where both iron and bronze are used, it is preferable to keep the mass of the iron larger than that of the bronze.

A.16.6 The bleeder valve, if available, should be used prior to the removal of a hose, a cap, or other closure connected to an intake. The bleeder valve should also be used while filling a hose connected to an intake with water. Failure to use the bleeder valve in these situations might result in serious injury or death.

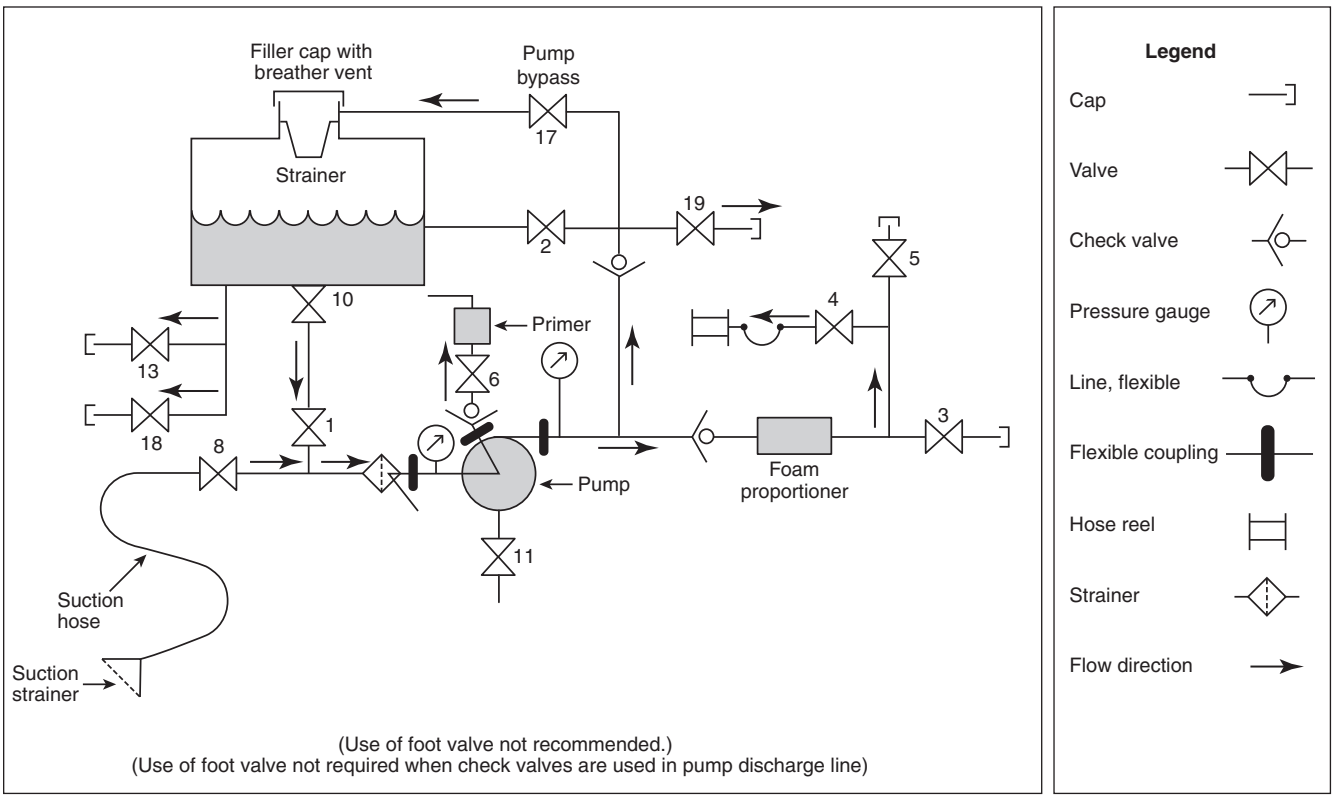
A.16.6.1 Intakes can be larger than the size of the suction hose specified in Table 16.2.4.1(a). It is also advantageous to have valves on one or more of the intakes. On wildland fire apparatus the intake is usually a male thread fitting. The purchaser should specify if larger intakes are to be provided, if the intakes are to be male or female thread fittings, and if any of the intakes are to be equipped with valves.

Intakes at the front or rear of the apparatus or otherwise specially situated might not allow drafting-rated capacity at rated pressure. The purchaser should specify the flow rates required from auxiliary intakes, especially front and rear intakes or other intakes located 10 ft (3 m) or more away from the pump. When provided, the purchaser should also consider requiring the manufacturer to certify the actual flow rates from auxiliary intakes.

A.16.6.1.1 The purchaser should specify if there are any state regulations requiring backflow devices for hydrant operation. Backflow devices might restrict pump performance from draft.

A.16.6.1.3 Pressurizing a suction inlet could create a dynamic water hammer that might cause a hose or fitting failure, resulting in injury or death to anyone in the immediate vicinity. Valves should be opened and closed slowly, and lines should be charged slowly. [**1901:**A.16.6.1.3]

A.16.6.2.2 Sizing of the openings of the strainer(s) is intended for debris of generally uniform dimensions. It is recognized that debris of nonuniform dimensions — that is, long in relation to cross section — might be able to pass through the strainer(s) while not being able to pass through the pump. [**1901:**A.16.6.2.2]



Valve Numbering System

The numbering system below has been adopted by the USDA Forest Service (other systems might also be available).

No. 1 from tank to pump
No. 2 from pump to tank
No. 3 from pump to overboard discharge
No. 4 from pump to hose reel
No. 5 engine protection
No. 6 from pump to primer
No. 7 adjustable pressure relief valve*
No. 8 from overboard suction intake to pump
No. 9 reserve supply from tank to pump*‡
No. 10 tank to plumbing shutoff valve
No. 11 pump or plumbing drain valve
No. 12 pump coolant clean-out*‡
No. 13 gravity tank drain
No. 14 foam-differential-valve shunt*‡
No. 15 pump transfer valve*
No. 16 engine cooler line (heat exchanger)*‡
No. 17 pump bypass
No. 18 low volume gravity (back pack fill)
No. 19 water-only valve
No. 20 feed #2 and/or #19*
No. 21 discharge plumbing isolation valve*
No. 22 tank fill with air gap*

**Valves not shown in diagram.*
‡Valves not commonly used.

FIGURE A.16.5 Typical Plumbing Schematic for Centrifugal Pump.

A.16.6.10 If the purchaser plans to carry a valve, siamese, or adapter on a suction inlet while the apparatus is in motion, the manufacturer needs to know the details of the valve, siamese, or adapter so the manufacturer can accommodate the size of that valve, siamese, or adapter without it extending beyond the running board.

A.16.7.1 The flows listed for each outlet size are minimum and are for rating purposes only. If piping and valving are sufficient, much higher flows for a given outlet size might be achievable.

A wildland fire apparatus might need a check valve in the plumbing, and the discharge side of the pump is the best location for the check valve, for the following reasons:

(1) With a check valve in the discharge line of the pump, the suction plumbing and suction hose will not be subject to high pressures when the pump is shut down when pumping a high vertical distance [such as 600 ft (180 m) or more]. [Suction hose is generally not rated for high pressure; it is usually rated for about 100 psi (690 kPa).]
(2) With the check valve located in the discharge line of the pump, the pump can be primed with a discharge valve open.
(3) A check valve located in the discharge line of the pump will prevent foam solution from flowing back into the fire apparatus water tank or other water source.
(4) With a check valve in the plumbing of a wildland fire apparatus, the water in a long hose lay will not be lost when the pump is shut down due to running out of water.
(5) Higher suction flow rates and higher suction lifts can be obtained when the check valve is in the discharge line of the pump, as opposed to the use of a foot valve.

(6) With a check valve in the discharge line of the pump or the use of a foot valve, the pump will hold prime when the pump is shut down.

If a check valve is used in the discharge plumbing or other location, it should be properly sized to reduce pressure drop. It should have a drain downstream of the checking device to permit water that might freeze and cause damage to be drained.

A.16.7.2.1 If flows greater than 100 gpm (400 L/min) through preconnected lines are needed, piping from the pump to the preconnected hose lines should be larger than 1½ in. (38 mm) in order to keep the friction loss to a reasonable level.

A.16.7.2.2 For interoperability among fire departments at major incidents, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections. [**1901:**A.16.7.2.2]

A.16.7.5 This standard does not specify where the valves should be located on discharge lines. Based on local operations, the purchaser should specify whether discharge valves are to be centralized at the pump operator's position or installed at the hose connection point. If the apparatus is designed for pump and roll, additional control might be desired inside the driving compartment.

A.16.7.5.3 Control of discharges on apparatus are now available in pull-type actuators, trunnion or swing valves, flexible push/pull controls, gear-operated hand wheel controls, and hydraulic, air, and electric operators. These are available with either quick-operating or slow-operating valve mechanisms. The nozzle and hose reaction and operational effort for high-flow or high-pressure discharges are critically important to many fire departments. Because of the variations in types of individuals and characteristics of operators involved with pump operations, a purchaser should carefully evaluate valve controls.

A.16.7.8 The flow should be no greater than 1 percent and no less than 0.5 percent of the pump's rated flow at the pump classification pressure or 150 psi (1000 kPa). If the recirculation valve is automatic, a check valve should be provided and a override shutoff should be considered if a foam system is provided.

A.16.7.8.3 An automatic pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open can be provided between the pump discharge and the water tank. This is not, however, recommended with an around-the-pump foam system.

A.16.7.9 Where possible, discharge outlets should be positioned in an area away from the pump operator's position. [**1901:**A.16.7.9]

If a deck gun or monitor is to be mounted on the top of the apparatus, consideration should be given to designing the system so it can be operated without the need for a person to climb to the top of the apparatus. This can be accomplished by using a remotely operated monitor or by positioning the device so it is operable from the pump operator's position. [**1901:**A.16.7.9]

A.16.9.1 Ideally, having no intake or discharge connections at the operator's position would simplify and improve safety for the operator. If complete removal of these connections is impractical, the reduction and careful placement of these connections, with operator safety in mind, would improve the situation considerably. [**1901:**A.16.9.1]

Operation of pump and discharge controls should not compromise the clearances of the operator's space on a top-mount pump panel or provide sharp edges, projections, or barriers to movement. The purchaser might want to state the clear walkway minimum space that is required. [**1901:**A.16.9.1]

Many fire departments have found it useful to color code the labels used to identify the various discharge and intake controls. While this process can simplify pump operations, it can also create confusion if a pattern is not followed on all apparatus in the department. For standardization, the color-coding scheme in Table A.16.9.1 is recommended for all new apparatus labels. [**1901:**A.16.9.1]

A.16.10 The indicator lights and interlocks specified in this section are minimums. Some manufacturers or users might choose to add additional indicator lights or interlocks. [**1901:**A.16.10]

A.16.10.1.2 Pumps are operated from the side, top, front, or rear of the vehicle, and stationary pumping requires that no power is applied to the wheels during pumping. Therefore, it is essential that any controls that could apply power to the wheels while pumping be equipped with a means to prevent dislocation of the control from its set position in the pumping mode. [**1901:**A.16.10.1.2]

A.16.10.2 There are several ways to drive a pump from the chassis engine through a PTO. Each of them can be used with either an automatic or a manual transmission, but the interlocks and indicators with a manual transmission do not sense or depend on the gear selected. Generally, a driveshaft connects the PTO to the pump, except in the case of a split shaft PTO with a midship pump. In some cases, the PTO drives a hydraulic pump which drives a hydraulic motor driving the pump . The following are common PTO types:

Table A.16.9.1 Color Scheme for Labels on Discharge and Intake Controls

Discharge	Color
Preconnect #1 or front bumper jump line	Orange*
Preconnect #2	Red*
Preconnect #3 or discharge #1	Yellow*
Preconnect #4 or discharge #2	White*
Discharge #3	Blue
Discharge #4	Black
Discharge #5	Green
Deluge/deck gun	Silver
Water tower	Purple
Large-diameter hose	Yellow with white border
Foam line(s)	Red with white border
Booster reel(s)	Gray
Inlets	Burgundy

*Because the vast majority of fires are extinguished using preconnected lines, a fire department should give consideration to matching the hose jacket color to the color of these labels. Fire departments using this system have reported an improvement in fireground operations. [**1901:**Table A.16.9.1]

(1) *Pump driven through a split shaft PTO.* The driveline goes through a gearboxthat either powers the rear driveline (road position) or the pump (pump position). This PTO can transmit the full power of the vehicle engine but cannot provide pump-and-roll functionality.
(2) *Pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel (rear engine) PTO.* Each of these PTOs can be designed for stationary pumping only or for stationary pumping and pump-and-roll. Generally, there is a limit on the power available, but in some cases pumps as large as 1500 gpm (6000 lpm) can be driven. Each type of PTO has its advantages and disadvantages. Front-of-engine crankshaft PTOs are used for front-mount pumps. These drive choices are usually the only options if pump-and-roll capability is required from the chassis engine.
(3) *Pump driven through a transfer case PTO or auxiliary transmission PTO.* The transfer case is part of the 4-wheel-drive system and can provide a PTO output for driving the pump. An auxiliary transmission PTO–driven pump functions much like a transfer case PTO–driven pump for 2-wheel-drive apparatus. These PTOs are suitable only for stationary pumping. These have been largely replaced by transmission-mounted or engine flywheel PTOs.

[**1901:**A.16.10.2]

The following are descriptions of the interlocks and indicators for each type of chassis transmission and pump drive arrangement:

Stationary pump driven through split shaft PTO — automatic chassis transmission. Where the apparatus is equipped with an automatic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift process has successfully completed. An “OK to Pump” indicator is provided both in the driving compartment and at the pump operator’s panel to indicate that the pump and parking brake are engaged and the chassis transmission is in pump gear. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the chassis transmission is in neutral and the parking brake is on. [**1901:**A.16.10.2]

Stationary pump driven through split shaft PTO — manual chassis transmission. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided in the driving compartment and at the pump operator’s panel to indicate that the pump and parking brake are engaged. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the parking brake is on. [**1901:**A.16.10.2]

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — automatic chassis transmission. Where the apparatus is equipped with an automatic chassis transmission; the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided both in the driving compartment and at the pump operator’s panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the chassis transmission is in neutral and the parking brake is on. [**1901:**A.16.10.2]

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission; the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided both in the driving compartment and at the pump operator’s panel to indicate that the pump and parking brake are engaged. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the parking brake is on. [**1901:**A.16.10.2]

Stationary and “pump-and-roll” pump — automatic chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the automatic chassis transmission in neutral and “pump-and-roll” pumping mode in a road gear, an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A “Pump Engaged” indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided both in the

driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the chassis transmission is in neutral and the parking brake is on. An “OK to Pump-and-Roll” indicator is provided in the driving compartment and is energized when the pump is engaged, the chassis transmission is in road gear, and the parking brake is released. When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized. [**1901:**A.16.10.2]

Stationary and “pump-and-roll” pumps — manual chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the chassis transmission in neutral and “pump-and- roll” pumping mode in a road gear; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A “Pump Engaged” indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided in both the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the parking brake is on. An “OK to Pump-and-Roll” indicator is provided in the driving compartment and is energized when the pump is engaged and the parking brake is released. When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized. [**1901:**A.16.10.2]

Stationary pumps driven through transfer case PTOs or auxiliary transmission — automatic chassis transmissions. Where the apparatus is equipped with an automatic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged, the chassis transmission is in pump gear, and the transfer case drive to the chassis wheels is in neutral . A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the chassis transmission is in neutral and the parking brake is on. [**1901:**A.16.10.2]

Stationary pumps driven through transfer case PTOs or auxiliary transmission PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided in both the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged, and the transfer case drive to the chassis wheels is in neutral. A “Throttle Ready” indicator is provided at the pump operator’s panel to indicate throttle control at the pump operator’s panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator’s panel when the parking brake is on. [**1901:**A. 16.10.2]

A.16.10.2.2 Completion of the pump shift might require that the chassis transmission be shifted into pump gear. [**1901:**A. 16.10.2.2]

A.16.10.2.4 When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized. **[1901:**A.16.10.2.4]

A.16.10.2.5.3 The purchaser should specify if they want throttle control at the pump panel when not in “OK to Pump” mode. Engine speed advancement control at the operator’s panel might be required for apparatus with the need to control the engine speed during operation of a generator, aerial device, alternator, or other chassis engine–driven device. The indicating device for this “Throttle Ready” condition is the same indicating device as in 16.10.2.5.2. [**1901:**A.16.10.2.5.3]

Other apparatus might not have equipment for which it is necessary to control engine speed from the pump operator’s panel. Engine speed control at the pump operator’s panel for these apparatus might not be desirable because, on many chassis engines, activating remote throttle operation automatically disables the in-cab accelerator pedal. For such apparatus, engine speed advancement control at the pump operator’s panel is not required when the chassis transmission is in neutral and the parking brake is engaged, so a “Throttle Ready” indication is not required. [**1901:**A.16.10.2.5.3]

A.16.10.4 The purpose of a pressure control system is to control the discharge pressures in order to protect fire fighters who are operating hose streams as well as to protect discharge hose from damage in the event attack hose streams are shut off or other valves are closed, reducing flow rates. [**1901:**A. 16.10.14]

The system could consist of a discharge relief valve, a pressure regulator that controls the speed of the pump, an intake relief valve, or any combination of these devices. Pressure control systems will relieve excess pressure when valves are closed in a normal manner, but some water hammer conditions could occur due to valves being closed so quickly that the system cannot respond fast enough to eliminate damage to equipment. Proper fireground procedures are still required. [**1901:**A.16.10.14]

A.16.10.4.1 Pressure control systems can be supplied in the following forms:

(1) Integral with the pump and supplied by the pump manufacturer
(2) As an external system of components supplied by the apparatus manufacturer
(3) As an external control system provided by a pressure control manufacturer
(4) Properly selected pump, PTO ratio, and discharge sizes to limit pressure rise to less than 30 psi (207 kPa)

[**1901:**A.16.10.14.1]

Pressure governors control the engine speed, which relates directly to the net pump pressure. If the speed is raised, the pressure goes up; if the speed is lowered, the pressure goes down.

Discharge relief valves control pressure by passing water from the discharge side of the pump back into the intake side of the pump. This type of system works in a pressure differential of at least 70 psi to 90 psi (500 kPa to 600 kPa) between the intake and discharge sides of the pump. If the pressure differential is not present, the discharge relief valve might not control a pressure rise completely. [**1901:**A.16.10.14.1]

If either a discharge relief valve or a pressure governor is used with high incoming inlet pressures, an intake relief valve or total control system should be added. [**1901:**A.16.10.14.1]

In the case where an intake relief valve is selected, it should be of sufficient size and response time to handle the pump performance range. It should also be easily controlled by the pump operator so that this incoming pressure can be adjusted for each incident. For best results, the operator should set the intake relief valve to operate at 90 psi (600 kPa) below the desired discharge operating pressure. [**1901:**A.16.10.14.1]

The pressure control system should be certified by the appropriate manufacturer or an independent third-party certification organization. Because of the importance of these systems, the purchaser might wish to have performance tests conducted on the installed system. [**1901:**A.16.10.14.1]

A.16.10.5 Departments that need to attain a draft while conducting operations off tank water will find that adding a primer selector valve or second priming control valve to allow attaining a draft on the outboard side of the gated pump suction valve will reduce the potential loss of continuous water flow while supplying attack lines. A vacuum line is run to the outboard side of the valve and connected through a selector valve to the primer. Side, front, and rear selector settings can be arranged to allow priming off any side of the unit with one primer.

A.16.10.5.3 For best priming and pump performance when priming from the suction with the pump running, the following should be adhered to:

(1) A check valve should be used at the discharge of the pump.
(2) The prime should be taken at the eye of the impeller or at the top of the intake to the pump.
(3) A smooth bell-shaped strainer inlet should be used on the end of the suction hose. A foot valve should not be used.
(4) Suction hose should only be as long as necessary.
(5) There should be no humps in the suction hose.

A.16.11.1 The electronic throttle control systems that are currently available will provide greater flexibility for the operator because they can be set like a traditional throttle or a pressure governor. [**1901:**A.16.11.1]

A.16.12.1.1 A pumping engine fuel level indicator or red warning light indicating when the fuel level falls below one-fourth of the capacity of the tank(s) should be provided on the pump operator's panel. [**1901:**A.16.12.1.1]

A.16.12.2 The purchaser may wish to require a ¼ NPT test port at the pump output and the pump intake to improve the efficiency of the annual pump test process.

A.16.12.2.1.5 A drain should be installed at the connection of the pressure line to the gauges (back of the gauge or bottom, both intake and discharge gauges).

A.16.12.2.2 A drain can be installed at the connection of the pressure line to the gauges (back or bottom of the gauge, both intake and discharge gauges).

A.16.12.2.4 It might also be desirable to have a pressure gauge in the cab in view of the driver when the pump that is being used in a pump-and-roll operation is driven by a separate engine.

A.16.12.3.2 Because the rated operating pressure of large-diameter supply hose is substantially less than that of attack fire hose, an individual pressure gauge is required to allow the operator to control the discharge pressure even where a flowmeter is provided. [**1901:**A.16.12.3.2]

A.16.13.1.3 The purchaser might want to consider an instruction plate mounted at the pump operator's position giving basic instructions on valve positions for standard fire-fighting operations, possibly including the following:

(1) Pumping fighting fire from tank
(2) Fighting fire from external water source
(3) Refilling tank from external water source

A.16.13.2.1.2 Where tests are performed inside a structure or other location having limited air circulation, carbon monoxide monitoring equipment should be used. Such equipment should be checked and calibrated regularly and should include a warning device.

A.16.13.2.1.2(4) The suction lift capability of a fire pump is certified by the pump manufacturer for specific conditions of altitude above sea level, atmospheric pressure, water temperature, and friction and entrance loss caused by the flow of water through the intake strainers and hose as stated in 16.2.4.1. As the temperature of the water increases and barometric pressures decreases, the suction lift capability of the fire pump is reduced. While the minimum lift of the test site for the pumping test is 3 ft (1 m), the test site configuration must not provide a vertical lift that exceeds the suction lift capability of the pump as a result of elevated water temperatures and reduced barometric pressure. See Table A.16.13.2.1.2(4). [**1901:**A.16.13.2.1.2(4)]

Table A.16.13.2.1.2(4) Effect of Water Temperature and Barometric Pressure on Suction Lift Capability

Water Temperature		Effect on Lift		Barometric Pressure		Effect on Lift	
°F	°C	ft	m	in. Hg	kPa	ft	m
60	16	0	0	29.9	101.3	0	0
90	32	-1	-0.3	29.0	98.2	-1	-0.3
110	43	-2.3	-0.7				
120	49	-3.3	-1.0				

[**1901:**Table A.16.13.2.1.2(4)]

A.16.13.2.2.3 Square-edged circular orifice and pressure gauge is an accurate method of measuring low pump flows found on wildland fire apparatus. Flow through a square-edge circular orifice can be determined using the following formula:

[A.16.13.2.2.3]

$$Q = 29.8 \times C \times d^2 \times \sqrt{P}$$

where:
Q = flow (gpm)
C = orifice discharge coefficient (0.62 recommended)
d = orifice diameter (in.)
P = pressure (psi)

For best accuracy, the water supply line to the square-edge circular orifice should be a minimum of two times the diameter of the orifice.

A.16.13.2.3.1 Figure C.3(c) of NFPA 1911, shows a test data form for recording the test readings and other necessary data. [**1901:**A.16.13.2.3.1]

A.16.13.2.3.2 Where an engine is operating at or near full power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that, when touched, can cause extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

The suction lift can be determined either by measuring the negative pressure (vacuum) in the pump intake manifold with a test gauge that measures vacuum accurately or by adding the vertical lift and the value of friction and entrance loss from Table 16.2.4.1(b) or Table 16.2.4.1(c). To be accurate, the vacuum gauge should be at the same level as the intake of the pump with no gauge line or a very short gauge line. If a long gauge line is used, a purge valve at the gauge connection to the gauge line should be installed and opened and closed when running to purge the gauge line of any water. If the vacuum gauge and the pump intake are at different levels with water in the gauge line, an incorrect reading will result. Opening and closing the purge valve at the vacuum gauge when operating will purge the gauge line. Every foot of water in the vacuum gauge line will result in almost an inch of mercury error of vacuum.

The net pump pressure can be calculated by using the following formula:

U.S. units:

[A.16.13.2.3.2a]

$$P = D + (H \times 0.5)$$
or
$$P = D + 0.43\ (L + F)$$

where:
P = net pump pressure (psi)
D = discharge gauge pressure (psi gauge)
H = vacuum gauge reading (in. Hg)
L = vertical lift (ft)
F = friction and entrance loss (ft of water)

SI units:

[A.16.13.2.3.2b]

$$P_m = D_m + H_m$$
or
$$P_m = D_m + F_m + 9.8\ L_m$$

where:
P_m = net pump pressure (kPa)
D_m = discharge gauge pressure (kPa gauge)
H_m = vacuum gauge reading (kPa)
F_m = friction and entrance loss (kPa)
L_m = vertical lift (m)

A.16.13.6.5 When the test is done with intake valves open and intakes capped, the apparatus could have a bad intake valve that would not be detected. By conducting a second test with the intake valves closed and intakes not capped, a leaking intake valve would be detected. [**1901:**A.16.13.6.5]

A.16.13.8 The engine speed advancement interlock system test verifies the proper functioning of the throttle controls and indicator for various conditions of chassis transmission(s), parking brake, and pump shift control action status. Testing should be performed with a qualified person positioned in the driving compartment and a qualified person verifying indicators and engine speed control status at the pump operator's panel. Shifting of the pump transmission/PTO should be done in accordance with the manufacturer's instructions. [**1901:**A.16.13.8]

A.16.13.10 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that these tests also be certified by the independent third-party certification organization. [**1901:**A.16.13.10]

A.18.2.1 If the tank fill flow rate exceeds the vent capabilities of the tank, the tank will be damaged.

A.18.2.3 Water tanks should have provisions that allow for complete inside cleaning. The purchaser should indicate in the specifications if access to the interior of the tank is required. [**1901:**A.18.2.2]

A.18.2.4 Water tanks can appear in several different configurations, such as round, elliptical, rectangular, or T-shaped. Handling characteristics of the apparatus can be greatly affected by its vertical and horizontal centers of gravity. The purchaser should indicate the filling and dumping rates required if those rates exceed the requirements of this standard, and any other local needs, and let the apparatus manufac-

turer design the tank shape to best meet the axle-loading and center-of-gravity requirements.

If the tanks are made as one unit with the body and compartments, the material used is important. It should be corrosion proof and should not easily cause condensation.

A.18.2.6 The design of a water tank can be a critical factor in the handling characteristics of fire apparatus. If water is free to travel either longitudinally or laterally in a tank, as would be the case if the tank were half full, a tremendous amount of inertia can build up that will tend to force the fire apparatus in the direction the water has been traveling. When the water reaches the end of the tank, this sudden application of force can throw the fire apparatus out of control and has been known to cause the fire apparatus to turn over or skid when going around a curve or coming to a sudden stop. The only way to prevent such accidents is to restrict or disrupt the movement of the water so that the inertia will not build up in one direction. This is done with the installation of swash partitions to either contain the water in smaller spaces within the tank (containment method) or disrupt its momentum by changing its direction of motion (dynamic method). The partitions in a containment system create compartments that are interconnected by openings between them so that air and water can flow at the specified rate when the tank is being filled or emptied. The partitions in a dynamic system are often staggered in an arrangement designed to change the direction of the water and turn it into a turbulent motion that absorbs much of its own energy. [**1901:**A.18.2.5]

A.18.3.3 A check valve installed in the tank-to-pump line is the most common method used to prevent water from backflowing into the tank at an excessive rate if the pump is being supplied from a hydrant or relay pumper and the tank-to-pump line valve has been inadvertently left in the open position. [**1901:**A.18.3.3]

A hole up to ¼ in. (6 mm) is sometimes provided in the check valve to release steam or other pressure buildup. [**1901:**A.18.3.3]

A.18.4.1.1 The intent of 18.4.1.1 is to allow filling the tank by the insertion of a common 2½ in. (65 mm) hose with coupling into the fill opening. The opening does not need to be round in shape. [**1901:**A.18.4.1.1]

A.18.4.1.4 An excessive flow rate when a tank is being filled could result in a pressure buildup in the tank that could cause permanent damage or failure. [**1901:**A.18.4.1.4]

A.18.4.2.1 Adequate venting is usually achieved when the vent area is at least one quarter the area of the tank outlet. If operations require filling or draining of the tank at rates in excess of the rated capacity of the pump, increased venting capability might be needed. The required rate of filling or draining the tank should be specified by the purchaser.

During heavy braking, if water is allowed to fall in front of the rear tires, braking force will be decreased and an uncontrollable spin may develop. Having water fall in front of the rear axle can be avoided by directing the discharge vent or overflow tube outlet so that any discharge from the overflow tube will fall behind the rear axle. This method can be used effectively on integral units. Discharge from the vent or overflow can also be avoided by placing the vent or overflow outlet at the rear of the tank in a position where no water will be discharged during heavy braking. This method can be used effectively on slip-on units.

A.18.4.2.2 A vent/overflow outlet is necessary so that overpressurization does not occur within the tank while it is being filled. However, water is likely to spill out of the vent/overflow while the fire apparatus is moving (e.g., accelerating, decelerating, or cornering). The fill tower and vent/overflow outlet should be arranged so that water spillage is minimized and is directed behind the rear tires. [**1901:**A.18.4.2.2]

The purchaser might wish to specify a sealed water tank and overflow system design that will eliminate water spill while the vehicle is in motion. [**1901:**A.18.4.2.2]

A.18.4.3.1 If a larger fill line is desired, the buyer should consult with the manufacturer on construction of the tank inlet location and any required reinforcement or alternation of the tank baffles. It is necessary to design the tank with venting and overflow capability for the maximum fill rate. [**1901:**A.18.4.3.1]

A.18.4.3.3 A locking-type quarter-turn valve suitable for throttling service should be used.

A.18.6.1 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that the water tank capacity also be certified by the independent testing organization.

A.20.1 When a foam system is installed, the purchaser should consider specifying a water-only (no foam) discharge. A water-only discharge can be used to offload clear water to another apparatus or portable water tank, to prevent foam solution from re-entering the water tank when operating an ejector, and for operation near sensitive environmental areas. Much research and development has been done in recent years with foam and foam systems, particularly in the areas of Class A and CAFS foams. It is generally accepted that Class A foam can increase efficiency of plain water to approximately double and with CAFS to increase as much as four times. There are many ways to introduce foam into the pumping systems on fire apparatus, some of which are simple and inexpensive. When evaluating options for new apparatus, purchasers should consider their operating requirements to determine their needs for foam systems. The addition of a foam system can add a substantial amount of efficiency to fire scene operations and ultimately increase safety for fire fighters.

It is important for the purchaser to understand the types and properties of mechanical foam and its application in order to specify a foam proportioning system properly. Specific information regarding foam concentrates and their application is available in NFPA 11. Information on foam concentrates for Class A fires is available in NFPA 1150.

The following terms are not used in this document but are associated with foam proportioning systems and are included here to aid understanding.

Aerated Foam. The end product of a discharge of foam solution and air.

Aspirate. To draw in air. Nozzle aspirating systems draw air into the nozzle to mix with the agent solution.

Aspirated Foam. The end product of a mechanically induced air stream that is drawn into the foam solution at atmospheric pressure to create foam. The aeration is generated by the energy of the foam solution stream.

Batch Mix. The manual addition of foam concentrate to a water storage container or tank to make foam solution.

Foam Blanket. A body of foam used for fuel protection that forms an insulating and reflective layer from heat.

Foam-Capable Fire Apparatus. A fire apparatus carrying aspirating foam nozzle(s) and equipped with an automatic regulating foam proportioning system injecting foam concentrate into the discharge or pressure side of the water pump.

Injector. A device used in a discharge or intake line to force foam concentrate into the water stream.

Proportioning Ratio. The ratio of foam concentrate to water, usually expressed as a percentage.

Surface Tension. The elastic-like force in the surface of a liquid that tends to bring droplets together to form a surface.

Wetting Agent. A chemical that reduces the surface tension of water and causes it to spread and penetrate more effectively than plain water but does not foam.

A.20.2 Foam proportioning systems can be designed with the following features:

(1) The ability to proportion different types of foam concentrate, including Class A and Class B foam concentrates
(2) The ability to proportion foam concentrate at fixed or variable proportioning ratios
(3) The ability to proportion foam concentrate into single- or multiple-discharge outlets
(4) The ability to supply foam solution and water simultaneously from multiple-discharge outlets
(5) Manual or automatic foam proportioning system operation

[**1901:**A.20.2]

A.20.2.1 In-line eductor foam proportioning systems are installed in the water pump discharge as a permanently installed device or as a portable device. Water is forced through the eductor venturi by water pump discharge pressure, creating a vacuum that causes foam concentrate to be pushed by atmospheric pressure into the eductor (into the water stream) at the design rate of the device [*see Figure A.20.2.1(a)]*. By design, a nonrecoverable pressure drop of 30 percent or greater is required for eductor operation. The maximum recovered pressure, including friction loss and static head pressure, is nominally 65 percent of the inlet pressure to the eductor. The in-line eductor is a manually regulated foam proportioning system. [**1901:**A.20.2.1]

A variable flow bypass eductor system is a modification of the in-line eductor foam proportioning system. An eductor is placed in a bypass line around the main line waterflow control valve so that when the valve is adjusted to produce waterflow through the bypass eductor, foam concentrate is drawn into the eductor (into the water stream) [*see Figure A.20.2.1(b)]*. The foam solution in the bypass line is then joined with the main line waterflow downstream of the waterflow control valve. The variable flow bypass eductor is a manually regulated foam proportioning system. [**1901:**A.20.2.1]

A variable pressure eductor is another modification of the in-line eductor foam proportioning system. This type of eductor is designed to automatically adjust the area of the eductor venturi to compensate for changes in water pressure at the inlet of the device. Better performance (less pressure loss) can be achieved by having the eductor in the straight line position with the main line and the waterflow control valve in the offset position. The reason for this is that the small eductor sets the pressure drop and the water control valve merely matches the pressure losses of the eductor and fittings directing flow to the eductor. If the eductor flow has to flow through two branching tees and two elbows, the water control valve must match those pressure losses. If the eductor is in the straight line position, pressure losses of two branching tees and two elbows are not present in the eductor branch of the variable flow bypass eductor; therefore, the total pressure loss across the proportioning system is only that of the eductor. The variable pressure eductor is a manually regulated foam proportioning system. [**1901:**A.20.2.1]

A.20.2.2 Self-educting master stream nozzles are mounted on the discharge side of the pump. These devices make up a complete foam proportioning system consisting of a foam proportioner and application device (nozzle).

A.20.2.3 An intake-side foam proportioning system is a manually regulated system. An in-line device installed in the water pump intake line provides a connection through a foam concentrate metering valve to the foam concentrate tank. The vacuum created by the water pump allows atmospheric pressure to push foam concentrate directly into the pump intake. Hydrant or relay operation is not possible with this type of foam proportioning system. [**1901:**A.20.2.3]

A.20.2.4 Around-the-pump proportioning systems operate with an eductor installed between the water pump discharge and the intake. A small flow of water from the water pump discharge passes through the eductor, which creates a vacuum

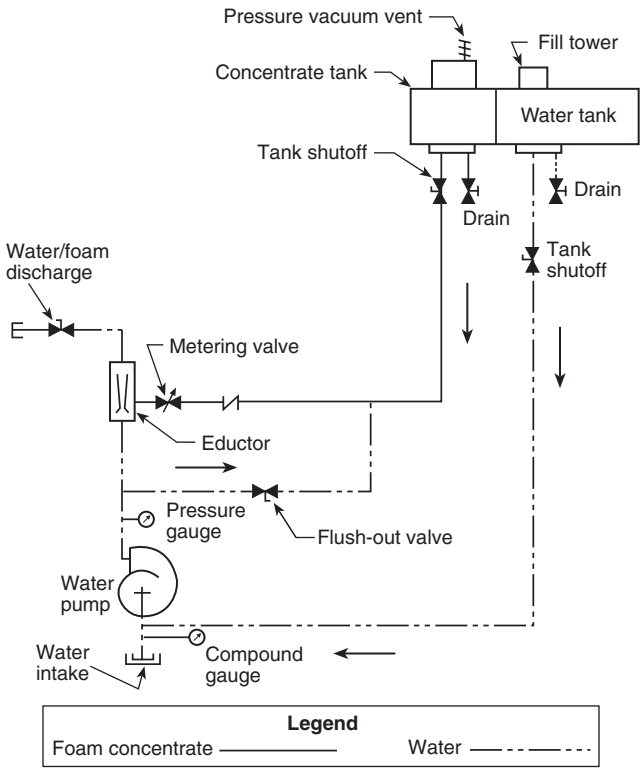


FIGURE A.20.2.1(a) In-Line Eductor Foam Proportioning System. [1901: Figure A.20.2.1(a)]

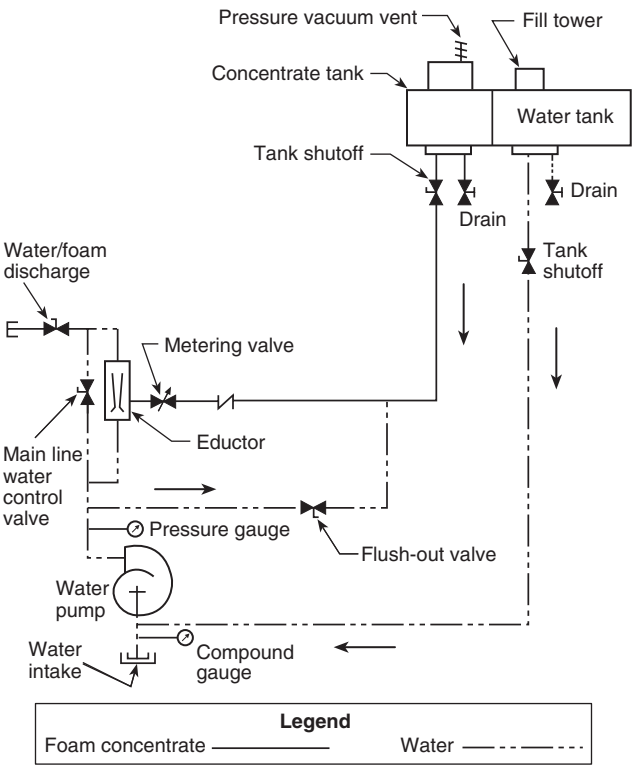


FIGURE A.20.2.1(b) Variable Flow Bypass Eductor System. [1901: Figure A.20.2.1(b)]

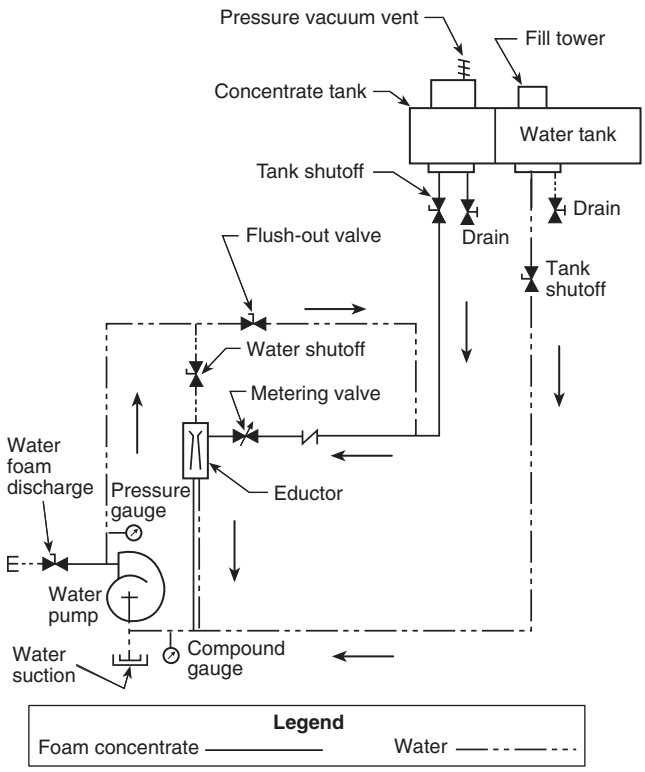


FIGURE A.20.2.4(a) Manual Around-the-Pump Proportioning System. [1901:Figure A.20.2.4(a)]

that causes foam concentrate to be pushed into the eductor and discharged into the pump intake. Around-the-pump foam proportioning systems require a pressure differential of 30 percent to 50 percent of inlet pressure for efficient operation. [**1901:**A.20.2.4]

A manual around-the-pump proportioning system utilizes a manually adjustable foam concentrate metering valve to control the proportioning ratio. *[See Figure A.20.2.4(a).]* [**1901:**A.20.2.4]

A flowmeter-sensing around-the-pump proportioning system utilizes a flowmeter-sensing system to monitor total solution flow and foam concentrate flow. The flow data are transmitted to an electronic control that controls the proportioning ratio through a foam concentrate metering valve. *[See Figure A. 20.2.4(b).]* [**1901:**A.20.2.4]

A.20.2.5 Balanced pressure foam proportioning systems are installed on the discharge side of the water pump. Two orifices discharge water and foam concentrate into a common ratio controller (proportioner) located in the water pump discharge. By adjusting the area of the orifices to a particular ratio, the percentage of injection can be controlled if the intake pressures are equal. The method of controlling or balancing the foam concentrate pressure with the water pressure varies with different balanced pressure system designs. The two basic types of balanced pressure systems are systems without a foam concentrate pump and systems with a concentrate pump. Balanced pressure foam proportioning systems generally are automatic regulating foam proportioning systems. [**1901:**A. 20.2.5]

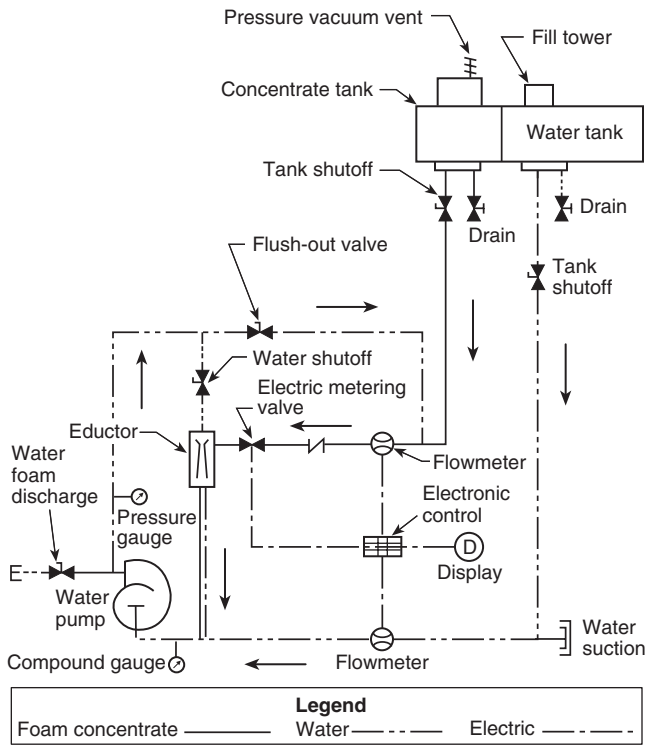


FIGURE A.20.2.4(b) Flowmeter-Sensing Around-the-Pump Proportioning System. [1901:Figure A.20.2.4(b)]

Balanced pressure systems without a foam concentrate pump are referred to as "pressure proportioning systems" *[see Figure A.20.2.5(a)]*. These systems utilize a pressure vessel with an internal bladder to contain the foam concentrate. When in operation, water pump pressure is allowed to enter the pressure vessel between the shell and the internal bladder to exert pressure on the internal bladder. The foam concentrate is forced out of the bladder to the foam proportioner at a pressure equal to the water pump pressure. [**1901:**A.20.2.5]

Two basic types of balanced pressure foam proportioning systems utilize a foam concentrate pump: a bypass system and a demand system. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank in these types of foam proportioning systems. [**1901:**A.20.2.5]

The bypass system utilizes a valve in the foam concentrate pump recirculating line that balances the foam concentrate and water pressure by bypassing excess foam concentrate. *[See Figure A.20.2.5(b).]* [**1901:**A.20.2.5]

The demand system is designed to control the speed of the foam concentrate pump, resulting in control of the pump discharge pressure to achieve a balance of foam concentrate and water pressure within the system. *[See Figure A.20.2.5(c).]* [**1901:**A.20.2.5]

A.20.2.6 Direct injection foam proportioning systems utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while the foam concentrate tank is being refilled. Direct injection foam proportioning systems generally are automatic regulating foam proportioning systems. [**1901:**A.20.2.6]

Automatic flow-sensing direct injection foam proportioning systems utilize an in-line flowmeter(s) to monitor the system operating conditions. System operating data are transmitted to an electronic control, which controls the proportioning ratio. Two different flow-sensing systems are available:

(1) An electronic control receives electronic signals corresponding to the proportioning ratio from the control panel and waterflow data from the flowmeter. The electronic control then commands the foam concentrate pump module to deliver foam concentrate at the proportional rate. *[See Figure A.20.2.6(a).]*
(2) An electronic control receives electronic signals corresponding to the foam concentrate flow from a foam concentrate flowmeter, the proportioning ratio from the control panel, and waterflow data from the water flowmeter. The electronic control regulates the proportioning ratio through a foam concentrate metering valve. *[See Figure A.20.2.6(b).]*

[**1901:**A.20.2.6]

A.20.2.7 In a water motor foam proportioning system, a water motor drives a positive displacement foam concentrate pump. The water motor can be either a positive displacement type or a turbine type. Water motor foam proportioning systems are automatic regulating foam proportioning systems. [**1901:**A.20.2.7]

Where a positive displacement water motor drives the foam concentrate pump, the ratio of the water motor displacement to the displacement of the foam concentrate pump is the ratio of the desired foam solution. A positive displacement water motor proportioning system requires no external power. *[See Figure A.20.2.7.]* [**1901:**A.20.2.7]

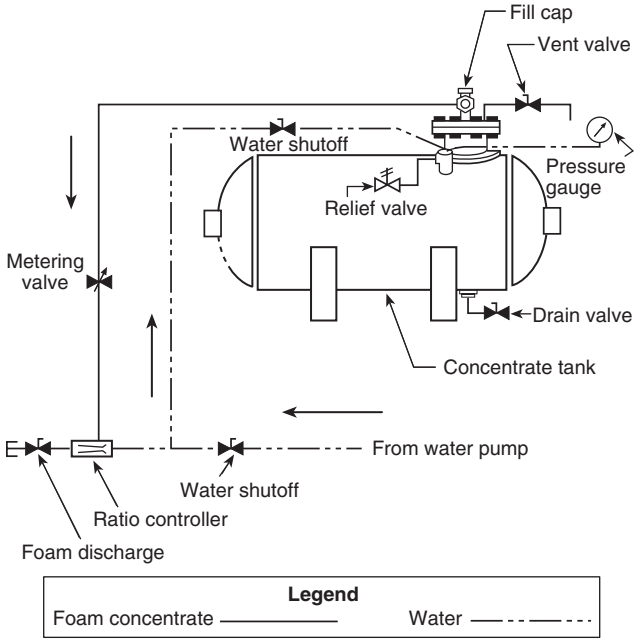


FIGURE A.20.2.5(a) Pressure Proportioning Balanced Pressure Foam Proportioning System. [1901:Figure A.20.2.5(a)]

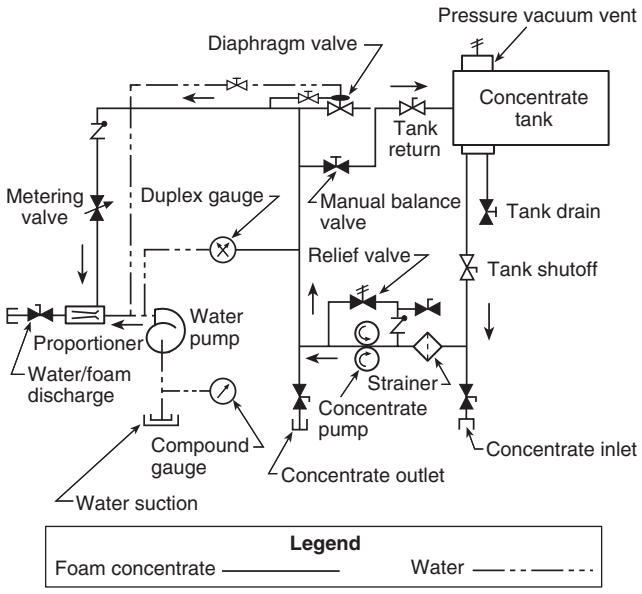


FIGURE A.20.2.5(b) Bypass Balanced Pressure Foam Proportioning System. [1901:Figure A.20.2.5(b)]

A.20.3.1 Foam proportioning systems that inject foam concentrate into the water pumping system at a higher pressure than the water pressure have the potential to force foam concentrate or foam solution into an external water source. This condition will occur when there is no water flowing and the foam proportioning system is activated in the automatic mode. Backflow

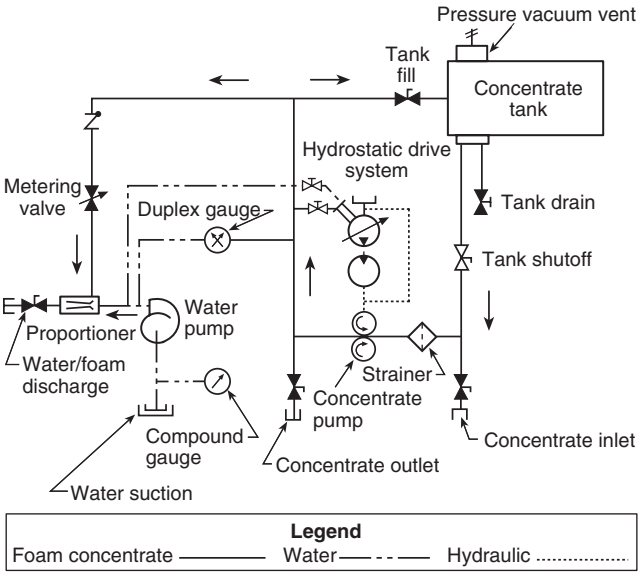


FIGURE A.20.2.5(c) Demand Balanced Pressure Foam Proportioning System. [1901:Figure A.20.2.5(c)]

prevention devices, or any devices that create additional friction loss in the system, should be installed only with the approval and specific instructions of the foam proportioning system manufacturer.

A.20.3.4 Most foam concentrate manufacturers differentiate between the materials they recommend for foam proportioning system components that are designed to be flushed with water after operation and those components that are intended to be continuously wetted with foam concentrate.

A.20.3.7.2 The use of fire chemicals, including foam, might be restricted in sensitive natural and cultural resource areas. Some land management agencies prohibit fire chemicals from being used within a specified distance of any waterway to protect critical habitats, including threatened and endangered species. To operate in these areas, the purchaser should consider specifying a water-only (no foam) discharge. In addition, the purchaser should specify that the pump recirculation line be plumbed such that the water returning to the water tank is free of foam solution if a foam proportioner is installed on the apparatus. [**1901:**A.20.3.7]

A.20.4.1 It is desirable to have a visual indicator on the operator's panel that shows whether the foam proportioning system is in the "operating" position or the "off" position. A visual

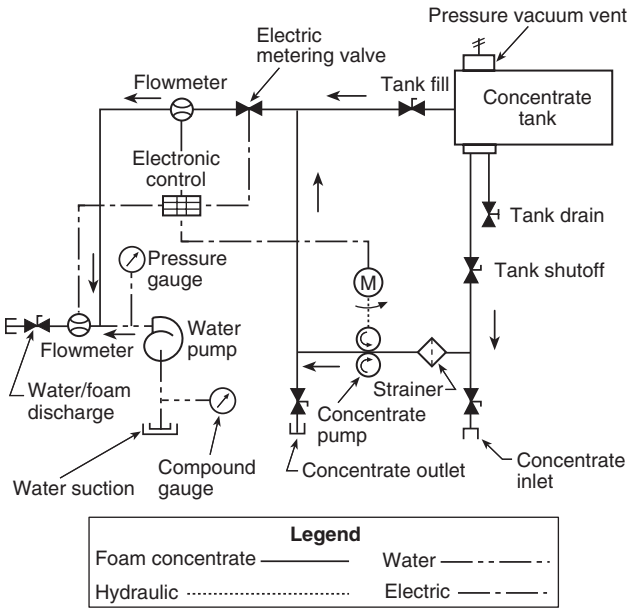


FIGURE A.20.2.6(b) Dual-Meter Flow-Sensing Direct-Injection Foam Proportioning System. [1901:Figure A.20.2.6(b)]

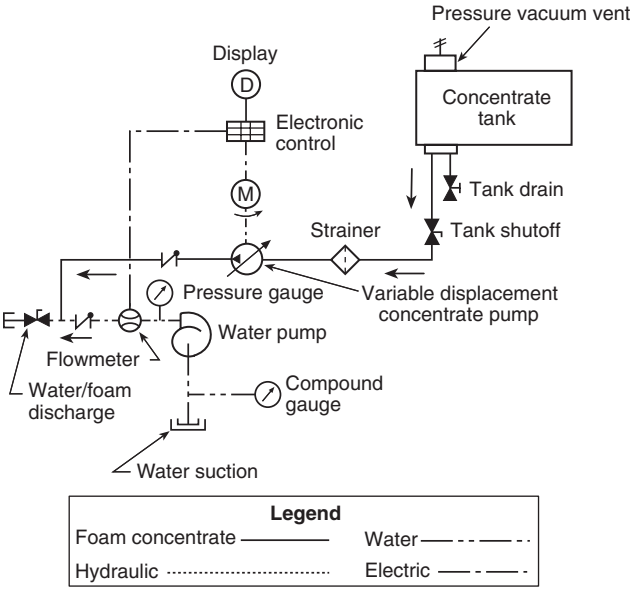


FIGURE A.20.2.6(a) Single-Meter Flow-Sensing Direct-Injection Foam Proportioning System. [1901:Figure A.20.2.6(a)]

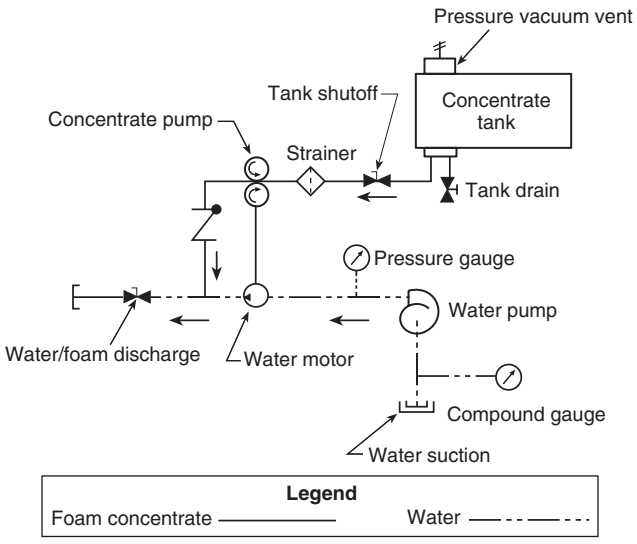


FIGURE A.20.2.7 Water Motor Foam Proportioning System. [1901:Figure A.20.2.7]

means of indicating positive foam concentrate flow at the operator's panel is also helpful. [**1901:**A.20.4.1]

A.20.6.3.2 The means to attach the cover to the fill tower could include a threaded cap or a hinged cover with a mechanical latching device.

A.20.6.3.4 The purchaser may want to consider a foam tank refill system to allow refilling the foam tank with a pump so fire fighters do not need to climb on top of the apparatus and lift foam pails to the top of the apparatus. It should discharge to the bottom of the tank to minimize aeration.

A.20.6.6 On fire apparatus where a single foam storage tank is used, provisions should be made to flush the tank and all foam concentrate plumbing to avoid contamination of dissimilar foam concentrates when switching types or brands. [**1901:**A.20.6.6]

A.20.6.8 The foam concentrate tank(s) can be an integral part of the water tank. [**1901:**A.20.6.8]

A.20.6.10.2 Different types and brands of concentrates can be incompatible with each other and should not be mixed in storage. Concentrate viscosity varies with different types of products and temperatures. [**1901:**A.20.6.10.2]

A.20.7 The foam concentrate pump is a critical component of both balanced pressure and direct-injection foam proportioning systems. Positive displacement pumps are recommended for several reasons. Positive displacement pumps are relatively slow in speed compared to centrifugal pumps, which is advantageous with viscous foam concentrates that are difficult to shear. Centrifugal pumps can become air bound when trying to pump viscous foam concentrates, which results in a complete shutdown of the system. The self-priming feature of positive displacement pumps allows them to draw foam concentrate from drums or any external source without priming the pump. [**1901:**A.20.7]

A.20.7.2 Corrosion-resistant materials are materials such as brass, copper, Monel®, stainless steel, or equivalent materials. [**1901:**A.20.7.2]

A.20.7.5 A suitable intake connection is required for the type of system being utilized to operate from an external source as specified by the purchaser. [**1901:**A.20.7.5]

A.20.9.3(5) It is necessary that the operator be familiar with the specific types of foam concentrates the foam proportioning system manufacturer has designed the system to operate with and proportion accurately. The foam proportioning system could require modification or recalibration if a foam concentrate is introduced into the system that was not intended for use in the system by the manufacturer.

A.20.10.1 There are four methods for testing a foam proportioning system for calibration accuracy. They are:

(1) Substituting water for foam concentrate
(2) Measuring foam concentrate pump output directly **[A. 20.10.1]**
(3) Determining foam percentage by use of a refractometer
(4) Determining foam percentage by use of a conductivity meter

[**1901:**A.20.10.1]

Test Method 1: Substituting Water for Foam Concentrate. The foam proportioning system is operated at the waterflow rates at which the system is to be tested. Water is used as a substitute for foam concentrate. The substitute water for the foam concentrate is drawn from a calibrated tank instead of foam concentrate from the foam concentrate tank. The volume of water drawn from the calibrated tank divided by the volume of water pumped over the same time period multiplied by 100 represents the percentage of foam that the foam proportioning system is producing. [**1901:**A.20.10.1]

Test Method 2: Measuring Foam Concentrate Pump Output Directly. With some direct injection systems, it is possible to directly measure the foam concentrate pump output. With the foam proportioning system operating at a given waterflow rate and either foam concentrate or water used as a substitute for foam concentrate, the output of the foam concentrate pump is measured by diverting that output into a calibrated container for direct measurement over a given period of time. An alternative is to measure the foam concentrate flow or water substitute with a calibrated meter. [**1901:**A.20.10.1]

Test Method 3: Determining Foam Percentage by Use of a Refractometer. A refractometer is used to measure the refractive index of a foam solution sample.

First, a base calibration curve is prepared using the same water and foam concentrate that will be used with the system to be tested. Three known foam solution samples are needed and should include the following:

(1) The nominal intended percentage
(2) The nominal intended percentage plus 1 percent
(3) The nominal intended percentage minus 1 percent

[**1901:**A.20.10.1]

If the nominal intended percentage is 1 percent or less, the three samples should be as follows:

(1) The nominal intended percentage
(2) The nominal intended percentage plus 0.3 percent
(3) The nominal intended percentage minus 0.3 percent

[**1901:**A.20.10.1]

The required amount of water is placed in a 100 mL or larger graduated cylinder, leaving space for the foam concentrate. A 10 mL pipette or 10 cc syringe is used to carefully add the required amount of foam concentrate to the water. Each measured foam solution is then poured from the graduated cylinder into a 100 mL or larger plastic bottle, and the bottle is marked indicating the percentage solution it contains. The bottle is capped and thoroughly shaken to mix the foam solution. [**1901:**A.20.10.1]

An alternative method for making the three foam solution samples is to use a very accurate scale. The density of the foam concentrate must be known and can be found on the product data sheet or the Material Safety Data Sheet (MSDS) for the foam concentrate. For example, to make a 100 mL sample of a 3 percent foam solution using a foam concentrate with a density of 1.04, 97 g of water is measured into a beaker and 3.12 g of foam concentrate is added to the beaker ($1.04 \cdot 3$ g = 3.12 g). [**1901:**A.20.10.1]

After the foam solution samples are thoroughly mixed, a refractive index reading is taken of each foam solution sample. This is done by placing a few drops of the solution on the refractometer prism, closing the cover plate, and observing the scale reading at the dark field intersection. Because the refractometer is temperature compensated, it could take 10 seconds to 20 seconds for the sample to be read properly. It is impor-

tant to take all refractometer readings at ambient temperatures of 50°F (10°C) or above. [**1901:**A.20.10.1]

Using standard graph paper, the refractive index readings are plotted on one axis and the percentage of concentration on the other. This plotted curve serves as the known baseline for the test series. The solution samples should be set aside in the event the measurements need to be checked. [**1901:**A. 20.10.1]

Foam solution samples are then collected from the proportioning system, making certain that the samples are taken at an adequate distance downstream from the foam proportioning system being tested to allow for complete mixing of the water and the foam concentrate. Refractive index readings of the samples are taken and compared to the plotted curve to determine the percentage of foam. [**1901:**A.20.10.1]

This method might not be accurate for aqueous film-forming foam (AFFF), alcohol-resistant foam, or certain other types of foam that typically exhibit very low refractive index readings. Also, the refractometer method should not be used when testing foam percentages of 1 percent or lower because the accuracy for determining the percentage of foam concentrate in a solution when using a refractometer is ±0.1 percent, at best. For this reason, Test Method 4, the conductivity method, might be preferable where AFFF, alcohol-resistant foam, or 1 percent or less foam (Class A foam) is to be tested. [**1901:**A.20.10.1]

Test Method 4: Determining Foam Percentage by Use of a Conductivity Meter. The conductivity test method is based on changes in electrical conductivity as foam concentrate is added to water. Conductivity is a very accurate method, provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages. Because saltwater and brackish water are very conductive, this method might not be suitable where these waters are used because of the small conductivity changes as foam concentrate is added. If saltwater or brackish water is used, it is necessary to make foam solutions in advance to determine if adequate changes in conductivity can be detected. This method cannot be used if the water has more total solids than the foam concentrate. [**1901:**A.20.10.1]

The following three variations of this test method can be used to determine the foam percentage by the conductivity method:

(1) *Direct Reading Conductivity Method.* A sample of the water to be used in the test is put in a 100 mL or larger container. The conductivity meter head is immersed in the water sample, and the meter display is set at zero. If the direct reading foam solution conductivity meter is mounted in a discharge line, the meter should be set at zero with plain water flowing.
If the conductivity meter manufacturer does not indicate that the percentage of foam solution can be read directly for the foam concentrate being used, a calibration curve needs to be developed. The calibration curve might show that the direct meter readings are correct for the foam concentrate being used, or it might indicate that the calibration curve needs to be used when that foam concentrate is used in the test.
The foam proportioning system is operated, and a sample of the foam solution produced by the system is collected using a 100 mL or larger container. The conductivity meter head is immersed in the foam solution sample, and the percentage of the foam solution is read on the meter display. If the conductivity meter is mounted in a discharge line, the percentage of the foam solution is read on the meter display while foam solution is being discharged.

(2) *Conductivity Comparison Method.* A sample of the water to be used in the test is put in a 100 mL or larger container. Using a conductivity meter reading in microsiemens per centimeter (mscm), the conductivity valve of the water sample is determined. The foam proportioning system is operated, and a sample of the foam solution produced by the system is collected in a 100 mL or larger container. Using the conductivity meter, the conductivity value of the foam solution sample is determined. The conductivity value of the water sample is subtracted from the conductivity value of the foam solution sample, and the result is divided by 500 to obtain the percentage of foam concentrate in the solution.

[A.20.10.1]

$$\text{percentage of foam} = \frac{\begin{pmatrix}\text{conductivity of}\\ \text{foam solution}\end{pmatrix} - \begin{pmatrix}\text{conductivity}\\ \text{of water}\end{pmatrix}}{500}$$

Note that the divisor is 500 only if the conductivity meter units are microsiemens per centimeter. Other units of conductivity can be used, but the value of the divisor (500) will need to be adjusted.

(3) *Conductivity Calibration Curve Method.* A base calibration curve is prepared using the water and foam concentrate from the system to be tested. Three known foam solution samples are made using the procedure in Test Method 3. After the foam solution samples are thoroughly mixed, the conductivity of each solution is measured using a conductivity meter. Care should be taken to ensure that the proper procedures are used for taking readings and that the meter is switched to the correct conductivity range. Most synthetic-based foams used with freshwater result in foam solution conductivity readings of less than 2000 mscm. Protein-based foams used with freshwater generally produce conductivity readings in excess of 2000 mscm. Because of the temperature-compensation feature of the conductivity meter, it could take a short time to obtain a consistent reading.

[**1901:**A.20.10.1]

Once the solution samples have been measured and recorded, the bottles should be set aside as control sample references. The conductivity readings then should be plotted on standard graph paper. It is more convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis. [**1901:**A.20.10.1]

A straight line should be drawn that approximates the connection of all three points. While it might not be possible to connect all three points with a straight line, they should be very close. If not, the conductivity measurements should be repeated, and, if necessary, new control sample solutions should be prepared and used until all three points plot in a nearly straight line. This plot serves as the known base (calibration) curve to be used for the test series. [**1901:**A.20.10.1]

Once a base curve has been plotted, foam solution samples are collected from the proportioning system. The conductivity

of the test samples is measured, and the percentage of foam solution is determined from the base curve. Foam solution samples that have been allowed to drain from expanded foam should not be used, because they can produce misleading conductivity readings. [**1901:**A.20.10.1]

A.20.10.1.2 Depending on the foam proportioner technology, the manufacturer could require the system to be calibrated at the low end, high end, or somewhere midrange, to ensure the system meets the accuracy requirements in the standard. For example, if the system runs richer as percentages increase, the manufacturer could anchor the low percentage during calibration. Therefore the manufacturer needs to have the flexibility to pick this point, knowing how the technology reacts over the full operating range. [**1901:**A.20.10.1.2]

A.20.11.1(2) Users may want to specify additional test points and viscosities to ensure that their full range of operational requirements is satisfied. [**1901:**A.20.11.1(2)]

A.20.11.1(3) See A.20.10.1.

A.21.1 The following terms are not used in this document but are associated with CAFS and are included here to aid in understanding. [**1901:**A.21.1]

CAFS-Capable Fire Apparatus. A fire apparatus equipped with a compressed air foam system (CAFS) with the following capabilities:

(1) Automatic regulating foam proportioning system capable of injecting foam concentrate into the discharge or pressure side of the pump
(2) Air compressor with the capacity to supply the required standard cubic feet per minute (SCFM) and automatic air pressure controls
(3) Controls to mix the air and foam solution

Chatter. An unacceptable flow condition wherein air is not fully mixed with the foam solution.

High-Energy Foam Generator. A foam generator that uses a large amount of external energy to aerate the foam.

Low-Energy Foam Generator. A foam generator that uses the energy of the foam stream to aerate the foam.

Mixing Chamber. A device used to produce fine, uniform bubbles in a short distance as foam solution and air flow through it.

Scrubbing. The process of agitating foam solution and air in a confined space such as a hose, pipe, or mixing chamber to produce tiny, uniform bubbles.

Slug Flow. The discharge of distinct pockets of water and air due to the insufficient mixing of foam concentrate, water, and air in a CAFS.

Surge. The sudden decompression of a discharge line caused by the rapid opening of the discharge appliance.

[**1901:**A.21.1]

A.21.2.2.1 The airflow in standard cubic feet per minute (SCFM) [stand cubic meters per minute (SCCM)] at 125 psi (862 kPa) represents a rating of the air compressor capacity. Air compressor capacity varies according to the delivery pressure of the compressor. The basis for rating air compressors for CAF systems in NFPA 1901 and NFPA 1906 is 125 psi (862 kPa). It is recognized that in actual operation, the air pressure of the CAF stream might vary from this rating basis due to operational characteristics of the CAF system. [**1901:**A.21.2.2.1]

The 125 psi (862 kPa) rating point utilized in determining the pressure rating for air compressors used in compressed air foam systems (CAFS) has been identified as a minimum requirement based on significant testing by multiple fire-fighting agencies. The ability of the compressor to perform at 125 psi (862 kPa) ensures that the CAFS will perform in instances where long hose lays are used, ensures a safe amount of reach in fire-fighting activities, and allows for lines to be safely charged without risk of kinking during interior attack or other instances where hoses might be wrapped around obstructions. [**1901:**A.21.2.2.1]

A.21.2.4 It is recommended that compressed air not be injected into the discharge piping until the flow of foam solution has been established. The nozzle reaction at the end of a hose can be quite high if air and water are flowing in the discharge line. The nozzle reaction could be a safety issue if the operator is not expecting or not properly braced to withstand this reaction force. The reaction force is substantially reduced when a foam solution is flowing in the discharge hose. Also, a charged CAFS line should be opened slowly to lower the nozzle reaction force that can be very high if opened rapidly. [**1901:**A.21.2.4]

A.21.2.5 Pressure in the form of compressed air can remain trapped in a CAFS as a result of the system being deactivated. It is important for the operator to relieve any pressure in the foam proportioning system and connected hose lines before disconnecting hose lines or performing any operation that opens the system to atmosphere. [**1901:**A.21.2.5]

A.21.4 If the expansion ratio is to be tested, the following equipment and test procedures are recommended:

(1) *Equipment.*
    (a) Gram scale, 1500 g capacity accurate to 0.1 g
    (b) One 1000 mL container that can be struck at 1000 mL (a 1000 mL graduated cylinder cut off at 1000 mL works well.)
(2) *Procedure.* The empty container is placed on the scale, and the scale is set to zero. Using the container, a full sample of foam is collected and the foam is struck at the 1000 mL level. The container is placed on the scale, and the mass is read in grams.

[A.21.4]

$$\text{Expansion} = \frac{1000}{\text{Foam mass in grams}}$$

The foam mass in grams assumes that 1 g of foam solution occupies 1 mL of volume.
[**1901:**A.21.4]

A.21.5 Any components of the piping system exposed to pressurized air from the CAFS should be designed for a burst gauge pressure of at least 500 psi (3400 kPa).
[**1901:**A.21.5]

A.21.7.6 Some systems provide automatic regulation of the waterflow; however, instrumentation is still useful to the operator. Even automatic systems have adjustments and performance limits that warrant instrumentation. Where the system design does not allow for such automatic regulation, or where the operator has the ability to control waterflow or airflow, air and

water flowmeters are necessary for the operator to monitor the operational performance of the CAFS where the nozzle person cannot be seen. Where pumping long hose lays or pumping to great heights, the operator needs to know what is flowing in order to be certain the proper product is being delivered. [**1901:**A.21.7.6]

A.21.9 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that these tests also be certified by the independent third-party certification organization. [**1901:**A.21.9]

A.21.9.1.1.1 The CAFS capacity rating test is performed with the system discharging 2 gpm of water for every 1 SCFM (250 L/min of water for every 1 SCMM) of compressed air discharge. This test verifies that the system is capable of these capacities without failure of any component of the CAFS. It is recognized that in actual fire-fighting use, the ratio of water-flow to airflow might vary depending on how wet or dry the CAF stream is desired for a particular application. [**1901:**A. 21.9.1.1.1]

A.21.9.1.3.3 Care should be taken to avoid injuries to personnel from the discharging airstream. Only those persons actually conducting the tests should be in the test area, and they should wear protection for their ears, eyes, and face from noise and dust during the airflow test. [**1901:**A.21.9.1.3.3]

A.25.1.1 Winches are classified by manufacturers for different applications and uses. The purchaser might want to specify that winches meet the requirements of SAE J706, *Rating of Winches*. Winches installed on fire apparatus are not designed or suited for lifting or lowering personnel in rescue applications. Winches rated at under 20,000 lbf (89 kN) on fire apparatus are not designed for removal of apparatus from "buried" off-road conditions. A heavy-duty wrecker should be used for towing and lifting of fire apparatus. [**1901:**A.25.1.1]

Most electric (12-volt or 24-volt dc) winches used for fire apparatus applications are rated at between 5000 lbf (22.2 kN) and 25,000 lbf (111.2 kN) line pull. Smaller winches of the removable type might be specified by the purchaser. Hydraulically driven winches are typically rated for 6000 lbf to 30,000 lbf (26.7 kN to 133.5 kN) line pull. [**1901:**A.25.1.1]

A.25.4.1 There is virtually no control over the speed of a single-speed electric winch. The winch runs at the speed the load dictates — faster with light loads and slower with heavy loads. [**1901:**A.24.4.1]

Two-speed electric winches provide only for preselection of the winch gear ratio — that is, one gear ratio for pulling heavy loads, a second for light loads — and are not designed for shifting under load to improve line speed. [**1901:**A.25.4.1]

A.25.5 A fast-idle switch should also be provided. The switch should be interlocked with the neutral position of the transmission to prevent accidental movement of the apparatus.

A.25.5.4.1 Completion of the engagement might require that the chassis transmission be shifted into the proper gear (split shaft PTOs only). [**1901:**A.25.5.5.1]

A.27.3 Skid plates can be used to protect the transfer case, gear box, pump, engine oil pan, radiator, auxiliary coolers, exhaust components, brake lines or components, fuel tank, steering gear, and axle differential.

A.28.2.4 For apparatus with the rating for the ultra-high pressure fire pump based on the pump taking water from the apparatus water tank, the supply of water from the water tank through the plumbing to the pump should provide adequate pressure at the pump intake to avoid cavitation while pumping. By the pump manufacturer certifying the net positive suction head required (NPSHR) value for the rated capacity and discharge pressure, the apparatus manufacturer can design water tank–to–pump plumbing to ensure that the performance as installed on the finished apparatus will meet requirements.

A.28.5.2 The arrangement of ultra-high pressure fire pumps and associated equipment, including the apparatus water tank and associated intake piping and valves, might require controls at more than one pump operator's position.

A.28.5.3 Apparatus used outside of the United States can have intake connections other than NH if specified by the authority having jurisdiction.

A.28.6.1 The arrangement of ultra high pressure fire pumps and associated equipment, including the discharges, might require controls at more than one pump operator's position. Discharges designed to be operated while the apparatus is moving can be controlled only from the cab pump operator's position. [**1901:**A.28.6.1]

A.28.6.7 On UHP systems on which a tank fill line is included, the large pressure drop that exists between the UHP pump discharge should be considered when sizing the line and material and for choosing the design and type of valve. The use of an orifice or other means of providing the pressure drop should be considered.

A.28.8.1 The pump system discharge manifold can be equipped with a start/run valve to bypass the normal operating discharge system and primary pressure valve. This start/run valve would divert water flow from the pump discharge to atmosphere or the tank providing easy starting of the pump engine or drive system and avoiding pressure buildup in the discharge manifold until it is needed for operation. [**1901:**A. 28.8.1]

A.28.8.5.1 For apparatus that will be exposed to freezing temperatures, consideration should be given to a winterization system that includes a small tank for antifreeze solution and proper valves to inject a mixture of antifreeze into the pump and hose reel system. It can be difficult to drain a piston- or plunger-type pump and hose reel with a standard drain valve. Air blow out systems can be used on trucks with air systems. An antifreeze injection system is a simple and effective way to winterize the pump and hose reel system. [**1901:**A.28.8.6.1]

A.28.8.6.1 A large pressure drop exists between the UHP pump discharge and the water tank that should be considered when sizing the line and material. The use of an orifice or other means of providing the pressure drop should be considered. Consideration should be given to using thermally activated overheat protection devices that are available that sense water temperature within the pump. When the water reaches a predetermined temperature, the device releases water from the pump discharge to ground or back to the apparatus water tank.

A.28.10 UHP systems can experience issues with high operating temperatures, or damage due to cavitation or running dry without an adequate water supply. Consideration should be given to specifying an oversight system that can monitor discharge pressure, water temperature, and water tank level/

water supply and that can reduce engine speed or shut off the engine if system parameters fail to meet established values and the pump operator is not able to take corrective action in a timely manner. [**1901:**A.28.10]

A.28.11.3 It might be desirable to also have a pressure gauge in the cab in view of the driver when the pump that is being used in a pump-and-roll operation is driven by a separate engine.

A.28.12.1.2 The purchaser might want to consider an instruction plate mounted at the pump operator's position giving basic instructions on valve positions for UHP fire-fighting operations.

A.28.12.4.1 Figure C.3(c) of NFPA 1911 shows a test data form for recording the test readings and other necessary data.

A.28.12.4.2 Where an engine is operating at or near full power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that, when touched, can cause extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

A.28.12.5.7 Values for intake and discharge pressure can be obtained with test gauges in 28.12.3.3 connected to the pump intake and discharge. Alternatively, if the pumping test is performed from the apparatus water tank and the intake plumbing does not include provisions for connection of a test gauge, the pressure at the pump intake can be determined by calculating the tank head pressure less the friction loss through the intake plumbing. If the pump discharge does not include provisions for connection of a test gauge and the pump has more than one discharge outlet, the pump discharge pressure can be measured at an unused discharge outlet connection. [**1901:** A.28.12.5.7]

A.28.12.7(6) Positive displacement UHP pumps equipped with trap pressure unloaders trap pressure between a check valve in the outlet of the unloader and the discharge nozzle when the spray nozzle is closed while bypassing pump output back to the pump intake or back to a tank. The pump recirculates water without building any more pressure than is required to overcome the friction loss of pushing the water through the unloader and through whatever passageway (internal passageway or external hose, pipe, etc.) back to intake or tank. UHP systems on which the discharge pressure gauge is installed on the pump head will indicate a significant drop in the observed gauge pressure when the discharge is closed. If the observed final discharge pressure reading during the pressure control test fails to indicate a significant drop, this might indicate that the setting of the unloader is incorrect, the check valve is damaged or fails to fully close, or the bypass passageway has become restricted. Such changes indicate that the unloader should be investigated and repaired. [**1901:** A.28.12.7(6)]

A.28.12.8.1 The ability for a priming system to evacuate the UHP fire pump is affected by altitude above sea level, atmospheric pressure and water temperature. As the temperature of the water increases or barometric pressure decreases, the evacuation or lift capability of the priming system is reduced. Table A.28.12.8.1 provides the effect of water temperature and barometric pressure on lift. Conditions at the test site should not cause a vertical lift requirement that exceeds the lift capability required of the priming system in 28.12.8.1.

Table A.28.12.8.1 Effect of Water Temperature and Barometric Pressure on Suction Lift Capability

Water Temperature		Effect on Lift		Barometric Pressure		Effect on Lift	
°F	°C	ft	m	in. Hg	kPa	ft	m
60	16	0	0	29.9	101.3	0	0
90	32	–1	–0.3	29.0	98.2	–1	–0.3
110	43	–2.3	–0.7				
120	49	–3.3	–1.0				

A.28.12.10 See A.16.13.8.

A.28.12.12.2.3 The closures, caps, or plugs furnished with the apparatus as required by 28.5.3.3 are only required to be capable of withstanding pressures 250 psi above the maximum pump close-off pressure. Special capping means can be used to perform the piping integrity test at 1.4 times the maximum pump close-off pressure.

A.28.12.12.3.1(5) The cooling flow should be as low as possible to prevent damage to the pump while maximizing the hydrodynamic test pressure. [**1901:**A.28.12.12.3.1(5)]

Annex B Specifying and Procuring Wildland Fire Apparatus

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General. The purchase of new fire apparatus involves a major investment and should be treated as such. Fire apparatus are complex mechanical equipment that should not be purchased in a haphazard manner. A purchase should be made only after a detailed study of the fire department's apparatus needs, taking into consideration other equipment the department owns or plans to buy.

The local fire chief and fire department staff know the conditions under which the apparatus will be used. However, competent advice should also be obtained from knowledgeable and informed sources such as other experienced fire service personnel, wildland fire agencies, trade journals, training instructors, maintenance personnel, and fire equipment and component manufacturers. The fire insurance rating authority should also be consulted.

The study should look not only at current operations and risks to be protected but also at how these might change over the life of the fire apparatus.

B.2 Writing the Specifications. This standard provides the minimum technical requirements that new wildland fire apparatus are expected to meet. It is recognized that many purchasers will want additional features of operation over and above these minimum requirements. The requirements in this standard, together with the annex material, should be studied carefully. Details, such as anywhere that the apparatus being specified needs to exceed the minimum requirements or where a specific arrangement is desired, should be carefully defined in the specifications for the apparatus. These specifications might include special performance requirements, defining the number of seats and the seating arrangement for fire fighters riding on the apparatus, or providing space for extra hose or equipment the apparatus will be required to carry. Completion of the form shown in Figure B.2 should assist the purchaser in

developing specifications and provide the information required in the various sections of this document. The purchaser should fill in only those sections where there are specific requirements over and above the standard. Care must be taken not to specify incompatible requirements, such as a 3000 gal (11,400 L) water tank, which weighs approximately 30,000 lb (13,600 kg), and a 10,000 lb (4500 kg) GVWR chassis. When more restrictive details are specified, fewer manufacturers will be able to bid, and the cost of the apparatus might be higher.

B.2.1 The first consideration in the design of a fire apparatus is a definition of the mission of the apparatus. The purchaser should define the basic specifications as follows:

(1) The type of apparatus to be purchased
(2) Types of responses
(3) The response environment (level terrain, hilly terrain, on-road, off-road, responses of hundreds of miles, etc.)
(4) Crew size (number of seats)
(5) Size of pump
(6) Size of tank(s)
(7) Hose load, if any
(8) Commercial or custom chassis
(9) Chassis configuration (conventional, cab over, cab forward, rear engine)
(10) Size or weight limitations due to firehouse, roads, bridges, terrain, neighborhoods
(11) Budget considerations
(12) Expected service life (years) and duty cycle (runs per day or month)

B.2.2 The second consideration in the design of a fire apparatus is the fixed equipment components. These major support function components can represent the most concentrated and heaviest load elements of the vehicle. It is vital that these elements be laid out early in the initial designs and be situated on the vehicle to provide for the following:

(1) Good load distribution
(2) Balance (both front-to-rear and right-to-left)
(3) Low center of gravity

Fixed components can be located in exterior compartments or in the interior of the vehicle to be functional and organized in a layout to be user-friendly in emergency applications. The following are examples of fixed equipment:

(1) Electrical generators
(2) Water tanks, fire pumps, and other fire-fighting equipment
(3) Reels of all types

B.2.3 A major support function of any fire apparatus, no matter the type, is the portable equipment. That is why this document places so much emphasis on final GVWR and carrying capacity of the completed vehicle, which includes both fixed and portable equipment.

The listings of portable and fixed equipment are so variable, depending on the mission of the vehicle, that the fire department needs to measure and weigh its specific equipment.

The fire department should classify the equipment as follows:

(1) Existing — currently owned equipment that will be carried
(2) Proposed — new equipment that will be carried as the apparatus goes in service
(3) Future — equipment that might be carried in the future

In this way, a chassis with an adequate GVWR can be provided to ensure that the vehicle will not be overloaded in the future.

B.2.4 After determining the list of existing, proposed, and future equipment, the fire department should analyze the actual space (cubic feet or cubic meters) necessary for the equipment. One source of information is comparing the equipment to be carried on the new apparatus with the equipment carried on existing apparatus and thus the relative space requirements. The actual usable space in compartments also should be considered, in addition to the individual space (in cubic feet or cubic meters) for each item of equipment to be carried. The following factors might increase the required storage space required and thus the size of the vehicle body:

(1) Compartment door and box pan interference
(2) Mounting implications
(3) Compartment shelving
(4) Slide trays
(5) Components of the body such as compartment flanges, notches, and other interferences that affect removal of equipment from compartments
(6) Ventilation of generator, air compressor, pump engines, or other equipment

B.2.5 Where local operating conditions necessitate apparatus of unusual design, the purchaser needs to define carefully the special requirements in the specifications. Height, width, under-vehicle clearance, wheelbase, turning radius, length, and so forth might occasionally need special attention. For example, a community with many narrow, winding streets should have apparatus capable of readily negotiating switchbacks without delay.

B.2.6 This standard is designed to ensure sound equipment that is capable of good performance, with the inclusion of restrictive features only where needed to specify minimum requirements. The tests are an important feature, and the results should be carefully analyzed to ensure that the completed apparatus meets the specified performance.

Since the passage of Public Law 89-563, the National Traffic and Motor Vehicle Safety Act of 1966, the federal government has adopted certain motor vehicle safety standards applicable to all manufacturers of trucks, including fire apparatus. It is unlawful for a manufacturer to deliver a truck not in compliance with these federal standards. These federal safety standards are frequently changed, and their provisions make the incorporation of certain features and devices mandatory. Apparatus manufacturers face substantial penalties for infraction of these rules and, therefore, cannot build apparatus to specifications that would require them to perform unlawfully, delete required items, or include any that are illegal.

APPARATUS PURCHASING SPECIFICATION FORM

PROCUREMENT ISSUES

* Date of bid opening: _____

* Purchaser's name and address: _____

_____

_____

* Contact name and telephone number: _____

_____

_____

* Sealed bid envelope information, address, and identification marking: _____

_____

_____

* The bidder is to honor the bid price for _____ days.

* Are interim inspection trip(s) to the assembly plant to be provided? ❑ Yes ❑ No

If yes, indicate number of trips _____ number of participants _____

Who will pay expenses? _____

How many service and operation manuals are to be provided? _____

* Where is the delivery of the apparatus to occur? _____

_____

* Where and when is the acceptance to occur? _____

_____

_____

* The operation and service instruction and demonstration is to be conducted at _____

_____

for _____ persons for _____ days.

Is a special payment plan or schedule required? ❑ Yes ❑ No

If yes, what are the requirements? _____

_____

_____

Is an approval drawing required? ❑ Yes ❑ No

Is a bid bond required? ❑ Yes ❑ No

If yes, what percent of the bid price? _____

Is a performance bond required? ❑ Yes ❑ No

If yes, what percent of the bid price? _____

Is an extended warranty on specific components required? ❑ Yes ❑ No

If yes, indicate which components are to be covered and the length of the warranty: _____

_____

_____

Is a warranty bond required? ❑ Yes ❑ No

If yes, in what amount? _____

*Generally required for manufacturer to bid on and build apparatus.

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FIGURE B.2 Specification Form for Purchasing Apparatus.

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

GENERAL REQUIREMENTS

Special design features required on this apparatus: _____

_____

_____

_____

_____

What are the maximum allowable dimensions of the apparatus?

Overall height in inches (millimeters): _____ (measured at the highest projection)

Overall length in inches (millimeters): _____ (measured at the front and rearmost projections)

Wheelbase in inches (millimeters): _____ (measured from the center of the front axle to the center of the rear axle)

Width in inches (millimeters): _____ (measured at the outside of the mirrors)

Gross vehicle weight in pounds (kilograms): _____

Maximum weight on the front axle in pounds (kilograms): _____

Maximum weight on the rear axle in pounds (kilograms): _____

What is the maximum wall-to-wall turning radius allowable? _____ ft (meters)

* Maximum elevation at which the apparatus will operate if over 2000 ft (600 m): _____

Maximum grade for stationary operation if over 10 percent: _____

Maximum grade that apparatus must be able to maneuver on if more than across a 20 percent grade and up and down a 25 percent grade: _____

Apparatus road performance if it is to exceed the minimum specified in this standard: _____

_____

_____

_____

_____

* Maximum road speed required: _____

* Minimum ambient air temperature in which the apparatus is to operate: _____

* Maximum ambient air temperature in which the apparatus is to operate: _____

* Maximum number of persons to ride on the apparatus: _____

_____

* **Hose Thread Size Information**

(TPI × OD or size and type) (i.e., 2½ in. NH or 1 in. NPSH)	
¾ in. =	1 in. =
1½ in. =	2 in. =
2½ in. =	3 in. =
3½ in. =	4 in. =
4½ in. =	5 in. =
6 in. =	Hydrant =

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Testing and Acceptance

Is independent third-party certification of test results required for the pump system? ❑ Yes ❑ No

Is anyone representing the purchaser to witness the manufacturer's predelivery tests? ❑ Yes ❑ No

If yes, who? _____

_____

Where are the road tests to be conducted? _____

_____

_____

* What tests will the contractor be required to perform on delivery? _____

_____

_____

CHASSIS AND VEHICLE COMPONENTS

Desired chassis make and model or style: _____

_____

Desired location of the engine: _____

Type of propulsion engine: _____

Is an electric fuel pump or repriming pump required? ❑ Yes ❑ No

Special lubrication system requirements: _____

_____

_____

Special cooling system requirements: _____

_____

_____

Is an automatic throttle control device required? ❑ Yes ❑ No

Is a manual emergency engine shutdown required? ❑ Yes ❑ No

Type of fuel filters required: _____

_____

Type of air filters required: _____

_____

Enhanced performance ember separator requirements: _____

_____

Exiting location of the exhaust system: _____

_____

Type of brake system required: _____

_____

Is an auxiliary brake system required? ❑ Yes ❑ No

If yes, type and control: _____

_____

_____

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Style and type of tires required: _____

_____

_____

Indicate whether cast spoke, hub piloted, stud piloted, steel disc, or aluminum wheels are required: _____

_____

_____

Are rear fender liners required? ❑ Yes ❑ No

Are automatic tire chains required? ❑ Yes ❑ No

Minimum axle housing and ground clearance required: _____

_____

Increased underbody clearance required greater than the standard's minimum: _____

_____

Angle of approach required if greater than 20 degrees: _____

Angle of departure required if greater than 20 degrees: _____

Ramp breakover angle required: _____

Specify the steering system cramp angle if it exceeds the standard's minimum: _____

_____

Is a drive axle traction control or no-spin differential required? ❑ Yes ❑ No

If yes, what design or style? _____

_____

Is rear wheel steering required? ❑ Yes ❑ No

If yes, what design or style? _____

_____

Is a special suspension system required? ❑ Yes ❑ No

If yes, what design or style? _____

_____

Is an automatic or manual transmission required? _____

Fuel tank capacity required: _____ gal (L)

Must tow hooks be accessible without opening compartment doors? ❑ Yes ❑ No

Is a rear license plate bracket and light required? ❑ Yes ❑ No

Special cab trim features: _____

_____

_____

LOW-VOLTAGE ELECTRICAL SYSTEMS AND WARNING DEVICES

* Indicate whether a battery charger, conditioner, or polarized receptacle is to be provided: _____

_____

_____

If a built-in battery charger or conditioner is provided, indicate the required charging rate: _____

_____

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Specify the location of the receptacle for the battery charger or conditioner: _____

_____

Is a second "master disconnect on" indicator on the outside of the vehicle required? ❑ Yes ❑ No

Where? _____

Specify any electrical loads beyond those defined in the standard that are to be part of the minimum continuous electrical load: _____

_____

If a load management system is required, specify the sequence of control (shutdown): _____

_____

_____

Is certification of the testing of the low-voltage electrical system by an independent third-party certification organization required? ❑ Yes ❑ No

Is the vehicle to be equipped to call for or block right-of-way on a public highway? ❑ Yes ❑ No

If yes, specify warning light and siren information:

Warning Light Information

Location	Make and Model	Color
Upper forward-facing		
Upper-level side-facing near front		
Upper-level side-facing near midship		
Upper-level side-facing near rear		
Upper-level rear-facing		
Lower-level forward-facing		
Lower-level side-facing near front		
Lower-level side-facing near midship		
Lower-level side-facing near rear		
Lower-level rear-facing		

Make, model, location, and controls of the siren: _____

_____

_____

Are air horns required? ❑ Yes ❑ No

If yes, make preferred, type of control, and their location: _____

_____

Special emergency lighting or warning features or equipment required: _____

_____

Are cab hand lights or mounted adjustable spotlights required? ❑ Yes ❑ No

Ground lighting required: _____

Hose bed lighting required: _____

Step and surface lighting required: _____

Cab interior lighting required: _____

Compartment lighting required: _____

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FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Specify if additional driving or crew compartment lighting is required: _____

Are provisions needed for rechargeable equipment? ❑ Yes ❑ No

If yes, make and model of equipment: _____

Is a backup camera system required? ❑ Yes ❑ No

If yes, make and model: _____

DRIVING AND CREW AREAS

Special seating requirements or arrangements for the driver: _____

Special seating requirements or arrangements for the officer: _____

Special seating requirements or arrangements for the crew: _____

Is an intercom system required? ❑ Yes ❑ No

Make, model, or type: _____

Locations: _____

Radio interface: _____

Special requirements: _____

Special requirements for carrying tools or equipment within the driving or crew compartment: _____

Special requirements for carrying EMS equipment within the driving or crew compartment: _____

Special step or handrail arrangements required: _____

Is a tilt or telescoping steering column required? ❑ Yes ❑ No

If yes, design or style: _____

Extra driving compartment instrument panel features required: _____

Type and style of driving compartment mirrors: _____

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

BODY, COMPARTMENTS, AND EQUIPMENT MOUNTING

Body material: _____

_____

Compartment capacity required: _____ ft^3 (m^3)

Special compartment features and finish required: _____

_____

Compartment floor material or covering required: _____

_____

Type and style of compartment doors required: _____

_____

Style of door latches, locks, or stays required: _____

_____

Type of compartment lighting required: _____

_____

Radio equipment to be used: _____

Is the manufacturer to provide the radio? ❑ Yes ❑ No

Is the manufacturer to install the radio? ❑ Yes ❑ No

Make and model: _____

Mounting location for radio: _____

Mounting location for control(s) and speaker(s): _____

_____

Provisions required for computer equipment or electronics: _____

_____

_____

Type of body tread plate material required: _____

_____

Type of step and platform material required: _____

_____

* Color of apparatus: _____

Paint number and manufacturer, if known: _____

Striping, decoration, and lettering required: _____

_____

_____

Areas not to be painted: _____

_____

Miscellaneous body trim: _____

_____

Is rustproof treatment required? ❑ Yes ❑ No

If yes, locations to be treated: _____

_____

FIGURE B.2 ***Continued***

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

* **Hose to Be Carried for Preconnected Lines**

Length	Size	Location	Bed or Reel

* **Hose to Be Carried in Hose Bed or on Reels**

Length	Size	Location	Bed or Reel

Is a hose bed cover(s) required? ❑ Yes ❑ No

If yes, specify type: _____

Is the fire-fighting system to be a slip-on unit? ❑ Yes ❑ No

If yes, lifting arrangement required: _____

Anchoring system required: _____

WATER PUMP

* Pump-rated capacity: _____ gpm (L/min) at _____ psi (kPa)

* Number of pump stages required: _____

Pump type: _____

Pump location: _____

Is the pump to be driven by the chassis propulsion engine? ❑ Yes ❑ No

If no, how is the pump to be driven? _____

Pump testing authority: _____

Pump-and-roll performance required:

Flow _____ gpm (L/min) at _____ psi (kPa)

Vehicle speed _____ mph (km/hr)

Type of priming system: _____

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Special pump performance requirements:

If altitude over 2000 ft (600 m), specify altitude: _____

If lift over 10 ft (3 m), specify lift: _____

If through more than 20 ft (6 m) of suction hose, specify length: _____

Do local water conditions require special materials for pump construction and piping? _____

_____

Location of pump operator's position: _____

Pump panel and gauge panel material, if required: _____

Type of intake and discharge valve controls desired: _____

_____

Size of the master gauges: _____

_____

Are individual line pressure gauges required? ❑ Yes ❑ No

If yes, are there any special requirements? _____

_____

Are individual line flow meters required? ❑ Yes ❑ No

If yes, are there any special requirements? _____

_____

Are any special gauges, instruments, or other features required at the pump operator's position? _____

_____

Are special pump and piping features required to deal with extremely low temperatures? _____

_____

Should the engine speed control at the pump panel be enabled when the apparatus is parked but not in pump mode (pump driven by chassis engine only)? ❑ Yes ❑ No (ref 16.10.10.3)

Is a pump pressure governor or a relief valve to be supplied? _____

* **Pump intake connections**

Indicate the following for each pump intake:

Size	Type of Connection	Location	Valved Y/N

Are specific flow rates required for auxiliary intakes? ❑ Yes ❑ No

If yes, specify details: _____

_____

Is certification of intake flow rates required? ❑ Yes ❑ No

FIGURE B.2 *Continued*

APPARATUS PURCHASING SPECIFICATION FORM *(continued)*

Are special adapters required on the pump intakes? ❑ Yes ❑ No

If yes, indicate type: _____

* Will a valve, siamese, or adapter be carried on any intakes? ❑ Yes ❑ No

If yes, specify where, make, and model: _____

_____

* **Pump Discharge Outlets Without Preconnected Hose Lines**

Size	Type of Connection	Location	Flow Requirement	Valved Y/N

* **Pump Discharge Outlets for Preconnected Hose Lines**

Size	Type of Connection	Location	Flow Requirement	Valved Y/N

Is a deck gun required? ❑ Yes ❑ No

Type: _____

Mounting location: _____

Piping size and arrangement: _____

Is pump panel color or number coding required? ❑ Yes ❑ No

Specify details: _____

_____

Is a booster reel required? ❑ Yes ❑ No

How many reels? _____

Location: _____

Hose size and length: _____

Reel rewind type: _____

Piping to reel: _____

FIGURE B.2 *Continued*