NFPA 1906

Standard for Wildland Fire Apparatus

2001 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

IMPORTANT NOTICE ABOUT THIS DOCUMENT

NFPA codes, standards, recommended practices, and guides, of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards.

The NFPA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this document available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the NFPA list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

See inside back cover for additional important notices and information.

NOTICES

All questions or other communications relating to this document and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA documents during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

Users of this document should be aware that this document may be amended from time to time through the issuance of Tentative Interim Amendments, and that an official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments then in effect. In order to determine whether this document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments, consult appropriate NFPA publications such as the *National Fire Codes®* Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed above.

A statement, written or oral, that is not processed in accordance with Section 6 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

The NFPA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of this document, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this document should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

Licensing Policy

NFPA 1906

Standard for

Wildland Fire Apparatus

2001 Edition

This edition of NFPA 1906, *Standard for Wildland Fire Apparatus,* was prepared by the Technical Committee on Fire Department Apparatus and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 12–15, 2000, in Orlando, FL. It was issued by the Standards Council on January 13, 2001, with an effective date of February 9, 2001, and supersedes all previous editions.

This edition of NFPA 1906 was approved as an American National Standard on February 9, 2001.

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.

The 2001 edition updates the 1995 edition. The requirements for low-voltage electrical systems, including the emergency warning systems, have been moved to a separate chapter and brought in line with the requirements in NFPA 1901, *Standard for Automotive Fire Apparatus.* The pump chapter was reorganized to provide requirements for four types of pumps with the range of pump 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 updated where appropriate to make the requirements consistent with those in NFPA 1901.

Technical Committee on Fire Department Apparatus

Jeffrey Bowman, *Chair*
Anaheim Fire Dept., CA [E]

Kenneth L. Koch, *Secretary*
Sutphen Corp., OH [M]

Robert J. Barraclough, Class I, Inc., TX [M]
Ralph Craven, Mission College/EVS, NV [SE]
Rep. California Fire Mechanics Assn.
Peter F. Darley, W. S. Darley & Co., IL [M]
Rep. National Truck Equipment Assn.
Donald L. Frazeur, Los Angeles City Fire Dept., CA [U]
Ron W. French, JDK Management Inc., IL [SE]
Gary Handwerk, Hale Products Inc., PA [M]
Thomas A. Hillenbrand, Underwriters Laboratories Inc., IL [RT]
Calvin S. Kunkle, Purdue University, IN [SE]
W. Kenneth Menke, Fire Service Research Institute, MO [SE]
J. Allen Metheny, Sr., Hartly Volunteer Fire Co., DE [U]
Rep. National Volunteer Fire Council
Thomas J. Mettler, Waterous Co., MN [M]
David A. Ogilvie, Pierce Manufacturing Inc., WI [M]
William C. Peters, City of Jersey City Fire Dept., NJ [E]
Jeff Piechura, Northwest Fire District, AZ [E]
W. Michael Pietsch, Insurance Services Office, Inc., TX [I]
Gary R. Pope, Fairfax County Fire/Rescue Dept., VA [U]
Carl E. Punkay, Champaign Fire Dept., IL [U]
Roger A. Ruth, National Foam Inc., PA [M]
Rep. Fire Apparatus Manufacturers Assn.
James A. Salmi, Ladder Towers Inc., PA [M]
Alan Saulsbury, Saulsbury Fire Rescue Inc., NY [M]
Gary B. Selig, California Department of Forestry, CA [U]
James T. Steffens, JTS & Associates, FL [I]
Rep. Volunteer Firemen's Insurance Services, Inc.
Robert D. Tutterow, Jr., Charlotte Fire Dept., NC [U]
Alan D. Van Guilder, City of Reno Fire Dept., NV [U]
William von Zehle, Jr., Wilton Fire Dept., CT [E]
Rep. International Association of Fire Chiefs
Gary C. Weidner, City of Virginia Beach Fire Dept., VA [U]
David White, Fire & Safety Specialists, Inc., TX [SE]
John R. Witt, Safetek Emergency Vehicles Ltd., Canada [M]

Alternates

Gene P. Carlson, Oklahoma State University, OK [SE]
(Alt. to D. White)
Ronald L. Ewers, Class I, Inc., FL [M]
(Alt. to R. J. Barraclough)
Jimmy O. Iveson, City of Reno Fire Dept., NV [U]
(Alt. to A. D. Van Guilder)
James E. Johannessen, Underwriters Laboratories Inc., PA [RT]
(Alt. to T. A. Hillenbrand)
William F. McCombs, Emergency One, Inc., FL [M]
(Alt. to A. Saulsbury)
Thomas H. McCullough, II, VFIS Claims Management, Inc., PA [I]
(Alt. to J. T. Steffens)
John McDonald, International Association of Fire Fighters, VA [SE]
(Alt. to W. K. Menke)
Tim McDonald, Pierce Manufacturing Inc., WI [M]
(Alt. to D. A. Ogilvie)
Tom Reser, Edwards Manufacturing Inc., OR [M]
(Alt. to R. A. Ruth)
Thomas G. Stites, Sutphen Corp., OH [M]
(Alt. to K. L. Koch)
Edward F. Straw, Insurance Services Office, Inc., GA [I]
(Alt. to W. M. Pietsch)
Dean David Ulrich, Los Angeles City Fire Dept., CA [U]
(Alt. to D. L. Frazeur)

Nonvoting

William F. Foley, Orland Fire Protection District, IL
(Member Emeritus)
Howard L. McMillen, City of Fort Worth Fire Dept., TX
(Member Emeritus)
Heinz E. Otte, Mendota Heights, MN
(Member Emeritus)

Carl E. Peterson, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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.

Contents

NFPA 1906

Standard for

Wildland Fire Apparatus

2001 Edition

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

Information on referenced publications can be found in Chapter 15 and Appendix C.

Chapter 1 Administration

1.1* Scope. This standard shall apply to new automotive fire apparatus designed primarily to support wildland fire suppression operations. The apparatus shall consist of a vehicle equipped with a pump, water tank, hose, and equipment whether designed to be integral with the chassis or as a slip-on fire-fighting module mounted on the apparatus.

If the primary purpose of the apparatus is to support structural fire fighting or associated fire department operations, the requirements of NFPA 1901, *Standard for Automotive Fire Apparatus*, shall apply.

1.2 Purpose. This standard specifies the minimum requirements for a new automotive wildland fire apparatus.

1.3 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. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.4 Application. This standard is applicable to new fire apparatus contracted for on or after July 1, 2001; however, nothing shall prevent the use of the standard prior to July 1, 2001 if the purchaser and contractor agree. The standard is not intended to be applied retroactively.

1.5* Responsibility of Purchaser. It shall be the responsibility of the purchaser to specify the details of the fire apparatus; its required performance, including pump performance, where operations at elevations above 2000 ft (610 m) or on highway grades greater than 20 percent are required; the maximum number of fire fighters to ride within the apparatus; specific added continuous electrical loads that exceed the minimum of this standard; and any hose, ground ladders, or equipment to be carried by the apparatus that exceeds the minimum requirements of this standard.

1.6 Responsibility of Contractor.

1.6.1 The contractor shall provide a detailed description of the apparatus, a list of equipment to be furnished, and other construction and performance details to which the apparatus shall conform. This shall include, but shall not be limited to, estimated weight, wheel base, turning clearance radius, principal dimensions, angle of approach, angle of departure, ramp breakover angle, transmission, and axle ratios, if applicable. The purpose of these contractor specifications shall be to define what the contractor intends to furnish and deliver to the purchaser.

1.6.2 Responsibility for the apparatus and equipment shall remain with the contractor until they are accepted by the purchaser.

1.6.3 A qualified and responsible representative of the contractor shall instruct personnel specified by the purchaser in the operation, care, and maintenance of the fire apparatus and equipment delivered.

1.7 Definitions.

1.7.1 Acceptance. An agreement between the purchasing authority and the contractor that the terms and conditions of the contract have been met.

1.7.2 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.

1.7.3 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.

1.7.4 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.

1.7.5 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.

1.7.6* Approved. Acceptable to the authority having jurisdiction.

1.7.7 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.*

1.7.8* Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

1.7.9* Automatic Electrical Load Management System. A device that continuously monitors the electrical system voltage and sheds predetermined loads in a selected order to prevent overdischarging of the apparatus' batteries.

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

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

1.7.12 Back-Up Alarm. An audible device designed to warn that the vehicle is in reverse gear.

1.7.13 Bubble (Foam). A thin-walled, roughly spherical, film of liquid inflated with air.

1.7.14 Carbon Monoxide Monitor. A monitoring device that samples a purified air stream for trace elements of carbon monoxide (CO).

1.7.15 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.

1.7.16 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).

1.7.17 Class A Fire. A fire in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

1.7.18 Class A Foam. Foam intended for use on Class A fires.

1.7.19* Compound Gage. A gage that indicates pressure both above and below atmospheric pressure.

1.7.20* Compressed Air Foam System (CAFS). A foam system that combines air under pressure with foam solution to create foam.

1.7.21 Continuous Duty. Operation at a constant rated load for an indefinitely long period.

1.7.22* Contractor. The person or company responsible for fulfilling an agreed upon contract.

1.7.23 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.

1.7.24 Defect. A discontinuity in a part or a failure to function that interferes with the service or reliability for which the part was intended.

1.7.25 Discharge Outlet Size. The nominal size of the first fire hose connection from the pump.

1.7.26 DOT Cylinder. A pressure vessel constructed and tested in accordance with 49 *CFR* 178.37, that is used for the storage and transportation of air under pressure.

1.7.27* Eductor. A device placed in a hose line or a discharge pipe that incorporates a venturi and proportions foam concentrate into the water stream.

1.7.28 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.

1.7.29 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.

1.7.30 Expansion Ratio. The ratio of the volume of foam in its aerated state to the original volume of nonaerated foam solution.

1.7.31 FMVSS. Abbreviation for Federal Motor Vehicle Safety Standard. Regulations promulgated by 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.

1.7.32 Foam. An aerated fire-extinguishing solution created by mixing air into foam solution to form bubbles.

1.7.33 Foam Concentrate. The fire chemical product, as received from the supplier, that when diluted with water, becomes foam solution.

1.7.34 Foam Proportioner. A device or method to add foam concentrate to water to make foam solution.

1.7.35 Foam Proportioning System. The apparatus and techniques used to mix concentrate with water to make foam solution.

1.7.36 Foam Solution. A homogeneous mixture of water and foam concentrate in the proper proportions.

1.7.37 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.

1.7.38 Gage. A round, analog pressure-indicating device that uses mechanical means to measure pressure.

1.7.39 Gage Pressure. Pressure measured by an instrument where the pressure indicated is relative to atmospheric pressure.

1.7.40 Gallon. United States gallon.

1.7.41* GAWR (Gross Axle Weight Rating). The chassis manufacturer's specified maximum load-carrying capacity of an axle system as measured at the tire-ground interfaces.

1.7.42 GCWR (Gross Combination Weight Rating). The chassis manufacturer's specified maximum load-carrying capacity for tractor trailer–type vehicles having three or more axle systems (a multiaxle axle installation is one system).

1.7.43 gpm. Gallons per minute.

1.7.44* Grade. A measurement of the angle used in road design and expressed as a percentage of elevation change over distance.

1.7.45 Ground Clearance. The clearance under a vehicle at all locations except the axles and driveshaft connections to the axle.

1.7.46* GVWR (Gross Vehicle Weight Rating). The chassis manufacturer's specified maximum load-carrying capacity of a vehicle having two axle systems (a multiaxle axle installation is one system).

1.7.47 Intake Connection Size. The nominal size of the first fire hose connection from the pump.

1.7.48 Interlock. A device or arrangement by means of which the functioning of one part is controlled by the functioning of another.

1.7.49 Label. A visual indication whether in pictorial or word format that provides for the identification of a control, switch, indicator or gage, or the display of information useful to the operator.

1.7.50 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.

1.7.51* 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.

1.7.52 Low-Voltage Circuit, Equipment, or System. An electrical circuit, equipment, or system where the voltage does not exceed 30 volts (V) rms (ac) or 42.4 V peak (dc), usually 12 V dc in fire apparatus.

1.7.53 Manufacturer. The person or persons, company, firm, corporation, partnership, or other organization responsible for turning raw materials or components into a finished product.

1.7.54* 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.

1.7.55 Minimum Continuous Electrical Load. The continuous electrical current required to operate the minimum requirement of electrical devices defined by this standard.

1.7.56 Momentary Switch. A switch that returns to the neutral position (off) when released.

1.7.57 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, *Standard for Fire Hose Connections*.

1.7.58* 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.

1.7.59 Nozzle Reaction. Force that occurs when a water stream is discharged from the nozzle.

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

1.7.61* 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.

1.7.62 Operator's Panel. A panel containing gages, switches, instruments, or controls where an operator can visually monitor the applicable functions.

1.7.63 Optical Center. The point specified by the optical warning device manufacturer of highest intensity when measuring the output of an optical warning device.

1.7.64 Optical Power. A unit of measure designated as candela-seconds/minutes 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.

1.7.65* Optical Source. Any single, independently mounted, light emitting component in a lighting system.

1.7.66 Optical Warning Device. A manufactured assembly of one or more optical sources.

1.7.67 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.

1.7.68* 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.

1.7.69 psi. Pounds per square inch.

1.7.70 PTO. Power takeoff.

1.7.71 Pump Operator's Panel. The area on a fire apparatus that contains the gages, controls, and other instruments used for operating the pump.

1.7.72 Pump Operator's Position. The location from which the pump operator operates the pump.

1.7.73 Purchaser. The authority having responsibility for the specification and acceptance of the apparatus.

1.7.74 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.

1.7.75 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, work, or project.

1.7.76 Ramp Breakover Angle. The angle measured between two (2) 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.

1.7.77 Rated Capacity (Water Pump). The flow rate at which the pump manufacturer certifies compliance of the pump with the requirements set forth in this standard.

1.7.78 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.

1.7.79 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.

1.7.80 Shall. Indicates a mandatory requirement.

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

1.7.82 Sign. A visual indication whether in pictorial or word format that provides a warning to the operator or other persons near the apparatus.

1.7.83 **Siren.**

1.7.83.1* 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.

1.7.83.2* Electronic Siren. An audible warning device that produces sound electronically through the use of amplifiers and electromagnetic speakers.

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

1.7.85 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.

1.7.86 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.

1.7.87 Standard Cubic Feet per Minute (scfm). An expression of airflow rate in which the airflow rate is corrected to standard temperature and pressure.

1.7.88 Strainer. A device used in pump inlets or tank fill openings that prevents foreign materials that cannot pass through the pump without causing damage from entering the tank or pump.

1.7.89 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 head.

1.7.90 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.

1.7.91 Swash Partition. A vertical wall within a tank structure designed to control the unwanted movement of the fluid within that tank.

1.7.92 Turning Clearance Radius. One half the larger of the left or right full circle wall-to-wall turning diameter.

1.7.93 Wildland Fire Apparatus. Fire apparatus designed for fighting wildland fires that is equipped with a pump having a capacity normally between 10 gpm and 500 gpm (38 L/min and 1900 L/min), a water tank, limited hose and equipment, and that has pump and roll capability.

1.8* Conversion Factors. In this standard, values for measurement are followed by an equivalent in SI units, but only the value that first appears shall be considered as the requirement, since the value in SI units could be approximate. Table 1.8 provides the conversion factors that shall be used where SI units are not provided in the text or where more precision is desired.

Table 1.8 Conversion Factors

U.S. Customary Units	SI Units
1 gallon per minute (gpm)	3.785 liters per minute (L/min)
1 gallon per minute (gpm)	0.833 imperial gallons per minute
1 pound per square inch (psi)	6.895 kilopascals (kPa)
1 inch of mercury (in. Hg)	3.386 kilopascals (kPa)
1 inch (in.)	25.40 millimeters (mm)
1 foot (ft)	0.305 meters (m)
1 square inch (in.^{2})	645.2 square millimeters (mm^2)
1 mile per hour (mph)	1.609 kilometers per hour (kmph)
1 pound (lb)	0.454 kilograms (kg)
1 horsepower (hp)	0.746 kilowatts (kW)

Chapter 2 General Requirements

2.1 Legal Requirements. The apparatus shall comply with all applicable federal and state motor vehicle laws and regulations.

2.2 Personnel Protection.

2.2.1* Guards, shields, or other protection shall be provided where necessary to prevent injury of personnel by hot, moving, or rotating parts during nonmaintenance operations. Electrical insulation or isolation shall be provided where necessary in order to prevent electrical shock from onboard electrical systems.

2.2.2 Vehicular workmanship shall ensure an operating environment free of accessible sharp projections and edges.

2.2.3 Safety related (e.g., caution, warning, danger) signs shall meet the requirements of ANSI Z535.4, *Product Safety Signs and Labels.*

2.3 Controls and Instructions.

2.3.1 All required signs, plates, and labels shall be permanent in nature, securely attached, and capable of withstanding the effects of extremes of weather and temperature.

2.3.2 No gage or visual display shall be more than 84 in. (2134 mm) above the level where the operator stands to read the instrument.

2.3.3 The central midpoint or centerline of any control shall be no more than 72 in. (1830 mm) vertically above the ground or platform that is designed to serve as the operator's standing position.

2.4 Component Protection. Hydraulic lines, air system tubing, control cables, and electrical lines shall be clipped to the frame or body structure of the apparatus and 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 lay against a sharp metal edge.

Exception: Where a through-the-frame connector is provided, metal protective looms or grommets shall not be required.

2.5 Vehicle Stability.

2.5.1 The finished, fully loaded, and equipped vehicle shall meet one of the following two criteria.

(a) The calculated center of gravity shall be no higher than 75 percent of the rear vehicle axle track width for a vehicle with a GVWR of 33,000 lb (14,969 kg) or less, and 85 percent of the rear vehicle axle track width for a vehicle with a GVWR greater than 33,000 lb (14,969 kg). The rear vehicle axle track width shall be measured from the center of the rear wheel assembly on one side of the vehicle to the center of the rear wheel assembly on the other side.

(b) When the completed and fully loaded fire apparatus is placed on a tilt table with an aggressive surface and without blocking of the down slope tires, a vehicle of 33,000 lb (14,969 kg) or less GVWR shall be able to be tilted to 30 degrees before lifting a front or rear tire. A vehicle with a GVWR greater than 33,000 lb (14,969 kg) shall be able to be tilted to 27 degrees before lifting a front or rear tire.

2.5.2* The front-to-rear weight distribution of the fully loaded vehicle as defined in Section 3.1 shall be within the limits set by the chassis manufacturer. 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.

2.5.3 The difference in weight on the end of each axle, from side to side, when the vehicle is fully loaded and equipped as defined in Section 3.1 shall not exceed 7 percent.

2.6 Fire Apparatus Performance.

2.6.1* The fire apparatus shall meet the requirements of this standard at elevations up to 2000 ft (610 m) above sea level.

2.6.2* The fire apparatus shall meet all the requirements of this standard while stationary on a grade of 20 percent in any direction.

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

2.7 Roadability.

2.7.1 The fire apparatus, when fully equipped and loaded as defined in Section 3.1, shall be capable of the following performance on dry, paved roads in good condition.

(1) From a standing start, the vehicle shall attain a speed of 35 mph (56 kmph) within 25 seconds on a level road.
(2)* If the apparatus is designed to respond on public roads, it shall attain a minimum top speed of 50 mph (80 kmph) on a level road.
(3)* The apparatus shall be able to maintain a speed of at least 20 mph (32 kmph) on any grade up to and including 6 percent.

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

2.8 Serviceability.

2.8.1 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 or without the need for hand tools. 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.

2.8.2 Where special tools are required for routine service on any component of the apparatus, such tools shall be provided with the apparatus.

2.8.3 At least two (2) copies of a complete, detailed operation and service manual for the apparatus shall be provided. This manual shall include the chassis, pump, wiring diagrams, lubrication charts, and fire-fighting equipment for that apparatus.

2.9 Road Tests.

2.9.1 Road tests shall be conducted as detailed in 2.9.2 through 2.9.4 to verify that the completed fire apparatus is capable of compliance with Section 2.7. The tests shall be conducted at such locations and in such a manner so as not to violate local, state, or federal traffic laws.

2.9.2 The apparatus shall be fully equipped and loaded as required in 3.1.1. The tests shall be conducted on dry, level, paved roads that are in good condition. The engine shall not operate in excess of the maximum governed speed.

2.9.3 Acceleration tests shall consist of two (2) runs in opposite directions over the same route.

2.9.3.1 The vehicle shall attain a speed of 35 mph (56 kmph) from a standing start within 25 seconds.

2.9.3.2 If the apparatus is designed to respond on public roads as an emergency vehicle, it shall attain a minimum top speed of 50 mph (80 kmph).

2.9.4 The service brakes shall bring the fully laden apparatus to a complete stop from an initial speed of 20 mph (32 kmph) in a distance not exceeding 35 ft (10.7 m) by actual measurement on a hard, level surface road that is free of loose material, oil, or grease.

2.10 Tests on Delivery. If acceptance tests are desired at the point of delivery, they shall be run in accordance with the provisions of this standard and shall duplicate the tests that the purchaser specifies.

2.11 Apparatus Certification. The manufacturer or organization responsible for the final assembly of the fire apparatus shall document that the following criteria have been met.

(1) The weight of the completed apparatus, when fully loaded and equipped as defined in Section 3.1, does not exceed the GVWR and GAWR ratings of the chassis.
(2) The complete unit, when fully loaded and equipped as defined in Section 3.1, meets the weight distribution and vehicle stability requirements, as defined in Section 2.5.
(3) The unit meets all required federal standards pertaining to the manufacture and completion of the fire apparatus, and the manufacturer shall affix a label or tag to the apparatus stating the same.

2.12 Data Required of the Contractor. The contractor shall supply, at the time of delivery, at least one copy of the following:

(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
f. Rear tire size and total rated capacity in pounds
g. Chassis weight distribution in pounds with water and manufacturer mounted equipment (front and rear)
h. Engine make, model, serial number, rated horsepower and related speed per SAE J690, *Certificates of Maximum Net Horsepower for Motor Trucks and Truck Tractors*, and governed speed
i. Type of fuel and fuel tank capacity
j. Electrical system voltage and alternator output in amperes
k. Battery make, model, and capacity in Cold Cranking Amperes (CCA)
l. Chassis transmission make, model, and serial number; if so equipped, chassis transmission PTO(s) make, model, and gear ratio
m. Pump make, model, rated capacity in gallons per minute (liters per minute where applicable) and serial number
n. Pump transmission make, model, serial number, and gear ratio
o. Auxiliary pump make, model, rated capacity in gallons per minute (liters per minute where applicable and serial number
p. Water tank certified capacity in gallons or liters
q. Paint numbers
r. Company name and signature of responsible company representative

(2) The pump manufacturer's certification of suction capability
(3) The pump manufacturer's certification of hydrostatic test
(4) The certification of inspection and test by the pump manufacturer or contractor
(5) Weight documents from a certified scale showing actual loading on the front axle, rear axle(s), and overall vehicle (with the water tank full but without personnel, equipment, and hose)
(6) Written load analysis and results of the electrical system performance tests required in Chapter 4

Chapter 3 Chassis and Vehicle Components

3.1* Carrying Capacity.

3.1.1* The GAWR and GVWR of the chassis shall be adequate to carry the weight of the fully equipped fire apparatus. That weight shall include the full water tanks, fuel tanks, and all other reservoirs; the designed hose load; the equipped personnel weight; and a miscellaneous equipment allowance at least equal to the weight as shown in Table 3.1.1.

Table 3.1.1 Minimum Miscellaneous Equipment Allowance

Chassis GVWR		Equipment Weight	
lb	**kg**	**lb**	**kg**
5,000–10,000	2,268–4,536	300	136
10,001–15,000	4,537–6,803	500	227
15,001–20,000	6,804–9,072	1,000	454
20,001–26,000	9,073–11,804	1,500	681
26,000 and up	11,805 and up	2,000	908

3.1.2 The equipped personnel weight shall be calculated at 250 lb (113 kg) per person multiplied by the number of seating positions on the apparatus.

3.2 Engine and Engine System Design.

3.2.1* Engine Speed Control. 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; this shall be the maximum governed speed.

3.2.1.1* Automatic engine shutdown systems shall be permitted where they are an integral part of the standard engine management system. They shall also be permitted to automatically shut down the pump drive engine when the pump is out of water, provided that the system must be manually armed.

3.2.1.2 The installation of the engine, and transmission, and engine- and transmission-driven accessories (PTOs, etc.) installation shall meet the engine and transmission manufacturer's installation recommendations for the service intended.

3.2.2 Cooling System.

3.2.2.1* The cooling system of the engine shall be adequate to 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.

3.2.2.2 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. Drain valves shall be designed such that they will not open accidentally due to vibration.

3.2.2.3 The radiator shall be mounted to prevent the development of leaks caused by twisting or straining where the apparatus operates over uneven ground. Radiator cores shall be compatible with commercial antifreeze solutions.

3.2.3 Lubrication System.

3.2.3.1* The engine shall be provided with an oil filter of the type approved by the engine manufacturer.

3.2.3.2 The engine oil fill-pipe shall be large enough and located so as to allow easy filling.

3.2.3.3 A permanent plate in the driving compartment shall specify the quantity and type of the following fluids used in the vehicle:

(1) Engine oil
(2) Engine coolant
(3) Chassis transmission fluid
(4) Pump transmission lubrication fluid
(5) Pump primer fluid
(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

3.2.4 Fuel and Air Systems.

3.2.4.1 Diesel Engines.

3.2.4.1.1* A dry-type air filter shall be provided in the diesel engine's intake air system. Air inlet restriction shall not exceed the engine manufacturer's recommendations. The inlet shall be protected to prevent burning embers and water from entering the air intake system.

3.2.4.1.2* The fuel supply lines and fuel filters shall meet the engine manufacturer's recommendations.

3.2.4.1.3* 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. When the system is not being intentionally operated, it shall be isolated from the fuel system and inoperable.

3.2.4.2 Gasoline Engines.

3.2.4.2.1* A dry-type air filter shall be provided in the gasoline engine's intake air system. Air inlet restriction shall not exceed the engine manufacturer's recommendations. The inlet shall be protected to prevent burning embers and water from entering the intake system.

3.2.4.2.2 All fuel lines and filters or strainers shall meet the engine manufacturer's recommendations, along with the requirements found in 49 *CFR* 393 E, "Fuel Systems." 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. The line(s) shall be protected from mechanical damage.

3.2.5* Exhaust System. 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. Exhaust pipe discharge shall be directed away from the pump operator's position. Silencing devices shall be provided. Exhaust back pressure shall not exceed the limits specified by the engine manufacturer. Where parts of the exhaust system are exposed in a manner likely to cause injury to operating personnel, protective guards shall be provided.

3.3 Vehicle Components.

3.3.1 Braking System.

3.3.1.1* 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 the use of air horns or other air-operated accessories when the system's air gage pressure drops below 80 psi (552 kPa)

3.3.1.2* Parking brakes shall control the rear wheels, or all wheels, and shall be of the positive, mechanically actuated type. The parking brake system shall hold the fully loaded apparatus on at least a 20 percent grade. 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.

3.3.1.3 The service brakes shall be capable of bringing the fully laden apparatus to a complete stop from an initial speed of 20 mph (32 kmph), in a distance not exceeding 35 ft (10.7 m) by actual measurement, on a hard, level surface road that is free of loose material, oil, or grease.

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

3.3.1.5* Any time a secondary braking device such as transmission retarders and exhaust restriction devices are used, they shall have a switch to turn them off during adverse road conditions.

3.3.2 Suspension and Wheels.

3.3.2.1 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 the Tire and Rim Association — Year Book, or as recommended by the tire manufacturer, when the apparatus is loaded as indicated in Section 3.1. Compliance shall be determined by weighing the load supported by the tires on each axle, with all movable loads located, as they would be with the apparatus in service.

3.3.2.2* The minimum axle housing clearance and ground clearance shall be as specified in Table 3.3.2.2.

Table 3.3.2.2 Under-Vehicle Clearance

Chassis GVWR		Axle Housing Clearance		Ground Clearance	
lb	kg	in.	mm	in.	mm
5,000–10,000	2,268–4,536	6	152	9	229
10,001–15,000	4,537–6,803	8	203	12	305
15,001–20,000	6,804–9,072	9	229	13	330
20,001–26,000	9,073–11,804	10	254	15	381
26,001 and up	11,805 and up	10	254	15	381

3.3.2.3* An angle of approach and an angle of departure of at least 20 degrees shall be maintained at the front and rear of the vehicle when it is loaded as indicated in Section 3.1.

3.3.2.4 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.*

3.3.2.5 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 non-driving front axles, and at least 28 degrees for driving front axles. Power steering or power-assisted steering shall be provided.

3.3.3 Power Train.

3.3.3.1* Transmission. The transmission shall be rated for heavy duty service and shall be designed to match engine torque and speed to the load demand. 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.

3.3.3.2 Power Train Capability.

3.3.3.2.1 All components in the power train, from the engine to the pump, and from the engine to the driving axles, shall be capable of transmitting available torque necessary to power the pump, as installed in the apparatus, for the pump performance rating, without exceeding the component manufacturer's continuous duty torque/speeding rating.

3.3.3.2.2 When pumping continuously at each of the pump performance points specified in 7.1.1, 7.1.2, or 7.1.3, 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.

3.3.3.2.3* The power train shall allow the vehicle to function and operate smoothly at 2 mph (3.2 kmph).

3.3.4 Fuel Tanks.

3.3.4.1* A minimum of a single original equipment manufacturer fuel tank shall be permitted. Any additional fuel system tanks or components shall meet 49 *CFR* 393 E, "Fuel Systems."

3.3.4.2 A label near the tank fill opening shall indicate the proper fuel.

3.3.4.3 The tank fill piping shall be positioned so it is protected from mechanical damage during the normal use of the fire apparatus, and both the tank and the fill piping shall be positioned so they are not exposed to heat from the exhaust system or other source of ignition.

3.3.4.4 Gasoline-fueled chassis shall have fuel withdrawal fittings above the normal fuel level, as called for in 49 *CFR* 393.67, "Liquid Fuel Tanks."

3.3.5 Towing Attachment Points and Hardware. Tow hook(s) or tow eye(s) shall be attached directly to the frame structure to provide a means to allow recovery from the front and rear. Hardware shall have a clear and unobstructed access.

Chapter 4 Low-Voltage Electrical Systems and Warning Devices

4.1* General. Any 12-volt or 24-volt electrical systems or warning devices installed on the fire apparatus shall be appropriate for the service intended and shall meet the specific requirements of Chapter 4.

4.2 Wiring. All electrical circuit feeder wiring supplied and installed by the fire apparatus manufacturer shall meet the requirements of 4.2.1 through 4.2.8.

4.2.1* The wire shall be stranded copper or copper alloy conductors of a gage rated to carry 125 percent of the maximum current for which the circuit is protected. Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent. The use of star washers for circuit ground connections shall not be permitted. All circuits shall otherwise be wired in conformance with SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring.*

4.2.2 Wiring and Wire Harness Construction.

4.2.2.1 All insulated wire and cable shall conform to SAE J1127, *Battery Cable;* SAE J1128, *Low Tension Primary Cable,* type SXL, GXL or TXL; or SAE J1560, *Low Tension Thin Wall Primary Cable.*

4.2.2.1.1 All conductors shall be constructed in accordance with SAE J1127, *Battery Cable;* SAE J1128, *Low Tension Primary Cable;* or SAE J1560, *Low Tension Thin Wall Primary Cable;* except when good engineering practice dictates special strand construction. 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.

4.2.2.1.2 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127, *Battery Cable;* SAE J1128, *Low Tension Primary Cable;* or SAE J1560, *Low Tension Thin Wall Primary Cable;* except when good engineering practice dictates special conductor insulation.

4.2.2.2 The overall covering of conductors shall be moisture-resistant loom or braid. This covering shall have a minimum continuous rating of 194°F (90°C) except when good engineering practice dictates special consideration for loom installations exposed to higher temperatures.

4.2.3 The overall covering of jacketed cables shall be moisture resistant and have a minimum continuous temperature rating of 194°F (90°C) except when good engineering practice dictates special consideration for cable installations exposed to higher temperatures.

4.2.4 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection and shall be installed in accordance with the device manufacturer's instructions. Wire nut, insulation displacement, and insulation piercing connections shall not be used.

4.2.5 Wiring shall be restrained to prevent damage caused by chafing or ice buildup, and protected against heat, liquid contaminants, or other environmental factors.

4.2.6* 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 schema. *(See 2.8.3.)*

4.2.7 Circuits shall be provided with properly rated low-voltage overcurrent protective devices. Such devices shall be readily accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray. Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices. 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*

4.2.8 Switches, relays, terminals, and connectors shall have a direct current (dc) rating of 125 percent of maximum current for which the circuit is protected.

4.3 Power Supply.

4.3.1* A 12-volt or 24-volt electrical alternator shall be provided. It shall have a minimum output at idle to meet the minimum continuous electrical load of the fire apparatus as defined in 4.3.2, at 200°F (93°C) ambient temperature within the engine compartment, and shall be provided with full automatic regulation.

4.3.2 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 clearance and marker lights, headlights, and other electrical devices mandated by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, *Lamps, reflective devices, and associated equipment,* and other laws or regulations

(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 amperes continuous shall be used.)

(4) The lighting necessary to produce 1 footcandle (11 lx) of illumination on all walking surfaces on the apparatus and on the ground at all egress points onto and off the apparatus, 5 footcandles (54 lx) of illumination on all control and instrument panels, and 50 percent of the total compartment lighting loads

(5) The minimum optical warning system required in Section 4.8, where the apparatus is blocking 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 defined by the purchaser as critical to the mission of the apparatus

4.3.3* The condition of the low-voltage electrical system shall be monitored by a system that provides an audible and visual warning to persons on, in, or near the apparatus of an impending electrical system failure caused by the excessive discharge of the battery set. The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the system voltage. If system voltage is monitored, the alarm shall sound if the system voltage at the battery or at the master load disconnect switch drops below 11.8 volts for 12-volt nominal systems or 23.6 volts for 24-volt nominal systems for more than 120 seconds.

4.3.4 A voltmeter shall be mounted on the driver's instrument panel to allow direct observation of the system voltage.

4.3.5 Load Management.

4.3.5.1* If the total connected electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 4.3.1, an automatic electrical load management system shall be required.

4.3.5.2 The minimum continuous electrical loads defined in 4.3.2 shall not be subject to automatic load management.

4.4* Batteries.

4.4.1 Batteries shall be of the high-cycle type.

4.4.2 The battery system shall be able to restart the engine after providing the minimum continuous electrical load for at least 10 minutes with the engine off. The minimum continuous electrical load shall not discharge the battery system by more than 50 percent of the reserve capacity rating during the 10-minute period.

4.4.3 The battery system CCA rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer.

4.4.4 The batteries shall be mounted to prevent movement during fire apparatus operation and shall be protected against road spray.

4.4.4.1* The batteries shall be readily accessible for examination, test, and maintenance.

4.4.4.2* Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes. The batteries shall also be protected against vibration and temperatures that exceed the battery manufacturer's recommendation.

4.4.5* The alternator shall be wired directly to the batteries through the ammeter shunt(s), if one is provided, and not through the master load disconnect switch.

4.4.6 To minimize the load placed on the electrical system during apparatus start-up for an emergency response, a sequential switching device shall be permitted to energize the optical warning devices required in 4.3.2 and other high-current devices. Where incorporated, the switching device shall first energize the electrical devices required in 4.3.2 within 5 seconds.

4.5 Starting Device.

4.5.1 An electrical starting device shall be provided for the engine.

4.5.2 Where 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.*

4.6 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.

4.7* Electromagnetic Interference. Electromagnetic interference suppression shall be provided, as required, to satisfy the radiation limits specified in SAE J551-2, *Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats and Spark-Ignited Engine-Driven Devices.* The purchaser shall indicate if testing and certification under SAE J551-2 is required.

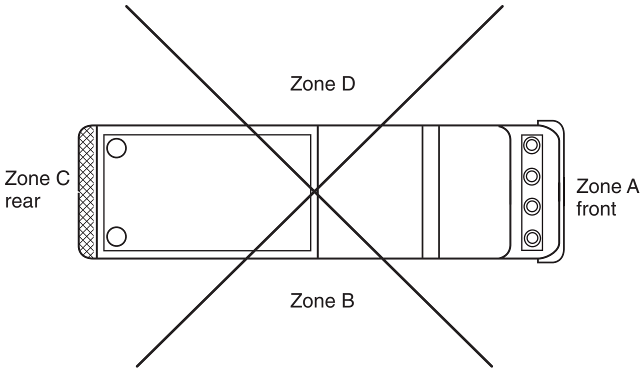
4.8* Optical Warning Devices. Each apparatus that responds on public roads as an emergency vehicle by calling for or blocking the right-of-way from other traffic shall have a system of optical warning devices that meets or exceeds the requirements of this section. If the vehicle is not equipped to call 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.

4.8.1* The optical warning system shall consist of an upper and lower warning level. 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.

4.8.2 For the purpose of defining and measuring the required optical performance, the upper and lower warning levels shall each be divided into four warning zones. The four zones shall be determined by drawing lines through the geometric center of the apparatus at 45 degrees to a line lengthwise of the apparatus through the geometric center. 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 4.8.2.)*

FIGURE 4.8.2 Warning zones for optical warning devices.



4.8.3 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.

4.8.4 A master optical warning device switch that energizes all of the optical warning devices shall be provided.

4.8.5 The optical warning system on the fire apparatus shall be capable of two separate signaling modes during emergency operations. One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way. The other mode shall signal that the apparatus is stopped and is blocking the right-of-way.

4.8.6* A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission. When the master optical warning system switch is closed 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. When the master optical warning system switch is closed 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. The system shall be permitted to have a method of modifying the two signaling modes.

4.8.7 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).

4.8.8 The front optical warning devices shall be placed so as to maintain the maximum possible separation from the headlights.

4.8.9 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.

4.8.10* Flash Rate.

4.8.10.1 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.

Steady burning nonflashing optical sources shall be permitted to be used. The optical energy provided by these nonflashing optical sources shall not be included in the calculations of the zone's total optical power.

4.8.10.2 The flasher of any current-interrupted flashing device shall otherwise meet the requirements of SAE J1054, *Warning Lamp Alternating Flashers*.

4.8.11* Permissible colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 4.8.11. All colors shall be as specified in SAE J578, *Color Specification*, for red, blue, yellow, or white.

Table 4.8.11 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

4.8.12* Requirements for Large Apparatus. 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 4.8.12.1 through 4.8.12.5 shall apply.

4.8.12.1 The upper-level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practical in order to define the clearance lines of the apparatus. However, these 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 100 ft (30.5 m) from the optical warning device of less than 50 percent of that required at the optical center.

4.8.12.2 In order 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 forward of the front axle centerline and as close to the front corner points of the apparatus as is practical. The optical center of the lower-level optical warning devices at the rear of the vehicle shall be mounted behind the rear axle centerline and as close to the rear corners of the apparatus as is practical. The optical center of any lower-level device shall be between 18 in. and 62 in. (457 mm and 1575 mm) above level ground.

4.8.12.3* A midship optical warning device shall be mounted on both the right and left sides of the apparatus with the optical center of the device at a distance between 18 in. and 62 in. (457 mm and 1575 mm) above level ground if the distance between the front and rear lower-level optical devices exceeds 25 ft (7.6 m) at the optical center. 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.

4.8.12.4* 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 4.8.12.4.

4.8.12.5 No individual measurement point shall be less than that shown in Table 4.8.12.4.

Table 4.8.12.4 Minimum Optical Power Requirements for Large Apparatus

		Mode of Operation					
		Clearing Right-of-Way			Blocking Right-of-Way		
Zone	Level	H	At Any H Point	At Any Point 5° Up or 5° Down from H	H	At Any H Point	At Any Point 5° Up or 5° 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.

4.8.13* Requirements for Small Apparatus. 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 4.8.13.1 through 4.8.13.4 shall apply.

4.8.13.1 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. They 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.

4.8.13.2 One or more lower-level optical warning devices shall be mounted as close as practical to each front corner of the apparatus with the optical center of the device at a distance between 18 in. and 48 in. (457 mm and 1220 mm) above level ground.

4.8.13.3 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 4.8.13.3.

4.8.13.4 No individual measurement point shall be less than that shown in Table 4.8.13.3.

4.8.14 Tests of Optical Warning Devices.

4.8.14.1 Mechanical and Environmental Test. All optical warning devices including those tested under SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*, and SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, shall be tested in conformance with SAE J845, *360 Degree Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*. All devices 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

Exception: Optical devices and components designed for mounting only in weatherproof, interior spaces shall be required to comply only with the vibration test and the warpage test for plastic components.

Table 4.8.13.3 Minimum Optical Power Requirements for Small Apparatus

	Mode of Operation					
	Clearing Right-of-Way			Blocking Right-of-Way		
Zone	H	At Any H Point	At Any Point 5° Up or 5° Down from H	H	At Any H Point	At Any Point 5° Up or 5° 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	10,000	3,500
C	400,000	10,000	3,500	800,000	10,000	3,500
D	200,000	8,000	3,500	200,000	10,000	3,500

Notes:
1. All values are in candela-seconds/minute.
2. H = Horizontal plane passing through the optical center.

4.8.14.2 Photometric Test Procedures for Optical Devices. Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 4.8.14.2.1 through 4.8.14.2.4. The results of the testing shall be used by the apparatus builder or purchaser to determine compliance with this standard. The goniometer, integrating photometer, and other equipment used to take the test measurements shall meet the requirements of SAE J1330, *Photometry Laboratory Accuracy Guidelines*.

4.8.14.2.1 The optical source shall be mounted in a goniometer and operated as it would be in a normal system application. 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). The goniometer shall be oriented and the integrating photometer shall be set to integrate light pulses from the source for 20 seconds.

4.8.14.2.2 For all tests performed with the power applied, the lighting system, or component thereof, shall be operated at 12.8 volts ±0.1 volt for 12-volt rated equipment and 25.6 volts ±0.2 volt for 24-volt rated equipment measured at the point of entry into the component. If the equipment is rated for operation on both 12 volts and 24 volts, the tests shall be performed at both voltages.

4.8.14.2.3 The technique described in 4.8.14.2.1 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 right of the optical center throughout the active horizontal angle of light emission of the optical source.

4.8.14.2.4 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 a line passing through the optical center, and perpendicular to the horizontal plane and passing through the optical center. The measurements shall be repeated at 5-degree intervals to the left and right of this line throughout the active horizontal angle of light emission of the optical source. If the optical warning device contains more than one optical source, the test shall be repeated for each optical source.

4.8.15* Certification of Compliance. The apparatus manufacturer shall be permitted to demonstrate compliance of the warning system by one of the following methods.

(a) Certification that the system was installed within the geometric parameters specified by the manufacturer of the system and referencing the optical source test reports provided by the manufacturer of the system.

(b) Certification that a mathematical calculation performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements of this standard. This calculation shall be based on test reports for individual optical sources provided by the manufacturer of the device.

(c) Actual measurement of the lighting system after installation on the apparatus.

4.9 Audible Warning Devices.

4.9.1 Audible warning equipment in the form of at least one automotive traffic horn shall be provided on the fire apparatus.

4.9.2* If the apparatus responds as an emergency vehicle on public roads, one electric or electronic siren shall be provided. The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*. A means shall be provided to allow the activation of the siren within convenient reach of the driver.

4.9.3 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 practical. Audible warning equipment shall not be mounted on the roof of the apparatus.

4.10 Work Lighting.

4.10.1 The work area immediately behind the vehicle shall be illuminated to a level of at least 3 footcandles (33 lx) within a 10 ft × 10 ft (3 m × 3 m) square to the rear of the vehicle. If a hose bed is provided, lighting on this hose bed shall be at a level of 3 footcandles (33 lx) or higher. Lateral hose beds (crosslays) that are permanently covered shall not be required to be illuminated.

4.10.2 The fire apparatus shall be equipped with lighting that is capable of providing illumination at a minimum level of 1 footcandle (11 lx) on ground areas within 30 in. (762 mm) of the edge of the apparatus in areas designed for personnel to climb onto the apparatus or descend from the apparatus to the ground level. Lighting designed to provide illumination on areas under the driver and crew riding area exits shall be activated automatically when the exit doors are opened. All other ground area lighting shall be switchable. *(For pump control panel light requirement, see 7.7.2.)*

4.10.3 Apparatus shall have sufficient lighting to provide an average minimum level of 1 footcandle (11 lx) in the crew compartment(s), the engine compartment, the pump compartment, and each enclosed tool and equipment compartment greater than 4 ft^3 (0.11 m^3) in volume and having an opening greater than 144 $in.^2$ (92,900 mm^2), as well as on all work areas, steps, and walkways.

4.10.4 Switches for all work lighting shall be readily accessible. The lights shall be arranged to minimize accidental breakage.

4.11 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*.

4.12 Stop, Tail, and Directional Lights. The apparatus shall be equipped with all stop, tail, and directional lights required by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, *Lamps, reflective devices, and associated equipment*. Equipment shall be mounted so that it will not obscure the rear stop, tail, and directional lights. Directional lights shall be visible from the front, sides, and rear of the apparatus. 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.

4.13 Electrical System Performance Tests.

4.13.1* The fire apparatus low-voltage electrical system shall be tested and certified. The certification shall be delivered to the purchaser with the apparatus.

4.13.2 Tests shall be performed when the air temperature is between 0°F and 110°F (–18°C and 43°C).

4.13.3 Test Sequence. The following three tests in 4.13.3.1 through 4.13.3.3 shall be performed in the order in which they appear. 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. Failure of any of these tests shall require a repeat of the sequence.

4.13.3.1 Reserve Capacity Test. 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. The engine shall be shut off and the minimum continuous electrical load shall be activated for 10 minutes. All electrical loads shall be turned off prior to attempting to restart the engine. The battery system shall then be capable of restarting the engine. Failure to restart the engine shall be considered a test failure.

4.13.3.2 Alternator Performance Test at Idle. The minimum continuous electrical load shall be activated with the engine running at idle speed. The engine temperature shall be stabilized at normal operating temperature. The battery system shall be tested to detect the presence of battery discharge current. The detection of battery discharge current shall be considered a test failure.

4.13.3.3 Alternator Performance Test at Full Load. The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed. The test duration shall be a minimum of 2 hours. Activation of the load management system shall be permitted during this test. However, an alarm sounded by excessive battery discharge, as detected by the system required in 4.3.3, or a system voltage of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system, for more than 120 seconds, shall be considered a test failure.

4.13.4 Low-Voltage Alarm Test.

4.13.4.1 Following the completion of the tests described in 4.13.3.1 through 4.13.3.3, the engine shall be shut off. The total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates.

4.13.4.2 The battery voltage shall be measured at the battery terminals. With the load still applied, a reading of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system shall be considered a test failure.

4.13.4.3 The battery system shall then be able to restart the engine. Failure to restart the engine shall be considered a test failure.

4.14 Documentation. At the time of delivery, the manufacturer shall provide the following:

(1) Documentation of the electrical system performance tests
(2) A written load analysis, including the following:
    a. The nameplate rating of the alternator
    b. The alternator rating under the conditions specified in 4.3.1
    c. Each component load specified in 4.3.2 comprising the minimum continuous load
    d. Additional loads that, when added to the minimum continuous load, determine the total connected load
    e. Each individual intermittent load

Chapter 5 Driving and Crew Areas

5.1 General.

5.1.1* 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. Each crew riding position shall be within a fully enclosed personnel area. Materials used within the driving and crew compartment(s) shall comply with Federal Motor Vehicle Safety Standard (FMVSS) No. 302, *Flammability of interior materials*. 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 conforming to the Federal Motor Vehicle Safety Standard (FMVSS) No. 209, *Seat belt assemblies*. All seat belt assembly anchorages shall conform to the Federal Motor Vehicle Safety Standard (FMVSS) No. 210, *Seat belt assembly anchorages*.

5.1.2 Signs that read "Occupants must be seated and belted when apparatus is in motion" shall be provided. They shall be visible from each seated position. A label that states the number of personnel the vehicle is designed to carry shall be located in an area visible to the driver.

5.1.3 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), except that the test shall be performed with the vehicle traveling at a steady speed of 45 mph (72 kmph) on a level, hard, smooth surface road.

5.1.4 All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening. Door handles shall meet Federal Motor Vehicle Safety Standard (FMVSS) No. 206, *Door lock and door retention components*.

5.1.5 Head height at any seat shall be at least 37 in. (940 mm) from the seat to the ceiling with the seat depressed 1 in. (25 mm). Each seating space shall have a minimum width of 22 in. (560 mm) at the shoulder level. Seat cushions shall be a minimum of 18 in. (457 mm) in width and 15 in. (381 mm) from the front of the cushion to the face of the seat back. A back cushion that extends from the face of the seat vertically at least 18 in. (457 mm) and that is a minimum of 18 in. (457 mm) wide shall be provided. The back cushion shall be permitted to be split to accommodate a fully recessed self-contained breathing apparatus (SCBA) and bracket. Where the back cushion is split, a headrest shall be supplied.

5.1.6* Where SCBA units are mounted within a driving or crew compartment, a positive mechanical means of holding the SCBA device in its stowed position shall be provided. The bracket holding device and its mounting shall retain the SCBA unit when subjected to a 9-G force and shall be installed in accordance with the bracket manufacturer's requirements.

5.1.7 All equipment required to be used during an emergency response shall be securely fastened. 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 a fully enclosed and latched compartment capable of containing the 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.

5.1.8 Steps and access handrails that comply with 6.4.1, 6.4.2, 6.4.3, and Section 6.5 shall be provided as necessary for access to all driving and crew compartments.

5.1.9 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.

5.2 Cab Tilt Systems. If the fire apparatus has a cab tilt system, the system shall meet the requirements of 5.2.1 through 5.2.3.

5.2.1 If the operation of the tilt cab system is accomplished by air hydraulic means, the system shall be equipped with devices to prevent the motion of the cab in the event of any hydraulic hose failure.

5.2.2 If the cab has a powered tilting system, the system shall be interlocked to operate only when the parking brake is engaged. This system shall be configured so that the failure of a single component will not result in unintentional tilting of the cab.

5.2.3 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. A mechanical means shall be provided to hold the cab in a fully raised position. 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.

5.3* Driving Compartment.

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

5.3.2 The driver's seat shall be readily adjustable by the driver. The seat shall be arranged to accommodate a human conforming to at least the fifth percentile female through 95th percentile male as defined in SAE J833, *Human Physical Dimensions*.

5.3.3* 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.

5.3.4* 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) Odometer
(3) Oil pressure indicator or gage
(4) Coolant temperature indicator or gage
(5) Voltmeter
(6) Brake air pressure gage(s), if applicable
(7) Turn signal control and indicator lights
(8) Headlight/DOT light switch
(9) High beam headlight switch and indicator
(10) Fuel level gage(s)
(11) Heater/defroster controls
(12) Warning lights and siren switches, if applicable
(13) "Battery on" indicator light
(14) Windshield wipers and windshield washer control
(15) PTO-engaged indicator, if applicable

5.3.5 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.

Chapter 6 Body, Compartments, and Equipment Mounting

6.1 Compartmentation.

6.1.1* Any enclosed external compartments shall be weather resistant, dust resistant, water resistant, and have provision for drainage of moisture.

6.1.2 All electrical junctions or wiring within compartments shall be protected from mechanical damage resulting from equipment stored in the compartment. All terminal strips shall have protective covers.

6.2* Radio Space. A protected space or a compartment shall be provided for the installation of radio equipment.

6.3* Equipment Containment. Equipment holders or compartments shall be provided for all tools, equipment, and other items that are on the fire apparatus. Equipment holders shall be attached and shall be designed so that equipment remains in place under all vehicle operating conditions. All tools and equipment shall be readily accessible.

6.4 Stepping, Standing, and Walking Surfaces.

6.4.1* Steps, platforms, or secure ladders shall be provided so fire fighters have access to all working and storage areas of the fire apparatus. The maximum stepping height shall not exceed 18 in. (457 mm), with the exception of the stepping height from the ground to the first step, which shall not exceed 24 in. (610 mm). When it is not possible to maintain the minimum or specified angle of departure using a fixed rear step with the ground to first step height not exceeding 24 in. (610 mm), the first step shall be designed to be movable so as not to be damaged when the vehicle traverses terrain that requires the full angle of departure. All steps shall have a minimum area of 35 in.^{2} (22,580 mm^2), and shall be of such a shape that a 5-in. (127-mm) diameter disk does not overlap any side, when placed on the step, and shall be arranged to provide at least 8 in. (203 mm) of clearance between the leading edge of the step and any obstruction. All platforms shall have a minimum depth of 8 in. (203 mm) from the leading edge of the platform to any obstruction. All ladders shall have at least 7 in. (178 mm) of clearance between any rung and the body or other obstruction.

6.4.2 All steps, platforms, or ladders shall be designed and installed to sustain a minimum static load of 500 lb (227 kg) without deformation.

6.4.3 Slip Resistance.

6.4.3.1* 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 ASTM F 1679, *Standard Test Method for Using a Variable Incidence Tribometer (VIT)*, or 0.52 when tested wet using the Brungraber Mark II Tester in accordance with ASTM F 1677, *Standard Test Method for Using a Portable Inclinable Articulated Strut Slip Tester (PIAST)*. A standard Neolite® test sensor shall be used with either tester.

6.4.3.2 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 ASTM F 1679, *Standard Test Method for Using a Variable Incidence Tribometer (VIT)*, or 0.47 when tested dry using the Brungraber Mark II

Tester in accordance with ASTM F 1677, *Standard Test Method for Using a Portable Inclinable Articulated Strut Slip Tester (PIAST).* A standard Neolite® test sensor shall be used with either tester.

6.4.3.3 Sampling Strategy.

6.4.3.3.1 For uniformly patterned materials, at least 16 readings shall be taken on each sample. Each reading shall be taken 90 degrees clockwise from the previous orientation, resulting in at least 4 readings in each orientation. The readings shall be averaged and reported as the slip resistance for the material.

6.4.3.3.2 For directionally patterned materials, at least 32 readings shall be taken on each sample. Each reading shall be taken 45 degrees clockwise from the previous orientation, resulting in at least 4 readings in each orientation. The 4 readings in each direction shall be averaged and reported as the slip resistance for the material in that orientation.

6.4.3.4 The contractor shall supply at the time of delivery of the 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 6.4.3.

6.4.3.5 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.

6.4.4 An accident prevention sign(s) shall be located on the vehicle at the rear step areas, and at front bumper extensions and cross walkways, if they exist. The sign(s) shall warn personnel that standing on these areas while the vehicle is in motion is prohibited.

6.5* Access Handrails. Access handrails shall be provided at each entrance to a driving or crew compartment and at each position where steps or ladders for climbing are located. Access handrails shall be constructed of or covered with a slip-resistant, noncorrosive material. Handrails shall be between 1 in. and $1^5/_8$ in. (25 mm and 41 mm) in diameter and have a minimum clearance between the handrails and any surface of at least 2 in. (51 mm). All handrails shall be designed and mounted to reduce the possibility of hand slippage and to avoid snagging of hose, equipment, or clothing.

6.6 Metal Finish.

6.6.1* All exposed ferrous metal surfaces that are not plated or stainless steel shall be cleaned and prepared thoroughly and shall be painted or coated. The paint or coating, including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendation.

6.6.2 Each fire apparatus shall have a reflective stripe(s) affixed to the perimeter of the apparatus. The stripe, or combination of stripes, shall be a minimum of 4 in. (100 mm) in total width and shall conform to the minimum requirements of ASTM D 4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Type I, Class 1 or Class 3. At least 50 percent of the cab and body length on each side, at least 50 percent of the width of the rear, and at least 25 percent of the width of the front of the apparatus shall have the reflective material affixed to it. A graphic design meeting the reflectivity requirements of 6.6.2 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 in 6.6.2.

6.7 Hose Storage.

6.7.1 If a hose storage area(s) is provided, the area(s) shall be designed to prevent the accumulation of water and allow for ventilation to aid in drying hose in the storage area. The bottom shall be made of sections fabricated from noncorrosive materials. The interior shall be smooth and free from all projections, such as nuts, sharp angles, or brackets, that might cause damage to the hose. Reels, handrails, ladders, and equipment holders shall not be placed to obstruct the laying or removal of hose from the storage area. If suction hose is to be carried, space shall be provided for carrying the suction hose.

6.7.2 If a hose reel is provided, it shall be equipped with a brake. It shall have a capacity of not less than 100 ft (30 m) of $^3/_4$-in. (19-mm) booster hose. When the reel is equipped with over 100 ft (30 m) of hose, the reel shall have power rewind capability.

6.8 Slip-On Fire-Fighting Module. If the pump, piping, and tank are built as a slip-on, self-contained unit, the unit shall meet the requirements of 6.8.1 through 6.8.3.3. The major components of the slip-on module including the pump and plumbing, pumping engine, water and agent tanks, and electrical system shall meet the requirements of the applicable chapters of this standard covering those components.

6.8.1 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.

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

(1) Weight empty
(2) Weight full of water and other liquids
(3) Horizontal center of gravity when full of water and other liquids
(4) Overall dimensions

6.8.3 Mounting.

6.8.3.1 The slip-on unit shall be mounted in a manner that allows access to the engine, pump, and auxiliary systems for routine maintenance. The slip-on unit shall not be welded or otherwise permanently secured to other components.

6.8.3.2* Anchorage shall be provided on the vehicle chassis and on the slip-on fire-fighting module to secure it to the vehicle chassis. This anchorage shall be designed to prevent movement of the unit during rapid acceleration, deceleration, or during side-hill operation.

6.8.3.3 No drilling on chassis frame flanges or welding to chassis frame shall be permitted.

Chapter 7 Water Pumps

7.1 Performance Requirements. Pumps on wildland fire apparatus shall be rated as either low pressure pumps, medium pressure pumps, high pressure pumps, or extra high pressure pumps.

7.1.1 If the pump is to be rated as a low pressure pump, it shall flow one of the rated capacities stated in Table 7.1.1 at 100 psi (690 kPa) net pump pressure.

Table 7.1.1 Low Pressure Pump Rated Capacities

gpm	L/min
10	38
20	76
30	115
50	190

7.1.2 If the pump is to be rated as a medium pressure pump, it shall be capable of delivering one of the rated capacities stated in Table 7.1.2 under the following conditions:

(1) 100 percent of rated capacity at 150 psi (1035 kPa) net pump pressure

(2) 70 percent of rated capacity at 200 psi (1380 kPa) net pump pressure

(3) 50 percent of rated capacity at 250 psi (1725 kPa) net pump pressure

Table 7.1.2 Medium Pressure Pump Rated Capacities

gpm	L/min
30	115
60	230
90	345
120	460
250	950
350	1325
400	1520
500	1900

7.1.3 If the pump is to be rated as a high pressure pump, it shall flow one of the rated capacities stated in Table 7.1.3 at 300 psi (2070 kPa) net pump pressure.

Table 7.1.3 High Pressure Pump Rated Capacities

gpm	L/min
10	38
20	76
30	115
50	190
100	375
200	750

7.1.4 If the pump is to be rated as an extra high pressure pump, it shall flow one of the rated capacities stated in Table 7.1.4 at 400 psi (2760 kPa) net pump pressure.

Table 7.1.4 Extra High Pressure Pump Rated Capacities

gpm	L/min
10	38
20	76
30	115
50	190
100	375
200	750

7.2* Pumping Suction Capability. The pump manufacturer shall certify that the pump can deliver its rated capacity at rated net pump pressure, under the following conditions:

(1) Up to an altitude of 2000 ft (610 m) above sea level
(2) Through a single inlet with 20 ft (6 m) of suction hose of the size specified in Table 7.2(a) and equipped with a suction hose strainer
(3) With a lift of 10 ft (3 m)
(4) At 29.9 in. Hg (101.2 kPa) atmospheric pressure (corrected to sea level)
(5) At a water temperature of 60°F (16°C)
(6) Entrance and friction for the 20 ft (6 m) of suction hose and strainer listed in Table 7.2(b)

Table 7.2(a) Suction Hose Size by Rated Capacity

Flow Rate		Maximum Suction Hose Size	
gpm	L/min	in.	mm
10	38	1	25
20	76	1 1/2	38
30	115	1 1/2	38
50	190	2	51
60	230	2	51
90	345	2 1/2	65
100	375	2 1/2	65
120	460	2 1/2	65
200	750	3	76
250	950	3	76
350	1325	4	100
400	1520	4	100
500	1900	4 1/2	113

Table 7.2(b) Friction and Entrance Loss in 20 ft (6 m) of Suction Hose, Including Strainer

	Suction Hose Size (Inside Diameter)													
	1 in.		$1^1/_2$ in.		2 in.		$2^1/_2$ in.		3 in.		4 in.		$4^1/_2$ in.	
Flow Rate (gpm)	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
Low Pressure, High Pressure, and Extra High Pressure Pumps														
10	3.0	2.65												
20	11.3	9.97	1.3	1.15										
30			2.7	2.38										
50			7.0	6.18	1.7	1.50								
100					6.2	5.47	2.0	1.77						
200							8.0	7.06	3.3	2.91				
Medium Pressure Pumps														
30			2.7	2.38										
21			1.4	1.24										
15			0.74	0.65										
60			9.6	8.40	2.4	2.12								
42			5.0	4.41	1.2	1.06								
30			2.7	2.38	0.66	0.58								
90					5.4	4.77	1.7	1.50						
63					2.7	2.38	0.78	0.69						
45					1.3	1.15	0.36	0.32						
120					8.6	7.59	2.8	2.47						
84					4.6	4.06	1.4	1.24						
60					2.4	2.12	0.70	0.62						
250							13.0	11.47	5.2	4.59				
175							6.0	5.30	2.6	2.29				
125							3.2	2.82	1.3	1.15				
350									10.0	8.83	2.4	2.12		
245									5.0	4.41	1.2	1.06		
175									2.6	2.29	0.65	0.57		
400											3.2	2.82	2.3	2.03
280											1.6	1.41	1.1	0.97
200											0.8	0.71	0.58	0.51
500											5.0	4.41	3.5	3.09
350											2.4	2.12	1.7	1.50
250											1.3	1.15	0.9	0.79

7.3 Priming.

7.3.1* 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 Section 7.2 through 20 ft (6 m) of suction hose of the size specified in Table 7.2(a) and a strainer, and discharging water in not more than 30 seconds.

7.3.2* 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

7.3.3 The completed pumping system shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) at an altitude of 2000 ft (610 m), by means of the pump priming device and sustaining the vacuum for at least 5 minutes, with a loss not to exceed 10 in. Hg (33.9 kPa). The pump primer shall not be used during the 5-minute period. This shall be demonstrated with all intake valves open, all intakes capped or plugged, all discharge caps removed, and without the use of the pump primer during the 5-minute period.

7.3.4 An automatic method shall be provided to prevent the loss of vacuum or backflow through the priming device. The priming device shall have a manual method to shut the priming device off preventing loss of vacuum and preventing backflow when the priming device is not in use. The method used to shut the priming device off shall be permitted to be a separate device integrated into the primary control.

7.4* Construction Requirements.

7.4.1 Suitable means shall be provided for completely draining the pump and all lines and accessories in cold weather, or provide for the placement of antifreeze.

7.4.2 The pump body shall be tested to a hydrostatic pressure of 100 psi (690 kPa) above the maximum rated close-off pressure or a gage pressure of 300 psi (2070 kPa), whichever is higher, for 10 minutes. The pump manufacturer shall provide a certificate of completion for the hydrostatic test.

7.4.3* The pump impellers, rotors, pistons, vanes, or water contacting gears (if applicable) shall be constructed of a corrosion-resistant material.

7.4.4 Where an auxiliary pump is provided in combination with a water pump 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 its maximum rated hydrostatic pressure.

7.4.5 The entire discharge and intake piping system, valves, drain cocks and lines, and intake and outlet closures, excluding the tank fill and tank to pump lines on the tank side of the valves in those lines, shall be capable of withstanding a minimum hydrostatic burst gage pressure of 300 psi (2069 kPa).

7.4.6 The pump shaft shall be constructed of stainless steel or shall be protected from corrosion.

7.5 Pump Intake.

7.5.1* Intakes of the same or larger size as specified in Table 7.2(a) for suction hose size shall be provided.

7.5.1.1* The intakes specified shall have male national standard hose thread (NH) except 1 in. (25 mm) and 2 in. (51 mm), which shall have national pipe straight hose coupling threads (NPSH).

7.5.1.2 If the couplings on the suction hose carried on the fire apparatus are of a different size or have other means of hose attachments than the threaded connections provided on the intakes, suitable adapters shall be provided on each appropriate intake.

7.5.2 Any 3-in. (76-mm) or larger intake valve shall be a slow operating valve.

Exception: This requirement shall not apply to the tank to pump intake valve.

7.5.3* Each intake shall be provided with piping and a suitable closure that is capable of withstanding 100 psi (690 kPa) over the maximum rated pump close-off pressure or 300 psi (2070 kPa) gage pressure, whichever is higher. Each intake that has male threads shall be equipped with a cap.

7.5.4 Where a cap, plug, or other closure is provided for a $3^1/_2$-in. (89-mm) or smaller intake, it shall be secured to the pumping unit with a suitable chain or cable.

7.5.5* Each intake shall have a removable or accessible strainer inside the connection. The strainer(s) shall restrict spherical debris that is too large to pass through the pump.

7.6 Pump Discharge.

7.6.1* 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 7.6.1.

Table 7.6.1 Flow Rates for Various Outlet Sizes

Outlet Size		Flow Rates	
in.	**mm**	**gpm**	**L/min**
1	25	50	189
$1^1/_2$	38	125	473
$2^1/_2$	65	250	950

7.6.2 Each discharge outlet over 1 in. (25 mm) in size shall be equipped with male national standard hose thread (NH). Adapter couplings with special threads or other means for hose attachment shall be permitted to be furnished on any or all outlets. Discharge outlets 1 in. (25 mm) or less in size shall be permitted to have NPSH thread.

7.6.3 Each discharge outlet, except an outlet to which a hose is to be pre-connected, shall be equipped with a suitable cap or closure that is capable of withstanding 100 psi (690 kPa) over the maximum rated pump close-off pressure or 300 psi (2070 kPa) gage pressure, whichever is higher. Where an adapter is provided on a discharge outlet, the closures shall fit on the adapter. If a cap or closure is provided, it shall be secured to the pumping unit with a suitable chain or cable.

7.6.4* Each discharge outlet shall be equipped with a valve that can be opened and closed smoothly at the flows shown in Table 7.6.1 at pump discharge gage pressures of 250 psi (1724 kPa). 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; 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. Any 3-in. (76-mm) or larger discharge valve shall be a slow operating valve.

7.6.5 Any $2^1/_2$-in. (65-mm) or larger discharge outlet that is located more than 42 in. (1067 mm) above the ground and to which a hose is to be connected, but which is not in a hose storage area, shall be equipped with a sweep elbow of at least 30 degrees downward.

7.6.6 An automatic 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. A check valve shall be included to facilitate priming. Where a foam system is provided, this line shall be plumbed so the water returning to the water tank is free of foam solution.

7.6.7 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 or larger than the nominal inside diameter of the hose to be carried on the reel. A shutoff valve shall be provided between the pump and the reel. High-pressure booster hose of the same nominal size shall be permitted in place of piping.

7.6.8 All discharge valves 1 in. (25 mm) or over in size shall be quarter-turn types.

7.6.9 Where the valve operating mechanism does not indicate the position of the valve, an indicator shall be provided to show when the valve is open.

7.6.10 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.

7.6.11 When a foam eductor is installed, a water-only (no foam) discharge shall be installed.

7.6.12 Valves used on the fireground shall be marked as to their function, such as "Intake," "Tank to Pump," "Pump to Tank," "Discharge," and so forth.

7.7 Pump Operator's Position.

7.7.1 The pump panel and other pump controls, gages, and instruments shall be accessed from ground level, a working platform, or a driver's compartment.

7.7.2 A minimum level of 5 footcandles (54 lx) of illumination shall be provided to illuminate all gages, discharge outlets, pump intakes, and controls.

7.7.3* A test plate shall be provided at the pump operator's position 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 control, and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve. The plate shall be completely stamped with all information at the factory and attached to the vehicle prior to shipping.

7.7.4 The control for the primer shall be capable of being operated by a person operating controls at the primary pump operator's position.

7.8 Gages and Instruments.

7.8.1 A master pump compound gage shall be provided on the pump panel. If a round gage is used, it shall be at least size $2^1/_2$ in accordance with paragraph 3.1 of ASME B40.1, *Gages — Pressure Indicating Dial Type — Elastic Element.* If a digital gage is used, the digits shall be at least $^5/_8$ in. (16 mm) high. It shall read from 30 in. Hg (101.6 kPa) vacuum to at least 100 psi (690 kPa) higher than the maximum pump close-off pressure. The accuracy of the gage shall be a minimum of Grade B as defined in ASME B40.1. Pressure gage shall be connected directly at the pump discharge, before any check valves.

7.8.2 If one or more $2^1/_2$-in. (65-mm) or larger external pump inlets are provided, a pump intake gage shall be provided on the pump panel and shall be located to the left of or below the pump discharge gage. If a round gage is used, it shall be at least size $2^1/_2$ in accordance with paragraph 3.1 of ASME B40.1, *Gages — Pressure Indicating Dial Type — Elastic Element.* If digital gages are used, the digits shall be at least $^5/_8$ in. (16 mm) high. The gage shall read from 30 in. Hg (101.6 kPa) vacuum to at least 300 psi (2069 kPa). The accuracy of the gage shall be a minimum of Grade B as defined in ASME B40.1.

7.8.3 If both an intake gage and a master discharge gage are provided, a label at the intake gage shall read "Pump Intake" and a label at the master discharge gage shall read "Pump Discharge."

7.8.4* Each pressure-indicating device or flowmeter, and its respective display, shall be mounted and attached so it is protected from accidental damage and excessive vibration.

7.9* Pump Controls.

7.9.1 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. Indicator and interlock systems shall be provided as required by this pump control section.

7.9.1.1 Where the pump is driven by the chassis engine and engine compression brakes or engine exhaust brakes are furnished, they shall be automatically disengaged for pumping operations. Where an automatic fan clutch is furnished, the fan shall be engaged for pumping operations.

7.9.1.2 Any control device used in the pumping system power train between the engine and the pump shall be equipped with a means to prevent unintentional movement of the control device from its set position in the pumping mode.

7.9.1.3 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.

7.9.1.4 Where the pump is driven by the chassis engine and transmission through a split shaft PTO, the driving compartment speedometer shall register when the pump drive system is engaged. Where chassis transmission retarders are furnished, they shall be automatically disengaged for pumping operations.

7.9.2* Where the fire apparatus is equipped with an automatic chassis transmission and the water pump is driven by the chassis engine through the transmission main driveline and the apparatus is to be used for stationary pumping only, an interlock system shall be provided to ensure that the pump drive system components are properly engaged in the pumping mode of operation so that the pumping system can be safely operated from the pump operator's position.

7.9.2.1 A "Pump Engaged" indicator shall be provided in the driving compartment to indicate that the pump shift has been successfully completed.

7.9.2.2 An "OK to Pump" indicator shall be provided in the driving compartment to indicate that the pump is engaged, the chassis transmission is in pump gear, and the parking brake is engaged.

7.9.2.3 A "Throttle Ready" indicator shall be provided at the pump operator's panel that indicates that the apparatus is in "OK to Pump" mode or that the chassis transmission is in neutral and the parking brake is engaged.

7.9.3 Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crank shaft 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 shall be provided to ensure that the pump drive system components are properly engaged in the pumping mode of operation, so that the pump system can be safely operated from the operator's position.

7.9.3.1 A "Pump Engaged" indicator shall be provided both in the driving compartment and at the pump operator's position to indicate that the pump shift has been successfully completed.

7.9.3.2 An "OK to Pump" indicator shall be provided in the driving compartment to indicate that the pump is engaged, the chassis transmission is in neutral, and the parking brake is engaged.

7.9.3.3 A "Throttle Ready" indicator shall be provided at the pump operator panel that is energized when the "OK to Pump" indicator is energized or when the chassis transmission is in neutral and the parking brake is engaged.

7.9.4 Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankcase PTO, or engine flywheel PTO, and the apparatus is to be used for either stationary or "pump and roll" pumping with the automatic chassis transmission either in neutral for stationary pumping or in a road gear for pump and roll, an interlock system shall be provided. The interlock system shall ensure that the pump drive system components are properly engaged in the pumping mode of operation so that the apparatus can be safely operated in either stationary or pump and roll pumping mode.

7.9.4.1 A "Pump Engaged" indicator shall be provided both in the driving compartment and at the pump operator panel to indicate that the pump shift has been successfully completed.

7.9.4.2 An "OK to Pump" indicator shall be provided in the driving compartment to indicate that the pump is engaged, the chassis transmission is in neutral, and the parking brake is engaged. An "OK to Pump and Roll" indicator shall be provided in the driving compartment and shall be 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 shall not be energized.

7.9.4.3 A "Throttle Ready" indicator shall be provided at the pump operator's panel that is energized when the "OK to Pump" indicator is energized or when the chassis transmission is in neutral and the parking brake is engaged.

7.9.5 An interlock system shall be provided to prevent advancement of the engine speed at the pump operator's panel unless the chassis transmission is in neutral and the parking brake is engaged, or the apparatus is in "OK to Pump" mode.

7.9.6 With parallel/series centrifugal pumps, the control positions for parallel operation (volume) and series operation (pressure) shall be indicated. The control for changing the pump from series to parallel, and vice versa, shall be operable at the pump operator's position.

7.9.7* Pressure Control Systems.

7.9.7.1 On pumps of 250 gpm (946 L/min) or larger, a system shall be provided that, when set in accordance with the manufacturer's instructions, will automatically control the pressure to a maximum of 30 psi (207 kPa) pressure rise above the set pressure(s) when all discharge valves are closed no more rapidly than in 3 seconds, and no more than in 10 seconds, during all of the following conditions:

(1) Over a range of pressures from 100 psi to 300 psi (690 kPa to 2069 kPa) net pump pressure with intake pressure between –10 psi and 185 psi (–69 kPa and 1276 kPa) and discharge pressure between 90 psi and 300 psi (621 kPa and 2069 kPa)
(2) Over a range of flows from 150 gpm (568 L/min) to the rated capacity of the pump

7.9.7.2 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. 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. Either system shall be controllable by one (1) person at the pump operator position.

7.9.7.3 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.

7.9.7.4 The pressure control system shall be certified as meeting the requirements of 7.9.7.1.

7.10* Pump and Roll Performance. The vehicle drive engine and drive train shall be arranged so that the pump can deliver at least its rated capacity or 20 gpm (76 L/min), whichever is less at a gage pressure of 80 psi (552 kPa), while the fire apparatus is moving at 2 mph (3.2 kmph) or less.

7.11 Required Testing.

7.11.1* General. The pump shall be tested after the pump and all its associated piping and equipment have been installed on the fire apparatus. The tests shall be conducted at the manufacturer's approved facility and certified by the contractor. The testing shall include at least the pumping tests (*see 7.11.2*), the priming device test (*see 7.11.3*), the vacuum test (*see 7.11.4*), the water tank-to-pump flow test (*see 7.11.5*), and the piping integrity test (*see 7.11.6*).

7.11.2 Pumping Tests.

7.11.2.1 Conditions for Tests.

7.11.2.1.1 The test site shall be adjacent to a supply of clear water at least 4 ft (1.2 m) deep, with the water level not more than 10 ft (3 m), or less than 5 ft (1.5 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.

7.11.2.1.2* Tests shall be performed under the following conditions:

(1) Water temperature: 35°F to 90°F (2°C to 32°C)
(2) Barometric pressure (corrected to sea level): 29 in. Hg (98.2 kPa), minimum

7.11.2.1.3 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests.

7.11.2.1.4 All structural enclosures, such as gratings, grills, and heat shields, not furnished with a means for opening in normal service shall be kept in place during the tests.

7.11.2.2 Equipment.

7.11.2.2.1 Suction hose shall be of the size specified in Table 7.2(a) for the rated capacity of the pump.

7.11.2.2.2 A suction hose and strainer that allows flow with total entrance and friction loss not greater than that specified in Table 7.2(b) shall be used.

7.11.2.2.3 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 nozzles 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 $1^1/_2$-in. (38-mm) hose].

7.11.2.2.4 Discharge shall be measured using a smoothbore nozzle and pitot tube or other equipment such as flow meters, volumetric tanks, or weigh tanks.

7.11.2.2.5 All test gages shall meet the requirements for Grade A gages as defined in ASME B40.1, *Gages — Pressure Indicating Dial Type — Elastic Element*, and shall be at least size 32, in accordance with paragraph 3.1 of ASME B40.1. The suction gage shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gage or 30 in. Hg (100 kPa) vacuum to a gage pressure of 150 psi (1035 kPa) for a compound gage. The discharge pressure gage shall have a gage pressure range of zero to 400 psi (0 to 2758 kPa). Pitot gages shall have a gage pressure range of at least zero to 160 psi (0 to 1103 kPa). A mercury manometer shall be permitted to be used in lieu of a pump intake gage. All gages shall have been calibrated in the year preceding the tests. Calibrating equipment shall consist of a dead-weight gage tester or a master gage that meets the requirements for Grade 3A or Grade 4A gages as defined in ASME B40.1 and that has been calibrated by its manufacturer within the preceding year.

7.11.2.2.6 All test gage connections shall include "snubbing" means such as needle valves to damp out rapid needle movements.

7.11.2.2.7 Speed-measuring equipment shall consist of a tachometer or other device for measuring revolutions per minute.

7.11.2.3* Procedure. 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 the pump test.

7.11.2.3.1 The pump shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated net pump pressure. If the pump is stopped before the test is completed, the entire pump test shall be repeated.

7.11.2.3.2 The discharge volume, discharge pressure, suction pressure, and engine speed shall be recorded at least three (3) times at approximately 15-minute intervals. The average net pump pressure shall be calculated and recorded based on the average values for discharge and suction pressure.

7.11.2.3.3 The engine, pump, transmission, and all parts of the fire apparatus shall exhibit no undue heating, loss of power, over-speed, leaks, or other defect during the entire test.

7.11.3 Priming Device Test.

7.11.3.1 With all openings to the pump closed, the primer shall be operated in accordance with the manufacturer's instructions. The maximum vacuum attained shall be at least 17 in. Hg (57.6 kPa). At altitudes above 2000 ft (610 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.6 kPa) by 1 in. Hg (3.4 kPa) per 1000 ft (305 m) of altitude above 2000 ft (610 m).

7.11.3.2 With the pumping unit set up for the pumping test, the primer shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water. The interval from the time the primer is started to the time the pump discharges water shall be recorded. This test shall be permitted to be performed in connection with priming the pump for the pumping test. The time required to prime the pump shall not exceed 30 seconds. Only biodegradable products shall be permitted to be discharged onto the ground.

7.11.4 Vacuum Test. A vacuum test shall be performed and shall consist of subjecting the interior of the pump, with capped intake and capped discharge outlets, to a vacuum of 17 in. Hg (57.6 kPa) by means of the pump's priming device. The vacuum shall not drop more than 10 in. Hg (33.9 kPa) in 5 minutes. The primer shall not be used after the 5-minute test period has begun. The engine shall not be operated at any speed greater than the governed speed during this test.

7.11.5* Water Tank-to-Pump Flow Test. A water tank-to-pump flow test shall be conducted as follows.

(a) The water tank shall be filled until it overflows.

(b) All intakes to the pump shall be closed.

(c) The tank fill shall be closed.

(d) A hose line(s) and nozzle(s) suitable for discharging water at the required flow rate shall be connected to one or more discharge outlets.

(e) The tank-to-pump valve and the discharge valves leading to the hose lines and nozzles shall be opened fully.

(f) The engine throttle shall be adjusted until the required flow rate, –0, +5 percent, is established. The discharge pressure shall be recorded.

(g) The discharge valves shall be closed and the water tank refilled.

(h) The discharge valves shall be reopened fully and the time recorded. If necessary, the engine throttle shall be adjusted to maintain the discharge pressure recorded as noted in 7.11.5(f).

(i) When the discharge pressure drops by 5 psi (34 kPa) or more, the time shall be recorded and the elapsed time from the opening of the discharge valves calculated and recorded.

The required tank-to-pump flow rate shall be maintained until 80 percent of the rated capacity of the tank has been discharged. The volume discharged shall be calculated by multiplying the rate of discharge in gpm by the time in minutes elapsed from the opening of the discharge valves until the discharge pressure drops by at least 5 psi (34 kPa) on level.

7.11.6 Piping Integrity Test. The pump and its connected piping system shall be tested hydrostatically to a gage pressure of 250 psi (1725 kPa) or 100 psi (690 kPa) above rated pump pressure, whichever is less. The hydrostatic test shall be conducted with the tank fill line valve and the tank-to-pump valve closed. All discharge valves shall be open and the outlets capped. All intake valves shall be closed, and non-valved intakes shall be capped. This pressure shall be maintained for 3 minutes.

Chapter 8 Pump Engines

8.1 General. If a separate pump engine drives the pump, that engine shall meet the requirements of Chapter 8.

8.2 Engine and Engine System Design.

8.2.1* 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; this shall be the maximum governed speed.

8.2.2* Automatic engine shutdown systems shall be permitted when they are an integral part of the standard engine management system. They shall also be permitted to automatically shut down the pump drive engine when the pump is out of water, provided the system is required to be manually armed.

8.3 Cooling System.

8.3.1 The engine shall be air cooled or liquid cooled, with a self-contained cooling system. The cooling system of the engine shall be adequate to 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.

8.3.2 If the engine is liquid cooled and equipped with drain valves, they shall be installed at the lowest point of the cooling system and protected.

8.3.3 If the engine is liquid cooled, the radiator shall be mounted to prevent the development of leaks caused by twisting or straining where the apparatus operates over uneven ground. Radiator cores shall be compatible with commercial antifreeze solutions.

8.3.4 If the pump drive engine has a liquid cooling system, a coolant temperature gage or high-temperature indicator light shall be provided on the pump panel.

8.4 Lubrication System.

8.4.1 The engine oil fill-pipe shall be large enough and located so as to allow easy filling.

8.4.2 If the pump drive engine has a positive pressure lubrication system, a low oil pressure indicator or oil pressure gage shall be provided on the pump panel.

8.4.3 Clearance or an extension shall be provided so the engine oil can be drained and captured.

8.5 Fuel and Air System.

8.5.1 Diesel Engines.

8.5.1.1 A dry-type air filter shall be provided. Air inlet restrictions shall not exceed the engine manufacturer's recommendations. The air inlet shall be protected so as to prevent burning embers and water from entering the air intake system.

8.5.1.2 The fuel supply lines and fuel filters shall meet the engine manufacturer's recommendations.

8.5.1.3 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. When the electric fuel priming system is not being intentionally operated, it shall be isolated from the fuel system and inoperable.

8.5.2 Gasoline Engines.

8.5.2.1 A dry-type air filter shall be provided. Air inlet restrictions shall not exceed the engine manufacturer's recommendations. The air inlet shall be protected so as to prevent burning embers and water from entering the air intake system.

8.5.2.2 All fuel lines and filters or strainers shall meet the engine manufacturer's recommendations. 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. The line(s) shall be protected from mechanical damage.

8.6* Exhaust System. The exhaust piping and its discharge shall be located so as not to expose any portion of the unit to excessive heating. Exhaust pipe discharge shall be directed away from the pump operator's position. The exhaust system shall be provided with an approved spark arrestor unless 100 percent of the exhaust gases pass through a turbo charger. Exhaust back-pressure shall not exceed the limits specified by the engine manufacturer.

8.7 Engine Controls.

8.7.1* A non-keyed switch to start or stop the pump engine shall be furnished and shall be located at the pump operator's panel.

8.7.2* The engine speed shall be permitted to be controlled by an automatic speed controller or a manually adjustable throttle. 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. The throttle shall be located so that it can be manipulated from the pump operator's position with all instrumentation in full view.

8.8 Electrical System and Devices.

8.8.1 The electrical system on the pump engine shall meet the requirements of Section 4.2 and 4.4.4 through 4.4.4.2.

8.8.2 Where a separate battery(s) is provided, a built-in means to charge the battery(s) shall be provided. 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), and shall be provided with full automatic regulation.

8.8.3* Battery power for the separate engine-driven pump shall be permitted to be supplied from the chassis battery(s).

8.9 Starting Device. An electrical starting device shall be provided; its characteristics shall be such that, when operating under maximum load, the voltage drop of the conductors shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits.*

8.10* Fuel Tanks.

8.10.1 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.

8.10.2* The pump engine shall be permitted to draw fuel from the chassis fuel tank, when done in accordance with the chassis manufacturer's recommendation.

8.10.3 Each fuel tank shall be labeled near the fill opening to indicate the type of fuel.

Chapter 9 Water Tanks

9.1 Tank Capacity. A water tank with a minimum capacity of 50 gal (190 L) shall be provided.

9.2 Tank Construction.

9.2.1* The water tank shall be constructed of noncorrosive material or other materials that are protected against corrosion and deterioration. It shall have a means to permit complete cleaning of the tank.

9.2.2* If the water tank is independent of the body and compartments, it shall be equipped with a method for lifting the tank(s) out of the body.

9.2.3 Tanks shall be cradled, cushioned, spring mounted, or otherwise protected from undue stress resulting from travel on uneven terrain. Tanks shall be mounted in accordance with the tank manufacturer's requirements.

9.2.4* All water tanks shall be provided with baffles or swash partitions to form a containment or dynamic method of water movement control.

9.2.4.1 If a containment method of baffling is used, a minimum of one transverse or longitudinal vertical baffles shall be provided. There shall be a maximum distance of 48 in. (1220 mm) between any combination of tank vertical walls and baffles. Each baffle shall cover at least 75 percent of the area of the plane that contains the baffle.

9.2.4.2 If a dynamic method of partitioning is used, the tank shall contain vertical transverse and longitudinal partitions. The vertical partitions shall be secured to the top and bottom of the tank. The longitudinal partitions shall extend a minimum of 75 percent of the tank length. The partitions shall be arranged in such a manner that the vertical plane of each partition shall create cells for which no dimension shall exceed 48 in. (1220 mm).

9.2.5 An indicator shall be provided that shows the level or amount of water in the tank(s). If the fire apparatus is not equipped with a pump, the indicator shall be visible at the inlet valve position.

9.3 Tank to Pump Intake Line. 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 (950 L/min). The valve control shall be located at the pump operator's position. This flow shall be sustainable while pumping a minimum of 80 percent of the certified tank capacity with the fire apparatus on level ground.

9.4 Filling and Venting.

9.4.1* A readily accessible covered fill opening designed to prevent spillage and having a minimum inside diameter of $3^1/_4$ in. (83 mm) shall be provided. The cover shall be marked with a label that reads "Water Fill." An easily removed and cleaned screen shall be installed in the opening. The cover, or another device, shall open as a vent to release pressure buildup in the tank.

9.4.2* Adequate venting of the tanks shall be provided 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 (950 L/min), whichever is lower.

9.4.3* A valved tank fill line, sized in accordance with Table 9.4.3, shall be provided. The valve control shall be located at the pump operator's position.

9.5* Water Tank Capacity Certification. The manufacturer shall certify the capacity of the water tank prior to delivery of the fire apparatus. This capacity shall be recorded on the manufacturer's record of construction (*see Section 2.12*), and the certification shall be provided to the purchaser when the apparatus is delivered.

Table 9.4.3 Size of Tank Fill Line

Pump Size		Tank Size: 250 gal or less (950 L or less)		Tank Size: 251 gal to 999 gal (951 L to 3784 L)		Tank Size: 1000 gal or more (3785 L or more)	
gpm	L/min	in.	mm	in.	mm	in.	mm
60 or less	227 or less	$^3/_4$	19	1	25	1	25
61 to 120	228 to 454	1	25	1.5	38	1.5	38
121 or greater	455 or greater	1	25	1.5	38	2	51

Chapter 10 Equipment Carried on Wildland Fire Apparatus

10.1* Suction Hose. If suction hose is provided, the hose shall comply with NFPA 1961, *Standard on Fire Hose*, and a suction strainer shall be furnished.

10.2* Minor Equipment.

10.2.1 Equipment on the following list shall be available on the wildland fire apparatus before the apparatus is placed in service.

Two solid bottom wheel chocks mounted in a readily accessible location

One approved, dry chemical portable fire extinguisher with a minimum 40-B:C rating mounted in a bracket fastened to the apparatus

One first-aid kit

One set of tire tools including a jack and lug wrench, if a spare tire is carried on the apparatus

One reflective triangle kit

10.2.2 Brackets or compartments shall be furnished to organize and protect the equipment.

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

Chapter 11 Class A Foam Concentrate Proportioning Systems

11.1* Application. If the wildland fire apparatus is equipped with a foam concentrate proportioning system for Class A foam, it shall comply with the applicable sections of Chapter 11.

11.2* Requirements by Type of Foam Proportioning System.

11.2.1* Eductor System. An eductor foam proportioning system shall meet the requirements of 11.3.1 through 11.3.6, 11.3.8, and Sections 11.4, 11.5, 11.6, 11.9, and 11.10.

11.2.2* Self-Educting Master Stream Nozzle. A self-educting master stream nozzle shall meet the requirements of Sections 11.3, 11.4, 11.6, 11.9, and 11.10.

11.2.3* Intake-Side System. An intake-side foam proportioning system shall meet the requirements of Sections 11.3, 11.4, 11.5, 11.6, 11.9, and 11.10.

11.2.4* Around-the-Pump System. An around-the-pump foam proportioning system shall meet the requirements of Sections 11.3, 11.4, 11.5, 11.6, 11.9, and 11.10.

11.2.5* Balanced Pressure System. A balanced pressure foam proportioning system shall meet the requirements of Sections 11.3 through 11.10.

11.2.6* Direct Injection System. A direct injection foam proportioning system shall meet the requirements of Sections 11.3, 11.4, 11.5, 11.6, 11.7, 11.9, and 11.10.

11.2.7* Water-Powered Direct Injection Foam Proportioning System. A water motor or water turbine foam proportioning system shall meet the requirements of Sections 11.3, 11.4, 11.5, 11.6, 11.7, 11.9, and 11.10.

11.3 Design and Performance Requirements of a Foam System.

11.3.1* 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. The foam proportioning system water flow characteristics and the range of proportioning ratio(s) shall be specified by the purchaser.

11.3.2 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.

11.3.3* Components 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 the deterioration of the foam concentrate caused by contact with incompatible materials.

11.3.4 The foam proportioning 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.

11.3.5 The foam concentrate supply line shall not collapse under all operating conditions specified by the manufacturer of the foam proportioning system.

11.3.6 A means shall be provided to prevent water backflow into the foam proportioning system and the foam concentrate storage tank. Where water is supplied directly from a potable water source, a means shall be provided to prevent foam solution backflow into the water source.

11.3.7 A device shall be provided on the foam concentrate supply side of the foam proportioner to prevent any debris that might affect the operation of the foam proportioning system from entering the system. The device shall consist of a removable element and shall allow full flow capacity of the foam supply line.

11.3.8 A foam concentrate system flush line(s) shall be provided as required by the foam system manufacturer. 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. 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.

11.4 Controls for Foam Systems.

11.4.1* The foam proportioning system operating controls shall be located at the pump operator's position and shall be identified as required by 11.9.2.

11.4.2 Foam proportioning systems that require flushing after use shall be provided with readily accessible controls that enable the operator to completely flush the system with water according to the manufacturer's instructions.

11.4.3 Foam proportioning systems that incorporate foam concentrate metering valves shall have each metering valve calibrated and marked with a plate to indicate the rate(s) of the foam concentrate proportioning available as determined by the design of the system.

11.4.4 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.

11.5 Foam System Pressure Indicating Devices, Flow Meters, and Indicators.

11.5.1 The displays of all pressure indicating devices or flow meters, 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 2.3.2.

11.5.2 Where an analog pressure gage is used, it shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gages — Pressure Indicating Dial Type — Elastic Element*. Numerals for master gages shall be a minimum of $^{5}/_{32}$ in. (4 mm) high. There shall be graduation lines showing at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (690 kPa). Analog pressure gages shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gage.

11.5.3 If digital pressure indicating devices are used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa). Digital pressure indicating devices shall have an accuracy of ±3 percent over the full scale.

11.5.4 Each pressure indicating device or flow meter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

11.5.5 A gage(s) shall be provided for balanced pressure foam proportioning systems that simultaneously indicates water pressure and foam concentrate pressure.

11.6 Atmospheric Foam Concentrate Tank. If the foam proportioning system incorporates an atmospheric foam concentrate tank, 11.6.1 through 11.6.12 shall apply.

11.6.1 The foam concentrate tank or tanks 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.

11.6.2 All foam concentrate tanks shall be provided with sufficient swash partitions so that the maximum dimension perpendicular to the plane of any partition shall not exceed 36 in. (915 mm). The swash partition(s) shall extend from wall to wall and shall cover at least 75 percent of the area of the plane of the partition.

11.6.3* The foam concentrate tank shall be provided with a fill tower or expansion compartment that has a minimum area of 12 in.^{2} (7742 mm^2) and that has a volume of not less than 1 percent of the total tank volume. The fill tower opening shall be protected by a completely sealed airtight cover. The cover shall be attached to the fill tower by mechanical means. The fill opening shall incorporate a removable screen with a mesh not to exceed $^{1}/_{4}$ in. (6 mm) and shall be arranged so that foam concentrate from a 5-gal (19-L) container can be dumped directly to the bottom of the tank to minimize aeration without the use of funnels or other special devices.

11.6.4 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. The pressure/vacuum vent shall not allow atmospheric air to enter the foam tank except during operation or to compensate for thermal fluctuations. The vent shall be protected to prevent foam concentrate from escaping or directly contacting the vent at any time. The vent shall be of sufficient size to prevent tank damage during filling or foam withdrawal.

11.6.5 The foam concentrate tank shall not be equipped with an overflow pipe or any direct opening to the atmosphere.

11.6.6* The foam concentrate tank(s) shall be designed and constructed to facilitate complete interior flushing and cleaning as required.

11.6.7 A minimum $^{1}/_{2}$-in. (13-mm) valved drain shall be provided at the lowest point of any foam concentrate tank. The drain shall be piped to drain directly to the surface beneath the fire apparatus without contacting other body or chassis components.

11.6.8* The foam concentrate tank shall be constructed and installed to be independent of the apparatus body.

11.6.9 The foam concentrate discharge system design shall prevent the siphoning of foam concentrate.

11.6.10* A label that reads "Foam Tank Fill" shall be placed at or near any foam concentrate tank fill opening. A label shall be placed at or near any foam concentrate tank fill opening that specifies the following:

(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"

11.6.11 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 vehicle level.

11.6.12 The foam concentrate tank inlet connection, if provided, shall prevent aeration of the foam concentrate under all operating conditions.

11.7* Foam Concentrate Pump. If the foam proportioning system is equipped with a foam concentrate pump, 11.7.1 through 11.7.5 shall apply.

11.7.1 The foam concentrate pump shall operate without cavitation when delivering maximum rated flow.

11.7.2* 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 plate required by 11.9.3.

11.7.3 Drive train components that transmit power to the foam concentrate pump shall be in accordance with the fire apparatus manufacturer's design performance provided on the plate required by 11.9.3.

11.7.4 A means to relieve excess pressure in the foam concentrate pumping system shall be provided to protect the foam concentrate pump from damage.

11.7.5* Foam concentrate pumps that are intended to be supplied from an external source of foam concentrate shall be provided with an external valved intake and discharge connection.

11.8 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, 11.8.1 through 11.8.8 shall apply.

11.8.1 If the tank is charged with a compressed gas or a pressurized liquid, and it falls within the scope of Section VIII, Division 1 of the ASME *Boiler and Pressure Vessel Code*, it shall be designed, fabricated, and stamped in accordance with the requirements of Section VIII, Division 1 of the ASME *Boiler and Pressure Vessel Code*, for the rated pressure.

11.8.2 Foam proportioning system piping and components shall be designed to withstand a minimum of $1^1/_2$ times the maximum working pressure of the pressure vessel and shall be tested to the working pressure of the pressure vessel after installation.

11.8.3 The pressure vessel tank shall be protected against corrosion from the foam concentrate or water stored in the tank.

11.8.4 If the tank is equipped with a gravity fill (i.e., has a fill cap), the fill opening shall be a minimum 2-in. (51-mm) inside diameter.

11.8.4.1 The fill cap shall be equipped with nontapered threads and a compressible gasket.

11.8.4.2 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.

11.8.4.3 A safety vent hole shall be located in the fill cap so that it vents the tank pressure while at least $3^1/_2$ threads remain engaged.

11.8.5 A minimum $^1/_2$-in. (13-mm), manually operated, valved vent shall be provided on all pressure vessel tanks.

11.8.6 If the pressure vessel is charged with a compressed gas or a pressurized liquid, a relief valve that meets the applicable requirements of Section VIII, Division 1 of the ASME *Boiler and Pressure Vessel Code* shall be installed on the pressure vessel and set to prevent the vessel pressure from exceeding 110 percent of the maximum allowable working pressure.

11.8.7 A minimum $^1/_2$-in. (13-mm), manually operated, valved drain connection shall be provided on all pressure vessel tanks.

11.8.8 A device indicating the internal pressure of the pressure vessel shall be located at the operator's position.

11.9 Labels, Plates, and Instructions.

11.9.1 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.

11.9.2 Each control, gage, and indicator necessary to operate the foam proportioning system shall be marked with a label as to its function.

11.9.3* A plate, located at the operator's position, shall provide the following information pertaining to the operating specifications of the foam proportioning system:

(1) Foam classification type (Class A, Class B, or Class A and B)
(2)* Types of foam concentrates compatible with system design *(see Operation Manual)*
(3) Proportioning rate (percent)
(4) Maximum/minimum water flow (gpm)
(5) Maximum/minimum operating pressure

11.9.4 Two copies of an operations and maintenance manual shall be provided. They shall include a complete diagram of the foam system together with operating instructions, system foam concentrate capabilities, original system calibration, and details outlining all recommended maintenance procedures.

11.10* Foam Proportioning System Accuracy. The foam proportioning system shall be accurate throughout the manufacturer's stated range of flow(s) and pressure(s). The accuracy of the foam proportioning system shall be tested by the fire apparatus manufacturer prior to delivery of the apparatus. Systems designed to produce foam solution at ratios of less than 1 percent shall proportion foam concentrate to an accuracy of ±20 percent. Systems designed to produce foam solution at ratios of 1 percent or greater shall proportion foam concentrate to an accuracy of minus 0 plus 30 percent or 1 percentage point, whichever is less.

Chapter 12 Compressed Air Foam Systems (CAFS)

12.1* Application. If the wildland fire apparatus is equipped with a compressed air foam system (CAFS), it shall comply with the applicable sections of Chapter 12.

12.2 General Requirements.

12.2.1 An automatic regulating foam proportioning system shall be used and shall comply with the applicable requirements of Chapter 9.

12.2.2 The total CAFS rating shall be expressed in terms of air and water flow. The air flow shall be expressed in standard cubic feet per minute (scfm) and shall be based on the continuous flow capacity of the compressed air source(s) at a minimum gage pressure of 125 psi (862 kPa). The water flow shall be expressed in gallons per minute (gpm) at a gage pressure of 125 psi (862 kPa).

12.2.3 The fire apparatus shall be capable of supplying power for operating the CAFS at its rated capacity in addition to all other power dependent systems installed on the apparatus.

12.2.4* On CAFS, the water pump and air pressures shall be automatically balanced up to the rated pressure of the air compressor within ±5 percent.

12.2.5* A means shall be provided on all CAFS for the operator to relieve all pressure from the system after the system has been deactivated.

12.3 Compressed Air Source.

12.3.1 The compressed air source operating in clean environment conditions shall be designed to provide a continuous rated supply for 6 hours duration without needing adjustment, addition of lubrication, or changing of air filters.

12.3.2 The compressed air system shall be equipped with an air pressure relief valve that is set to prevent the compressed air system from exceeding 110 percent of the maximum allowable working pressure of the system. The outlet of the relief device shall be routed to an area that does not expose personnel to air blasts or cause the creation of dust.

12.3.3 If the possibility exists for moisture to build up in the compressed air system, the system shall be equipped with moisture drain valves.

12.3.4 If a holding, surge, or separator tank (DOT tank or ASME pressure vessel) is provided, it shall comply with 29 *CFR* 1910.169, "Air Receivers," or equal, for the rated pressure.

12.3.4.1 Transportable air tanks shall comply with 49 *CFR* 178.37, "Specification 3AA and 3AAX Seamless Steel Cylinders," or 29 *CFR* 1910.169, "Air Receivers." Relief valves shall be of the ASME type on ASME cylinders and of the DOT type on DOT cylinders or equal for the rated pressure.

12.3.4.2 Valves installed on air tanks shall meet the requirements of the Compressed Gas Association or equivalent standards regarding pressure and usage with compressed air.

12.3.4.3 Air tanks shall be permanently stamped or identified in accordance with DOT or ASME regulations. If the installation utilizes DOT cylinders, 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.

12.4* Air Mixing.

12.4.1 An automatic means shall be provided to prevent the backflow of all liquids and gases including the backflow of water or foam solution into the compressed air source, air into the water pump, and both water and air into the foam proportioning equipment.

12.4.2 A means of mixing air and foam solution shall be provided on CAFS. The air and foam solution mixing system shall provide homogeneous mixing of the compressed air and foam solution.

12.5* Compressed Air System Piping. The discharge plumbing shall be configured to minimize the use of elbows or abrupt turns.

12.6 Air Source Controls.

12.6.1 All compressed air source controls shall be located at the pump operator's position and shall be identified with a plate in accordance with the requirements of 12.8.1.

12.6.2 CAFS 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.

12.7 Foam System Pressure Indicating Devices, Flow Meters, and Indicators.

12.7.1 The displays of all pressure indicating devices, flow meters, 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 2.3.2.

12.7.2 Where an analog pressure gage is used, it shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gages — Pressure Indicating Dial Type — Elastic Element.* Numerals for master gages shall be a minimum of $^{5}/_{32}$ in. (4 mm) high. There shall be graduation lines showing at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (690 kPa). Analog pressure gages shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gage.

12.7.3 If digital pressure indicating devices are used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa). Digital pressure indicating devices shall have an accuracy of ±3 percent over the full scale.

12.7.4 Each pressure indicating device and flow meter, and its respective display, shall be mounted and attached so it is protected from accidental damage and excessive vibration.

12.7.5 Flow meter displays shall be located at the pump operator's position and shall indicate the airflow in standard cubic feet per minute. The displays shall also indicate the water flow in gallons per minute. Flow meters shall be rated to a hydrostatic burst gage pressure of 500 psi (3447 kPa) if located on the pressure side of the system.

12.7.6* A pressure indicating device shall be provided for the compressed air source.

12.8 Labels and Instruction Plates.

12.8.1 A plate indicating the identification, function, and operation shall be provided for each control, gage, and indicator required to operate the CAFS.

12.8.2 A label shall be provided at the pump operator's position that gives the rated continuous flow capacity of the compressed air source at 125 psi (862 kPa).

12.8.3 An instruction plate shall be provided at the pump operator's position that states the following:

(1) Open and close valves slowly.
(2) Do not run with just air/water.
(3) Shut off air when foam tank is empty.
(4) Be prepared for high nozzle reactions — open nozzle slowly.

12.9* Manufacturer's Predelivery Tests. The manufacturer shall conduct the tests that are detailed in 12.9.1 and 12.9.2 prior to delivery of the fire apparatus.

12.9.1 Capacity Rating Test.

12.9.1.1 The operation of the water pump and the compressed air source shall be tested simultaneously to determine the integrity of the complete system and to ensure that there is adequate power available to operate these components of the CAFS. The compressed air source shall be operated at its flow capacity at a minimum 125 psi (862 kPa), and the water pump shall discharge 2 gpm (7.6 L/min) of water at 125 psi (862 kPa) net pump pressure for every one scfm of compressed air discharge. The discharge shall be through at least two separate discharge openings, one discharging air only and the other discharging water only.

12.9.1.2 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 (1900 L/min) for $2^{1}/_{2}$-in. (65-mm) hose]. The discharge shall be measured using a smoothbore nozzle and pitot tube or other equipment such as flow meters, volumetric tanks, or weigh tanks. Test gages shall meet the requirements of 7.11.2.2.5 and 7.11.2.2.6.

12.9.1.3* The airflow rate shall be measured using a pressure and temperature compensated flow-measuring device. The airflow shall be measured in standard cubic feet per minute (scfm) at a minimum of 125 psi (862 kPa). The airflow-measuring device shall have been calibrated for accuracy within the previous 3 months. The air discharge outlet shall have nothing attached directly to it except the test device(s).

12.9.1.4 The water pump and the compressed air source shall be started and the rated flows and pressures as specified in 12.9.1.1 shall be maintained. The system shall be run for 1 hour. Readings of the airflow rate and pressure, and the water pump pressure and discharge rate shall be taken at least every 10 minutes.

12.9.1.5 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.

12.9.2* Standby Run Test. One 200-ft (61-m) line of $1^1/_2$-in. (38-mm) hose shall be connected to the discharge of the CAFS and shall be stretched out on level ground. A quarter-turn valve of the same nominal size as the hose shall be installed at the discharge end. The hose shall be restrained immediately behind the valve at the discharge end to prevent uncontrollable movement when the valve is opened. Operating as a CAFS, with gage air output at 125 psi (862 kPa), a foam flow shall be established in the hose line. With the water tank at the one-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. The engine(s) speed shall be maintained for 10 minutes without discharging water, air, or foam solution from the CAFS and without operator intervention. A bypass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits. At the end of 10 minutes, the valve shall be reopened no faster than in 3 seconds and no slower than in 10 seconds. Any damage to the system 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.

Chapter 13 Winches

13.1 General. If a chassis-mounted winch is installed on the fire apparatus, it shall meet the requirements of Chapter 13 and SAE J706, *Rating of Winches.*

13.2 Rating.

13.2.1* The winch shall have a minimum single line pull rating of 50 percent of the vehicles rated GVWR.

13.2.2 The winch shall have a minimum wire rope length of 125 ft (38 m). The wire rope shall be of a type and size recommended by the winch manufacturers. The wire rope assembly, including hardware such as clevices, hooks, and snatch blocks provided for attachment to the winch, shall have a design load rating greater than the line pull rating of the winch.

13.3 Electric-Powered Winches.

13.3.1 Controls.

13.3.1.1* Control of the electric motor shall be by means of a handheld switch with forward, neutral, and reverse positions. The switch shall be located at the end of a minimum 25 ft (7.6 m) electrical cord that plugs into a receptacle near the winch location. Alternately, the switch shall be permitted to be located on a handheld transmitter of a Federal Communications Commission (FCC)-approved radio frequency winch control device.

13.3.1.2 A free-spooling clutch shall be provided in addition to the remote control device if the winch is not visible to the operator.

13.3.2 Power Supply. Dedicated power and ground circuits shall be utilized. Wiring shall be sized in accordance with the manufacturer's installation instructions and 4.2.1 of this standard.

13.4 Hydraulic Winches.

13.4.1 All hydraulic hose shall be designed for hydraulic pressures encountered for the specified hydraulic components. Hose shall be a wire braided–type with a female swivel on one end.

13.4.2 Hydraulic Tanks.

13.4.2.1 The hydraulic fluid tank shall be sized to prevent overheating of the fluid or cavitation of the hydraulic pump at its maximum output level.

13.4.2.2 The tank shall permit visual checking of the fluid level and easy refilling. The fill point shall have a label permanently attached near the fill point stating the hydraulic oil quantity and type.

13.4.2.3 A drain plug shall be installed to permit complete draining of the tank.

13.4.2.4 A tank return line diffuser shall be installed in the tank. A tank swash partition shall be installed in the tank between the suction and return lines.

13.4.2.5 A vent shall be supplied and shall be designed to prevent dirt and moisture from entering the tank.

13.4.3 The hydraulic system shall be equipped with necessary filters and strainers to keep the hydraulic fluid within the cleanliness requirements necessary for operation of the system.

13.4.4* The winch shall be equipped with a clutch assembly to permit free-spooling and quick removal of cable. This control shall be accessible without reaching under the fire apparatus. If the winch is installed under the vehicle, it shall be remotely controlled.

13.4.5 Driving Compartment Controls.

13.4.5.1 The hydraulic pump engagement controls shall be located in the driving compartment and shall be marked with a plate indicating their purpose and use.

13.4.5.2 A red light shall be installed in the driving compartment to indicate when the winch drive system is engaged.

Chapter 14 Vehicle Protection Systems

14.1 Brush Rails. If brush rails are installed on the fire apparatus, they shall meet the requirements of 14.1.1 through 14.1.3.

14.1.1 Rails shall be supported directly by members attached to the vehicle chassis frame. 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.

14.1.2 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 fire-fighting equipment.

14.1.3 The rails shall not block the full function of any of the vehicle lighting systems, whether normal travel lights, warning lights, or work area lights on the vehicle.

14.2 Grill Guard. If a grill guard is installed on the fire apparatus, it shall meet the requirements of 14.2.1 through 14.2.4.

14.2.1 The grill guard shall protect the front of the cab, including the headlights and radiator air inlet.

14.2.2 The grill guard shall be supported directly by the bumper at the front of the cab or by members attached to the vehicle chassis frame. The 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.

14.2.3 The guard shall not impede the normal opening of the engine enclosures.

14.2.4 The guard shall not block the full function of any of the vehicle lighting systems, whether normal travel lights, warning lights, or work area lights on the vehicle.

14.3* Skid Plates. If skid plates are installed on the fire apparatus, they shall meet the requirements of 14.3.1 through 14.3.4.

14.3.1 Skid plates shall be installed on nonmovable components that protrude below the normal truck chassis parts.

14.3.2 Skid plates shall be supported directly by the component they are protecting or the chassis frame and shall be removable without the use of welding or cutting equipment.

14.3.3 Skid plates shall not impede the normal function of the vehicle or any of its systems.

14.3.4 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 15 Referenced Publications

15.1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix C.

15.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 1999 edition.

NFPA 1961, *Standard on Fire Hose*, 1997 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1998 edition.

15.1.2 Other Publications.

15.1.2.1 ANSI Publication. American National Standards Institute, Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI Z535.4, *Product Safety Signs and Labels*, 1998.

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

ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 and Division 2, 1998.

ASME B 1.20.7, *Hose Coupling Screw Threads, Inch*, 1991.

ASME B 40.1, *Gages — Pressure Indicating Dial Type — Elastic Element*, 1991.

15.1.2.3 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, 1995.

ASTM F 1677, *Standard Test Method for Using a Portable Inclinable Articulated Strut Slip Tester (PIAST)*, 1996.

ASTM F 1679, *Standard Test Method for Using a Variable Incidence Tribometer (VIT)*, 1996.

15.1.2.4 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J156, *Fusible Links*, 1997.

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

SAE J551-2, *Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats and Spark-Ignited Engine-Driven Devices*, 1996.

SAE J553, *Circuit Breakers*, 1996.

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

SAE J578, *Color Specification*, 1995.

SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*, 1983.

SAE J683, *Tire Chain Clearance — Trucks, Buses (except Suburban, Intercity, and Transit Buses), and Combinations of Vehicles*, 1985.

SAE J690, *Certificates of Maximum Net Horsepower for Motor Trucks and Truck Tractors*, 1964.

SAE J706, *Rating of Winches*, 1985.

SAE J833, *Human Physical Dimensions*, 1989.

SAE J845, *360 Degree Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, 1997.

SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*, 1993.

SAE J1054, *Warning Lamp Alternating Flashers*, 1994.

SAE J1127, *Battery Cable*, 1995.

SAE J1128, *Low Tension Primary Cable*, 1995.

SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring*, 1981.

SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, 1998.

SAE J1330, *Photometry Laboratory Accuracy Guidelines*, 1994.

SAE J1560, *Low Tension Thin Wall Primary Cable*, 1992.

SAE J1849, *Emergency Vehicle Sirens*, 1995.

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

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

15.1.2.5 TRA Publication. The Tire and Rim Association, Inc., 175 Montrose Ave. West, Copley, OH 44321.

Tire and Rim Association — Year Book.

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

Title 29, *Code of Federal Regulations*, Part 1910.169, "Air Receivers."

Title 49, *Code of Federal Regulations*, Part 571, "Federal Motor Vehicle Safety Standards (FMVSS)":

No. 108, *Lamps, reflective devices, and associated equipment*

No. 206, *Door lock and door retention components*

No. 209, *Seat belt assemblies*

No. 210, *Seat belt assembly anchorages*

No. 302, *Flammability of interior materials*

Title 49, *Code of Federal Regulations*, Part 178.37, "Specification 3AA and 3AAX Seamless Steel Cylinders."

Title 49, *Code of Federal Regulations*, Part 393, Subpart E, "Fuel Systems."

Title 49, *Code of Federal Regulations*, Part 393.67, "Liquid Fuel Tanks."

Title 49, *Code of Federal Regulations*, Part 393.94(c), "Vehicle Interior Noise Levels Test Procedure."

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix 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 or off-road locations. To a limited degree, this apparatus can be used to protect exposures or fight structure fires from the exterior. The apparatus covered by this standard is not intended to replace or supersede the function of a pumper or initial attack fire apparatus.

The term *new* as used in this standard is intended to apply to the original construction of a fire apparatus. 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 recommended that the apparatus be brought into line with this standard to the degree possible.

A.1.5 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. 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 study should look not only at current operations and risks protected but also at how these could change over the life of the fire apparatus. See Appendix B for information on specifying and procuring wildland fire apparatus.

A.1.7.6 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 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.1.7.8 Authority Having Jurisdiction. The phrase "authority having jurisdiction" 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.1.7.9 Automated Electrical Load Management System. Shedding of the electric loads occurs without human intervention and is capable of being manually overridden.

A.1.7.10 Automated Regulating Proportioning System. The automatic adjustments of the proportioning system are made based on changes in water flow or conductivity.

A.1.7.19 Compound Gage. On most gages, zero equals atmospheric pressure. Gages typically measure pressure above atmospheric pressure in pounds per square inch (psi) and below atmospheric pressure in inches of mercury (Hg).

A.1.7.20 Compressed Air Foam System (CAFS). A CAFS consists of a compressed air source, pressurized source of foam solution, and discharge hardware.

A.1.7.22 Contractor. The contractor might not necessarily manufacture the vehicle or any portion of the vehicle but is responsible for the completion, delivery, and acceptance of the entire unit.

A.1.7.27 Eductor. The pressure at the throat of a venturi is below atmospheric pressure, allowing foam concentrate at atmospheric pressure in storage to flow into the water stream.

A.1.7.41 GAWR (Gross Axle Weight Rating). It is a requirement of the Federal Motor Vehicle Safety Standards that GAWR be shown on a label on the vehicle. The system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

A.1.7.44 Grade. A 45-degree slope is equal to a 100 percent grade.

A.1.7.46 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 fixed 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.1.7.51 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.1.7.54 Maximum Pump Close-Off Pressure. The maximum pump close-off pressure of multistage series/parallel pumps is measured with the pump in the pressure (series) setting.

A.1.7.58 Net Pump Pressure. When operating from a hydrant, the net pump pressure is typically less than the discharge pressure. For example, if the discharge pressure gage reads 150 psi (1034 kPa) and the intake (suction) gage 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 gage reads 145 psi (1000 kPa) and the intake (suction) gage reads 10 in. Hg (34 kPa) vacuum, the net pump pressure will be 150 psi (1034 kPa). (1 in. Hg = 0.5 psi = 3.38 kPa).

A.1.7.61 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.1.7.65 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.1.7.68 Preconnected Hose Line. A preconnected hose line is commonly called a bucket line, cross lay, or mattydale.

A.1.7.83.1 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.

A.1.7.83.2 Electronic Siren. Varied types of warning sounds, such as a wail, yelp, or simulated air horn, can be produced by electric sirens.

A.1.7.84 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.1.8 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 unit is outside of but recognized by SI and commonly is used in international fire protection.

The conversions in Table A.1.8 are not SI conversions but could be useful to the user of this document.

Table A.1.8 Non-Metric Conversions

1 pound per square inch (psi)	2.31 feet of water (ft H_2O)
1 pound per square inch (psi)	2.036 inches of mercury
1 inch of mercury (in. Hg)	1.135 feet of water
1 inch of mercury (in. Hg)	0.491 psi
1 gallon water	8.34 pounds
1 gallon water	231 cubic inches

A.2.2.1 The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation.

A.2.5.2 The distribution of the weight between the front and rear wheels should be a major consideration, because improper distribution seriously affects the handling characteristics of the vehicle. Too little weight on the front wheels can cause a front-end skid and, over bumpy roads, can cause the front of the vehicle to veer from side to side. At the very least, it is difficult to keep the vehicle 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, in mud, or during braking. Further, overloading of either the front or rear wheels might necessitate that the tires be of different sizes.

A.2.6.1 The power generated by internal combustion engines might 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 to be used regularly at elevations above 2000 ft (610 m), the manufacturer needs to know the operating elevation to provide an engine that can deliver proper performance.

A.2.6.2 Subsection 2.7.2 imposes more stringent requirements on the apparatus for maneuvering. If the purchaser wishes to have the whole apparatus perform to these more stringent requirements while pumping or for stationary operations, these requirements should be detailed in the specifications for the apparatus.

A.2.6.3 The temperature conditions, either hot or cold, within which the vehicle is to 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 could be necessary. Likewise, if the unit is to be used or stored in subfreezing conditions, special system drains, engine heaters, pressure gage protectors, or other special components might be needed to prevent damage or to allow continued use.

A.2.7.1(2) Although this standard recognizes the need for the vehicle to be able to accelerate to a high speed while traveling on public roads, caution should be taken with regard to how fast the vehicle can travel. Consideration should be given to limiting the maximum speed the vehicle can obtain for safety.

A.2.7.1(3) The purchaser should specify the performance required on grades in excess of 6 percent. Occasional exposure to excessive grades is different than if it is an everyday occurrence. A combination of steep grades and narrow, winding roads might necessitate consultation with manufacturers prior to finalizing the apparatus specifications followed by the designation of special road tests. If apparatus is to be subjected to a class of service not normally encountered, a manufacturer cannot be expected to anticipate the need without sufficient specification details.

A.2.7.2 Where fire apparatus might have to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission or an automatic transmission, or any combination of these, might be desirable.

A.3.1 The carrying capacity of a vehicle is one of the least understood features of design and one of the most important. All vehicles are designed for rated GVWR or maximum total weight, which should not be exceeded by the apparatus manufacturer or by the purchaser after the vehicle has been accepted. There are many factors that make up the rated GVWR, including the design of the springs or suspension system, the rated axle capacity, the rated tire loading, and the distribution of the weight between the front and rear wheels.

One of the most critical factors is the size of the water tank. Water weighs approximately $8^1/_3$ lb per gal (1 kg per L). A value of 10 lb per gal (1.2 kg per L) can be used when estimating the weight of the tank and its water, making a 500-gal (1900-L) tank and its water weigh about 5000 lb (2270 kg).

Overloading of the vehicle by the manufacturer through design, or by the purchaser by adding a great deal of equipment after the vehicle is in service, materially reduces the life of the vehicle and undoubtedly will result in increased maintenance costs, particularly with respect to the transmission, clutch, and brakes. Overloading also can seriously affect handling characteristics, making steering particularly difficult.

Fire apparatus have to be able to perform their intended service under adverse conditions. Wildland apparatus often are required to operate off paved streets or roads. Chassis components should be selected with the rigors of service in mind.

A.3.1.1 The purchaser should specify the weight of the equipment to be carried if it is in excess of the allowance for miscellaneous and minor equipment. This 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.

If the apparatus is designed for off-road use, it is recommended that the fully equipped apparatus, including full water tanks, full agent tanks, and all other full reservoirs; the apparatus designed hose load; the equipped personnel weight; and a miscellaneous equipment allowance, should not exceed 80 percent of the chassis gross vehicle weight rating. In addition, the axle loads should not exceed 80 percent of the appropriate gross axle weight rating. If the vehicle chassis manufacturer certifies the GVWR and GAWR for 50 percent minimum off-road use, the full weight ratings can be utilized. The miscellaneous equipment allowance should be at least equal to the weights as shown in Table 3.1.1.

A.3.2.1 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.3.2.1.1 Automatic fuel line safety shutoff as required by DOT regulations is not considered an automatic engine shutdown. Some engines are provided with automatic engine shutdown systems as part of the engine management system, although certain chassis are available without engine shutdown systems. (The purchaser should try to use an engine without a shutdown system where possible.) The purchaser should specify when a manually armed, out-of-water, shutdown system is required.

A.3.2.2.1 Where a regular production model commercial chassis is used, it is recommended that the heavy duty radiator option be included where available.

Where local environmental extremes exist, i.e., high humidity and temperature or extreme low temperatures, the purchaser should state specifically those environmental conditions under which the apparatus is expected to operate.

A.3.2.3.1 Full-flow oil filters are mandatory with some diesel engines.

A.3.2.4.1.1 An air restriction indicator should be considered.

A.3.2.4.1.2 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 desired. 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 others. 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.

A.3.2.4.1.3 With the use of diesel engines, the concern for vapor lock common with gasoline engines does not exist, and electric fuel pumps are not usually 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. Where not properly marked with a label or where 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.

A.3.2.4.2.1 An air restriction indicator should be considered.

A.3.2.5 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.

Vehicle exhaust systems often are hung low on the undercarriage. They are susceptible to damage from objects such as rocks, logs, and stumps. Likewise, vertical-type diesel exhaust pipes often are exposed to tree limbs. The purchaser should specify special requirements for protecting the exhaust system if off-road use or other conditions warrant. Both state and federal regulations regulate chassis exhaust systems.

A.3.3.1.1 Adequate braking capacity is essential for the safe operation of fire apparatus. Although this subject normally is covered in state highway regulations, it should be noted that fire apparatus can have a special problem as compared with other vehicles of the same gross vehicle weight. Fire apparatus might need to make successive brake applications in a short period of time when attempting to respond to alarms in a minimum amount of time. Thus, the problem of brake fade and braking capacity can be critical unless the brakes provided take into account the service provided by the apparatus. Air-actuated brakes are recommended for fire service vehicles of over 25,000 lb (11,350 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 need attention to guard against condensation in the air lines, such as can occur in areas subject to changes in climate that affect the moisture content of the air. Air pressure drop should be limited to normal air losses. The presence of the following conditions indicates the need for immediate service:

(1) Air brake pressure drop of more than 2 psi (13.8 kPa) in one (1) minute with the engine stopped and service brakes released
(2) Air pressure drop of more than 3 psi (20.7 kPa) in one (1) minute with the engine stopped and service brakes fully applied

A.3.3.1.2 Subsection 2.7.2 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.3.3.1.4 Purchasers of apparatus with a GVWR of 31,000 lb (14,061 kg) or greater should 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. Auxiliary braking systems are recommended on apparatus that are exposed regularly to steep or long grades, that are operating in congested areas where repeated stops are normal, or that respond to a high number of emergencies. Examples of auxiliary braking systems include engine retarders, transmission retarders, exhaust retarders, and drive-line retarders. 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.

A.3.3.1.5 Transmission retarders and exhaust restriction devices can cause rear wheel skids on slippery surfaces.

A.3.3.2.2 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. The purchaser should consider the terrain over which the vehicle is to be used where specifying the desired ground clearance.

A.3.3.2.3 The angle of approach or departure affects the road clearance of the vehicle where driving over short, steep grades such as are found in a driveway entrance, crossing a high-crowned road at right angles, or in off-road service. Too low an angle of approach or departure results in scraping the apparatus body. In those cases where equipment is stored below the body, the angle of approach or departure should be measured to a line below the equipment.

A.3.3.3.1 Where automatic transmissions are used, the power takeoff applications can present problems, especially where dual PTO drives are required. In some instances, the PTO drive can be engaged only in torque converter range with a probability of overheating with prolonged use. If engine rpm is high, 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.3.3.3.2.3 If a 4×2, manual transmission equipped chassis is desired to go 2 mph (3.2 kmph), special gearing might have to be provided, such as a two-speed axle, an auxiliary transmission, or an extra low geared transmission.

A.3.3.4.1 The addition of fuel tanks or modification of fuel systems could be limited by safety regulations. This is particularly true for vehicles rated at less than 15,000 lb (6803 kg) GVWR. A single fuel tank is desirable unless fuel capacity needs cannot be met by a single tank. Where a second tank is used, it should include its own fill spout to ensure rapid refilling capability. Where different tank sizes are available, the largest single tank capacity should be provided.

Requiring the operator to operate valves manually to provide additional fuel supply to the engine is not recommended. Free flow from both tanks generally is recommended to prevent unused fuel from being "stored" in a tank for long periods. However, fuel equalization lines between fuel tanks often are located in a vulnerable position underneath the chassis. This should be recognized, particularly where the vehicle is designed for off-road use.

A.4.1 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.

A.4.2.1 The 125 percent requirement for wiring and circuits is intended to provide end users a minimum amount of extra electrical circuit capacity. It is not the intent to have the final-stage manufacturer replace the standard OEM chassis manufacturer's 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 apparatus manufacturer's installed wiring.

A.4.2.6 It is the intent of 4.2.6 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, 4.2.6 covers low-voltage wiring only and does not apply to shielded cables commonly used for communication purposes or wiring used in line voltage circuits.

A.4.3.1 The minimum alternator size is developed using 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 verses the load study supplied for the apparatus from the manufacturer for on-scene and responding modes.

A.4.3.2(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 this standard requires that the apparatus be capable of maintaining the minimum continuous electrical load under the conditions defined in 4.3.1. When that load 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 4.3.1.

A.4.3.3 The unexpected shutdown of a fire apparatus at a fire can place fire fighters in mortal danger and seriously impact 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.

A.4.3.5.1 Reduced crew sizes have forced the apparatus operator to assume many new fireground tasks in addition to that of operating 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.

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.

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.

Optical warning devices in excess of the minimum required in this standard can and should be load managed.

A.4.4 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.

Batteries usually have two ratings: "cold cranking amperes," which determines 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.

A.4.4.4.1 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 only be plugged into a receptacle protected by a ground-fault circuit interrupter (GFCI) at the shoreline origination point.

A.4.4.4.2 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.

A.4.4.5 When the apparatus is equipped with electrical loads in excess of the base electrical loads, the electrical system should have a master load disconnect switch. The master load disconnect switch should be installed between the starter solenoid(s) and the remainder of the electrical loads on the apparatus. The batteries should be connected directly to the starter solenoid(s). Electronic control systems and similar devices are permitted to be otherwise connected if so specified by their manufacturer.

A green "battery on" pilot light should be provided that is visible from the drivers seat. The purchaser might want to 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.

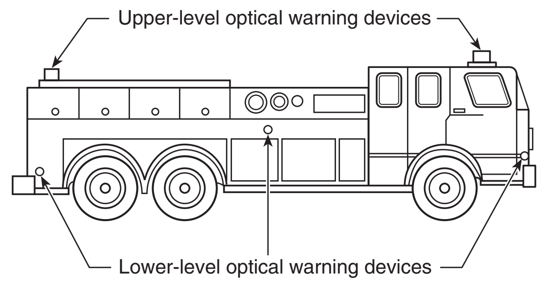
A.4.7 SAE J551-2, *Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats and Spark-Ignited Engine-Driven Devices*, provides test procedures and recommended levels to assist engineers in the control of broadband electromagnetic radiation and in the control of radio 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 magnetic radiation.

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.4.8 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 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 user desires to specify an apparatus without emergency lighting, care needs to be taken to make sure that no conflict exists with local, state, or federal laws for the user's jurisdiction. Even if the apparatus is not equipped with emergency lighting per state or federal law, it is still recommended that the apparatus be equipped with a system of amber flashers or rotating beacons.

A.4.8.1 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.4.8.1.)*

FIGURE A.4.8.1 Upper- and lower-level optical warning zones.



A.4.8.6 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. When responding in snow or fog, it could be desirable to turn off forward facing strobes or oscillating lights to reduce visual disorientation of the apparatus driver.

The intent of the warning light system is to provide full coverage signals through the operation of a single master switch when 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.

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.

A.4.8.10 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.

A.4.8.11 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.

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.

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 in the eyes of oncoming drivers.

A.4.8.12 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. 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 4.3 in order to supply the additional power required.

A.4.8.12.3 See Figures A.4.8.12.3(a) and A.4.8.12.3(b).

FIGURE A.4.8.12.3(a) Sample illustration showing the front and left sides of an apparatus using an optical warning system.

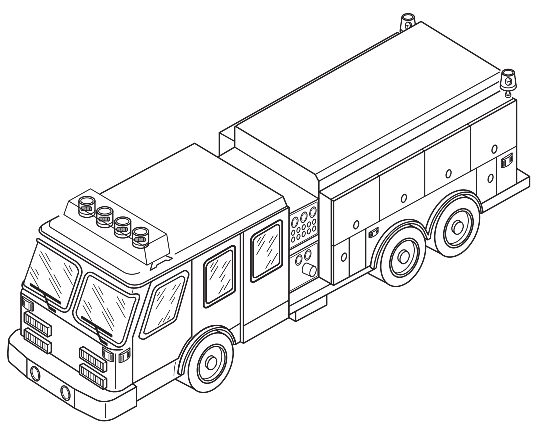
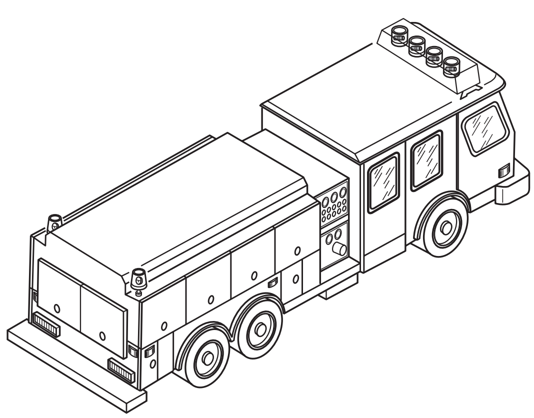


FIGURE A.4.8.12.3(b) Sample illustration showing the rear and right sides of an apparatus using an optical warning system.



A.4.8.12.4 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.

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 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.

The engineering basis of this section permits both the design and 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.

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/minute of optical energy is determined at each point and then the zone totals are calculated and compared to Table 4.8.12.4.

A.4.8.13 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.

A.4.8.15 In a few cases, a manufacturer might wish to type certify by actual measurement of the optical warning system on an apparatus. 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 about the geometric center of the apparatus. Each optical warning device used should be certified by its manufacturer as conforming to all of 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.

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.

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.

Measurements are made to determine all of 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 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.

A.4.9.2 If the purchaser wishes to have the siren controls within convenient reach of persons riding in both the right and left front seat positions, they should specify that. 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 should also be specified.

A.4.13.1 The purchaser might desire to have the entire low-voltage electrical system and warning device system certified by an independent testing organization.

A.5.1.1 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.

A.5.1.6 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. All equipment stored within the crew compartment should be provided with brackets or compartments to minimize the chance of injury.

A.5.3 The purchaser should consider specifying a style of mirror that swings when making contact with branches and trees.

A.5.3.1 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.

A.5.3.3 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.

A.5.3.4 Consideration should be given to providing a tachometer, and if equipped with an automatic transmission, a temperature indicator.

A.6.1.1 Compartmentation sized to meet the size, shape, and weight of special equipment might be required. Any special equipment to be carried on the apparatus should be identified in the specifications so the apparatus manufacturer can ensure that the equipment is accommodated properly within the design of the apparatus. Compartments sharing a common wall with the tank can sweat moisture when a common wall is used for ventilation, and drainage must be provided.

A.6.2 The purchaser should provide the apparatus manufacturer with the details of any special needs for communication equipment or its location.

A.6.3 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.

Where equipment other than that originally mounted on the apparatus is to be carried, the user of the vehicle should ensure that the equipment is securely attached to the vehicle with appropriate holders.

A.6.4.1 The intent of step size and placement requirements is to ensure that the fire fighter's foot is supported 7 in. to 8 in. (178 mm to 203 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.

A.6.4.3.1 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. Purchasers should designate which areas are stepping, standing, or walking areas during the design of the vehicle. It is important that proper materials are selected for the application and local conditions.

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 can deteriorate over time. It is also important for the user to properly maintain or replace slip-resistant materials as they deteriorate over time.

A.6.5 Handrails should be mounted to minimize the chances of damage or removal from contact with objects such as trees.

A.6.6.1 Corrosion protection, commonly known as undercoating, might be desired in areas where climatic conditions or road treatment corrodes vehicle components. The material, its application method, and the areas to be protected should be specified carefully so the corrosion protection adequately protects the vehicle's cab and body sheet metal components subject to corrosive conditions that could be encountered in the user's area.

The purchaser should give consideration to the choice of paint color(s) as it relates to the total conspicuousness of the vehicle. In addition, the purchaser needs to specify if nonferrous body components are to be painted and any lettering, numbering, or decorative striping is to be furnished.

A.6.8.3.2 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 its movement. Provisions to prevent accidental breakaway from chassis should be provided.

A.7.2 If the pump is expected to operate above 2000 ft (610 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. 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 derate the pump.

The suction hose size shown in Table 7.2(a) is for pump rating purposes only, and other sizes of suction hose can be carried for use in the field.

A.7.3.1 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 well as at the top of the pump suction inlet.

A.7.3.2 For best priming and pump performance when priming from the suction with the pump running, the following should be adhered to:

(a) A check valve should be used at the discharge of the pump.

(b) The prime should be taken at the eye of the impeller or at the top of the intake to the pump.

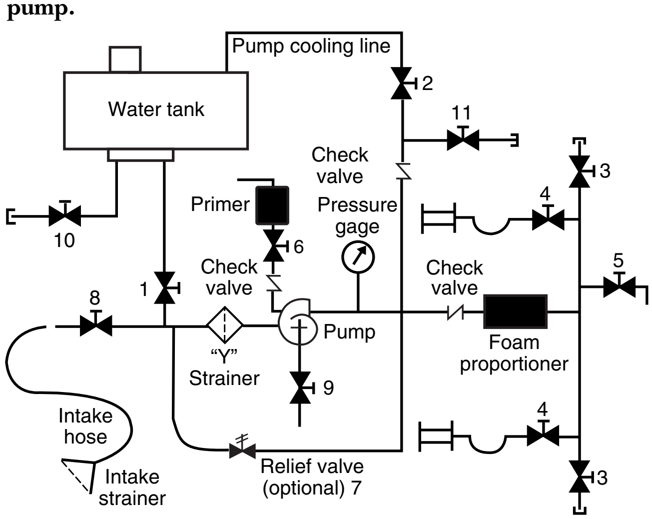
(c) A smooth bell-shaped strainer inlet should be used on the end of the suction hose. A foot valve should not be used.

(d) Suction hose should only be as long as necessary.

(e) There should be no high points in the suction line. If there are high points in the suction line, a prime or suction should also be taken at the top of the high point as well as at the intake to the pump.

A.7.4 Figure A.7.4 shows a typical plumbing schematic for an apparatus with a centrifugal pump.

FIGURE A.7.4 Typical plumbing schematic for a centrifugal pump.



Notes:
1. Use of foot valve not recommended.
2. Use of foot valve not required when check valves are used in pump discharge line.

Legend

Valves

1 from tank to pump
2 from pump to tank
3 from pump to discharge
4 from pump to hose reel or basket discharge
5 from pump to small auxiliary discharge
6 from pump to primer
7 relief valve (optional)
8 from intake to pump
9 pump drain valve
10 gravity tank drain
11 clean water line

A.7.4.3 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 fresh water after such use.

The term *all bronze* indicates that the pump's main casing, impeller, intake and discharge manifolds, and other principal components exposed to the water to be pumped, with the exception of the shaft bearings and seals, are of a high–copper alloy material. Use of like materials for the pump and piping is recommended.

A.7.5.1 Where larger size intakes or adapters are desired, they should be specified by the purchaser.

A.7.5.1.1 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.7.5.3 Each $2^1/_2$-in. (65-mm) or larger valved intake should be equipped with a bleeder valve having a minimum $^3/_4$-in. (19-mm) pipe thread connection to bleed off air or water from a hose connected to the intake. The bleeder valve should be operational without the operator having to get under the apparatus. If a valved appliance is attached to an intake, it should be equipped with a $^3/_4$-in. (19-mm) bleeder valve on each intake.

A.7.5.5 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) yet not be able to pass through the pump.

A.7.6.1 It is recognized that outlets of the size shown in Table 7.6.1 are capable of significantly greater discharge. The intent is to provide sufficient outlets to make the apparatus usable.

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:

(a) 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).]

(b) With the check valve located in the discharge line of the pump, the pump can be primed with a discharge valve open.

(c) 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.

(d) 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.

(e) 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.

(f) 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.

(g) With the use of a check valve in the discharge line of the pump, the suction plumbing can generally be more easily drained to prevent damage from freezing.

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 "down stream" of the checking device to permit water that might freeze and cause damage to be drained.

A.7.6.4 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.

Consideration should also be given to having the full pump discharge pass through check valves. One advantage of such an arrangement is that when pumping uphill and the pump is shut down, it prevents draining of the hose lay; it prevents applying pressure to the suction plumbing, which may not be rated for the pressure applied; and if foam is being used, it prevents contaminating the water tank or the outside water source such as a lake, stream, or water main with foam. Other advantages include being able to prime the pump if a discharge valve is left open and maintaining the prime without the need for a foot valve if the pump is shut down. Pumps can be primed from a greater depth and will pump more water if a foot valve is not used.

A.7.7.3 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, including the following:

(1) Tank to fire
(2) Intake (suction) to fire
(3) Intake (suction) to tank

A.7.8.4 If the unit might be stored in areas prone to freezing, the purchaser should consider specifying freeze protected gages and air bleeder valves near the connection to the gages.

A.7.9 The indicator lights and interlocks specified in Section 7.9 are minimum. Some manufacturers or users might choose to add additional indicator lights or interlocks.

A.7.9.2 Pumps are operated from the side, top, front, or rear of the vehicle, and stationary pumping requires that there is no power applied to the wheels while pumping. Therefore, it is essential that any pumping system controls, which shift the vehicle out of road mode of operation to place the pumping system into operation, be equipped with a means to prevent dislocation of the control from its set position in the pumping mode.

A.7.9.7 The purpose of a pressure control system is to control the discharge pressures 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.

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

A.7.10 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.4.3.1 of NFPA 1500, Standard on Fire Department Occupational Safety and Health Program.)*

A.7.11.1 If acceptance tests are desired at the point of delivery, they should be run in accordance with the provisions of Section 7.11 and should duplicate the portions of the tests that the purchaser specifies. Where the point of delivery is over 2000 ft (610 m) of elevation, it is important to test the pump and pumping engine performance to ensure that the engine can develop adequate power at point of delivery. This test can be performed with the pump supplied from a suitable fire hydrant, or at draft, with the net pressure maintained at manufacturer's pump rated press. The net pressure (P), when the pump is supplied from a hydrant with positive intake pressure, is the discharge gage pressure (D) minus the intake gage pressure (S).

A.7.11.2.1.2 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 suitable warning device.

A.7.11.2.3 Some blank test data forms for recording the test readings and other necessary data should be provided.

Where an apparatus is pumping at or near full engine power while stationary, the heat generated can raise the temperature of certain chassis or pumping system components above the level that can be touched without 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, the test should be considered acceptable.

The dynamic suction lift can be determined either by measuring the negative pressure (vacuum) in the pump intake manifold by means of a suitable test gage that measures vacuum accurately, or by adding the vertical lift and the value of entrance and friction loss from Table 7.2(b). To be accurate, gage readings should be corrected for the difference between the height of the gage and the centerline of the pump intake, but usually this distance is not significant and can be ignored. Thus, the net pump pressure can be calculated as formulas:

$$P = D + (H \times 0.5)$$

or

$$P = D + 0.43(L + F)$$

where:

P = Net pump pressure (psi)
D = Discharge gage pressure (psi)
H = Manometer reading (in. Hg)
L = Vertical lift (ft)
F = Friction and entrance loss (ft of water)

A.7.11.5 In lieu of time, a flow meter can be used to determine 100 percent flow.

A.8.2.1 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.8.2.2 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.8.6 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.8.7.1 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.8.7.2 The maximum governed speed is established by the engine manufacturer as a safe limit of engine speed for the engine application. 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.8.8.3 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 4.3.1.)*

A.8.10 The fuel tank(s) and systems that meet 49 *CFR* 393.65, "All Fuel Systems," 393.67, "Liquid Fuel Tanks," or 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.8.10.2 It is recommended that the pump engine use the same type of fuel as the chassis engine.

A.9.2.1 Tanks should be capable of being completely cleaned out. The purchaser should indicate in the specifications whether a removable tank lid is required.

A.9.2.2 Water tanks can appear in several different configurations (round, elliptical, rectangular, T-shaped). Handling characteristics of the apparatus can be greatly affected by its vertical and horizontal center of gravity. The purchaser should indicate the filling and dumping rates required if they exceed the requirements of this standard and any other local needs and let the apparatus manufacturer design the tank shape to best meet the axle loading and center of gravity requirements.

A.9.2.4 The design of a water tank can be a very 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 be built up that will tend to force the vehicle 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 vehicle out of control and has been known to cause fire apparatus to turn over or skid when going around a curve or coming to a sudden stop. The only methods of preventing such an accident 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 in a manner 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 filling and emptying the tank. 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.

A.9.4.1 An excessive flow rate when filling a tank could result in a pressure buildup in the tank that could cause permanent damage or failure.

A.9.4.2 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.

A.9.4.3 It is necessary to design the tank for adequate venting and overflow for the maximum fill rate. A locking-type ball valve, globe valve, needle valve, or other type suitable for throttling service should be used. A gate valve is not recommended. When designing fire apparatus plumbing, electrolysis protection for dissimilar metals should be provided. Tank fill circuit rate cannot exceed vent capabilities.

A.9.5 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.10.1 The purchaser should specify the total feet of suction hose required, the diameter, the length of each section, and the size of the couplings. The size of the suction hose specified in Table 7.2(a) relates to pump certification only. Other sizes of suction hose, compatible with local operations, might be specified.

A.10.2 The requirements of wildland fire suppression varies in different communities and wildland areas. This will necessitate additions to the equipment required. The following list of additional equipment is recommended to be carried on wildland fire apparatus. The equipment list provided does not detail each item sufficiently for purchasing purpose. The purchaser should provide detailed specifications for any equipment, such as the following, that is to be purchased with the fire apparatus.

Fire hose

One nozzle sized to the pump and hose carried

Two spanner wrenches, appropriate for fittings on hose carried

One round shovel

One head lamp for each seating position

One backpack pump

20-ft (6-m) hard suction

Suction strainer basket

Universal hydrant wrench

Wheel chocks provide an increased margin of safety for vehicle stability when parked on slopes. The wheel chocks should be capable of the following performance while on dry paved roads that are in good condition:

One wheel chock should hold the fully loaded vehicle on a 15 percent slope.

Two wheel chocks should hold the fully loaded vehicle on a 30 percent slope.

The following two methods test wheel chock performance:

(1) Place the apparatus on a 15 percent or greater grade and place the wheel chock on the downhill side of a wheel of the most heavily loaded axle.
(2) Weigh the apparatus and place it on a level surface. Place the wheel chock in front of the wheel of the most heavily loaded axle in the direction of pull and pull the apparatus using a dynamometer until it moves the wheel chock. Using W as the weight of the apparatus and P as the reading on the dynamometer when the apparatus moves, the following formula will give the percent grade at which the wheel chock will no longer hold the apparatus.

$$\text{Percent grade} = 100 \times \frac{P}{W}$$

When making a wheel chock selection, fire departments should take into consideration the type of surfaces encountered in their operation. For example, wheel chocks may perform differently when used on slippery or non-paved surfaces.

A.11.1 It is important for the purchaser to understand the types and properties of mechanical foam and its application to specify a foam proportioning system properly. Specific information regarding foam concentrates and their application is available in NFPA 11, *Standard for Low-Expansion Foam,* and NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems.* Information on foam concentrates for Class A fires is available in NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas.*

The following terms are not used in this document but are associated with foam 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.

Automatic Regulating Proportioning System. A proportioning system that automatically adjusts the flow of foam concentrate into the water stream to maintain the desired proportioning ratio. These automatic adjustments are made based on changes in water flow or conductivity.

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. A foam-capable fire apparatus is a fire apparatus carrying aspirating foam nozzle(s) and is equipped with automatic regulating 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.

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

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.11.2 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 proportion foam solution and water simultaneously from multiple discharges on the apparatus
(5) Manual or automatic foam proportioning system operation

A.11.2.1 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.11.2.1(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 proportioning system.

It is desirable for in-line eductor systems to have a label that indicates the following:

(1) Maximum hose length using $1^1/_2$ in., $1^3/_4$ 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."

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 mainline water flow control valve so that when the valve is adjusted to produce water flow through the bypass eductor, foam concentrate is drawn into the eductor (into the water stream) *[see Figure A.11.2.1(b)]*. The foam solution in the bypass line is then joined with the mainline water flow downstream of the water flow control valve. The variable flow bypass eductor is a manually regulated proportioning system.

Variable pressure eductors are a 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. The variable pressure eductor is a manually regulated proportioning system.

A.11.2.2 Self-educting master stream nozzles are mounted on the discharge side of the pump. These devices comprise a complete foam proportioning system, consisting of a foam proportioner and application device (nozzle).

A.11.2.3 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.

FIGURE A.11.2.1(a) In-line eductor foam proportioning system.

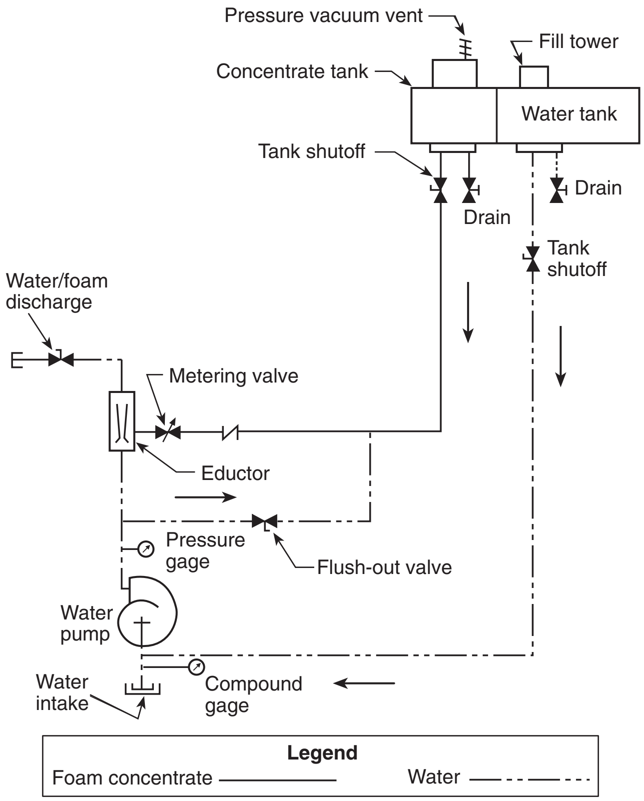
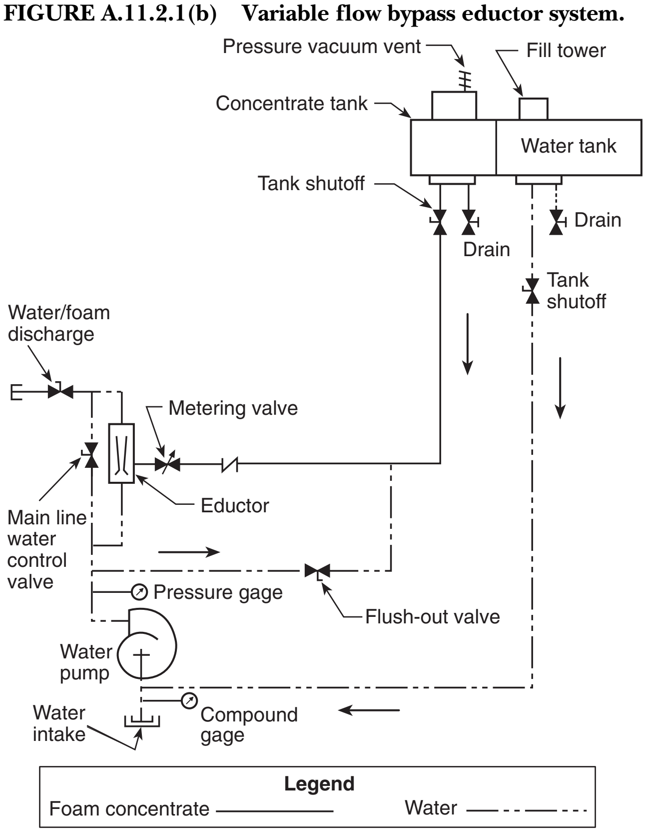


FIGURE A.11.2.1(b) Variable flow bypass eductor system.



A.11.2.4 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 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.

A manual around-the-pump proportioning system utilizes a manually adjustable foam concentrate metering valve to control the proportioning ratio. *[See Figure A.11.2.4(a).]*

A flow meter sensing around-the-pump proportioning system utilizes a flow meter sensing system to monitor total solution flow and foam concentrate flow. The flow data is transmitted to an electronic control that controls the proportioning ratio through a foam concentrate metering valve. *[See Figure A.11.2.4(b).]*

A conductivity sensing automatic variable metering around-the-pump proportioning system utilizes electrical conductivity meters to sense the foam solution percentage and provide feedback from the control sample module. Data from the electrical conductivity meters are transmitted to an electronic control that controls the proportioning ratio through a foam concentrate metering valve. *[See Figure A.11.2.4(c).]*

FIGURE A.11.2.4(a) Manual around-the-pump proportioning system.

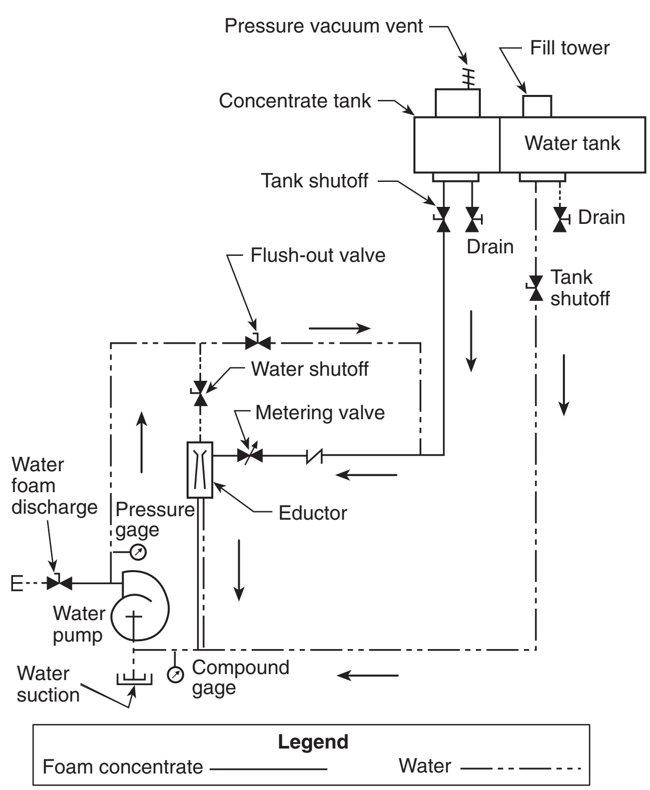


FIGURE A.11.2.4(b) Flow meter sensing around-the-pump proportioning system.

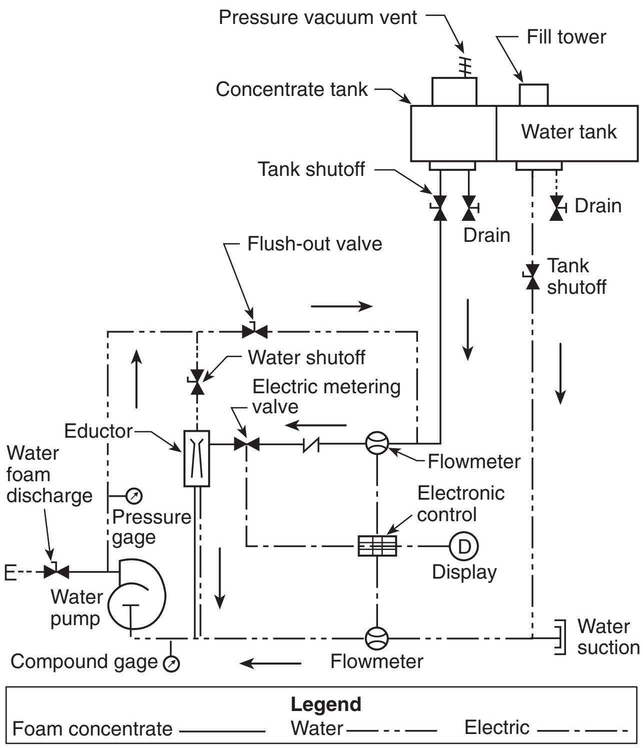
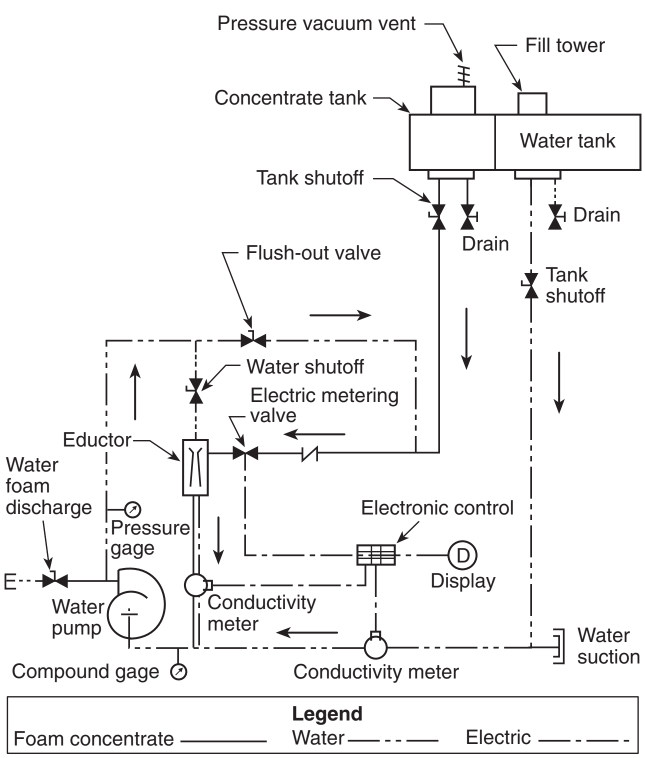


FIGURE A.11.2.4(c) Conductivity sensing automatic variable metering around-the-pump proportioning system.



A.11.2.5 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 percent 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 are generally automatic regulating proportioning systems.

Balanced pressure systems without a foam concentrate pump are referred to as "pressure proportioning systems" *[see Figure A.11.2.5(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.

There are two basic types of balanced pressure foam proportioning systems that utilize a foam concentrate pump. 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.

The bypass balanced pressure 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.11.2.5(b).]*

The demand balanced pressure 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.11.2.5(c).]*

FIGURE A.11.2.5(a) Pressure proportioning balanced pressure foam proportioning system.

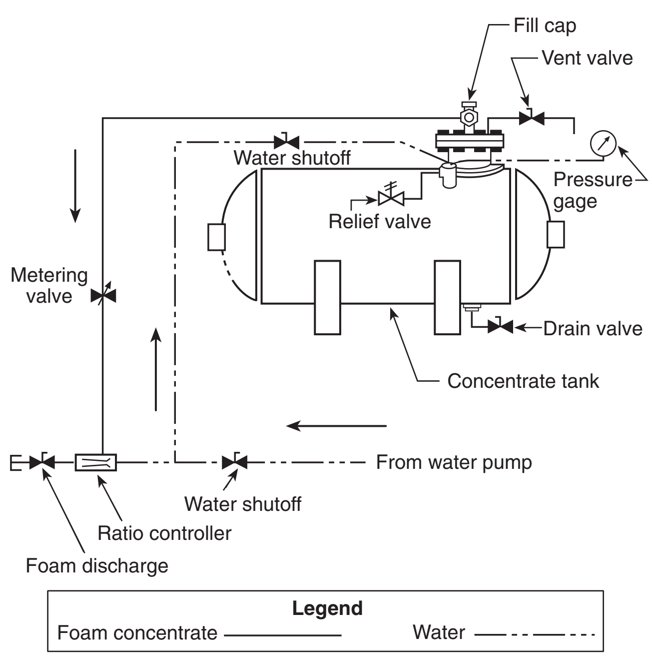


FIGURE A.11.2.5(b) Bypass balanced pressure foam proportioning system.

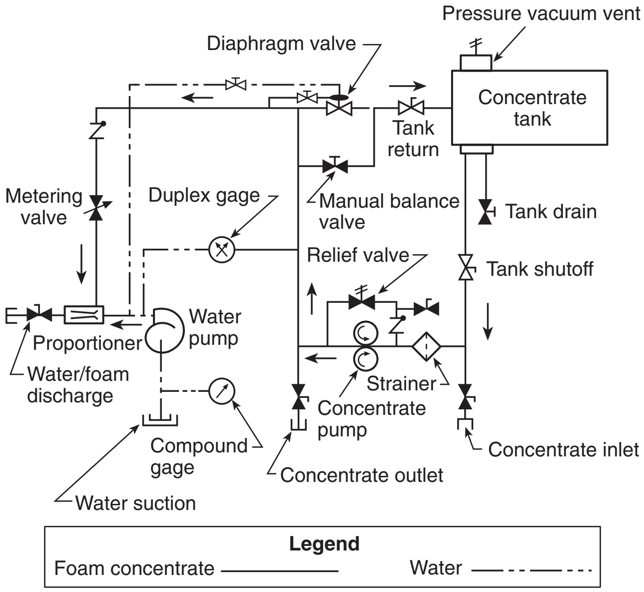
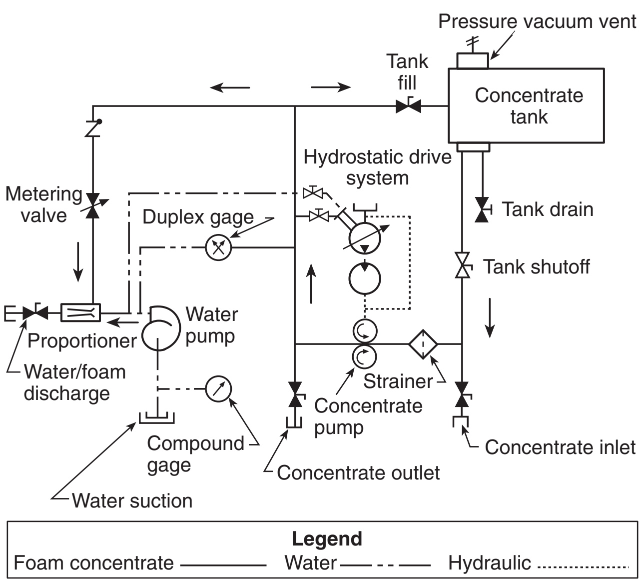


FIGURE A.11.2.5(c) Demand balanced pressure foam proportioning system.

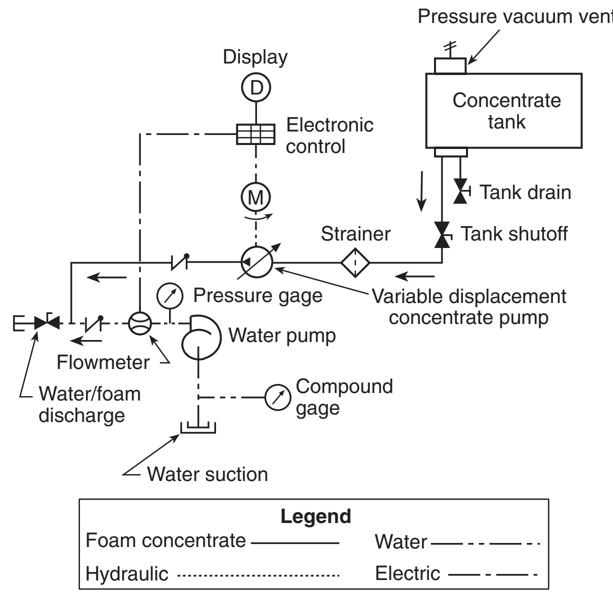


A.11.2.6 Direct injection foam proportioning systems utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank. Direct injection foam proportioning systems are generally automatic regulating proportioning systems.

Automatic flow sensing direct injection foam proportioning systems utilize an in-line flow meter(s) to monitor the system operating conditions. System operating data is transmitted to an electronic control, which controls the proportioning ratio. Two different flow sensing systems are available.

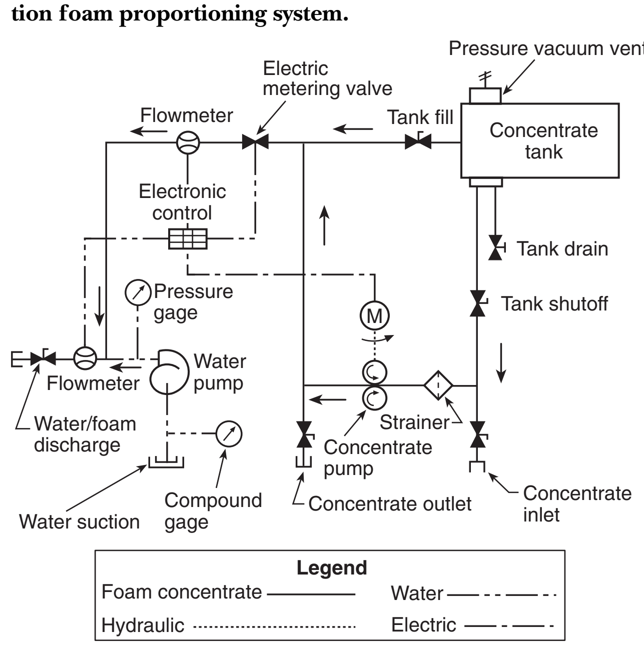
In one automatic flow sensing system, an electronic control receives electronic signals corresponding to the proportioning ratio from the control panel and water flow data from the flow meter. The electronic control then commands the foam concentrate pump module to deliver foam concentrate at the proportional rate. *[See Figure A.11.2.6(a).]*

FIGURE A.11.2.6(a) Single meter flow sensing direct injection foam proportioning system.



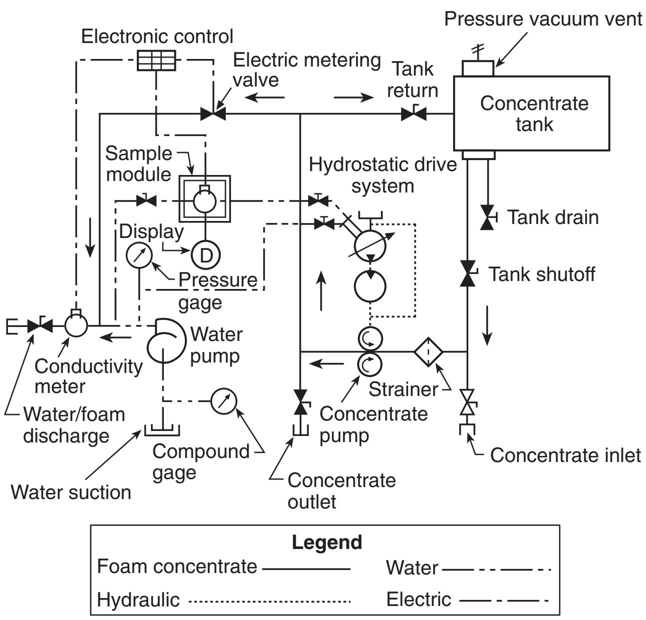
In the second flow sensing system, an electronic control receives electronic signals corresponding to the foam concentrate flow from a foam concentrate flow meter, the proportioning ratio from the control panel, and water flow data from the water flow meter. The electronic control controls the proportioning ratio through a foam concentrate metering valve. *[See Figure A.11.2.6(b).]*

FIGURE A.11.2.6(b) Dual meter flow sensing direct injection foam proportioning system.



A conductivity sensing direct injection foam proportioning system utilizes an electrical conductivity meter(s) to sense the proportioning ratio at the water pump discharge(s) and transmits this information to an electronic control that controls the proportioning ratio through a metering valve. A second electrical conductivity meter provides feedback from the control sample module to the electronic control. Foam pump pressure is maintained at a pressure higher than water pump pressure to ensure injection of the concentrate. *[See Figure A.11.2.6(c).]*

FIGURE A.11.2.6(c) Conductivity sensing direct injection foam proportioning system.



A.11.2.7 In a water motor–type foam proportioning system, a water motor drives a positive displacement foam concentrate pump. The water motor can be of either a positive displacement type or a turbine type. Water motor foam proportioning systems are automatic regulating proportioning systems.

Where a positive displacement–type 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.11.2.7(a).]*

A water turbine powered–type foam proportioning system uses a water turbine to power a positive displacement foam concentrate pump. Flow meters sense the foam concentrate pump output and the water flow, sending signals to an electronic control that controls the proportioning ratio by adjusting the water turbine speed. *[See Figure A.11.2.7(b).]*

A.11.3.1 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 prevention devices, or any device that creates additional friction loss in the system, should be installed only with the approval and specific instructions of the foam proportioning system manufacturer.

FIGURE A.11.2.7(a) Water motor foam proportioning system.

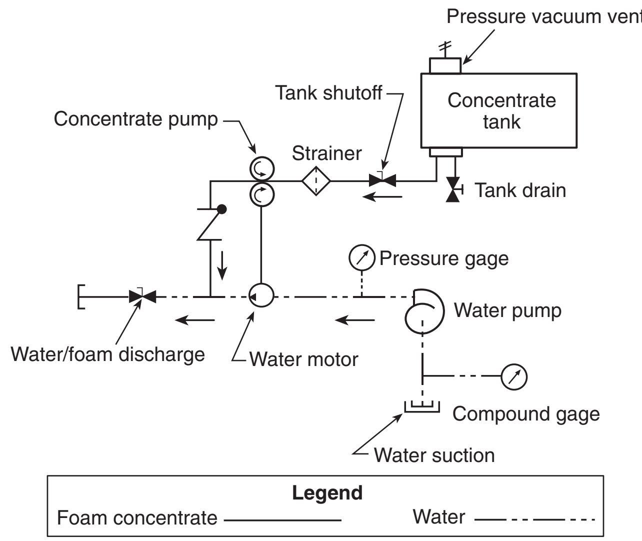
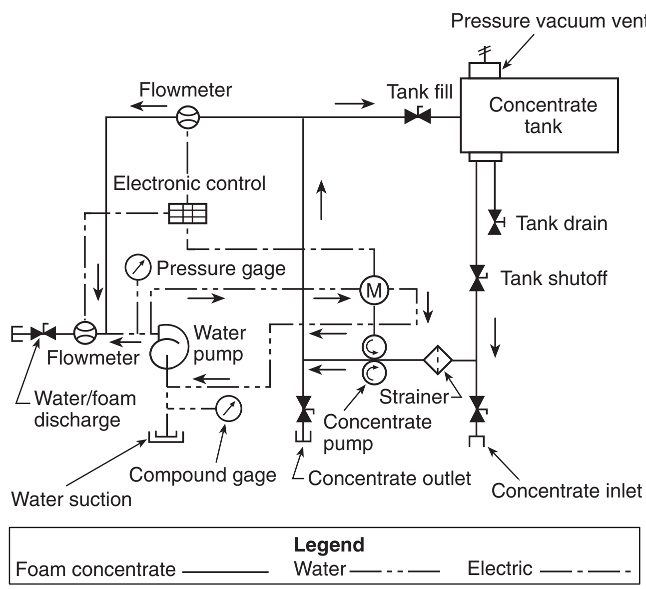


FIGURE A.11.2.7(b) Water turbine–driven flow sensing direct injection foam proportioning system.



A.11.3.3 Most foam concentrate manufacturers differentiate in the materials they recommend between those 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.11.4.1 It is desirable to have a visual indicator at the operator's position that shows that the foam proportioning system is in the "operating" or the "off" position. A visual means of indicating positive foam concentrate flow at the operator's position is also desirable.

A.11.6.3 Suitable means to attach the cover to the fill tower could include use of a threaded cap or a hinged cover with a mechanical latching device.

A.11.6.6 On vehicles 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.

A.11.6.8 The foam concentrate tank(s) can be an integral part of the water tank.

A.11.6.10 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.

A.11.7 The foam concentrate pump is a very 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 speed when compared to centrifugal pumps, which are desirable with viscous foam concentrates that are difficult to shear. Centrifugal pumps can become airbound 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.

A.11.7.2 Corrosion-resistant materials are materials such as brass, copper, monel, stainless steel, or equivalent materials.

A.11.7.5 A suitable suction device is required to operate from an external source such as 5-gal (19-L) pails, 55-gal (208-L) drums, and portable tanks or containers.

A.11.9.3 If an in-line eductor system is provided on the apparatus, the following information should also be provided on the plate: maximum usable hose length, the hose size required, the nozzle type, and allowable elevation changes.

If an around-the-pump system is specified, the following information should also be provided on the plate: maximum intake pressure or required intake to discharge pressure differential, and a table to indicate flow rate and the corresponding metering valve setting.

A.11.9.3(2) It is necessary for the operator to familiarize himself or herself 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.11.10 There are four methods for testing a foam proportioning system for calibration accuracy.

Test Method 1: Water Is Substituted for Foam Concentrate. The foam system is operated at the water flow rates at which the system is to be tested. Water is used as a substitute for foam concentrate. The substitute water for 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, including the water drawn from the calibrated tank, times 100 represents the percentage of foam the foam proportioner is producing.

Test Method 2: Foam Percent Is Determined by Use of a Refractometer. With the foam system in operation at a given flow, a solution sample is collected from each outlet. The foam concentration solution is measured using a refractometer to measure the refractive index of the collected foam solution sample. This method might not be accurate for AFFF or alcohol-resistant foam and 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, at best, for determining the percent of foam concentrate in a foam solution when using a refractometer is ±0.1 percent. For this reason, the conductivity method could be a preferable test method where AFFF, alcohol-resistant foam, or foam in 1 percent or less concentration (Class A foams) is to be tested.

To use a refractometer to determine percent of foam solution, a base calibration curve has to be prepared. The following equipment is required:

Four 100-ml or larger plastic bottles with caps

One measuring pipette (l0 ml) or syringe (10 cc)

One 100-ml or larger graduated cylinder

Three plastic-coated magnetic stirring bars

A refractometer

Standard graph paper

A ruler or other straight edge

Using the water and foam concentrate from the system to be tested, three known foam solution samples are made up using the 100-ml or larger graduated cylinder. These known foam solution samples should include the following:

(1) Nominal intended percentage
(2) Nominal intended percentage plus 1 percent
(3) Nominal intended percentage minus 1 percent

If the nominal intended percent is one percent or less, the three samples should be as follows:

(1) Nominal intended percentage
(2) Nominal intended percentage plus 0.3 percent
(3) Nominal intended percentage minus 0.3 percent

The water required is placed in the 100-ml or larger graduated cylinder leaving space for the foam concentrate. Using the pipette or syringe, the required foam concentrate samples are carefully added to the water. Each measured foam solution is poured from the 100-ml or larger graduated cylinder into a 100-ml or larger plastic bottle. Each bottle should be marked with a label indicating the percent solution it contains. A plastic stirring bar is added to the bottle. The bottle is capped and shaken thoroughly to mix the foam solution.

An alternate method of making up three foam solution samples is to use a very accurate scale. When a very accurate scale is used, only small amounts of water and foam concentrate are required. To use the scale method, the density of the foam concentrate has to be known. Look at the data sheet or the Material Safety Data Sheet (MSDS) for the foam product density. For example, to make 100 ml of a 3 percent foam solution using a foam concentrate with a density of 1.04, measure 97 g of water into a beaker, and add 3.12 g of foam concentrate to the beaker (1.04×3 g = 3.12 g).

After the foam solution samples are thoroughly mixed, a refractive index reading is taken of each percentage 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. Since the refractometer is temperature compensated, it could take 10 seconds to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at ambient temperatures of 50°F (10°C) or above.

Using standard graph paper, the refractive index readings are plotted on one axis and the percent of concentration on the other. It is most convenient to place the foam solution percentage on the horizontal axis and the conductivity reading on the vertical axis. 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.

Foam solution samples are then collected from the proportioning system using care to make certain that the samples are taken at an adequate distance downstream from the foam proportioner being tested. Refractive index readings of the samples are taken and compared to the plotted curve to determine the percentage of the collected test samples.

Test Method 3: Foam Concentrate Pump Output Is Measured Directly. With some direct injection systems, it is possible to directly measure foam concentrate pump output. With the foam system in operation at a given water flow rate, either using foam concentrate or water 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 measured period of time. An alternative is to measure the foam concentrate flow or water substitute with a calibrated meter.

Test Method 4: Foam Percent Is Determined 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. Since salt or brackish water is very conductive, this method might not be suitable due to small conductivity changes as foam concentrate is added to salt or brackish water. It is necessary to make foam and water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish. This method cannot be used when the water base has more total solids than the foam concentrate. The following three methods can be used to determine the foam percentage by the conductivity method.

(a) *Direct Reading Conductivity Test Method.* The following equipment is used to perform this method:

Two 100-ml or larger containers

One direct reading foam solution conductivity meter

A sample of the water to be used in the test is obtained using one of the 100-ml or larger containers. The conductivity meter head is immersed in the water sample and the meter display 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 has 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 has to be used when that foam concentrate is used.

The foam proportioning system is operated and a sample of the foam solution produced by the system is collected using the other 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.

(b) *Conductivity Comparison Method.* The following equipment is used to perform this method:

Two 100-ml or larger containers

Conductivity meter reading in µS/cm (microsiemens per centimeter)

A sample of the water to be used in the test is obtained using one of the 100-ml or larger containers. Using the conductivity meter, 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 obtained using the other 100-ml or larger container. Using the conductivity meter, the conductivity value of the foam solution sample is measured.

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 percent of foam concentrate in the foam solution.

$$\frac{\begin{pmatrix}\text{conductivity of}\\ \text{foam solution}\end{pmatrix} - \begin{pmatrix}\text{conductivity}\\ \text{of water}\end{pmatrix}}{500} = \text{percent of foam}$$

Note that 500 is used as the divisor assuming that the conductivity meter units are µS/cm (microsiemens per centimeter). Other units of conductivity can be used but will require the value of the divisor (500) to be adjusted.

(c) *Conductivity Calibration Curve Method.*

A handheld conductivity meter is used to measure the conductivity of foam solutions in microsiemen units.

The following equipment is used to perform this method:

Four 100-ml or larger plastic bottles with caps

One measuring pipette (10 ml) or syringe (10 cc)

One 100-ml or larger graduated cylinder

Three plastic-coated magnetic stirring bars

A portable temperature-compensated conductivity meter — Omega Model CDH-70, VWR Scientific Model 23198-014, or equivalent

Standard graph paper

A ruler or other straight edge

A base calibration curve is prepared using the water and foam concentrate from the system to be tested. Three standard solutions are made using the 100-ml or larger graduate. These known foam solution samples should include the following:

(1) Nominal intended percentage
(2) Nominal intended percentage plus 1 percent
(3) Nominal intended percentage minus 1 percent

If the nominal intended percent is one percent or less, the following should be the three samples:

(1) Nominal intended percentage
(2) Nominal intended percentage plus 0.3 percent
(3) Nominal intended percentage minus 0.3 percent

The water required is placed in the 100-ml or larger graduated cylinder leaving space for the foam concentrate. Using the pipette or syringe, the required foam concentrate samples are carefully added to the water. Each measured foam solution is poured from the 100-ml or larger graduated cylinder into a 100-ml or larger plastic bottle. Each bottle should be marked with a label indicating the percent solution it contains. A plastic stirring bar is added to the bottle. The bottle is capped and shaken thoroughly to mix the foam solution.

An alternate method of making up three foam solution samples is to use a very accurate scale. When a very accurate scale is used, only small amounts of water and foam concentrate are required. To use the scale method, the density of the foam concentrate has to be known. Look at the data sheet or the MSDS for the foam product density. For example, to make 100 ml of a 3 percent foam solution using a foam concentrate with a density of 1.04, measure 97 g of water into a beaker and add 3.12 g of foam concentrate to the beaker (1.04×3 g = 3.12 g).

After the foam solution samples are thoroughly mixed, the conductivity of each solution is measured. The instructions that come with the conductivity meter should be consulted to determine proper procedures for taking readings. It is necessary to switch the meter to the correct conductivity range setting in order to obtain a proper reading. Most synthetic-based foams used with fresh water result in foam solution conductivity readings of less than 2000 µS/cm. Protein-based foams generally produce conductivity readings in excess of 2000 µS/cm when fresh water is used to make the foam solution. Due to the temperature-compensation feature of the conductivity meter it could take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, the bottles should be set aside for control samples reference. The conductivity readings then should be plotted on the graph paper. It is most convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis.

A ruler or straight edge can be used to draw a line that approximates connecting all three points. Although 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 made 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.

Foam solution samples are collected then from the proportioning system using care to be sure the sample is taken at an adequate distance downstream from the foam proportioner being tested. Using foam solution samples that have been allowed to drain from expanded foam can produce misleading conductivity readings; therefore this type of sample should not be used to determine percent of foam solution.

When test samples have been collected, their conductivity is measured and the percent of foam solution is determined from the base curve prepared from the control sample foam solutions.

A.12.1 The following terms are not used in this document but are associated with compressed air foam systems and are included here to aid in understanding.

CAFS-Capable. A compressed air foam system (CAFS)-capable fire apparatus is a fire apparatus equipped with the following:

(1) Automatic regulating 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 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 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 compressed air foam system.

Surge. The sudden decompression of a discharge line caused by the rapid opening of the discharge appliance.

A.12.2.4 It is recommended that compressed air not be injected into the water/foam discharge piping until the flow of water/foam solution has been established in the discharge piping. The nozzle reaction at the end of a hose can be quite high if just air or air and water with no foam solution is flowing in the discharge line. The nozzle reaction could be a safety issue with an operator that 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. Pressure in the form of compressed air can remain trapped in a CAFS as a result of deactivating the system. It is important for the operator to relieve any pressure in the foam proportioning system and connected hose lines before disconnecting hose lines or any operation that opens the system to atmosphere.

A.12.2.5 Pressure in the form of compressed air can remain trapped in a CAFS as a result of deactivating the system. It is important for the operator to relieve any pressure in the foam proportioning system and connected hose lines before disconnecting hose lines or any operation that opens the system to atmosphere.

A.12.4 If it is desired to test the expansion ratio, the following test is recommended.

The equipment required consists of the following:

Gram scale, 1500-g capacity accurate to 0.1 g

One (1) 1000-ml container that can be struck at 1000 ml (A 1000-ml graduated cylinder cut off at 1000 ml works well.)

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.

$$\text{Expansion ratio} = \frac{100}{\text{Foam mass in grams}}$$

The foam mass in grams in the equation assumes that 1 g of foam solution occupies 1 ml of volume.

A.12.5 Any components of the piping system exposed to pressurized air from the CAFS should be designed for at least a burst gage pressure of 500 psi (3447 kPa).

A.12.7.6 Some systems provide automatic regulation of the water flow; however, instrumentation is still useful to the operator. Even automatic systems have adjustments and performance limits, which warrant instrumentation. Where the system design does not allow for such automatic regulation, or where the operator has the ability to control water flow or air flow, air and water flow meters 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.

A.12.9 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these also be certified by the independent testing organizations.

A.12.9.1.3 Care should be taken to avoid injuries to personnel from the discharging air stream. Only those persons actually conducting the tests should be in the test area, and they should wear hearing protection during the airflow test.

A.12.9.2 The person conducting the test should check with the manufacturer of the hose being used to ensure the hose has been approved for use with CAFS.

A.13.2.1 Most electric (12-V or 24-V dc) winches used for commercial/industrial applications are rated at between 6000 lb and 12,000 lb (26.7 kN and 53.4 kN) line pull. The winches feature a dc motor and control or solenoid box with two to four solenoids that reverse motor rotation.

Hydraulic-driven winches are typically rated for 6000 lb to 30,000 lb (26.7 kN to 133.5 kN) line pull.

A.13.3.1.1 There is virtually no control over the speed of a single-speed electric winch; that is, the winch runs at the speed the load dictates, faster with light loads and slower with heavy loads.

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.

A.13.4.4 The forward-neutral-reverse hydraulic control for the winch should be power operated to permit remote control of the hydraulic winch operations. The remote control device should be of a design that automatically returns to neutral when released. The remote control should have at least 25 ft (7.6 m) of cable. Alternately, the remote control could be accomplished by an FCC-approved radio frequency winch control device.

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.14.3 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.

Appendix B Specifying and Procuring Wildland Fire Apparatus

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General. It is the responsibility of the purchaser to provide the contractor with sufficient information to enable the contractor to prepare a bid and a complete description of the fire apparatus the contractor proposes to supply. The local fire chief and fire department staff know the conditions under which the apparatus is to be used. However, competent advice also should be obtained from knowledgeable and informed sources such as more experienced fire service personnel, wildland fire agencies, trade journals, training instructors, maintenance personnel, and fire equipment and component manufacturers. The fire insurance rating authority also should be consulted.

B.1.1 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 desire features of operation over and above these minimum requirements. The requirements in the standard, together with the appendix material, should be studied carefully. It is important to define carefully in the specifications for the apparatus requirements such as those that detail where the apparatus has to exceed the minimum requirements or where a specific arrangement is needed. These might include special performance requirements, defining the number of seats and the seating arrangement for fire fighters riding on the apparatus, or the provision of space for extra hose or equipment the apparatus will be required to carry. Completion by the purchaser of the form shown in Figure B.1.1 should assist the purchaser in developing their specifications and provide the information required in the various sections of this document.

Where local operating conditions necessitate apparatus of unusual design, the purchaser needs to define carefully the special requirements within the specifications. Height, width, undervehicle clearance, wheel base, turning radius, and length occasionally need special attention. For example, a community with many narrow winding streets needs apparatus capable of readily negotiating switchbacks without delay.

B.1.1.1 The equipment list provided in Chapter 10 relates to the operations to which a wildland fire apparatus is normally assigned. Because new apparatus should be fully equipped in order to provide effective service, it is recommended that new equipment be provided along with the apparatus.

B.1.1.2 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 analyzed carefully to ensure that the completed apparatus meets the specified performance.

B.1.1.3 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 that apply to all manufacturers of trucks, including fire trucks. It is unlawful for a manufacturer to deliver a truck not in compliance with these federal standards. These federal safety standards change frequently, 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 to specifications that would require them to perform unlawfully or to delete required items or to include any that are illegal.

B.1.1.4 Additional requirements are placed on both apparatus and engine manufacturers by the Clean Air Act, which is enforced by the Environmental Protection Agency (EPA). These standards have resulted in major changes in the performance of many engines. Neither the engine manufacturer nor the apparatus manufacturer can modify engines once they are certified to EPA standards. Because of the EPA standards, it often is necessary to install larger engines than might have been used previously in order to obtain the same apparatus performance.

B.1.1.5 Many apparatus purchasers find it desirable to provide for an interim inspection at the apparatus assembly plant. The advantages of such a provision include the opportunity to evaluate construction prior to final assembly and painting. The specifications should detail the particulars of such an inspection.

The chief of the fire department (or a designated representative) normally exercises the acceptance authority following satisfactory completion of tests and inspections for compliance with purchase specifications. The specifications should provide details of delivery expectations, including the desired training, the required acceptance tests, and identification of who is responsible for the various costs associated with the delivery and acceptance.

FIGURE B.1.1 Purchasing specification form.

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.

If an interim inspection trip(s) to the contractor's facility is to be provided, indicate the number of trips __________ and number of participants __________ .

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 training is to be conducted at ______________________________

____

for __________ persons for __________ days.

Specify details of any special payment plan or schedule required. ______________________________

____

____

Is an approval drawing required? ❑ Yes ❑ No

Is a bid bond required? ❑ Yes ❑ No

What percent of the bid price? ______________________________

Is a performance bond required? ❑ Yes ❑ No

What percent of the bid price? ______________________________

If an extended warranty on specific components is required, indicate which components and the length of the warranty. ______________________________

____

____

____

Is a warranty bond required? ❑ Yes ❑ No

In what amount? ______________________________

(NFPA 1906, 1 of 13)

FIGURE B.1.1 ***(Continued)***

GENERAL REQUIREMENTS — CHAPTER 2

Special design features required on this apparatus: ____________________

____

____

What are the maximum allowable dimensions of the apparatus?

Height in inches: __________(measured at the highest projection)

Overall length in inches: __________ (measured at the front and rearmost projections)

Wheelbase in inches: __________(measured from the center of the front axle to the center of the rear axle)

Width in inches: __________(measured at the outside of the mirrors)

Gross vehicle weight in pounds: ____________________

Maximum weight on the front axle in pounds: ____________________

Maximum weight on the rear axle in pounds: ____________________

What is the maximum turning radius allowable? __________ ft measured at ❑ Tires ❑ Body

Maximum elevation at which the apparatus will operate if over 2000 ft: ____________________

____

Maximum stationary operational grade if over 20 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: ____________________

Specify the apparatus road performance if it is to exceed the minimum specified in this standard. __________

____

____

____

Specify the maximum road speed required. ____________________

Specify the minimum and maximum ambient air temperature in which the apparatus is to operate. __________

____

HOSE THREAD SIZE INFORMATION

(TPI × OD or size and type) (i.e., 2½ in. NH or 4 in. storz)

1 in. =	1½ in. =
2 in. =	2½ in. =
3 in. =	3½ in. =
4 in. =	4½ in. =
5 in. =	6 in. =
Hydrant =	

TESTING AND ACCEPTANCE

Is independent certification of tests required for the pump system or other systems? ❑ Yes ❑ No

If yes, what independent testing organization is to certify the tests? ____________________

____

____

(NPFA 1906, 2 of 13)

FIGURE B.1.1 ***(Continued)***

Is anyone to witness the manufacturer's pre-delivery 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 — CHAPTER 3

Desired chassis make/model or style: ____

Specify the desired location of the engine. ____

Type of propulsion engine: ____

Is an electric fuel pump or re-priming pump required? ❑ Yes ❑ No

Specify any special lubrication system requirements. ______________________________________

Specify any special cooling system requirements. ____

Type of coolant required: ____

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: ____

Specify the existing location of the exhaust system. _____________________________________

Specify the type of brake system required. ____

Is an auxiliary brake system required? ❑ Yes ❑ No

Specify the type. ____

Specify the style and type of tires required. ____

(NFPA 1906, 3 of 13)