# NFPA 1906
## Standard for Wildland Fire Apparatus

## 1995 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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# NFPA 1906

## Standard for

# Wildland Fire Apparatus

## 1995 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 Fall Meeting held November 14-16, 1994, in Toronto, Ontario, Canada. It was issued by the Standards Council on January 13, 1995, with an effective date of February 7, 1995.

The 1995 edition of this document has been approved by the American National Standards Institute.

## Origin and Development of NFPA 1906

This first edition of NFPA 1906, *Standard for Wildland Fire Apparatus*, was developed by the Technical Committee on Fire Department Apparatus to provide a standard for apparatus that is basically designed and deployed to combat fires in the wildland. The apparatus covered by this document has pumps ranging in size from 20 gpm to 250 gpm (76 Lpm to 950 Lpm) and water tanks with a capacity of 125 gal (473 L) or more. Units with larger pumping capacity are covered in other NFPA apparatus standards and typically are not devoted exclusively to wildland fire suppression. The apparatus covered in this standard includes the built-to-specification apparatus and the fire-fighting packages designed to be slipped onto a vehicle chassis.

With the emergence of Class A foam as a fire suppressant agent, a chapter on proportioning systems for Class A foams and another chapter on Compressed Air Foam Systems (CAFS) have been included in this document.

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

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

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# NFPA 1906

## Standard for

# Wildland Fire Apparatus

## 1995 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 for wildland fire suppression. The apparatus consists of a vehicle equipped with a pump, water tank, limited hose, and equipment. The vehicle shall be capable of supporting pump and roll operations.

**1-2* Purpose.** This standard specifies the minimum requirements for a new automotive wildland fire apparatus.

**1-3* Definitions.**

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

**Acceptance Tests.** Tests performed on behalf of the purchaser at the time of delivery to determine compliance with the specifications for the fire apparatus.

**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.

**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.

**Approved.*** Acceptable to the authority having jurisdiction.

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

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

**Back-up Alarm.** An audible warning alarm device designed to warn that the vehicle is in reverse gear.

**Chassis.** The basic vehicle frame consisting of the mainframe rails, reinforcements, cross members, fasteners, brackets for suspension, suspension members (springs), axles, tires and wheels, cab, and power train.

**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 remains in equilibrium in any position.

**Compound Gauge.** A gauge that indicates pressure both above and below atmospheric pressure. On most gauges, zero equals atmospheric pressure. Gauges typically measure pressure above atmospheric pressure in pounds per square inch and below atmospheric pressure in inches of mercury.

**Contractor.** The person or company responsible for fulfilling a contract. The contractor is not necessarily the manufacturer of the vehicle or any portion of the vehicle but is responsible for the completion, delivery, and acceptance of the entire unit.

**Discharge Outlet Size.** The nominal size of the first fire hose thread from the pump available to the pump operator.

**Dynamic Suction Lift.** The sum of the vertical lift and the friction and entrance loss caused by the flow through the suction strainers and hose, expressed in feet of water head.

**Electric Siren (Electromechanical).** An audible warning device that produces sound by the use of an electric motor with an attached rotating slotted disk or rotating perforated disc. Only one type of warning sound can be produced, but the level or pitch can be varied by the speed of the motor.

**Electronic Siren.** An audible warning device that produces sound electronically through the use of amplifiers and electromagnetic speakers. Varied types of warning sounds can be produced, such as a wail, yelp, or simulated air horn.

**Enclosed Compartment.** An area confined on six sides and equipped with a latching and a closeable access opening(s) designed to protect stored items from environmental damage (weather resistant).

**Engine PTO.** A power takeoff that is driven directly by either the front or rear of the engine but that is not affected by the drive clutch, transmission, or transfer case.

**Fire Apparatus.** A vehicle used for fire suppression by a fire department, fire brigade, or other agency responsible for fire protection.

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

**Gallon.** United States gallon.

**GPM.** Gallons per minute.

**Grade.** A measurement of angle used in road design and expressed as a percentage of elevation change over distance. A 45-degree slope is equal to a 100 percent grade.

**Gross Axle Weight Rating (GAWR).** The value specified as the loaded weight rating of a single axle system, as measured at the tire ground interfaces.

**Gross Vehicle Weight Rating (GVWR).** The value specified by the chassis manufacturer as the loaded weight rating of a single vehicle.

**Ground Clearance.** The clearance under a vehicle at all locations except the axles and drive shaft connections to the axle.

**Intake Connection Size.** The nominal size of the first fire hose thread from the pump available to the pump operator.

**Intersection Lights.** Flashing emergency lights designed to provide early warning that an emergency vehicle is entering an intersection.

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

**Low-Voltage Circuit, Equipment, or System.** The terminology for the standard 12-volt or 24-volt dc electrical system used to start a vehicle and to provide energy for lights, sirens, radios, and other vehicle accessories.

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

**National Standard Hose Thread (NH).** A standard thread that has dimensions for inside and outside fire hose connection screw threads as defined in NFPA 1963, *Standard for Fire Hose Connections.*

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

**NPSH.** National pipe straight hose thread as specified in ASME B1.20.7, *Hose Coupling Screw Threads* (*inch*).

**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.

**Preconnected 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. Also commonly called a bucket line, cross lay, or mattydale.

**PSI.** Pounds per square inch.

**PSIG.** Pounds per square inch gauge (pressure above atmospheric pressure).

**PTO.** Power takeoff.

**Pump and Roll.** The ability of apparatus to pump water while it is moving under its own power.

**Pump Operator's Panel.** The area on a fire apparatus that contains the gauges, controls, and other instruments designed for primary control of the pump.

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

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

**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.

**Readily Accessible.** Able to be seen, reached, and serviced or removed without removing other components or parts of the apparatus and without the need to use special tools to open enclosures.

**Shall.** Indicates a mandatory requirement.

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

**Slip-on Fire-Fighting Package.** A self-contained unit including a pump, piping, a tank, and a hose reel(s) that is designed to be placed on a truck chassis, utility bed, or flat bed. These units typically can be placed on and removed from the vehicle with a minimum of time and effort.

**Split Shaft PTO.** A power takeoff (PTO) drive system that directs the chassis power either to the pump or to the chassis drive axle. This is accomplished by splitting the chassis driveline that connects the chassis transmission to the drive axle and inserting the split shaft PTO that has the shift mechanism necessary to direct the engine power as described above.

**Sump.** A recessed area of a tank assembly designed primarily to entrap sludge or debris for easy removal and to serve as a central water collection point.

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

**Wildland Fire Apparatus.** Fire apparatus equipped with a pump having a capacity between 20 gpm and 250 gpm (76 L/min and 950 L/min), a water tank, and equipment that meets or exceeds the requirements of this standard.

**1-4 Conversion Factors.** 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. 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 1-4 provides the conversion factors to be used where SI units are not provided in the text or where more precision is desired.

**Table 1–4 Conversion Factors**

| | |
|---|---|
| One gallon per minute (gpm) = | 3.785 liters per minute (L/min) |
| One gallon per minute (gpm) = | 0.833 imperial gallons per minute |
| One pound per square inch (psi) = | 6.895 kilopascals (kPa) |
| One pound per square inch (psi) = | 0.0690 bar (bar) |
| One pound per square inch (psi) = | 2.31 feet of water (ft $H_2O$) |
| One inch of mercury (in. Hg) = | 3.386 kilopascals (kPa) |
| One inch of mercury (in. Hg) = | 0.0340 bar (bar) |
| One inch (in.) = | 25.40 millimeters (mm) |
| One foot (ft) = | 0.305 meters (m) |
| One square inch (in.$^2$) = | 645.2 square millimeters (mm$^2$) |
| One mile per hour (mph) = | 1.609 kilometers per hour (kmph) |
| One pound (lb) = | 0.454 kilograms (kg) |
| One 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 Protection of Personnel and Components.**

**2-2.1** Guards or shields shall be provided where necessary to prevent injury of personnel by hot, moving, or rotating parts.

**2-2.2** All hydraulic lines, air system tubing, control cables, and all electrical lines shall be clipped to the frame or body structure of the apparatus and, except where a through-the-frame connector is necessary, shall be furnished with metal protective looms or grommets at each point where they pass through body panels or structural members.

**2-3 Vehicle Stability.**

**2-3.1** The center of gravity of the fully equipped and loaded vehicle shall be no higher than 75 percent of the rear track width of the vehicle above the flat and level surface upon which the vehicle rests, with all wheels on that surface. The rear vehicle track 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.

**2-3.2*** The weight distribution when the vehicle is fully loaded and equipped as defined in Section 3-1 shall not exceed the chassis manufacturer's recommended maximum limits.

**2-3.3** 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.

**2-4 Apparatus Performance.**

**2-4.1*** The apparatus shall meet the requirements of this standard at elevations of 2000 ft (610 m) above sea level.

**2-4.2*** The apparatus shall meet all the requirements of this standard while stationary on a grade of 20 percent in any direction.

**2-4.3*** The fire apparatus shall be designed to perform all its functions in an ambient temperature of 33°F to 110°F (1°C to 43°C).

**2-5 Road Ability.**

**2-5.1** The 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:

(a) From a standing start, the vehicle shall attain a true speed of 35 mph (56 kmph) within 25 seconds on a level road.

(b) *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) on a level road.

(c) *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.

**2-5.2*** The vehicle shall be capable of maneuvering across a 20-percent grade and up and down a 25-percent grade.

**2-6 Serviceability.**

**2-6.1** The apparatus shall be designed so that all recommended daily maintenance checks can be performed easily by the operator 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 capscrews 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.

**2-6.2** Where special tools are required for routine service on any component of the apparatus, such tools shall be provided with the apparatus.

**2-6.3** At least two 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.

## 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 fully equipped apparatus, including full water tanks, fuel tanks, and all other reservoirs; the apparatus designed hose load; the equipped personnel weight; and a miscellaneous and minor equipment allowance. The miscellaneous and minor equipment allowance shall be 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) |
| 5000 — 10,000 | 2268-4536 | 300 | 136 |
| 10,001 — 15,000 | 4537-6803 | 500 | 227 |
| 15,001 — 20,000 | 6804-9072 | 1000 | 454 |
| 20,001 and up | 9073 and up | 1500 | 681 |

**3-1.2** The unequipped personnel weight shall be calculated at 250 lb (113 kg) per person multiplied by the number of seating positions on the apparatus.

**3-1.3** A final manufacturer's certification of the GVWR and GAWR shall be supplied on a nameplate affixed to the vehicle.

**3-1.4** A permanent plate shall be affixed to the dash of the driving compartment indicating whether the apparatus is designed for on-road use only, off-road use only, or for both on-road and off-road use.

**3-2 Engine and Engine System Design.**

**3-2.1*** The engine supplied shall use a readily available commercial fuel.

**3-2.1.1*** If the engine is diesel-fuel powered, an engine governor shall be installed to limit the speed of the engine under all conditions of operation to that speed established by the engine manufacturer; this speed shall be the maximum no-load governed speed.

**3-2.1.2*** Automatic engine shutdown systems shall not be permitted unless they are an integral part of the standard engine management system.

**3-2.1.3** The engine and transmission 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 other points necessary to allow complete removal of the coolant from the system. Drain valves shall be designed so that they do 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 a replaceable-element 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:

(a) Engine oil;

(b) Engine coolant;

(c) Chassis transmission fluid;

(d) Pump transmission lubrication fluid, if used;

(e) Pump primer fluid, if used;

(f) Drive axle lubrication fluid.

**3-2.4 Fuel and Air System.**

**3-2.4.1 Diesel Engines.**

**3-2.4.1.1** 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 to prevent water and burning embers from entering the air intake system. An air restriction indicator shall be mounted in the cab and shall be visible to the driver.

**3-2.4.1.2*** The diesel fuel injection system shall be provided by the engine manufacturer and shall be of sufficient size to allow development of the rated power. Supply fuel lines and fuel filters shall be in accordance with the engine manufacturer's recommendations.

**3-2.4.2 Gasoline Engines.**

**3-2.4.2.1** 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 to prevent water and burning embers from entering the air intake system.

**3-2.4.2.2** Fuel lines and filters or strainers that meet the engine manufacturer's recommendations shall be of a serviceable type and shall be mounted in an accessible location. Where two or more fuel lines are installed, separate fuel pumps operating in parallel with suitable check valves and filtering devices shall be provided. 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 rocks, stumps, logs, or other objects that might cause 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, suitable protective guards shall be provided.

**3-3 Apparatus Electrical System and Devices.**

**3-3.1 General.**

**3-3.1.1** Any alternator, cranking motor, ignition wiring, distributor, or ignition coil shall be moisture resistant and shall be protected against excessive heat.

**3-3.1.2** Electromagnetic interference/suppression shall be provided in accordance with SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz).*

**3-3.1.3*** All electrical circuit feeder wiring supplied and installed by the apparatus manufacturer shall be stranded copper alloy conductors of a gauge rated to carry 125 percent of the maximum current for which the circuit is protected. Insulation shall be type SXL or GXL in accordance with SAE J1128, *Low Tension Primary Cable*, and wiring shall be in accordance with SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring*, for such loading at the potential employed. The voltage drop in any wiring between the power source and the using device shall not exceed 10 percent. The overall covering of conductors shall be loom or braid rated at 280°F (143°C) minimum, and shall be flame retardant and moisture resistant. All connections shall be made with lugs or terminals mechanically secured to the conductors. Wiring shall be well-secured in place and shall be protected suitably against heat, oil, and physical damage. All low-voltage wiring shall be color coded or printed with a circuit function code over the conductor's entire length. Wires of the same color and size, without a printed function code, shall not be used for unrelated circuits within the same harness.

**3-3.1.4** Circuits shall be provided with properly rated low-voltage overcurrent protective devices. Such devices shall be readily accessible and protected against excessive heat, physical damage, and water spray. Switches, relays, terminals, and connectors shall have a direct current rating of 125 percent of the maximum current for which the circuit is protected.

**3-3.2 Power Supply.**

**3-3.2.1*** A minimum of one cold-rated, 100-amp, 12-volt (nominal) electric alternator shall be provided. It shall have an output adequate to meet the continuous anticipated electrical load of the apparatus as manufactured at 200°F (93°C) ambient temperature in the engine compartment, and it shall be provided with full automatic regulation. It shall have a 60-amp minimum output at 200°F (93°C) at engine idle speed.

**3-3.2.2** A voltmeter shall be provided on the driver's instrument panel.

**3-3.2.3** If automatic throttle devices (high idle) are installed that increase the engine speed when the apparatus is parked to allow higher levels of power production by the alternator, they shall be provided with interlocks that prevent their activation when the pump is engaged, when the apparatus is in any gear other than park or neutral, and when the vehicle's parking brakes are not engaged.

**3-3.3* Batteries.**

**3-3.3.1*** Batteries shall be of the high-cycle type. They shall be mounted securely and protected adequately against physical damage and vibration, water spray, and engine and exhaust heat. Where an enclosed battery compartment is provided, it shall be ventilated adequately to prevent the buildup of heat and explosive fumes. The batteries shall be readily accessible for examination, test, and maintenance. If a battery is located in the engine compartment or adjacent to exhaust system components, heat shields shall be provided. A corrosion-resistant battery containment base tray shall be provided.

**3-3.3.2*** If an onboard battery conditioner or charger or a polarized inlet is provided for charging batteries, the associated line voltage electric power system shall be in accordance with Chapter 11.

**3-3.3.3*** The battery capacity and all starting circuit wiring and electrical equipment provided, including the starter switch, shall meet or exceed the engine manufacturer's minimum recommendations. The battery system capacity shall be a minimum of 850 cold cranking amps (CCA).

**3-3.4 Starting Device.** An electrical starting device shall be provided for the engine. When operating under maximum load, the voltage drop of the electrical conductors supplying the starting device shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits*.

**3-3.5 Lights and Warning Devices.**

**3-3.5.1*** Each apparatus that responds on public roads as an emergency vehicle shall have one or more rotating, oscillating, or flashing lights, visible through 360 degrees in a horizontal plane, mounted on the driving compartment roof or as high as practicable. In addition, a pair of flashing, oscillating, or rotating warning lights shall be affixed on the front of the vehicle. They shall face forward and be positioned below the windshield level. Another pair shall be affixed at the rear of the vehicle, facing to the rear. Also, an intersection light shall be affixed as low and as far forward as practicable between the front wheel and the front of the vehicle on each side. Intersection lights shall be arranged to emit maximum illumination perpendicular to the sides of the vehicle.

**3-3.5.2** All required warning lights shall be Class 1 as defined in SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*; SAE J845, *360 Degree Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*; or SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, for the applicable type of light.

**3-3.5.3** A master warning light switch shall be provided.

**3-3.5.4*** Apparatus that responds on public roads as an emergency vehicle shall have audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren. The siren shall meet the requirements of SAE J1849, *Emergency Vehicle Sirens*. Controls for operating the siren shall be provided within convenient reach for the persons riding in both the right and left front seat positions.

**3-3.5.5** Where furnished, air horns, an electric siren(s), and an electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practicable. Audible warning equipment shall not be mounted on the roof of the apparatus.

**3-3.5.6** Two clear, minimum 5000 candle power lights shall be provided at the rear of the apparatus for illumination of the work area.

**3-3.5.7*** Apparatus shall have sufficient lights to properly illuminate the crew compartment(s), pump operator's panel, engine compartment, work areas, and steps. Switches shall be conveniently located. Lights shall be arranged to minimize accidental breakage.

**3-3.5.8** An electric or electronic back-up alarm that meets the Type D (87 dba) requirements of SAE J994, *Alarm-Backup-Electric-Performance, Test, and Application*, shall be provided.

**3-3.5.9** Equipment shall be mounted so that it does not obscure the rear stop, tail, and directional lights. Directional lights shall be visible from the front, sides, and rear of the vehicle.

**3-4 Vehicle Components.**

**3-4.1* Braking System.**

**3-4.1.1*** Service brakes and parking brakes shall be independent and separate systems. All brakes shall be readily accessible for adjustment.

**3-4.1.2** The vehicle shall be equipped with an all-wheel anti-lock brake system if such a system is available from the chassis manufacturer.

**3-4.1.3*** Where air-actuated braking systems are provided, they shall include:

(a) An automatic moisture ejector,

(b) An air drier, and

(c) A pressure protection valve to prevent the use of air horns or other air-operated accessories when the system air pressure drops below 80 psig (552 kPag).

**3-4.1.4*** 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 hydraulic-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.

**3-4.2 Suspension and Wheels.**

**3-4.2.1** Each load-bearing tire and rim of the 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 *Yearbook* of the Tire and Rim Association, Inc., 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.

**3-4.2.2*** The minimum axle housing clearance and ground clearance shall be as specified in Table 3-4.2.2.

**Table 3-4.2.2 Under-Vehicle Clearance**

| Chassis GVWR | | Axle Housing Clearance | | Ground Clearance | |
|---|---|---|---|---|---|
| (lb) | (kg) | (in.) | (mm) | (in.) | (mm) |
| 5000—10,000 | 2268—4536 | 6 | 152 | 9 | 229 |
| 10,001—15,000 | 4537—6803 | 8 | 203 | 12 | 305 |
| 15,001—20,000 | 6804—9072 | 9 | 229 | 13 | 330 |
| 20,001 and up | 9073 and up | 10 | 254 | 15 | 381 |

**3-4.2.3*** If the apparatus is an on-road vehicle only, an angle of approach of at least 20 degrees 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 normally as indicated in Section 3-1. If the vehicle is designed for off-road use, the angle of approach shall be at least 30 degrees and the angle of departure shall be at least 25 degrees when it is loaded normally as indicated in Section 3-1.

**3-4.2.4** Fenders and guards shall be braced and firmly secured. Clearance for tire chains shall be provided in accordance with SAE J683, *Tire Chain Clearance-Trucks, Buses, and Combinations of Vehicles.*

**3-4.2.5** 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 nondriving front axles and at least 28 degrees for driving front axles. Power steering or power-assisted steering shall be provided.

**3-4.3 Transmission.**

**3-4.3.1*** The transmission shall be rated for heavy duty service and shall be designed to match engine torque and speed to the load demand. 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.

**3-4.3.2** The transmission shall allow the vehicle to function and operate smoothly at 2 mph (3.2 kmph).

**3-4.4 Fuel Tanks.**

**3-4.4.1*** A single fuel tank shall hold at least the capacity shown in Table 3-4.4.1. Additional fuel tanks shall be permitted.

**Table 3-4.4.1 Fuel Tank Capacity**

| Chassis GVWR | | Capacity | |
|---|---|---|---|
| lb | (kg) | (gal) | (L) |
| 5000—10,000 | 2268—4536 | 16 | 60 |
| 10,001—15,000 | 4537—6803 | 19 | 72 |
| 15,001—20,000 | 6804—9072 | 38 | 144 |
| 20,001 and up | 9073 and up | 45 | 171 |

**3-4.4.2** A conspicuous label near the tank fill opening shall indicate the proper fuel.

**3-4.4.3** The fuel gauge shall indicate the proportionate amount of fuel in the tank system at any time.

**3-4.4.4** 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. The tank shall be positioned so it is easily removable for repairs.

**3-4.5* Tow Hooks.** Front and rear tow hooks or tow eyes shall be attached to the frame structure to allow towing (not lifting) of the apparatus without damage.

**3-4.6* Driving and Crew Compartment.**

**3-4.6.1** A fully enclosed driving compartment with seating capacity for not less than two persons shall be provided.

**3-4.6.2** Steps and access handrails that comply with Sections 7-4 and 7-5 shall be provided as necessary for access to all driving and crew compartments.

**3-4.6.3*** The maximum number of persons expected to ride in the apparatus shall be specified by the purchaser. The manufacturer shall provide a seat with an approved seat belt within a fully enclosed area(s) for the total number of persons specified. Signs that state "Occupants must be seated and belted when apparatus is in motion" shall be provided. These signs shall be visible from each seated position. An accident prevention sign that states the number of personnel the vehicle is designed to carry shall be located in an area visible to the driver.

**3-4.6.4** 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 the *Code of Federal Regulations* (CFR), Title 49, paragraph 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-surfaced road.

**3-4.6.5** All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening.

**3-4.6.6** 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 of 22 in. (560 mm) at the shoulder level. Seat cushions shall be a minimum of 18 in. (458 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 vertically from the face of the seat at least 18 in. (458 mm) and that is a minimum of 18 in. (458 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.

**3-4.6.7*** Where SCBA units are mounted within the crew compartment, a positive mechanical means of holding the SCBA device in its stowed position shall be provided. The holding device shall be designed to minimize injury to crew compartment occupants in the event of rapid acceleration or deceleration of the apparatus.

**3-4.6.8*** Controls and switches that are expected to be operated by the driver while the apparatus is in motion shall be conveniently located within the driver's reach. The following instrumentation and controls shall be mounted in the driving compartment and shall be clearly identified and visible to the driver while seated:

(a) Speedometer;
(b) Odometer;
(c) Oil pressure indicator or gauge;
(d) Coolant temperature indicator or gauge;
(e) Voltmeter;
(f) Brake air pressure gauge(s), if applicable;
(g) Turn signal control and indicator lights;
(h) Headlight/DOT light switch;
(i) High beam headlight switch and indicator;
(j) Fuel level gauge(s);
(k) *Master ignition switch;
(l) Heater/defroster controls;
(m) Warning lights and siren switches, if applicable;
(n) Master electrical load switch;
(o) "Battery on" indicator light;
(p) Windshield wipers and washer.

## Chapter 4 Pumps

**4-1* Performance Requirements.** A pump that has a rated capacity at one of the increments shown in Table 4-1 and is capable of delivering and maintaining its rated capacity at 150 psi (1035 kPa) net pump pressure when pumping under the conditions specified in Section 4-2 shall be provided.

**Table 4-1 Suction Hose Size by Flow Rate**

| Flow Rate | | Hose Size | |
|---|---|---|---|
| **(gpm)** | **(L/min)** | **(in.)** | **(mm)** |
| 20 | 76 | 1 1/2 | 38 |
| 50 | 190 | 1 1/2 | 38 |
| 70 | 265 | 2 or 2 1/2 | 65 |
| 100 | 379 | 2 or 2 1/2 | 65 |
| 120 | 454 | 2 1/2 | 65 |
| 150 | 568 | 2 1/2 | 65 |
| 175 | 662 | 2 1/2 | 65 |
| 200 | 757 | 3 | 76 |
| 225 | 852 | 3 | 76 |
| 250 | 950 | 3 | 76 |

**4-2* Pumping Conditions.** The pump manufacturer shall certify that the pump can deliver its rated capacity at 150 psi (1035 kPa) net pump pressure under the following conditions:

(a) At an altitude of 2000 ft (610 m) above sea level;

(b) Through a single, 20-ft (6-m) line of suction hose of the size specified in Table 4-1 and equipped with a suction hose strainer;

(c) With a lift of 10 ft (3 m);

(d) At 29.9 in. Hg (101.2 kPa) atmospheric pressure (corrected to sea level);

(e) At a water temperature of 60°F (16°C); and

(f) With friction and entrance loss in suction hose and strainer as provided in Table 4-2.

**Table 4-2 Friction and Entrance Loss in 20 ft (6 m) of Suction Hose, Including Strainer**

| | Suction Hose Size (Inside Diameter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 1/2 in. | | 2 in. | | 2 1/2 in. | | 3 in. | |
| **Flow Rate (gpm)** | **Ft Water** | **In. Hg** | **Ft Water** | **In. Hg** | **Ft Water** | **In. Hg** | **Ft Water** | **In. Hg** |
| 20 | 1.3 | 1.1 | 0.3 | 0.3 | — | — | — | — |
| 50 | 7.0 | 6.2 | 1.7 | 1.5 | 0.5 | 0.4 | — | — |
| 70 | — | — | 3.3 | 3.0 | 1.0 | 0.9 | 0.4 | 0.4 |
| 100 | — | — | 6.3 | 5.6 | 2.0 | 1.7 | 0.9 | 0.8 |
| 120 | — | — | — | — | 2.9 | 2.6 | 1.2 | 1.1 |
| 150 | — | — | — | — | 4.5 | 4.0 | 1.9 | 1.7 |
| 175 | — | — | — | — | — | — | 2.6 | 2.3 |
| 200 | — | — | — | — | — | — | 3.4 | 3.0 |
| 225 | — | — | — | — | — | — | 4.2 | 3.7 |
| 250 | — | — | — | — | — | — | 5.2 | 4.6 |

**4-3 Priming.**

**4-3.1** When dry, the pump system shall be capable of taking suction and discharging water in not more than 30 seconds, through 20 ft (6 m) of suction hose of the size specified in Table 4-1 and a strainer, at a 10-ft (3-m) lift, at any elevation up to 2000 ft (610 m).

**4-3.2** The completed pump and any attached piping system shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) by means of the priming system and of sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (33.8 kPa). The pump primer shall not be used during the 5-minute period. This shall be demonstrated with the cap or plug removed from any valved intake or discharge.

**4-4 Pump Construction Requirements.**

**4-4.1** Suitable means shall be provided for completely draining the pump and all lines and accessories in cold weather.

**4-4.2** The pump body shall be subjected to a hydrostatic pressure test of 100 psi (690 kPa) above the maximum rated close-off pressure or 300 psig (2070 kPag), whichever is higher, for 10 minutes. The pump manufacturer shall provide a certificate of completion for the hydrostatic test.

**4-4.3** The pump casing shall be capable of being disassembled for inspection and replacement of parts.

**4-4.4*** The pump impellers, rotors, pistons, vanes, or water contacting gears (if applicable) shall be constructed of a corrosion-resistant material.

**4-4.5** The pump shaft shall be constructed of stainless steel or shall be protected from corrosion.

**4-5 Pump Intake Connections.**

NOTE: The following requirements do not apply to the intake connection between the water tank and the pump.

**4-5.1*** Intakes of the same or larger size as specified in Table 4-1 for suction hose size shall be provided.

**4-5.1.1** The intakes specified shall have male national standard hose thread (NH). Intakes of 2 in. (51 mm) or less shall be permitted to have NPSH thread.

**4-5.1.2** If the couplings on the suction hose carried on the 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.

**4-5.2** Each 3-in. (76-mm) or larger intake valve, except the valve in the tank-to-pump intake, shall have an operating mechanism that does not allow the flow regulating element of the valve to move from the fully closed position to the fully open position, or vice versa, in less than 3 seconds.

**4-5.3** Each $2^1/_2$-in. (63-mm) or larger valved intake shall be equipped with a bleeder valve that is located in close proximity to the intake to bleed off air (or pressure) from a hose connected to the intake.

**4-5.4** Each intake shall be provided with a suitable closure that is capable of withstanding 100 psi (690 kPa) over the maximum rated pump close-off pressure or 300 psig (2070 kPag), whichever is higher. Each intake that has male threads shall be equipped with a cap; each intake that has female threads shall be equipped with a plug. Where an adapter for special threads or other means for hose attachment is provided on the intake, a closure shall be provided for the adapter in lieu of a cap or plug.

**4-5.5** 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.

**4-6 Pump Discharge.**

**4-6.1*** Sufficient discharge outlets, in addition to 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 4-6.1.

**Table 4-6.1 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 | 51 | 175 | 663 |
| $2^1/_2$ | 65 | 250 | 950 |
| 3 | 76 | 375 | 1420 |
| $3^1/_2$ | 89 | 500 | 1900 |

**4-6.2** 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 $1^1/_2$ in. (38 mm) or less in size shall be permitted to have NPSH thread.

**4-6.3** Each discharge outlet, except an outlet to which a hose is to be preconnected, 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 psig (2070 kPag), 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 for an outlet $3^1/_2$ in. (89 mm) or smaller in size, it shall be secured to the pumping unit with a suitable chain or cable.

**4-6.4*** Each discharge outlet shall be valved individually. All valves shall be capable of being opened and closed smoothly and readily at the flows shown in Table 4-6.1 for the outlet size at the rated pressure of the pump.

**4-6.5** Each 3-in. (76-mm) or larger discharge valve shall have an operating mechanism that does not allow the flow regulating element of the valve to move from the fully closed position to the fully open position, or vice versa, in less than 3 seconds.

**4-6.6** All $1^1/_2$-in. (38-mm) or larger discharge outlets not readily relieved through the pump's main drain(s) shall be equipped with a drain or bleed-off valves for draining or bleeding off pressure from a hose connected to the outlet.

**4-6.7** Any 2-in. (51-mm) or larger discharge outlet that normally 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 supplied with a sweep elbow of at least 30 degrees downward.

**4-6.8*** A pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open shall be provided between the pump discharge and the water tank. Where a foam system is provided, this line shall be plumbed so the water returning to the water tank is free of foam solution.

**4-6.9** If the apparatus is equipped with a booster reel, the piping, valves, and swivel between the pump and booster reel shall be nominally the same size 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 to be used in place of piping.

**4-6.10** 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.

**4-7 Pump Operator's Position.**

**4-7.1** The pump panel and other pump controls, gauges, and instruments shall be located at a single pump operator's position.

**4-7.2** A minimum level of 5 foot-candles of illumination shall be provided to illuminate all gauges, discharge outlets, pump intakes, and controls.

**4-7.3** All required markings shall be of a permanent type, capable of withstanding the effects of weather and temperature extremes, and shall be attached securely.

**4-7.4** The midpoint or centerline of any valve control shall be not more than 72 in. (1829 mm) vertically above the ground or platform that normally serves as the operator's standing position.

**4-8 Gauges and Instruments.**

**4-8.1** A master pump discharge gauge shall be provided on the pump panel. If a round gauge is used, it shall be at least size $2^1/_2$ in accordance with ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element,* paragraph 3.1. If a digital gauge 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-rated pressure. The accuracy of the gauge shall be a minimum of Grade B as defined in ASME B40.1.

**4-8.2** Where one or more $2^1/_2$-in. (65-mm) or larger external valved pump inlets are provided, a pump intake gauge shall be provided on the pump panel and shall be located to the left of the pump discharge gauge. If a round gauge is used, it shall be at least size $2^1/_2$ in accordance with ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element,* paragraph 3.1. If digital gauges are used, the digits shall be at least $^5/_8$ in. (16 mm) high. The gauge shall read from 30 in. Hg (101.6 kPa) vacuum to at least 100 psi (690 kPa) higher than the maximum pump-rated pressure. The accuracy of the gauge shall be a minimum of Grade B as defined in ASME B40.1.

**4-8.3** If both an intake gauge and a master discharge gauge are provided, a label at the intake gauge shall read "Pump Intake" and a label at the master discharge gauge shall read "Pump Discharge."

**4-8.4** All gauges and instruments shall be mounted and attached so they are protected from accidental damage and excessive vibration. All analog water pressure gauges shall be liquid filled, vibration dampened, and capable of continuous operation to –40°F (–40°C) without damage.

**4-8.5** All instruments shall be located so that they are readily visible at the pump operator's position.

## Chapter 5 Pump Engines

**5-1 Application.**

**5-1.1** Sections 5-2 through 5-13 shall apply to auxiliary engine-driven pumps.

**5-1.2** Sections 5-14 through 5-16 shall apply to vehicle engine-driven pumps.

**5-2 Fuel.** The fuel for the engine shall be commercially available.

**5-3 Engine Running Indicator.** A green light shall be located in the driving compartment and shall be illuminated when the pump engine is running. A label at the light shall read "Pump Engine Operating."

**5-4 Engine Shutdown.**

**5-4.1*** A nonlocking switch to stop the engine shall be furnished and shall be located at the pump operator's position.

**5-4.2*** An automatic engine shutdown system shall not be permitted, except for an automatic shutdown that is activated only when the water pump is running out of water.

**5-5* Engine Speed Control.** The engine speed shall be permitted to be controlled by an automatic speed controller or a manually adjustable throttle and an independent governor that limits the engine speed, at no load, to the engine manufacturer's recommended maximum no-load governed speed for the application. An automatic speed controller shall automatically adjust the engine throttle as necessary to maintain the desired engine speed and shall limit the engine speed, at no load, to the engine manufacturer's recommended maximum speed for the application.

**5-6 Cooling System.**

**5-6.1** The engine shall be air-cooled or liquid-cooled, with a self-contained cooling system that does not pump cooling system water directly onto the ground during normal operating conditions.

**5-6.2** The cooling system shall be adequate to maintain the engine at or below the engine manufacturer's maximum temperature rating under all conditions of operation for which the unit is designed.

**5-6.3** If a liquid cooling system is provided, an adequate and readily accessible means to drain the cooling system shall be installed at the lowest point of the system and at other such points as are necessary to allow complete removal of the coolant from the system. Drain valves shall be designed so that they do not open accidentally due to vibration.

**5-6.4** Any radiator or heat exchanger shall be mounted to prevent the development of leaks due to twisting or straining when the wildland fire apparatus traverses uneven ground. Radiator cores shall be compatible with commercial antifreeze solutions.

**5-6.5** If the pump drive engine has a liquid cooling system, a coolant temperature gauge or high-temperature indicator light shall be provided on the pump panel.

**5-7 Lubrication System.**

**5-7.1** The engine oil-fill pipe shall be large enough and located so as to allow easy filling.

**5-7.2** If the pump drive engine has a positive pressure lubrication system, a low oil pressure indicator or oil pressure gauge shall be provided on the pump panel.

**5-8 Fuel and Air Systems.**

**5-8.1 Diesel Engines.**

**5-8.1.1** 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 to prevent incidental water and burning embers from entering the air intake system.

**5-8.1.2*** The diesel fuel system shall be of sufficient size to develop the rated power. The supply fuel lines and fuel filters shall be in accordance with the engine manufacturer's recommendations.

**5-8.2 Gasoline Engines.**

**5-8.2.1** 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 to prevent the entry of incidental water and burning embers from entering the air intake system.

**5-8.2.2** Fuel lines, and filters or strainers that meet the engine manufacturer's recommendations shall be provided. The fuel filters or fuel strainers shall be of a serviceable type and mounted in an accessible location. The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of an engine's exhaust system. The line(s) shall be protected from mechanical damage.

**5-8.2.3** Where a carburetor(s) is supplied, it shall be of sufficient size to develop the rated power and shall be located so as not to be subjected to pocketing of vapor or excessive heating. A manual or automatic choke shall be provided.

**5-9* Exhaust System.** The exhaust piping and discharge outlet 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 silencing devices shall be provided with a USDA Forest Service-approved spark arrestor or shall be water-cooled to reduce the exhaust temperature to below the ignition point of carbon particles. 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, suitable protective guards shall be provided.

**5-10 Service Accessibility.** The unit shall be designed so that all recommended daily engine maintenance checks can be performed easily by the operator without the need for hand tools. Pumping unit components that interfere with engine repair or removal 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 in place.

**5-11 Electrical System and Devices.**

**5-11.1** Any alternator, cranking motor, ignition wiring, distributor, or ignition coil shall be moisture resistant and shall be protected against excessive heat.

**5-11.2** Electromagnetic interference/suppression shall be provided in accordance with SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*.

**5-11.3*** All electrical circuit wiring not supplied by the original electrical component or engine manufacturer shall be stranded copper alloy conductors of a gauge rated to carry 125 percent of the maximum current for which the circuit is protected. Insulation shall be type SXL or GXL in accordance with SAE J1128, *Low Tension Primary Cable*, and wiring shall be in accordance with SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring*, for such loading at the potential employed. Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent. The overall covering of conductors shall be loom or braid rated at 280°F (143°C) minimum, and shall be flame retardant and moisture resistant. All connections shall be made with lugs or terminals mechanically secured to the conductors. Wiring shall be secured in place thoroughly and protected suitably against heat, oil, and physical damage. Wiring shall be color coded or printed with a circuit function code over the entire length of each conductor.

**5-11.4** Switches, relays, terminals, and connectors shall have a direct current rating of 125 percent of the maximum current for which the circuit is protected.

**5-11.5** 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.

**5-11.6 Batteries.**

**5-11.6.1*** Where electric starting is provided, batteries shall be mounted securely and protected adequately against physical damage and vibration, water spray, and engine and exhaust heat. Where an enclosed battery compartment is provided, it shall be ventilated adequately to prevent the buildup of heat and explosive fumes, and the batteries shall be readily accessible for examination, test, and maintenance. If the battery is located adjacent to exhaust system components, heat shields shall be provided.

**5-11.6.2*** Battery power for the pump engine shall be permitted to be supplied from the chassis battery(s).

**5-11.6.3** The battery capacity and wiring circuits provided, including the starter switch and circuit and the starter to battery connections, shall meet or exceed the pump engine manufacturer's recommendations.

**5-12 Starting Device.** Where an electrical starting device is 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*. An accessible mechanical means of starting the engine shall be provided in addition to any electrical starting device that might be supplied.

**5-13 Fuel Tanks.**

**5-13.1*** The fuel tank(s) shall be of sufficient size to permit operation of the pump at its rated capacity and pressure for at least 2 hours without refilling.

**5-13.2*** The pump engine shall be permitted to be tied into the chassis fuel system.

**5-14 Pump Controls.**

**5-14.1** Provisions shall be made for quickly and easily placing the pump in operation. All pump controls and devices shall be installed so as to be protected against mechanical injury or the effects of adverse weather conditions upon their operation.

**5-14.2*** 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.

**5-14.3** A nameplate indicating the chassis transmission shift selector position to be used for pumping shall be provided in the driving compartment and shall be located so that it can be read easily from the driver's position.

**5-14.4** Where the pump is driven by a split shaft PTO, a green indicator light shall be located in the driving compartment. This indicator light shall be illuminated when the pump shift has been completed. It shall have a label that reads "Pump Engaged." Where an automatic chassis transmission is provided, a second green indicator light in the driving compartment and a green indicator light located at the pump operator's position shall be provided and illuminated when both the pump shift has been completed and the chassis transmission is engaged in pump gear. A label at the light in the driving compartment shall read "OK to Pump." The light on the pump operator's panel shall be positioned adjacent to and preferably above the throttle control. It shall have a label that reads "Warning: Do Not Open Throttle Unless Light Is On." The green light on the pump operator's panel shall be permitted to be illuminated when the pump is not engaged and the transmission is in the neutral position.

**5-14.5** Where an automatic chassis transmission is provided and where the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and is used for stationary pumping with the chassis transmission in neutral, or is used for pump and roll with the chassis transmission in any forward or reverse gear, shift indicator lights shall be provided as specified in 5-14.5.1 and 5-14.5.2.

**5-14.5.1 Two Green Indicator Lights in the Driving Com-partment.** One of the lights shall be illuminated when the pump drive has been engaged. It shall have a label that reads "Pump Engaged." The second light shall be illuminated when both the pump drive has been engaged and the chassis transmission is in neutral; it shall have a label that reads "OK to Pump."

**5-14.5.2 One Green and One Red Indicator Light on the Pump Operator's Panel.** The green light shall be illuminated when both the pump drive has been engaged and the chassis transmission is in neutral. The green light shall be positioned adjacent to and preferably above the throttle. It shall have a label that reads "Warning: Do Not Open Throttle Unless Light Is On." The red light shall be illuminated when the chassis transmission is not in neutral and the ignition switch is activated. It shall be located adjacent to and preferably above the throttle. It shall have a label that reads "Danger: Do Not Open Throttle."

**5-14.6** Where a manual chassis transmission is provided and where the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and is used for stationary pumping, a pump-engaged green indicator light shall be provided in the driving compartment; it shall have a label that reads "Pump Engaged."

**5-14.7** Where the pump is driven by a chassis transmission-mounted (SAE) PTO, a visible or audible warning device that is actuated when the temperature of the lubricant in the chassis transmission exceeds the transmission manufacturer's recommended maximum temperature shall be provided and located at the operator's position.

**5-14.8** Where the pump is driven by a split shaft PTO, the chassis cab speedometer shall register when the split shaft PTO is in pump gear.

**5-14.9** When the maximum rated speed of the pump driving source exceeds the maximum rated speed for which the pump was designed, an automatic means shall be provided to limit the pump driving source to the maximum designed speed of the pump.

**5-15 Pump and Roll Performance.** The vehicle drive engine and drive train shall be arranged so that the pump can deliver at least 20 gpm (76 L/min) at 100 psi (690 kPa) while the apparatus is moving at 2 mph (3.2 kmph) or less.

**5-16 Engine Controls.** 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. It shall be located so that it can be manipulated from the pump operator's position with all instrumentation in full view.

## Chapter 6 Water Tanks

**6-1* Tank Capacity.** A water tank with a minimum capacity of 125 gal (473 L) shall be provided.

**6-2 Tank Construction.**

**6-2.1*** The water tank shall be constructed of noncorrosive material or other materials that are protected against corrosion and deterioration. It shall have readily accessible clean-out holes or other means that allow complete cleaning of the tank.

**6-2.2*** Any water tank shall be provided with sufficient swash partitions(s) so that the maximum dimension perpendicular to the plane of any partition shall not exceed 36 in. (915 mm).

**6-2.3** The swash partition(s) shall extend from wall to wall and cover at least 75 percent of the area of the plane of the partition. Swash partitions shall have suitable vents or openings at both the top and bottom to allow the movement of air and water between spaces, as necessary, to meet the flow requirements.

**6-3 Tank Connections.**

**6-3.1** A convenient, covered fill opening designed to prevent spillage shall be provided and designed to permit the insertion of a $2^1/_2$-in. (65-mm) hose with coupling. A label on the cover shall read "Water Fill." An easily removable, readily 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 of more than 2 psig (13.8 kPag).

**6-3.2*** 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 capacity of the pump.

**6-3.3** 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. The valve control shall be located at the pump operator's position.

**6-3.4*** A valved tank fill line of at least 1 in. (25 mm) nominal inside diameter shall be provided. The valve control shall be located at the pump operator's position.

## Chapter 7 Body and Compartmentation

**7-1 Compartmentation.**

**7-1.1*** Any enclosed external compartments that are larger than $2^1/_2$ ft$^3$ (0.07 m$^3$) in size or have an opening in excess of 144 in.$^2$ (92,903 mm$^2$) in size shall be weather resistant, ventilated, and have provision for drainage of moisture.

**7-1.2** 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.

**7-2* Radio Space.** Suitably protected space or a compartment shall be provided for the installation of radio equipment.

**7-3* Equipment Containment.** Equipment holders or compartments shall be provided for all tools, equipment, and other items that are on the apparatus. Equipment holders shall be attached firmly and shall be designed so that equipment remains in place under all vehicle operating conditions. All tools and equipment shall be readily accessible.

**7-4 Stepping Surfaces.**

**7-4.1*** Steps, platforms, or secure ladders shall be provided so fire fighters have access to all working and storage areas of the apparatus. The maximum stepping height shall not exceed 18 in. (458 mm), with the exception of the stepping height from the ground to the first step, which shall not exceed 24 in. (610 mm). All steps, platforms, or ladders shall sustain a minimum static load of 500 lb (227 kg) without deformation and shall have skid-resistant surfaces. All steps shall have a minimum area of 35 in.$^2$ (22 582 mm$^2$), 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.

**7-4.2** 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.

**7-5* Access Handrails.** Access handrails shall be provided at all entrances to the driving or crew compartment and at any location where a fire fighter is expected to climb up onto the apparatus for access to equipment. 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.

**7-6 Metal Finish.**

**7-6.1*** 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.

**7-6.2** Each apparatus that responds on public roads as an emergency vehicle 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 ASTM D4956, *Standard Specifications for Retroreflective Sheeting for Traffic Control*, Type III, Class 1 or 3. At least 50 percent of the perimeter length of each side, at least 50 percent of the perimeter width of the rear, and at least 25 percent of the perimeter width of the front of the apparatus shall have the reflective material affixed to it. A graphic design meeting the requirements of this paragraph for reflective material shall be permitted to replace all or part of the required striping if the design or combination thereof covers at least the required perimeter lengths specified above.

**7-7 Hose Storage.**

**7-7.1** If a hose storage area(s) is provided, the area(s) shall be reinforced at the corners. The bottom shall be made of removable sections fabricated from noncorrosive materials. The bottom shall be constructed to prevent the accumulation of water and allow ventilation to aid in drying the hose. The interior shall be smooth and free from all projections, such as nuts, sharp angles, or brackets, that might injure the hose. Reels, handrails, ladders, and equipment holders shall not be placed to obstruct the laying or removal of hose from the storage area.

**7-7.2*** If a hose reel is provided, it shall have a capacity of not less than 100 ft (30 m) of $^3/_4$-in. (19-mm) booster hose.

**7-8 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 this section.

**7-8.1** 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.

**7-8.2 Mounting.**

**7-8.2.1** 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.

**7-8.2.2** The slip-on unit shall be mounted in a manner to prevent damage by vibration.

**7-8.2.3** Special anchorage shall be provided on the vehicle chassis and on the slip-on fire-fighting module to secure the skid-mounted fire-fighting module to the vehicle chassis. This anchorage shall be designed to prevent movement of the unit during rapid acceleration, or during side-hill operation.

## Chapter 8 Equipment Carried on Wildland Fire Apparatus

**8-1* Suction Hose.** If suction hose is provided, the hose shall comply with NFPA 1961, *Standard for Fire Hose,* and a suitable suction strainer shall be furnished.

**8-2 Minor Equipment.** Equipment on the following list shall be available on the wildland apparatus before it is placed in service. Brackets or compartments shall be furnished to mount or contain the equipment properly. Any equipment that is carried in the driving or crew compartment(s) shall be secured in brackets or shall be suitably tied down to minimize injury to the occupants in the event of a rapid acceleration or deceleration of the apparatus.

(a) One axe of any type.

(b) One round point shovel.

(c) Two portable hand lights.

(d) One approved, portable fire extinguisher suitable for use on Class B and Class C fires with mounting brackets. The minimum size shall be 40 B:C rating.

(e) Two spanner wrenches.

(f) *200 ft (61 m) of fire hose.

(g) One nozzle sized to the pump and hose carried.

(h) One first-aid kit.

(i) One hand pump water extinguisher.

(j) Two wheel chocks mounted in readily accessible locations. Wheel chocks shall meet or exceed the requirements of SAE J348, *Standard for Wheel Chocks*, for the wheel diameter on which the chocks are to be used.

## Chapter 9 Class A Foam Concentrate Proportioning Systems

**9-1* 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 this chapter.

**9-2* Definitions.** For the purpose of this chapter, these terms shall be defined as follows:

**Bubble.** The building block of foam composed of a film of fluid enclosing a parcel of air.

**Class A Fire.** A fire in ordinary combustible solids (e.g., grass, wood, paper, cloth, rubber, plastics).

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

**Drain Time.** The rate at which the foam solution is released by the bubble structure.

**Eductor.** A device that uses the Venturi principle to introduce a proportionate quantity of foam concentrate into a water stream. The pressure at the throat is below atmospheric pressure, allowing concentrate at atmospheric pressure in storage to flow into the water stream.

**Foam.** An aerated fire extinguishing solution created by mixing air into foam solution to form bubbles that, upon application, adhere to fuels and reduce combustion by cooling, wetting, suppressing vapors, and excluding oxygen.

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

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

**Foam Solution.** A foam concentrate and water mixture to which air is added to produce foam.

**Proportioner.** A device or method to add foam concentrate to the water to make foam solution.

**9-3 Types of Class A Foam Proportioning Systems.**

**9-3.1* Eductor System.** An eductor foam proportioning system shall meet the requirements of Sections 9-4, 9-5, 9-6, 9-7, and 9-10, as applicable.

**9-3.2* Intake-side System.** An intake-side foam proportioning system shall meet the requirements of Sections 9-4, 9-5, 9-6, 9-7, and 9-10, as applicable.

**9-3.3* Around-the-Pump System.** An around-the-pump foam proportioning system shall meet the requirements of Sections 9-4, 9-5, 9-6, 9-7, and 9-10, as applicable.

**9-3.4* Balanced Pressure System.** A balanced pressure foam proportioning system shall meet the requirements of Sections 9-4 through 9-10, as applicable.

**9-3.5* Direct Injection System.** A direct injection foam proportioning system shall meet the requirements of Sections 9-4, 9-5, 9-6, 9-7, 9-8, and 9-10, as applicable.

**9-3.6* Water Motor Meter Foam Proportioning System.** A water motor meter foam proportioning system shall meet the requirements of Sections 9-4, 9-5, 9-6, 9-7, 9-8, and 9-10, as applicable.

**9-4 Design and Performance Requirements of a Foam System.**

**9-4.1** The proportioning system shall be capable of proportioning Class A foam concentrate(s) at a mix rate(s) selected from the range of 0.1 percent to 1 percent over the design range of flow and operating pressures.

**9-4.2** The 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.

**9-4.3** The apparatus manufacturer shall certify the design performance of the foam proportioning system to be operable as an integral part of the water delivery system. The following shall be provided:

(a) The maximum capacity of foam solution capable of being discharged from the foam unit in percentage of injection rate at an expressed gpm (L/min).

Example: 1 percent solution at 250 gpm (946 L/min).

(b) The maximum pressure at which the foam proportioning unit will operate.

(c) The pressure drop across each individual proportioning device at the device manufacturer's 25 percent, 50 percent, 75 percent, and 100 percent maximum designed flow rate.

(d) The performance accuracy of the foam proportioning system across its range of flows and pressures in percentage of concentrate flow rate.

(e) If so equipped, the concentrate pump drive source shall be capable of delivering the power necessary to provide rated pump capacity at maximum system pressure continuously for 24 hours without failure (*see 9-8.3*).

**9-4.4** Continuously wetted components shall be constructed of materials that provide reasonable service life 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.

**9-4.5** Components that can be flushed with water after use shall be constructed of materials that are resistant to corrosion after being flushed with water and allowed to dry. These components also shall be constructed of materials resistant to deterioration by foam concentrates.

**9-4.6** The foam concentrate supply hose shall be noncollapsible at 23 in. Hg (77.7 kPa) vacuum.

**9-4.7** A means shall be provided to automatically prevent water from flowing back from the foam proportioner to the foam concentrate storage tank. This non-return device shall allow the full flow of foam concentrate.

**9-4.8** A minimum of one strainer or filter shall be provided on the foam concentrate supply side of the proportioner to prevent any debris that might affect the operation of the foam proportioning system from entering the system. The strainer assembly shall consist of a removable straining screen, housing, and retainer. The strainer assembly shall allow full flow capacity of the foam supply line.

**9-4.9** If the foam proportioning system injects foam concentrate on the discharge side of the water pump, a means shall be provided to automatically prevent foam concentrate and foam solution from flowing back into the water pump or water tank.

**9-4.10** A concentrate system flush line(s) shall be provided as required by the proportioner manufacturer. The flush line(s) shall not allow back-flow into the foam tank or water tank.

**9-5 Controls for Foam Systems.**

**9-5.1*** All foam proportioning system operating controls shall be located at the pump operator's position and shall be identified clearly.

**9-5.2** Foam proportioning systems that require flushing after use shall be provided with readily accessible controls that allow the operator to completely flush the system with water according to the manufacturer's instructions.

**9-5.3** All foam systems shall incorporate features that introduce foam concentrate into the water stream only when a flow condition exists.

**9-5.4** Foam proportioning systems that incorporate foam concentrate metering valves shall have each metering valve calibrated and marked to indicate the range of the foam concentrate injection rate(s) available as determined by the design of the system.

**9-6 Gauges, Flow Meters, and Indicators of Foam Systems.**

**9-6.1** All gauges, flow meter displays, and indicators shall be located so they are readily visible from the pump operator's position. All gauges or flow meters shall be mounted in a manner that protects the gauge from physical damage and excessive vibration.

**9-6.2** All analog pressure gauges shall be liquid filled, vibration dampened, and capable of continuous operation to –40°F (–40°C) without damage.

**9-6.3** All analog pressure gauges shall be at least size $2^1/_2$ in accordance with ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, paragraph 3.1. The accuracy of the gauges shall be a minimum of Grade B, as defined in ASME B40.1.

**9-7 Atmospheric Foam Concentrate Tank.** If the foam proportioning system incorporates an atmospheric foam concentrate tank, 9-7.1 through 9-7.12 shall apply.

**9-7.1** The foam concentrate tank shall be provided with a fill tower with an area of at least 12 in.$^2$ (7742 mm$^2$) and a minimum volume of not less than 2 percent of the total tank volume. The tank opening shall be protected by a removable cover. The cover shall be attached to the tank fill by mechanical means such as a threaded cap or a hinged cover with a mechanical latching device.

**9-7.2** The fill opening shall be designed and located so that foam concentrate from a 5-gal (19-L) container can be dumped into the tank without the use of funnels or other special devices.

**9-7.3** An expansion compartment shall be provided on the foam concentrate tank that is of sufficient volume to allow expansion and contraction of the foam concentrate caused by changes in ambient temperature. The surface area of the expansion compartment shall not exceed 1 percent of the surface area of the foam concentrate tank.

**9-7.4** The foam concentrate tank shall be equipped with a pressure/vacuum vent that allows 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 not allow liquid concentrate to escape. The vent shall be of a size to prevent tank damage during filling or foam withdrawal.

**9-7.5** The foam concentrate tank shall not be equipped with an overflow pipe or any direct opening to the atmosphere.

**9-7.6** The foam concentrate tank shall be designed and constructed to facilitate cleaning the inside of the tank as required.

**9-7.7** 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 apparatus without contacting other body or chassis components.

**9-7.8** The foam concentrate tank shall be constructed to be independent of the apparatus body.

**9-7.9** The foam concentrate discharge system design shall prevent the siphoning of foam.

**9-7.10*** A label or visible permanent marking that reads "Foam Tank Fill" shall be placed at or near any foam concentrate tank fill opening. The label or marking shall specify the class or type of foam to be used, the maximum foam viscosity the foam concentrate system is designed to use, any restrictions on the types of foam concentrate that can be used with the system, and a warning message that reads "Warning: Do not mix brands and types of foam."

**9-7.11** The foam concentrate tank outlet connection shall be designed or located to prevent aeration of the foam concentrate and shall allow withdrawal of 95 percent of the foam concentrate tank storage capacity under all operating conditions.

**9-7.12** The foam concentrate tank inlet connection, if provided, shall be installed in a manner that prevents air entrainment of the foam concentrate from agitation when the foam concentrate level in the tank is below the inlet connection discharge.

**9-8 Foam Concentrate Pump.** If the foam proportioning system is equipped with a foam concentrate pump, 9-8.1 through 9-8.4 shall apply.

**9-8.1** The foam concentrate pump shall operate at a design speed that prevents cavitation and foaming in the concentrate system when delivering maximum design flow.

**9-8.2** Drive-train components that transmit power to the foam concentrate pump shall be capable of transmitting the power required by the pump under the maximum designed operating condition.

**9-8.3** The concentrate pump drive source shall be capable of delivering the power necessary to provide rated pump capacity at maximum system pressure continuously for a minimum of 24 hours without failure.

**9-8.4** A relief valve or other excess-pressure device shall be provided to protect the foam concentrate pump from damage.

**9-9 Pressure Vessel Foam Concentrate or Foam Solution Tanks.** If the foam proportioning system incorporates a pressure vessel foam concentrate tank, or if the foam solution is contained in a pressure vessel, 9-9.1 through 9-9.7 shall apply.

**9-9.1** If the tank is charged with a compressed gas, the tank shall be of welded construction and designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the required pressure.

**9-9.2** All pressure tanks and associated piping shall be designed to a minimum of $1^1/_2$ times maximum working pressure and shall be tested to the design pressure after installation.

**9-9.3** The pressure vessel tank shall be protected against corrosion from the foam concentrate or water stored in the tank.

**9-9.4** If the tank is equipped with a gravity fill (has a fill cap), the fill opening shall be a minimum 2-in. (51-mm) inside diameter.

**9-9.4.1** The fill cap shall be equipped with nontapered threads and a compressible gasket.

**9-9.4.2** Special wrenches or tools required to tighten the fill cap shall be supplied by the manufacturer and shall be securely mounted adjacent to the fill cap.

**9-9.4.3** 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.

**9-9.5** A minimum $^1/_2$-in. (13-mm) valved vent shall be provided on all pressure vessel tanks.

**9-9.6** If the tank is charged with a compressed gas, an approved ASME relief valve, properly set, shall be furnished on the tank to prevent tank pressure from exceeding 110 percent of the maximum permitted working pressure.

**9-9.7** A minimum $^1/_2$-in. (13-mm) valved drain connection shall be provided on all pressure vessel tanks.

**9-10 Labels, Nameplates, and Instructions.**

**9-10.1** All labels and marking shall be permanent in nature, capable of withstanding the effects of extremes of weather and temperature, and attached in a manner that requires mechanical means to effect removal.

**9-10.2** A nameplate that is marked clearly with the identification and function of each control, gauge, and indicator related to the foam proportioning system shall be provided.

**9-10.3** Two copies of an operations and maintenance manual shall be provided. They shall include a complete diagram of the system together with operating instructions and a manual outlining all recommended maintenance procedures.

**9-10.4** Eductor systems shall have a nameplate that indicates the system flow rate, the maximum usable hose length, the hose size required, the nozzle type, and the permitted elevation changes.

## Chapter 10 Compressed Air Foam Systems (CAFS)

**10-1 Application.** If the wildland fire apparatus is equipped with a compressed air foam system (CAFS), it shall comply with the applicable sections of this chapter.

**10-2* Definitions.** For the purpose of this chapter, these terms shall be defined as follows:

**Compressed Air Foam System (CAFS).** A foam system that combines air under pressure with foam solution to create foam in the hose or mixing chamber. A CAFS system consists of an air source, a water pump, a means to apply the foam, and a source of foam solution.

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

**SCFM (Standard Cubic Feet per Minute).** An expression of air flow rate in which the air flow rate is corrected to standard temperature and pressure. The metric conversion is shown as SCMS (Standard Cubic Meters per Second).

**10-3 General Requirements.**

**10-3.1** An automatic-regulating proportioning system shall be used and shall comply with the applicable requirements of Chapter 9.

**10-3.2** The total CAFS rating shall be expressed in terms of matched air and water flow. The air 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 100 psig (689 kPag).

**10-3.3*** The water pump supplying the CAFS shall have a rating in gpm (L/min) at 100 psig (689 kPag) of at least the rating of the air source in SCFM (SCMS) [e.g., a 125-gpm (473 L/min) pump and a 125-SCFM (0.06 SCMS) compressor].

**10-3.4** The 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.

**10-3.5** On a balanced pressure CAFS of 50 cfm (1.4 $m^3/s$) and over, the water pump discharge pressure shall automatically regulate the air pressure to balance the air and water pressures.

**10-4 Compressed Air Source.**

**10-4.1** The compressed air source operating in clean environment conditions shall be capable of providing a continuous rated supply for 6 hours duration without needing adjustment, addition of lubrication, or changing of air filters.

**10-4.2** The compressed air source shall be equipped with an air pressure relief valve that meets the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 2. 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.

**10-4.3** The compressed air source shall be equipped with moisture drain valves.

**10-4.4** If a holding, surge, or separator tank is provided, it shall be designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the required pressure.

**10-5* Air Mixing.**

**10-5.1** The proportion system's air to foam solution shall be accurate within 10 percent of the desired air ratio at the rated flow and pressure.

**10-5.2** An automatic means shall be provided to prevent the back-flow of all liquids and gases. This shall include the back-flow 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.

**10-5.3** A mixer shall be provided on all CAFS outlets, or a label near the outlet shall state the minimum hose length required. The air and foam solution mixer(s) shall provide homogeneous mixing of the compressed air and foam solution.

**10-6* Foam Discharge.**

**10-6.1** Any components of the piping system exposed to pressurized air from the CAFS shall be designed for at least 500 psig (3447 kPag) burst pressure.

**10-6.2** The discharge plumbing shall be configured to minimize the use of elbows or abrupt turns.

**10-6.3*** If a master stream device is provided, it shall consist of a full-flow, long turn monitor with a stream straightener. The stream straightener shall be at least five pipe diameters in length beyond the monitor. The master stream device shall be anchored securely to the apparatus and shall be capable of withstanding the initial surge pulse when the total horsepower of air and water are discharged without complete mixing occurring in the system. No shutoff valve shall be installed between the monitor and the tip.

**10-7 Air Source Controls.**

**10-7.1** All compressed air source controls shall be located at the pump operator's position and shall be identified clearly. They shall include a means for adjusting the air pressure.

**10-7.2** Air compressor systems that require flushing after use shall be provided with readily accessible controls that allow the operator to completely flush the system with water according to the manufacturer's instructions.

**10-8 Gauges, Flow Meters, and Indicators of Foam Systems.**

**10-8.1** All gauges, flow meters, and indicators shall be located so they are readily visible from the pump operator's position. All gauges or flow meters shall be mounted in a manner that protects the gauge from physical damage and excessive vibration.

**10-8.2** All analog pressure gauges shall be liquid filled, vibration dampened, and capable of continuous operation to –40°F (–40°C) without damage.

**10-8.3** All analog pressure gauges shall be at least size $2^1/_2$ in accordance with ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, paragraph 3.1. The accuracy of the gauges shall be a minimum of Grade B, as defined in ASME B40.1.

**10-8.4** Flow meters located at the pump operator's position shall indicate the air flow in standard cubic feet per minute and indicate the water flow in gallons per minute. Flow meters shall be rated to 500 psig (3447 kPag) burst pressure if located on the pressure side of the system.

**10-8.5*** Instrumentation shall be installed to provide indication of the system's operating condition. The instrumentation shall include the following:

(a) A pressure gauge on the discharge of the compressed air source.

(b) A foam flow indicator to indicate positive foam concentrate flow.

**10-9 Nameplates and Instruction Plates.**

**10-9.1** All labels and markings shall be permanent in nature, capable of withstanding the effects of extremes of weather and temperature, and attached in a manner that requires mechanical means to effect removal.

**10-9.2** A nameplate that is marked clearly with the identification and function of each control, gauge, and indicator related to the compressed air foam system shall be provided.

## Chapter 11 Line Voltage Electrical Systems

**11-1* Application.** If a line voltage (120-volt or 240-volt, or both) electrical system is provided, it shall meet the requirements of this chapter.

**11-2 National Electrical Code.** Except where superseded by the requirements of this chapter, all components, equipment, and installation procedures shall conform to NFPA 70, *National Electrical Code®* (*NEC*). Where the requirements of this chapter differ from NFPA 70, the requirements of this standard shall apply.

**11-3 Electrical Safety.**

**11-3.1 Listed Equipment.** The electrical equipment and material on the fire apparatus shall be listed. No ungrounded systems shall be used. All products shall be used only in the manner in which they have been tested and found suitable for the intended use.

**11-3.2* Grounding.**

**11-3.2.1** Grounding shall be in accordance with Section 250-6 of the *NEC.*

**11-3.2.2** An equipment grounding means shall always be provided in accordance with Section 250-91 of the *NEC.* Equipment grounding shall be accomplished with conductors that are green or green with yellow stripe or continuous rigid metal conduit.

**11-3.2.3** The grounded circuit conductor (neutral) shall be insulated from the equipment grounding conductors and from the equipment enclosures and other grounded parts. The neutral conductor shall be colored white or gray in accordance with Section 200-6 of the *NEC.* The grounded circuit (neutral) terminals in the distribution panel board and in appliances shall be insulated from the equipment enclosure. Bonding screws, straps, or buses in the distribution panel board or on appliances between the neutral and the equipment grounding conductor shall be removed and discarded.

**11-3.2.4*** The neutral shall be bonded to the frame at the generator set.

**11-3.2.5** All exposed, noncurrent-carrying, metal parts that might become energized shall be effectively bonded to the equipment grounding terminal or the enclosure of the distribution panel board. A bonding conductor shall connect any distribution panel board to an accessible terminal point on the chassis using a stranded copper conductor of the proper size.

**11-3.3 Water Resistance.** Except for devices and components mounted in the interior of a passenger compartment or in other weatherproof compartments, all devices and components of the line voltage electrical system shall be suitable for use in wet locations.

**11-3.4 Maximum Voltage.** The maximum voltage between any conductor and any other conductor or an earth ground shall not exceed 250 volts.

**11-4 Power Source.**

**11-4.1*** The power source shall be installed and vented in accordance with the manufacturer's instructions and shall be bonded effectively to the apparatus chassis. Adequate access shall be provided to allow both routine maintenance and removal for major servicing.

**11-4.2** Any gasoline or diesel-powered generator, whether fixed or portable, that can be operated while mounted on the vehicle shall:

(a) Be installed so fumes, vapors, heat, excessive noise, and vibrations do not enter the interior of any passenger compartment;

(b) Have the exhaust outlet located so it is away from any area in which personnel normally would be expected to be operating the vehicle or its associated components or equipment; and

(c) Comply with Article 445 of the *NEC.*

**11-5 Distribution Panels.**

**11-5.1** All permanently mounted electrical sources shall be hard-wired to a permanently mounted distribution panel. Individual circuit breakers shall be provided for each circuit and shall be sized for the intended circuit use in accordance with Section 240-3 of the *NEC.* Individual breakers shall be easily accessible. A permanent-type nameplate shall indicate the circuit that each breaker protects.

**11-5.2** Portable electrical sources shall be permitted to be connected to circuits and devices using the outlet receptacles with which they are supplied by their manufacturer.

**11-6 Wiring Methods.**

**11-6.1** Line voltage electrical wiring systems shall be limited to the following methods:

(a) Conduit; and

(b) Type SO cord [600 V, 90°C (194°F) minimum] in exposed areas, which is covered with minimum 150°C (302°F), flame-retardant, moisture-resistant loom.

**11-6.2** Only stranded copper conductors shall be used. Conductors shall be sized in accordance with Table 310-16 of the *NEC*. Aluminum or coppered aluminum conductors shall not be used.

**11-6.3** Boxes shall conform to and be mounted in accordance with Article 370 of the *NEC*. The maximum number of conductors permitted in the boxes shall be in accordance with Section 370-16 of the *NEC*.

**11-6.4** Where subject to physical damage, exposed cable shall be protected by guard strips, grommets, raceways, or other means.

**11-6.5** Conductor splices and connections at terminals shall be in accordance with Section 110-14 of the *NEC*.

**11-7* Plugs and Receptacles.**

**11-7.1** All exterior receptacle outlets and interior receptacles used to power external devices shall be of the grounding, weatherproof type and shall be installed in accordance with Section 210-7 of the *NEC*.

**11-7.2** Receptacles that are permanently mounted in the interior of a passenger compartment and used only to power devices operated in that compartment shall be permitted to be of the grounding, non-weatherproof type.

**11-7.3** No receptacle shall be installed in a face-up position. Plugs and receptacles shall be permitted to be of locking or nonlocking design.

**11-7.4*** When severe loads are applied to connector terminals, external load transfer from jacket to jacket shall be provided to avoid disconnection or placing excess strain on connector terminals.

**11-7.5** All single-phase plugs and receptacles rated at 30 amperes or less shall be of the NEMA configuration appropriate for their intended service (*see Table 11-7.5 for appropriate configurations*). For alternating current voltages and amperages other than those in Table 11-7.5, the correct configuration shall be selected from NEMA WD 6, *Dimensional Requirements for Wiring Devices*. For direct current voltages, the plugs and receptacles shall be rated for the appropriate direct current service.

**Table 11-7.5 Single-Phase AC Voltage**

| Amperage | Blade Type | 125V | 125/250V | 250V |
|---|---|---|---|---|
| 15A | Locking | L5-15 | None | L6-15 |
| | Nonlocking | 5-15 | 14-15 | 6-15 |
| 20A | Locking | L5-20 | L14-20 | L6-20 |
| | Nonlocking | 5-20 | 14-20 | 6-20 |
| 30A | Locking | L5-30 | L14-30 | L6-30 |
| | Nonlocking | 5-30 | 14-30 | 6-30 |

NOTE: The letter "R" following a configuration number indicates a receptacle, while the letter "P" denotes a plug. For example, the nonlocking 15-ampere, grounding receptacle found in most homes is configuration 5-15R and accepts a 3-prong plug in the configuration of 5-15P.

**11-7.6** Plugs and receptacles used in the low-voltage (12-volt or 24-volt dc) system shall not mate in any fashion with the connectors incorporated in the line voltage electrical system. No plug or receptacle of any permitted configuration for use with line voltage systems shall be used in the low-voltage system of the vehicle. All low-voltage plugs and receptacles shall be of the Milspec MS3112E12-3P type or shall be cigarette lighter-type receptacles. Cigarette lighter receptacles shall be limited to a maximum of 10-ampere service.

**11-7.7** A permanent nameplate at each receptacle shall indicate the voltage, type of current, phase, and ampere rating.

**11-8* Switches.**

**11-8.1** All switches shall be sized to handle the intended load and, if located on the exterior of the vehicle, shall be of a weatherproof design. A label at each switch shall indicate what function that switch controls.

**11-8.2** If the circuit is to be controlled by a 12-volt or 24-volt control circuit (low-voltage circuit), it shall be wired through an appropriately rated relay(s) mounted in a weatherproof enclosure. All power wires shall be controlled by the relay(s). The neutral and ground conductor(s) shall not be interrupted.

**11-8.3** Switches used to control direct current voltage shall have an appropriate direct current load rating.

## Chapter 12 Winches

**12-1 General.** If a winch is installed on the apparatus, it shall meet the requirements of this chapter and SAE J706, *Rating of Winches*.

**12-2 Rating.**

**12-2.1*** The winch shall have a minimum single-line pull rating of 6000 lb (26.7 kN).

**12-2.2** The winch shall have a minimum wire rope length of 100 ft (30 m). The wire rope shall be of a type and size recommended by the winch manufacturer. The wire rope assembly, including all hardware such as clevises, hooks, and snatch blocks provided for attachment to the winch, shall have a breaking strength greater than the line pull capacity of the winch.

**12-3 Electric Powered Winches.**

**12-3.1 Controls.**

**12-3.1.1*** Control of the electric motor shall be by means of a hand-held 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 hand-held transmitter of a Federal Communications Commission approved radio frequency winch control device.

**12-3.1.2** A free-spooling clutch shall be provided in addition to the remote-control device if the winch is not visible to the operator.

**12-3.2 Installation.** Electric winches shall be installed with the "hot" wire of the power solenoid connected to the positive terminal on the vehicle battery(s) and a ground wire connected to the negative battery terminal. It shall be permitted to ground the winch to the frame instead of running a wire to the negative battery terminal.

**12-3.3 Batteries.**

**12-3.3.1** A minimum of a 1700 cold-cranking amp (CCA) battery system shall be provided for an electric winch installation. Wiring shall be arranged to use both batteries and shall bypass any master switches and other electrical devices.

**12-3.3.2** The batteries shall be mounted as close as possible to the winch, and, or extra-size battery-type electric cable shall be used as necessary to avoid voltage drop to the winch.

**12-3.3.3** A fast-idle switch shall be provided to ensure full alternator output. The switch shall be interlocked with the neutral position of the transmission to prevent accidental movement of the apparatus.

**12-4 Hydraulic Winches.**

**12-4.1 Hydraulic Hoses.** All hydraulic hoses shall be designed for hydraulic pressures encountered for the specified hydraulic components. Hoses shall be of the wire-braided type, with a female swivel on one end.

**12-4.2 Hydraulic Tanks.**

**12-4.2.1** The hydraulic fluid tank shall be of sufficient size to prevent overheating of the fluid or cavitation of the hydraulic pump at its maximum output level.

**12-4.2.2** The tank shall allow 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.

**12-4.2.3** A drain plug shall be installed to permit complete draining of the tank.

**12-4.2.4** A return line diffuser shall be installed in the tank. A swash partition shall be installed in the tank between the suction and return lines.

**12-4.2.5** A vent shall be supplied and shall be designed to prevent dirt and moisture from entering the tank.

**12-4.3 Hydraulic Filters and Strainers.** The system shall be equipped with necessary filters and strainers to keep the hydraulic fluid within the cleanliness requirements necessary for good operation of the hydraulic system.

**12-4.4* Hydraulic Winch Operational Controls.** The winch shall be equipped with a clutch assembly to permit free-spooling and quick removal of cable. This control shall be easily accessible without reaching under the apparatus. If the winch is installed under the vehicle, it shall be remotely controlled.

**12-4.5 Driving Compartment Controls.**

**12-4.5.1** The hydraulic pump engagement controls shall be located in the driving compartment. A label shall indicate their purpose and use.

**12-4.5.2** A red light shall be installed in the driving compartment to indicate when the winch drive system is engaged.

## Chapter 13 Vehicle Protection Systems

**13-1 Brush Rails.** If brush rails are installed on the apparatus, they shall meet the requirements of 13-1.1 through 13-1.3.

**13-1.1** 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.

**13-1.2** 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.

**13-1.3** 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.

**13-2 Grill Guard.** If a grill guard is installed on the apparatus, it shall meet the requirements of 13-2.1 through 13-2.4.

**13-2.1** The grill guard shall protect the front of the cab, including the headlights and radiator air inlet.

**13-2.2** 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.

**13-2.3** The guard shall not impede the normal opening of the engine enclosures.

**13-2.4** 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.

**13-3* Skid Plates.** If skid plates are installed on the apparatus, they shall meet the requirements of 13-3.1 through 13-3.4.

**13-3.1** Skid plates shall be installed on nonmovable components that protrude below the normal truck chassis parts.

**13-3.2** 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.

**13-3.3** Skid plates shall not impede the normal function of the vehicle or any of its systems.

**13-3.4** 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 14 Test and Delivery Data Requirements

**14-1 Apparatus Certification Tests.**

**14-1.1*** The completed apparatus shall be tested and certified. The certification shall include at least the pumping tests (Section 14-2), the priming device test (Section 14-3), the vacuum test (Section 14-4), the water tank-to-pump flow test (Section 14-5), the water tank capacity test (Section 14-6), and the piping integrity test (Section 14-7).

**14-1.2** If the apparatus has a foam system, the foam system shall be tested in accordance with Section 14-8.

**14-1.3** If the apparatus has a compressed air foam system, that system shall be tested in accordance with Sections 14-8 and 14-9.

**14-2 Pumping Tests.**

**14-2.1 Conditions for Tests.**

**14-2.1.1** 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) 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.

**14-2.1.2*** Tests shall be performed under the following conditions:

| | |
|---|---|
| Air temperature: | 0°F to 100°F (–18°C to 38°C) |
| Water temperature: | 45°F to 100°F (7°C to 38°C) |
| Barometric pressure: | (corrected to sea level) 29 in. Hg (98.2 kPa), minimum |

**14-2.1.3** Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests.

**14-2.1.4** 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.

**14-2.2 Equipment.**

**14-2.2.1** Suction hose shall be of the size specified in Table 4-1 for the rated capacity of the pump.

**14-2.2.2** A suction strainer that allows flow with total friction and entrance loss not greater than that specified in Table 4-2 shall be used.

**14-2.2.3** 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 500 gpm (1900 L/min) for $2^1/_2$-in. (65-mm) hose].

**14-2.2.4** Discharge shall be measured using a smoothbore nozzle and pitot tube or other equipment such as flow meters, volumetric tanks, or weigh tanks.

**14-2.2.5** All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, and shall be at least size $3^1/_2$ in accordance with ASME B40.1, Paragraph 3.1. The suction gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to 150 psig (1035 kPag) for a compound gauge. The discharge pressure gauge shall have a range of zero to 400 psig (0 to 2758 kPag). Pitot gauges shall have a range of at least zero to 160 psig (1103 kPag). A mercury manometer shall be permitted to be used in lieu of a suction gauge. All gauges shall have been calibrated in the month preceding the tests. Calibrating equipment shall consist of a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges as defined in ASME B40.1 that has been calibrated by its manufacturer within the preceding year.

**14-2.2.6** All test gauge connections shall include "snubbing" means such as needle valves to damp out rapid needle movements, unless the gauges are liquid filled.

**14-2.2.7** Speed-measuring equipment shall consist of a tachometer or other device for measuring revolutions per minute.

**14-2.3* 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.

**14-2.3.1** 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.

**14-2.3.2** The discharge volume, discharge pressure, suction pressure, and engine speed shall be recorded at least three 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.

**14-2.3.3** The engine, pump, transmission, and all parts of the apparatus shall exhibit no undue heating, loss of power, overspeed, or other defect during the entire test.

**14-3 Priming Device Test.**

**14-3.1** 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 (57.4 kPa). At altitudes above 2000 ft (610 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.4 kPa) by 1 in. Hg (3.4 kPa) per 1000 ft (305 m) of altitude above 2000 ft (610 m).

**14-3.2** With the pumping unit set up for the pumping test, the primer shall be operated in accordance with the manufacturer's instruction 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.

**14-4 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 (57.4 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 no-load governed speed during this test.

**14-5 Water Tank-to-Pump Flow Test.** A water tank-to-pump flow test shall be conducted. The required flow shall be the rated capacity of the pump.

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

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

(c) The tank fill and bypass cooling line 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. The bypass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.

(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 14-5(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).

**14-6 Water Tank Capacity Test.** A water tank capacity test shall be conducted as follows:

(a) The tank shall be filled until water exits the top fill opening or the tank overflows.

(b) The pumping unit shall be weighed to determine the tank full weight (TFW).

(c) The water tank shall be emptied.

(d) The pumping unit shall be weighed to determine the tank empty weight (TEW).

(e) The rated tank capacity shall be calculated as

$$(TFW - TEW)/8.34$$

A tolerance of ±2 percent shall be acceptable to compensate for measurement tolerances of commercial scales.

**14-7 Piping Integrity Test.** The pump and its connected piping system shall be tested hydrostatically to 250 psig (1725 kPag). 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 nonvalved intakes shall be capped. This pressure shall be maintained for 3 minutes.

**14-8* Foam Proportioning Tests.** The accuracy of the foam proportioning system shall be tested. The foam system shall proportion foam concentrate within ±25 percent at 0.5 concentration across the manufacturer's stated range of water flow and pressure.

**14-9 CAFS System Tests.**

**14-9.1 Capacity Rating Test.**

**14-9.1.1** The operation of the water pump and the compressed air source shall be tested simultaneously to determine the integrity of the system and to ensure that there is adequate power available to operate these components of the CAFS. The compressed air source shall be operated at its flow capacity at 100 psig (689 kPag), and the water pump shall discharge 1 gal (3.8 L) of water at 100 psi (689 kPa) net pump pressure for every one SCFM of air discharged. The discharge shall be through at least two separate discharge openings, one discharging air only and the other discharging water only.

**14-9.1.2*** 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 gauges shall meet the requirements of 14-2.2.5 and all test gauge connections shall include "snubbing" means such as needle valves to damp out rapid needle movements, unless the gauges are liquid filled.

**14-9.1.3*** The air flow rate shall be measured using a pressure- and temperature-compensated flow-measuring device. The air flow shall be measured in SCFM at 100 psig (689 kPag). The air flow-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).

**14-9.1.4** The water pump and the compressed air source shall be started and the rated flows and pressures established. The system shall be run for $1^1/_2$ hours. Reading of the air flow rate and pressure and the water pump net pump pressure and discharge rate shall be taken at least every 10 minutes.

**14-9.1.5** 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.

**14-9.2* Standby Run Test.** One or more 200-ft (61-m) lines of hose of a size adequate to discharge the maximum output of the CAFS shall be connected to the discharge of the CAFS and shall be stretched out on level ground. A quarter-turn valve of the same size as the hose shall be installed at the discharge end. The hose shall be secured immediately behind the valve at the discharge end to prevent uncontrollable movement when the valve is opened. The CAFS shall be operated, and maximum output at 100 psig (689 kPag) shall be established in the hose line. With the water tank at the one-quarter full level, the valve at the discharge end of the hose shall be shut, and the engine(s) speed shall be maintained for 15 minutes without discharging water, air, or foam solution from the unit and without operator intervention. At the end of 15 minutes, the valve shall be reopened and a fire stream shall be available immediately. 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.

**14-10 Road Tests.**

**14-10.1** Road tests shall be conducted as follows to verify that the completed apparatus is capable of compliance with 2-6.1. The tests shall be conducted at such locations and in such a manner so as not to violate local, state, or federal traffic laws.

**14-10.2** 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 no-load governed speed.

**14-10.3** Acceleration tests shall consist of two runs in opposite directions over the same route.

**14-10.3.1** The vehicle shall attain a true speed of 35 mph (56 kmph) from a standing start within 25 seconds.

**14-10.3.2** 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).

**14-10.4** 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 substantially hard, level surface road that is free of loose material, oil, or grease.

**14-11 Data Required of the Contractor.** The contractor shall supply, at the time of delivery, at least one copy of:

(a) The pump manufacturer's certification of suction capability.

(b) The pump manufacturer's certification of hydrostatic test.

(c) The certification of inspection and test by the pump manufacturer or contractor.

(d) *The manufacturer's record of apparatus construction.

(e) 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) shall be supplied with the completed vehicle except when a slip-on unit is supplied without a chassis.

(f) Certification from the foam proportioning unit manufacturer that the foam proportioning system operates as an integral part of the water delivery system.

(g) The ASME certification for any pressure vessels or receiving tanks and a certificate from the air compressor manufacturer stating the maximum capacity of the compressor at the rated pressure and the maximum rated pressure, if the apparatus is equipped with a CAFS.

## Chapter 15 Referenced Publications

**15-1** The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

**15-1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 70, *National Electric Code*, 1993 edition.
NFPA 1961, *Standard for Fire Hose*, 1992 edition.
NFPA 1963, *Standard for Fire Hose Connections*, 1993 edition.

**15-1.2 Other Publications.**

**15-1.2.1 ASME Publications.** American Society of Mechanical Engineers, 345 E. 47th Street, New York, NY 10017.

ASME B1.20.7, *Hose Coupling Screw Threads*, 1991.
ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, 1991.
ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 and Division 2.

**15-1.2.2 ASTM Publication.** American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D4956, *Standard Specifications for Retroreflective Sheeting for Traffic Control*, 1993.

**15-1.2.3 NEMA Publication.** National Electrical Manufacturers Association, 2101 L Street NW, Suite 300, Washington, DC 20037.

NEMA WD 6, *Dimensional Requirements for Wiring Devices*, 1988.

**15-1.2.4 SAE Publications.** Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J348, *Standard for Wheel Chocks*, 1990.
SAE J541, *Voltage Drop for Starting Motor Circuits*, 1989.
SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*, 1990.
SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*, 1990.
SAE J683, *Tire Chain Clearance-Trucks, Buses, and Combinations of Vehicles*, 1985.
SAE J706, *Rating of Winches*, 1985.
SAE J845, *360 Degree Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, 1992.
SAE J994, *Alarm-Backup-Electric-Performance, Test, and Application*, 1993.
SAE J1128, *Low Tension Primary Cable*, 1988.
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*, 1986.
SAE J1849, *Emergency Vehicle Sirens*, 1989.

**15-1.2.5 TRA Publication.** Tire and Rim Association, Inc., 175 Montrose Avenue, W. Copley, OH 44321.

TRA *Yearbook*

**15-1.2.6 U.S. Government Publication.** Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

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

## Appendix A Explanatory Material

*This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**A-1-1** This standard is designed to cover new automotive fire apparatus used to fight wildland fires at both on-road or off-road locations. To a limited degree, this apparatus may 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 piece of apparatus, it is recommended that the apparatus be brought into line with this standard to the degree possible.

**A-1-2** 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 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.

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.

**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 must 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.

Where local operating conditions necessitate apparatus of unusual design, the purchaser needs to define carefully the special requirements within the specifications. Height, width, under-vehicle 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.

The equipment list provided in this standard relates to the operations to which a wildland fire apparatus is normally assigned. Since new apparatus should be fully equipped in order to provide effective service, it is recommended that new equipment be provided along with the apparatus.

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.

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.

Additional requirements are placed on both apparatus and engine manufacturers by the Clean Air Act, which is enforced by the Environmental Protection Agency. These standards have resulted in major changes in the performance of many engines. Neither the engine manufacturer nor the apparatus manufacturer may 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.

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 trip.

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.

Training of designated fire department personnel is essential to ensure that the purchaser and user are aware of, and instructed in, the proper operation, care, and maintenance of the apparatus acquired. This training should provide the initial instruction on the new apparatus. The training typically is delivered by a qualified representative of the contractor in the user's community. The specifications should identify clearly the arrangement for furnishing the training, including where it is to be provided, its duration, and what training aids, such as video tapes or training manuals, are to be furnished.

The purchaser also should define in the specifications the warranty desired for the completed apparatus. The warranty is a written guarantee of the integrity of the apparatus or its components that defines the manufacturer's responsibility within a given time period. The warranty sometimes is extended for a second warranty period beyond the terms of the basic warranty for specific components, such as the engine, pump, frame, and water tank. If a secondary manufacturer is involved in modifying components that are warranted by the original manufacturer, the responsibility for warranty work should be understood clearly by the original manufacturer, the secondary manufacturer, the contractor, and the purchaser.

The purchaser might want a warranty bond to ensure that any warranty work will be performed, even if the apparatus manufacturer goes out of business. A warranty bond is a third-party secured bond established by the manufacturer before delivery of a vehicle to guarantee workmanship, quality of material, or other stated performance of the vehicle components.

Finally, it is recommended that the fire chief, fire department staff, or the committee assigned to develop the specifications consult with the purchaser's attorney, engineer, and other appropriate officials for assistance in developing the detailed specifications.

**Obtaining and Studying Proposals.** When the specifications are complete, they should be distributed to apparatus manufacturers and contractors with a request for bids or proposals to furnish the specified apparatus. The request should specify a date, time, and place for the formal opening of the bids. This date should allow at least one month for the engineering departments of apparatus manufacturers to study the specifications and estimate the cost of the apparatus. More time might be required if engineering drawings of the proposed apparatus are required.

The request also should state the time period during which the purchaser expects the bidder to honor the bid price and whether a bid bond is required. A bid bond guarantees that if a contract is offered to the bidder within the defined time period, the bidder will enter into the contract under the terms of the bid.

It is recommended that a pre-bid meeting be held between the purchaser of a piece of fire apparatus and the apparatus manufacturers or their agents prior to the official release of the apparatus specifications. This meeting is designed to allow for a detailed review of the draft specifications by all present. Problems with the specifications, ideas on how to provide the purchaser with the desired apparatus in alternate ways, clarification of the purchaser's intent, and other questions can be resolved prior to the formal bid process. Such meetings often can solve misunderstandings or problems prior to their development.

With a performance specification, it usually is possible to obtain more favorable bids, since there is genuine competition and the specifications are not overly restrictive. The bid should be accompanied by a detailed description of the apparatus, a list of equipment to be furnished, and other construction and performance details including, but not limited to, estimated weight, wheel base, principal dimensions, transmission, and axle ratios. The purpose of the contractor's specifications is to define the apparatus the contractor intends to furnish and deliver to the purchaser.

Manufacturers' proposals can include amendments and exceptions. Frequently, these changes are offered to meet price restrictions or because individual manufacturers prefer to build apparatus in a manner more convenient to them. If the intent of the original specification is not changed and the bid is favorable, the purchaser should consider accepting these amendments with the approval of the purchasing authority. On the other hand, extreme care should be taken to avoid exceptions that merely devalue the apparatus and give a particular bidder an advantage.

The purchaser should study the proposals, look for deviations from the specifications, and obtain clarification where necessary. If the purchaser has specifically provided for alternatives when seeking bids, extra care should be exercised when evaluating the proposals, as combinations of complicated bid information need careful analysis. The financial arrangements, a delivery date, and the method of delivery should be stipulated and agreed to by the purchasing authority.

**Awarding the Contract.** With the award of a contract, it is important for the purchasing authority to understand the exact identity of the contractor and the nature of the contractor's relationship with the apparatus manufacturer. Some apparatus manufacturers work through a dealer network where the dealer purchases the apparatus from a manufacturer, including taking title, and then resells the apparatus to the purchasing authority. Other manufacturers work through sales agents or representatives who solicit and negotiate a contract between a purchasing authority and a manufacturer but who never take title to the apparatus. This difference can affect where the responsibility lies for the proper fulfillment of the contract.

Some purchasing authorities require a performance bond as part of the contract. A performance bond is a bond executed in connection with a contract that guarantees that the contractor will fulfill all of the undertakings, covenants, terms, conditions, and agreements contained in the contract. If the contractor fails to meet the terms of the contract, the bonding company is responsible for the difference in cost between the original contract price and the new price of the apparatus where it has to be supplied by another contractor.

Before signing a contract, the purchaser should make certain that the successful bidder has a complete and thorough understanding of the specifications. If there are any disagreements, these should be resolved in writing and made part of the contract. If any changes are agreed upon, they should be stated in writing and be signed by both parties. The contract should not be signed until the fire chief (or a designee) and the purchasing authority are satisfied.

**Acceptance.** When the apparatus is ready for delivery and acceptance, the purchaser has a responsibility to check the completed apparatus carefully against the specifications and contract to ensure that the apparatus contracted for has been delivered. This includes witnessing any required acceptance tests and verifying that the gross vehicle weight and the axle weight distribution are within the chassis and axle ratings.

The purchaser also should arrange for any training included as part of the delivery and ensure that it is properly carried out.

Only when the purchaser is totally satisfied that the contract has been fulfilled should payment be authorized.

**A-1-3 Definitions.**

**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 concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

**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.

**Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

**Net Pump Pressure.** When operating from a hydrant, the net pump pressure typically is less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psig and the intake (suction) gauge reads 20 psig, the net pump pressure equals 130 psi. When operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge is reading 145 psig and the intake (suction) gauge is reading 10 in. of mercury (Hg) vacuum, the net pump pressure will be 150 psi (1 in. Hg = 0.5 psi).

**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-2-3.2** The distribution of the weight between the front and rear wheels should be a major consideration, as improper design 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 or in mud. Further, overloading of either the front or rear wheels might necessitate that the tires be of different sizes.

**A-2-4.1** 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-2-4.2** Paragraph 2-5.2 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-2-4.3** 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, or other special components might be needed to prevent damage or to allow continued use.

**A-2-5.1(b)** 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-2-5.1(c)** 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-2-5.2** 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 liter). A value of 10 lb per gal (1.2 kg per liter) may be used when estimating the weight of the tank and its water, making a 500-gal (1900-L) tank and its water weigh about $2^1/_2$ tons (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 must be able to perform its intended service under adverse conditions. Wildland apparatus often is 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, agent tanks, and all other reservoirs; the apparatus designed hose load; the equipped personnel weight; and a miscellaneous equipment allowance 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 standard does not specify any minimum size engines, as the size of the engine should be chosen to correspond with the conditions of design and service.

Many fire departments have favored high torque, low-speed engines for fire department service because such engines have good performance characteristics both when powering the apparatus through city traffic and when driving the pump. However, high-speed engines frequently are employed for fire apparatus, particularly in the case of commercial vehicle chassis. Where high-speed gasoline engines are selected for use in fire apparatus that might have to operate off paved highways, it is recommended that one of the following components be specified: two-speed rear axle (two-wheel drive) with a high numerical ratio in low range or an auxiliary transmission.

The use of a gasoline engine should be discouraged, as refueling in open areas with ambient fire potential can be extremely dangerous due to the low flash point of gasoline as opposed to diesel fuel or a pressurized fuel such as liquefied natural gas, propane, or other pressurized tank fuels that need to be transferred through sealed systems.

**A-3-2.1.1** The maximum no-load 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 no-load governed speed.

**A-3-2.1.2** 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.

**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. Radiators with bolted top and bottom tanks and removable side braces, if available, are recommended. Optional features that might be desirable include a coolant conditioner, radiator sight gauge, and automatic radiator shutters, any of which, if used, should be of a type approved by the engine manufacturer.

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-3-2.4.1.2** 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 does not nullify the performance of the other(s). It should be noted 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-3-2.5** 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.

**A-3-3.1.3** The 125-percent requirement for wiring and circuits is intended to provide end users with a minimum amount of extra electrical circuit capacity to cover the addition of some user-added accessories. It is not the intent to have the final stage manufacturer replace standard OEM chassis manufacturer's wiring to meet the 125-percent requirement. It also is not the intent of this requirement to have electrical accessories purchased by the apparatus manufacturer rewired to meet the 125-percent requirement. Electrical device manufacturer-supplied wiring can be used to the point where it connects to the apparatus manufacturer's installed wiring.

**A-3-3.2.1** An alternator normally is the permanent source of electric power on fire apparatus. Alternators produce 12-volt (nominal) direct current at minimum speeds of 800 rpm to 1600 rpm.

Problems develop where the purchaser specifies electrical equipment, such as emergency lighting and scene lighting, that draws large amounts of current that is beyond the alternator's capacity.

Where voltage other than 12 volts (nominal) is desired, transformers need to be used. Any equipment driven by the current from the transformer should be equipped with a rectifier, or the transformer should be provided with a rectifier to prevent the burnout of electric motors.

Another method of producing 120-volt power is through the use of a power invertor that produces 120-volt alternating current at a constant frequency of 60 Hz. Power invertors take power directly from the alternator at a higher voltage or directly from the battery system.

**A-3-3.3** It is recommended that a master load disconnect switch be provided between the starter solenoid(s) and the remainder of the electrical loads, with the batteries connected directly to the starter solenoid(s). The alternator should be wired directly to the batteries through the ammeter shunt(s), if one is provided, and should not be wired through the master load disconnect switch. A green "battery on" pilot light that is visible from the driver's position should be provided, and the purchaser might want to consider a second "battery on" pilot light on the outside of the vehicle to warn that the batteries are on when the apparatus is parked in the fire station.

**A-3-3.3.1** Overheating of a battery causes rapid deterioration and early failure; evaporation of the water in the battery electrolyte also could be expected. Batteries in commercial vehicle chassis often are installed to take advantage of the cooling effect of the flow of air from motion in over-the-road operation and can be subject to overheating when the vehicle is stationary, such as during pumping operations.

The battery capacity is a very important and frequently overlooked factor in vehicle performance. A fire apparatus needs a much higher capacity battery than does a commercial vehicle because of the large number of lights and other power-consuming devices. Where a radio, a large siren, various flashing or rotating lights, spotlights, electric hose reels, and other power-consuming devices are installed, the total current needed for short periods might be more than that provided by an alternator, particularly with the engine idling, and the battery must be of ample size to carry the load.

The prime function of the battery in modern vehicles is to furnish sufficient power to crank the engine. The Society of Automotive Engineers (SAE) has developed a new rating system to enable the user to specify a battery that meets the cranking requirements of the engine. The new "cold-cranking test" specifies the minimum amperes available at 0°F (–18°C) and –20°F (–28°C) for cranking. This rating specifies the amperes the battery delivers for 30 seconds with a minimum voltage of 1.2 volts per cell. The 1.2 volts per cell requirement for new, fully charged batteries represents the voltage required for cranking the vehicle. Thirty seconds represents the maximum cranking time for an engine in an acceptable state of maintenance. With engine manufacturers specifying the cold-cranking amperes for satisfactory cold-cranking performance, the user can specify the proper capacity battery for the application.

Batteries also have a "reserve capacity rating" that represents the approximate time in minutes that it is possible to travel at night with an inoperative alternator and minimum electrical load. This rating, in minutes, is the time required to discharge a fully charged battery at 25 amperes at 80°F (27°C) to a terminal voltage of 1.7 volts per cell (10.2 volts for a 12-volt battery).

**A-3-3.3.2** When an apparatus returns to the station, the batteries often are not charged to full capacity due to large demands on the electrical system during the emergency. An onboard battery conditioner, charger, or polarized inlet should be provided for charging all batteries. The power cord from an onboard charger or battery conditioner should only be plugged into a receptacle protected by a ground-fault circuit-interrupter (GFCI).

**A-3-3.3.3** With the adoption of diesel engines for use in fire apparatus, the traditional dual battery system that previously had been developed for use with gasoline engines was modified to provide only a partial dual system. Because the diesel engine needed much greater cranking effort, it became common practice in the industry to connect the starter switches in parallel, thereby using both battery systems for engine cranking. Together, both batteries or battery systems met the engine manufacturer's recommendations for minimum battery size, but neither system alone could crank the engine when the engine was either up to operating temperature or below 45°F (7°C) for any length of time.

The dual battery system is complicated further by the fact that it needs regular switching to maintain a full charge in each battery system. Although the partial system provides some ability to operate lights and accessories if one system should fail or lose its charge, the modified dual system does not provide the ability to start or restart the diesel engine under many circumstances.

A truly functional dual battery system for larger engines necessitates the storage of batteries in additional compartments normally used for fire-fighting equipment. A single battery system arranged in accordance with the engine manufacturer's recommendations provides the user with the most reliable vehicle electrical system. Maintenance of the system is simplified, and numerous components and circuits associated with dual systems are eliminated.

**A-3-3.5.1** The purchaser needs to specify the color of emergency lights that are to be installed on the apparatus. The purchaser should consider seriously the use of a combination of red and blue warning lights where such combinations are permitted by state or local law. With lights of equal intensity, the color red is more effective in daylight, and the color blue is more effective at night.

**A-3-3.5.4** In some vehicles, 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), buzzer, or lights, are desired, they should be specified.

**A-3-3.5.7** A red flashing or rotating light located in the driving compartment that is illuminated automatically whenever any passenger or equipment compartment door is open is recommended.

Additional lighting should be considered for the pump compartment, if enclosed, and for each enclosed tool and equipment compartment.

**A-3-4.1** Brake components, such as brake cans, slack adjusters, and air and fluid lines should be positioned in a manner that protects them from damage from rocks, stumps, logs, or other objects. If this is not possible, they should be suitably protected.

Auxiliary braking devices such as transmission retarders and exhaust restriction devices should be disconnected when the apparatus is operated on slippery surfaces. These devices can cause skids on these surfaces.

**A-3-4.1.1** Service brake systems and parking brake systems are required to be independent and separate systems so that any failure of one braking system does not prevent stopping of the vehicle through the use of the other system.

**A-3-4.1.3** Adequate braking capacity is essential for the safe operation of fire apparatus. While 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:

(a) Air brake pressure drop of more than 2 psi (13.8 kPa) in 1 minute with the engine stopped and service brakes released.

(b) Air pressure drop of more than 3 psi (20.7 kPa) in 1 minute with the engine stopped and service brakes fully applied.

The fire department should consider providing one of the following options to maintain air in the air brake system:

(a) A quick-buildup section in the air reservoir system arranged so that the apparatus is able to move within 30 seconds of start-up from a completely discharged air system. The quick-buildup system should provide sufficient air pressure so that the apparatus has no brake drag and is able to stop under the intended operating conditions within the 30-second buildup time.

(b) An onboard automatic electric compressor with an automatically ejected electric shoreline.

(c) A fire station compressed air shoreline hookup to maintain full operating air pressure while the vehicle is not running.

**A-3-4.1.4** Paragraph 2-5.2 requires that the apparatus be able to traverse areas at grades of 25 percent. If there is a need to park the apparatus on such grades and get out of the vehicles, this capability will have to be designed into the parking brake system.

**A-3-4.2.2** 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. The purchaser should consider the terrain over which the vehicle is to be used where specifying the desired ground clearance.

**A-3-4.2.3** 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-3-4.3.1** 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-3-4.4.1** 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-3-4.5** If the purchaser wants the hooks or rings to be accessible without having to open compartment doors, the specifications should state this fact.

**A-3-4.6** The purchaser should consider specifying a style of mirror that swings when making contact with branches and trees.

**A-3-4.6.3** The purchaser should define how many seating positions are needed 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 to provide fully enclosed seating positions. The use of three-point seat belts, where available, is encouraged.

**A-3-4.6.7** 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 and safety restraining straps or should be in special equipment compartments to minimize the chance of injury.

**A-3-4.6.8** Consideration should be given to providing a tachometer and an automatic transmission temperature indicator or gauge.

**A-3-4.6.8(k)** If an ignition key is required to start the apparatus, it is recommended that the key be attached to the cab interior to prevent its accidental removal.

**A-4-1** The ability to pump at a minimum pressure of 150 psi (1035 kPa) is required to produce sufficient fire-fighting nozzle performance when using 1-in. to $2^1/_2$-in. (25-mm to 65-mm) fire hose. Modern fire-fighting hand line nozzles may require 100 psig (690 kPag) at their tip to function at full potential in throw and pattern. In addition, the fire hose itself causes losses in pressure, so a sufficient pump pressure is necessary to overcome this hose friction loss and still have 100 psig (690 kPag) at the nozzle tip. A typical example is a pump that produces 100 gpm (380 L/min) at 150 psi (1035 kPa) and is feeding 200 ft (61 m) of $1^1/_2$-in. (38-mm) fire hose. The friction loss in the hose is approximately 50 psi (345 kPa), thereby leaving 100 psi (690 kPa) to operate the nozzle.

Pumps capable of producing their rated capacity at 150 psi (1035 kPa) net pump pressure can vary in their other flow characteristics. Some pumps are capable of producing significantly higher flows at lower net pump pressure but cannot produce pressures much above their rating pressure. Others can produce lower flows at significantly higher pressures but perform poorly at flows above their rated capacity.

When studying the capabilities needed from the pump, the performance to operate each anticipated discharge hose line should be taken into account. Three-quarter-in. (19-mm) or 1-in. (25-mm) booster hose lines might at times require greater than 150 psi (1035 kPa). Also, a rise in elevation will require more pump pressure to maintain the same nozzle pressure. Approximately $^1/_2$ psi (3.5 kPa) should be added to the pump pressure for each 1 ft (0.3 m) of elevation increase between the pump and the nozzle.

**A-4-2** If the pumpis expected to 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 fr 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. Pumps should not be derated below the minimums specified in this standard.

The suction hose size shown in Table 4-1 is for pump rating purposes, only and other sizes of suction hose may be carried for use in the field.

**A-4-4.4** 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-4-5.1** Where larger size intakes or adapters are desired, they should be specified by the purchaser.

**A-4-6.1** It is recognized that outlets of the size shown in Table 4-6.1 are capable of significantly greater discharge. The intent is to provide sufficient outlets to make the apparatus usable.

**A-4-6.4** 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 operators position or installed at the hose connection point. If the apparatus is designed for pump and roll, additional control might be desired inside the driving compartment.

**A-4-6.8** Consideration should be given to providing a pump cooling/recirculation line that is automatic in operation, as pumps on wildland fire apparatus often are left unattended and a line that is automatic in operation ensures that the pump does not overheat.

**A-5-4.1** 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-5-4.2** 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-5-5** The maximum no-load 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 no-load governed speed.

**Table A–4-1(a) Discharge Pressure Required for 50 ft (15 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 107 | 102 | | | | |
| 20 gpm | 125 | 106 | 101 | | | |
| 30 gpm | | 112 | 102 | | | |
| 40 gpm | | 122 | 103 | | | |
| 50 gpm | | 135 | 105 | | | |
| 75 gpm | | | 110 | | | |
| 100 gpm | | | 117 | | | |
| 125 gpm | | | 125 | | | |
| 150 gpm | | | 137 | 112 | 106 | 102 |
| 175 gpm | | | 150 | 117 | 108 | 104 |
| 200 gpm | | | | 123 | 110 | 105 |
| 225 gpm | | | | 126 | 111 | 107 |
| 250 gpm | | | | 131 | 114 | 108 |

**Table A-4-1(b) Discharge Pressure Required for 100 ft (30 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 114 | 104 | | | | |
| 20 gpm | 150 | 112 | | | | |
| 30 gpm | | 123 | 104 | | | |
| 40 gpm | | 144 | 106 | | | |
| 50 gpm | | 166 | 109 | | | |
| 75 gpm | | | 120 | | | |
| 100 gpm | | | 134 | | | |
| 125 gpm | | | 150 | | | |
| 150 gpm | | | 171 | 123 | 111 | 105 |
| 175 gpm | | | | 134 | 116 | 107 |
| 200 gpm | | | | 146 | 120 | 109 |
| 225 gpm | | | | 152 | 122 | 111 |
| 250 gpm | | | | 161 | 128 | 113 |

**Table A-4-1(c) Discharge Pressure Required for 150 ft (46 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 121 | 105 | | | | |
| 20 gpm | 175 | 118 | | | | |
| 30 gpm | | 139 | 106 | | | |
| 40 gpm | | 168 | 109 | | | |
| 50 gpm | | 199 | 114 | | | |
| 75 gpm | | | 130 | | | |
| 100 gpm | | | 151 | | | |
| 125 gpm | | | 175 | | | |
| 150 gpm | | | 205 | 134 | 117 | 109 |
| 175 gpm | | | | 151 | 125 | 111 |
| 200 gpm | | | | 169 | 130 | 113 |
| 225 gpm | | | | | 133 | 117 |
| 250 gpm | | | | | 143 | 120 |

For conversion, 1 gpm = 3.785 L/min and 1 psi = 6.895 kPa

**Table A-4-1(d) Discharge Pressure Required for 200 ft (61 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 128 | 108 | | | | |
| 20 gpm | 200 | 124 | | | | |
| 30 gpm | | 146 | | | | |
| 40 gpm | | 188 | | | | |
| 50 gpm | | 232 | 119 | | | |
| 75 gpm | | | 140 | | | |
| 100 gpm | | | 168 | | | |
| 125 gpm | | | 200 | | | |
| 150 gpm | | | | 146 | 122 | 110 |
| 175 gpm | | | | 168 | 132 | 114 |
| 200 gpm | | | | | 140 | 118 |
| 225 gpm | | | | | 144 | 122 |
| 250 gpm | | | | | 156 | 126 |

**Table A-4-1(e) Discharge Pressure Required for 250 ft (76 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 135 | 110 | | | | |
| 20 gpm | 225 | 130 | | | | |
| 30 gpm | | 158 | | | | |
| 40 gpm | | 210 | | | | |
| 50 gpm | | 267 | 123 | | | |
| 75 gpm | | | 150 | | | |
| 100 gpm | | | 185 | | | |
| 125 gpm | | | 225 | | | |
| 150 gpm | | | | 158 | 128 | 112 |
| 175 gpm | | | | 185 | 140 | 118 |
| 200 gpm | | | | | 150 | 123 |
| 225 gpm | | | | | 155 | 129 |
| 250 gpm | | | | | 170 | 134 |

**Table A-4-1(f) Discharge Pressure Required for 300 ft (91 m) of Preconnected Hose Requiring 100 psi (690 kPa) Nozzle Pressure**

| | Hose diameter (in.) | | | | | |
|---|---|---|---|---|---|---|
| | $^3/_4$ | 1 | $1^1/_2$ | $1^3/_4$ | 2 | $2^1/_2$ |
| 10 gpm | 142 | 112 | | | | |
| 20 gpm | 250 | 136 | | | | |
| 30 gpm | | 169 | 112 | | | |
| 40 gpm | | 232 | 118 | | | |
| 50 gpm | | 298 | 127 | | | |
| 75 gpm | | | 160 | | | |
| 100 gpm | | | 202 | | | |
| 125 gpm | | | 250 | | | |
| 150 gpm | | | | 169 | 133 | 115 |
| 175 gpm | | | | 202 | 148 | 121 |
| 200 gpm | | | | | 160 | 127 |
| 225 gpm | | | | | 166 | 133 |
| 250 gpm | | | | | | 149 |

**A-5-8.1.2** 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 does not nullify the performance of the other(s).

**A-5-9** 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-5-11.3** It is not the intent of this requirement that electrical devices not manufactured by the wildland fire apparatus manufacturer or contractor, but that are mounted on the unit by the wildland fire apparatus manufacturer or contractor, be rewired to meet this requirement. Wiring supplied by the electrical device manufacturer can be used to the point where it connects to the wildland fire apparatus manufacturer's or contractor's installed wiring.

**A-5-11.6.1** Overheating of a battery causes rapid deterioration and early failure; evaporation of the water in the battery electrolyte also can be expected.

**A-5-11.6.2** 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 3-3.2 and 3-3.3.*)

**A-5-13.1** A pumping engine fuel level gauge or red warning light indicating when the fuel level falls below one quarter of the tank's capacity should be provided at the pump operator's position.

**A-5-13.2** It is recommended that the pump engine use the same type of fuel as the chassis engine.

**A-5-14.2** During stationary pumping operations, pumps may be operated from the side, top, front, or rear of the vehicle, and the design should be such that no power is applied to the wheels while pumping. Dislocation, through vibration or accidental jarring, of any levers that could transfer power to the wheels could result in a serious accident. Therefore, it is essential that any controls that shift the vehicle out of road mode and into stationary pumping operation be equipped with a means to prevent dislocation of the control.

**A-6-1** While this standard does not set an upper limit on the size of a water tank, if the function of the vehicle is to shuttle water for supplying other pumps or apparatus on the fire scene, the purchaser should use NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*, as the basis of design for the vehicle.

**A-6-2.1** Tanks should be capable of being completely cleaned out. The purchaser should indicate in the specifications whether a removable tank lid is required.

**A-6-2.2** The design of a water tank can be a very critical factor in the handling characteristics of the carrying vehicle. If water is free to travel either longitudinally or horizontally in a tank, as is the case if the tank is half full, a tremendous amount of inertia can be built up, which tends 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 method of preventing such an accident is to impede the motion of the water so that the inertia does not build up; this is done through the installation of swash partitions designed so that the water is contained in small spaces within the tank. These spaces are interconnected by openings at the top and bottom so that air and water can flow between compartments at the desired rate when filling and emptying the tank.

**A-6-3.2** 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-6-3.4** Larger size tank fill lines might be desirable where using larger size pumps. They allow the tank to be refilled faster. Table A-6-3.4 can be used as a guide.

**Table A-6-3.4**

| Pump Size | Tank Fill Line Size |
|---|---|
| 20 — 50 gpm (76-190 L/min) | 1 in. (25 mm) |
| 70 — 175 gpm (265-662 L/min) | $1^1/_2$ in. (38 mm) |
| 200 gpm (757 L/min) or larger | 2 in. (51 mm) |

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.

**A-7-1.1** 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.

**A-7-2** The purchaser should provide the apparatus manufacturer with the details of any special needs for communication equipment or its location.

**A-7-3** 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 attached securely to the vehicle with appropriate holders.

**A-7-4.1** 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-7-5** Handrails should be mounted to minimize the chances of damage or removal from contact with objects such as trees.

**A-7-6.1** 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 to be furnished.

**A-7-7.2** Booster hose on the apparatus reel assemblies should have power rewind capability. However, if a manual rewind is provided, attention should be paid to the location of the hand crank. It should be placed in a location that allows the operator to rewind the hose onto the reel without having to climb onto the apparatus.

If the apparatus is to be used or stored in subfreezing conditions, the reel should be equipped with an air chuck mechanism to allow connection of an external source of compressed air to facilitate removal of water within the booster hose assembly. This mechanism should be located on the discharge side of the booster reel valve.

**A-8-1** 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 4-2(a) relates to pump certification only. Other sizes of suction hose, compatible with local operations, might be specified.

**A-8-2(f)** If the hose is intended to be used with a compressed air foam system (CAFS), the user should check with the manufacturer of the hose to ensure that the hose has been approved for use with CAFS.

**A-9-1** 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.* Information on foam concentrates for Class A fires is available in NFPA 298, *Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas.*

**A-9-2** 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 proportioner system that automatically adjusts the flow of foam concentrate into the water stream to maintain the desired mix ratio. These automatic adjustments are made based on changes in water flow.

**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.

**Injector.** A device used in a discharge or suction line to force foam concentrate into the water stream.

**Manually Regulated Proportioning System.** A proportioner system that requires manual adjustment to maintain the mix ratio when there is a change of flow or pressure through the 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-9-3.1** 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 drawn into the eductor (into the water stream) at the design rate of the device [*see Figure A-9-3.1(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. Eductors are available with fixed or variable rate foam solution mix ratios.

(a) 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-9-3.1(b)].* The foam solution in the bypass line then is joined with the mainline water flow downstram of the water flow control valve. Proportioning is controlled by the use of a metering valve in the foam concentrate line together with adjustments of the water flow control valve.

(b) 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.

**A-9-3.2** An intake-side foam proportioning system is a manually regulated system. An in-line device, installed in the water pump intake or suction, provides a connection through a foam concentrate metering valve to the foam concentrate tank. The vacuum created by the water pump draws foam concentrate directly into the pump intake. Hydrant or relay operation is not possible with this type of foam proportioning system.

**A-9-3.3** 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 drawn into the eductor and discharged into the pump intake. Around-the-pump foam proportioning systems do not operate properly at a water pump intake pressure greater than 10 psi (69 kPa). These systems produce foam solution at all water pump discharge outlets when the system is operating.

(a) A manual around-the-pump proportioning system utilizes a manually adjustable foam concentrate metering valve to control the mix ratio. [*See Figure A-9-3.3(a).*]

(b) 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 a microprocessor that controls the mix ratio through a foam concentrate metering valve. [*See Figure A-9-3.3(b).*]

(c) 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 is transmitted to a microprocessor that controls the mix ratio through a foam concentrate metering valve. [*See Figure A-9-3.3(c).*]

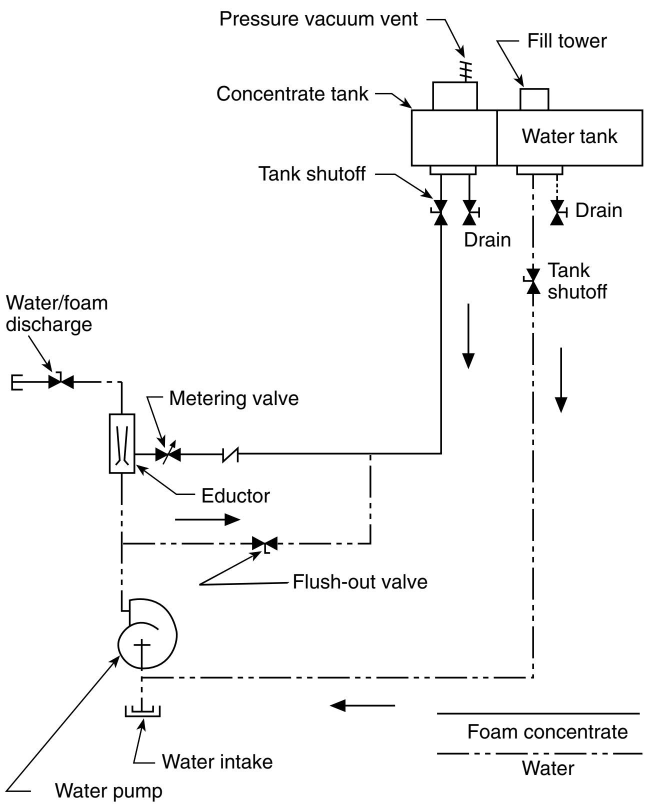


**Figure A-9-3.1(a) In-line eductor foam proportioning system.**

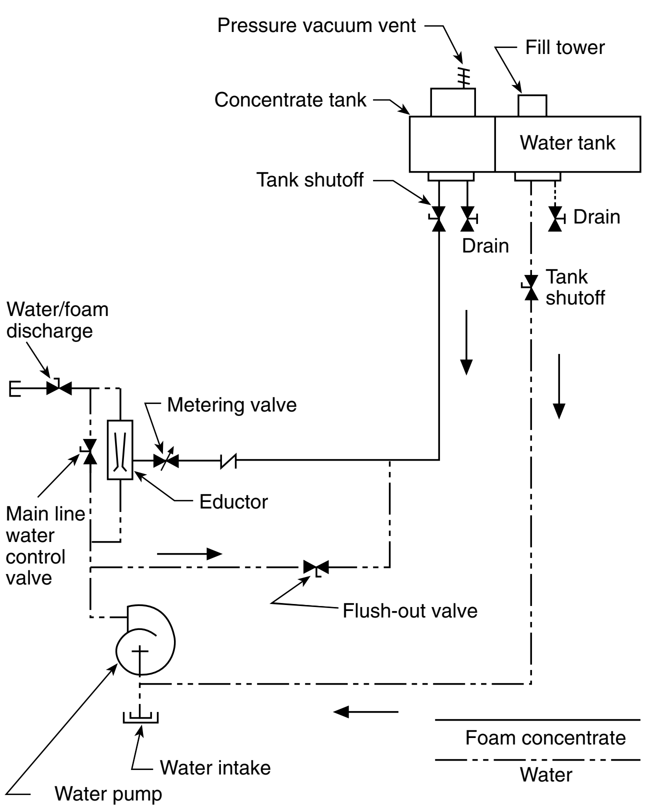


**Figure A-9-3.1(b) Variable flow bypass eductor system.**

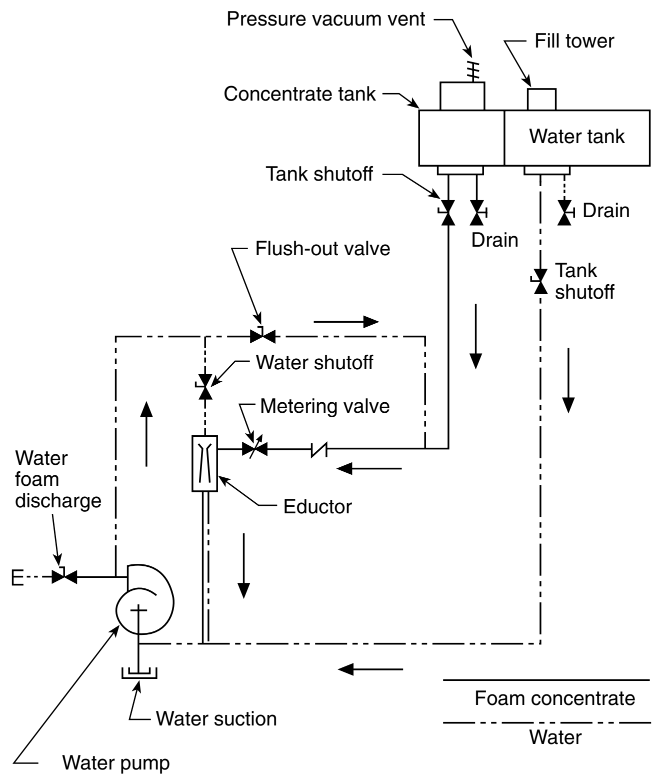


**Figure A-9-3.3(a) Manual around-the-pump proportioning system.**

**A-9-3.4** 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 foam concentrate pump.

Balanced pressure systems without a foam concentrate pump are referred to as "pressure proportioning systems." [*See Figure A-9-3.4(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 and exert pressure on the internal bladder. The foam concentrate is forced out of the bladder to the proportioner at a pressure equal to the water pump pressure. These systems are available with fixed or variable rate proportioning.

There are two basic types of balanced pressure foam proportioning systems that utilize a foam concentrate pump. These systems can discharge water and foam solution simultaneously from the water pump discharge outlets. The foam solution mix ratio is variable at each water pump discharge outlet connected to the foam proportioning system. This system is capable of proportioning different types of foam concentrate where more than one foam concentrate storage tank is linked to the foam concentrate pump by a selector valve system. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank.

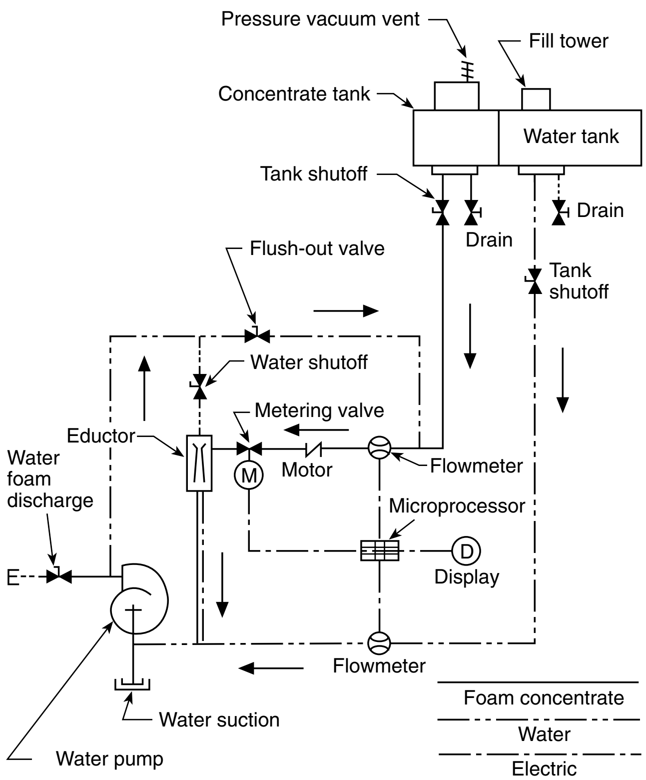


**Figure A-9-3.3(b) Flow meter sensing around-the-pump proportioning system.**

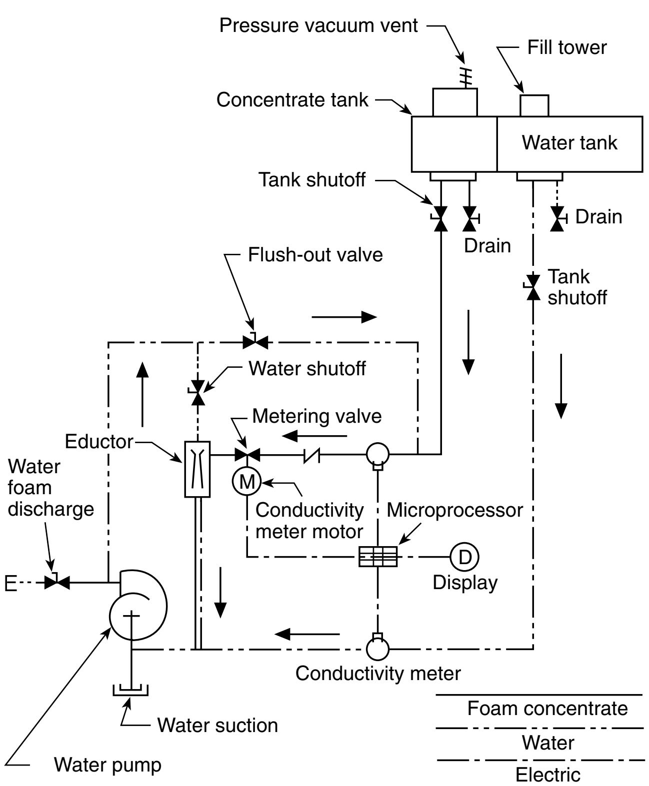


**Figure A-9-3.3(c) Conductivity sensing automatic variable metering around-the-pump proportioning system.**

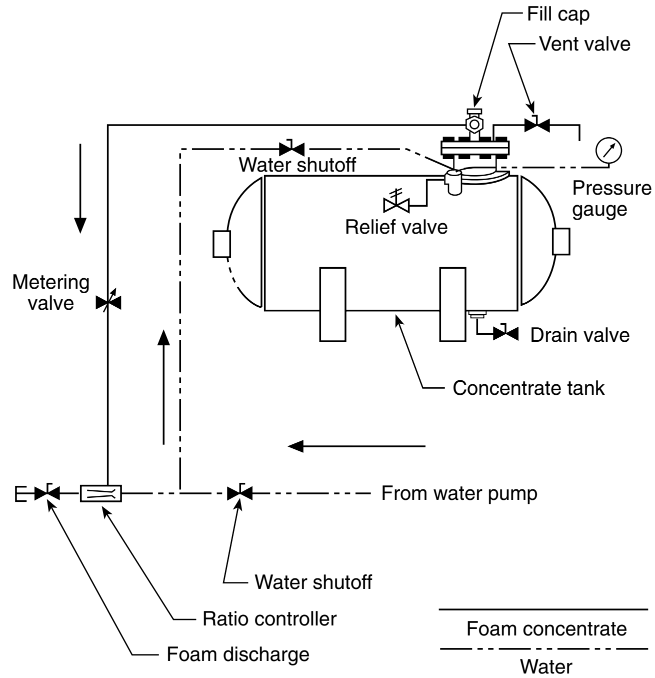


**Figure A-9-3.4(a) Pressure proportioning balanced pressure proportioning system.**

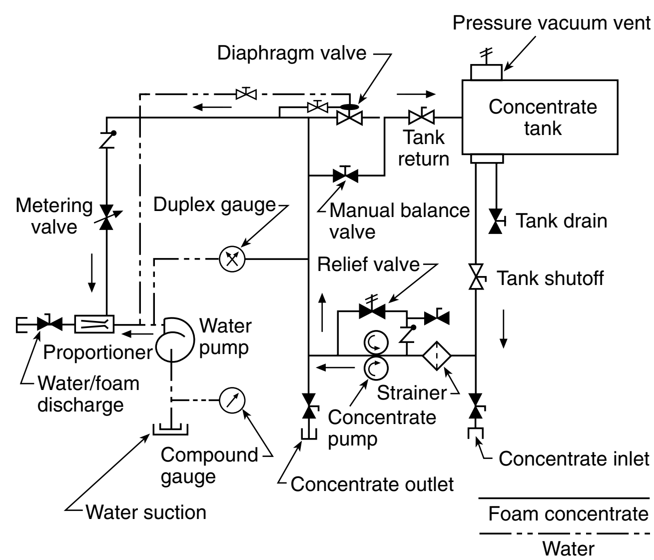


**Figure A-9-3.4(b) Bypass balanced pressure proportioning system.**

(a) A "bypass" system utilizes a diaphragm valve in the foam concentrate pump-to-tank line that automatically balances the foam concentrate and water pressure by bypassing excess foam concentrate back to the tank. [*See Figure A-9-3.4(b)*].

(b) A "demand" system is designed to automatically control the speed (rpm) of the foam concentrate pump to balance foam concentrate and water pressure within the system. [*See Figure A-9-3.4(c)*].

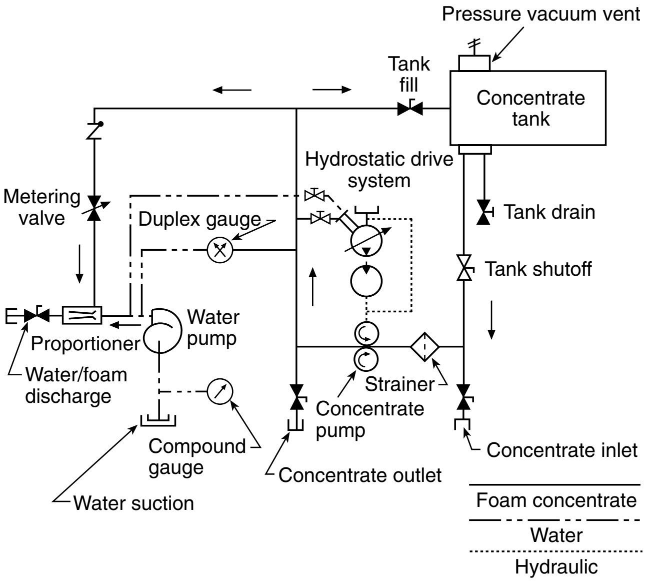


**Figure A-9-3.4(c) Demand balanced pressure proportioning system.**

**A-9-3.5** Direct injection foam proportioning systems utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. Water and foam solution can be discharged simultaneously from the water pump where individual injection points are provided for more than one water pump discharge. This system is capable of proportioning different types of foam concentrate where more than one foam concentrate storage tank is linked to the foam concentrate pump by a selector valve system. The foam solution mix ratio can be fixed or variable depending upon the system design. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank.

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 a microprocessor, which controls the mix ratio. Two different flow sensing systems are available.

(a) A microprocessor receives electronic signals corresponding to the mix ratio from the control panel and water flow data from the flow meter. The microprocessor then commands the foam concentrate pump module to deliver foam concentrate at the proportional rate. [*See Figure A-9-3.5(a).*]

(b) A microprocessor receives electronic signals corresponding to the foam concentrate flow from a foam concentrate flow meter, the mix ratio from the control panel, and water flow data from the water flow meter. The microprocessor controls the mix ratio through a foam concentrate metering valve. [*See Figure A-9-3.5(b).*]

A conductivity sensing direct injection foam proportioning system utilizes an electrical conductivity meter(s) to sense the mix ratio at the water pump discharge(s) and transmits this information to a microprocessor that controls the mix ratio through an electromechanical foam concentrate metering valve. A second electrical conductivity meter provides feedback from the control sample module to the microprocessor. Foam pump pressure is maintained at a pressure higher than water pump pressure to ensure injection of the concentrate. [*See Figure A-9-3.5(c).*]

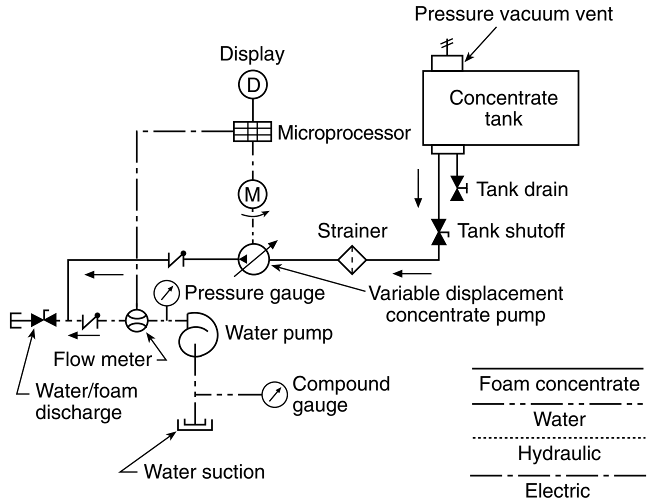


**Figure A-9-3.5(a) Single meter flow sensing direct injection foam proportioning system.**

**A-9-3.6** In a water motor meter proportioning system, a positive displacement water motor drives a positive displacement foam concentrate metering pump. The ratio of displacement by the water motor to the displacement by the metering pump is the ratio of the desired foam solution. Hence, the displacement by the metering pump is 0.005 of the displacement by the water motor where a 0.5 percent foam solution is desired. In practice, the displacement ratio is higher to compensate for volumetric losses. The water motor meter proportioning system requires no external power.

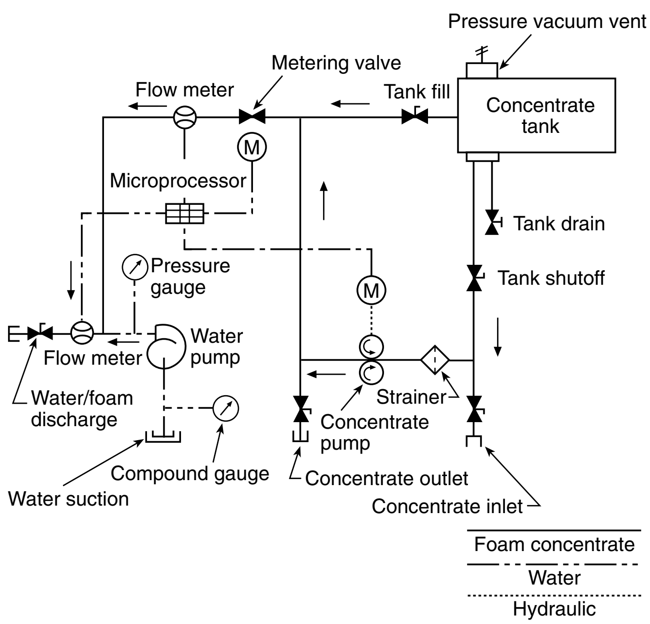


**Figure A-9-3.5(b) Dual meter flow sensing direct injection foam proportioning system.**

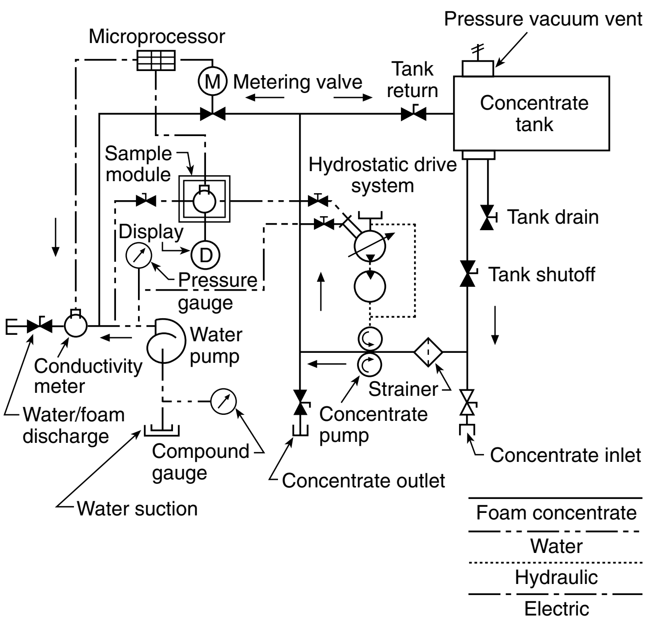


**Figure A-9-3.5(c) Conductivity sensing direct injection foam proportioning system.**

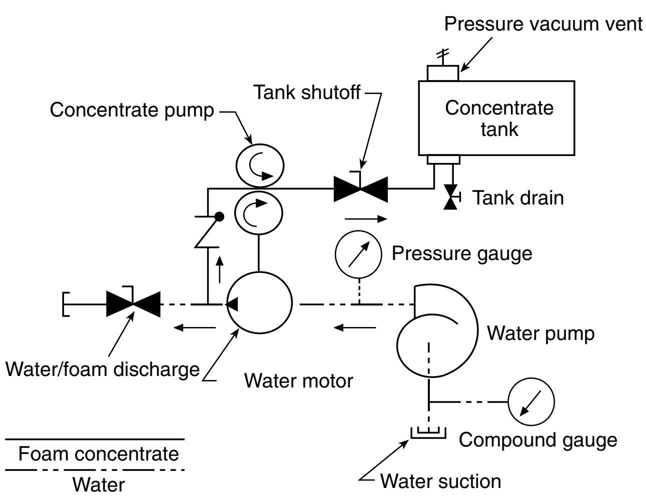


**Figure A-9-3.6 Water motor meter proportioning system.**

**A-9-5.1** It is desirable to have a visual indicator at the pump operator's position that shows that the foam injection system is in the "operating" or the "off" position. A visual means of indicating positive foam concentrate flow at the pump operator's position also is desirable.

**A-9-7.10** 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-10-2** The following terms are not used in this document but are associated with foam systems and are included here to aid in understanding.

**Chatter.** An unacceptable flow condition wherein air is not fully mixed with the foam solution.

**High-Energy Foam Generator.** A foam generator that uses a large amount of external energy to aerate the foam.

**Low-Energy Foam Generator.** A foam generator that uses the energy of the foam stream to aerate the foam.

**Mixing Chamber.** A device used to produce fine, uniform bubbles in a short distance as foam solution and air flow through it.

**Scrubbing.** The process of agitating foam solution and air in a confined space such as a hose, pipe, or mixing chamber to produce tiny, uniform bubbles.

**Slug Flow.** The discharge of distinct pockets of water and air due to the insufficient mixing of foam concentrate, water, and air in a compressed air foam system.

**Surge.** The sudden decompression of a discharge line caused by the rapid opening of the discharge appliance.

**A-10-3.3** It is recommended that the apparatus have the capability of supplying 2 gpm (7.6 L/min) of water per 1 SCFM (0.028 $m^3$) of air production to provide fire-fighting capability using both water and compressed air foam simultaneously.

**A-10-5** If it is desired to test the expansion ratio, the following test is recommended.

Equipment:

Gram scale, 1500-gram capacity accurate to 0.1 gram

One 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 zeroed. 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.

$$\text{Expansion ratio} = \frac{100}{\text{Foam mass in grams*}}$$

**A-10-6** The design of a CAFS on a wildland fire apparatus should allow the operator to engage the system and pump the desired consistency of foam in the same relative time and with the same ease as is needed to engage the water pump and begin flowing water.

**A-10-6.3** A shutoff valve located between the monitor and the tip can cause damage to the equipment and injury to personnel.

**A-10-8.5** On systems sensitive to back-pressure caused by the length of the hose lay or changes in elevation, a pressure gauge should be installed to measure the pressure at the point of convergence of air and foam solution, particularly where there are multiple discharge points on the same apparatus.

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 that 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 must know what is flowing in order to be certain the proper product is being delivered.

* Note: This assumes that 1 gram of foam solution occupies 1 ml of volume.

**A-11-1** In view of the increasing use of line voltage devices on apparatus, the provision of a line voltage electrical system of sufficient capacity is strongly recommended. Where line voltage equipment use is extensive, a separately driven generator is recommended.

Where only incandescent lighting is involved, alternating current or direct current power may be used. Where other electrical devices such as motor-driven equipment or electronic equipment are involved, single-phase ac power at 60 cycles normally is required. However, because of the substantial reduction of size and cost that results from 3-phase operation, ac motors larger than one horsepower usually are designed to operate on 3-phase ac current.

Attempting to operate electrical equipment using the wrong type of electrical power almost always damages electrical equipment.

Line voltage (120-, 120/240-, or 240-volt) electrical systems are a combination of several distinct subsystems. First, there is a power source (*see Figure A-11-1*). This device produces the line voltage power. The power then is sent to a distribution panelboard that distributes the power through overcurrent devices to wiring systems. Loads that are either permanently mounted or portable then are connected to the system through either receptacles or switches.

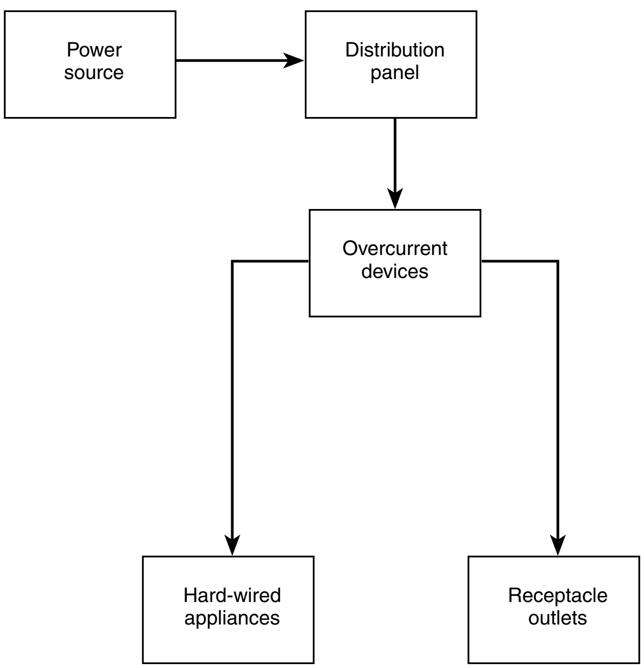


**Figure A-11-1 Schematic of line voltage electrical system.**

Portable generators combine the power source, distribution panelboard, overcurrent devices, wiring systems, and receptacles into one piece of equipment. (*See Figure A-11-1.*)

The system should be sized based on the total amount of fixed and portable equipment that is likely to be operated at the same time. Fixed and portable equipment includes lights, power tools, fans, and any other power-consuming equipment.

To properly design and install the system, there is a lot of information the manufacturer needs to know. The following information should be defined for each piece of line voltage equipment to be operated from the electrical system.

(a) The type of electrical current required, i.e., direct current (dc), alternating current (ac), or both ac or dc.

(b) If ac, the nominal operating voltage, the maximum amperage, and whether single-phase or 3-phase. For electronic equipment and some motors, the required quality of the alternating current also needs to be known, including the upper and lower limits of voltage and the allowable variation of frequency and wave form.

(c) If dc, the nominal operating voltage and the maximum operating current. For special equipment, the required quality of the direct current also needs to be known, including the upper and lower limits of voltage and the amount of ripple voltage.

(d) Whether the device is to be permanently mounted on the vehicle, carried on the vehicle but removable, or not a part of the vehicle but only powered by the line voltage system.

Where line voltage lighting is to be provided, the purchaser should define the following:

(a) Location and quantity of lights.

(b) Wattage of each light.

(c) Type of light mounting.

(d) Type of light bulb.

Where a permanently-mounted line voltage electric cord reel is to be provided, the purchaser should define the following:

(a) Location.

(b) Ampere rating and voltage of the device and cord.

(c) Quantity and type of cord.

(d) Type of connector body or junction box provided at end of cord.

(e) Type of reel rewind system desired.

**A-11-3.2** Because of the non-earth grounded nature of apparatus-mounted line voltage equipment and the wet environment in which it operates, great care should be taken in the use and maintenance of such line voltage circuits and equipment. (*See NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.*)

Ground-fault protection for personnel should be furnished through an assured equipment grounding conductor program in accordance with Section 305-6(b) of NFPA 70, *National Electrical Code*. All cord sets, receptacles, and electrical equipment should be maintained in accordance with NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.

This protection can be supplemented by the use of portable ground-fault circuit interrupters. These GFCIs should be attached to the end of distribution cords and located close enough to the point of operation so that they can be reset conveniently in the event of trips.

While this arrangement is desirable for fire service operating conditions and does protect fire fighters who are operating tools and lights downstream of the GFCI, it should be understood that no protection is provided between the source and the GFCI.

If premises wiring or other fixed wiring systems are to be powered by the generator, grounding of the system should comply with Section 250-5 of the *NEC*. If grounding rods, plates, clamps, or other means of bonding the vehicle and the source to an earth ground are desired, this equipment should be specified by the purchaser.

**A-11-3.2.4** The internal bonding of the neutral wire to the frame of the power source is provided by the manufacturer of the power source on most single-phase, portable generator sets. On larger generator sets, the installer should bond the neutral at the generator set.

**A-11-4.1** While the selection of the power source for the line voltage system is determined largely by the type and quantity of current desired, in many cases there are alternative choices. If the purchaser has a specific preference, that preference needs to be defined in the specifications for the apparatus.

The most common types of line voltage power sources are as follows:

(a) *Gasoline-Powered Generator.* A separate engine-driven device commonly used on fire apparatus.

(b) *Diesel-Powered Generator.* A separate engine-driven device commonly used for fire apparatus.

(c) *Hydraulic-Powered Generator.* A device in which the vehicle propulsion engine is used to drive a hydraulic pump, which, in turn, drives the hydraulic motor that powers the generator. Normally used to power larger generators, it generally is not used on pumping apparatus.

(d) *PTO-Powered Generator or Fan Belt-Driven Generator.* A device that also is driven by the vehicle propulsion engine; the need to maintain a constant engine speed tends to make these arrangements unsuitable for pumping apparatus.

(e) *12/24-Volt (Low-Voltage), Motor-Powered Generator.* A device powered directly from the vehicle's electrical system. These systems are limited by the alternator and battery set to about 1600 watts.

(f) *Transformer Connected to the Vehicle's 12/24-Volt-Alternator.* The normal output of 120 volts dc is usable only for work lights. The output wattage is limited by the alternator and battery set.

(g) *Converter/Invertor Connected to the Vehicle's 12/24-Volt Alternator.* These devices are subject to the same output limitation as the transformer and dc motor-driven systems, but they do produce alternating current suitable for operating motors as well as lights.

**A-11-7** If receptacles are desired in certain locations, the purchaser needs to define the number and location of the receptacles and switches that are needed. The purchaser also should specify the NEMA number and style if a specific plug or receptacle is desired.

**A-11-7.4** Locking-type plugs and receptacles are designed to prevent accidental disconnection when subjected to moderate pull-apart loads. Neither locking or nonlocking connectors are designed to withstand the loads that can be created when pulling long cords up buildings and stairs.

**A-11-8** If switches to control certain circuits or equipment are desired in certain locations, the purchaser needs to define the location of the switch and the devices to be controlled by the switch. The purchaser also should specify the NEMA number and style if a specific switch is desired.

**A-12-2.1** Most electric (direct current, 12-volt or 24-volt) winches used for commercial/industrial applications are rated at between 6000 lb (26.7 kN) line pull and 12,000 lb (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 typically are rated for 6000 lb (26.7 kN) line pull to 30,000 lb (133.5 kN) line pull.

**A-12-3.1.1** There is virtually no control over the speed of a single-speed electric winch, i.e., 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, i.e., one gear ratio for pulling heavy loads, a second for light loads. They are not designed for shifting under load to improve line speed.

**A-12-4.4** The forward neutral reverse hydraulic control for the winch should be power-operated to allow 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 or a Federal Communications Commission-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-13-3** Skid plates may be used to protect the transfer case, gear box, pump, engine oil pan, radiator, auxiliary coolers, exhaust components, brake lines or components, fuel tank, steering gear, and axle differential.

**A-14-1.1** If acceptance tests are desired at the point of delivery, they should be run in accordance with the provisions of Chapter 14 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 may be performed with the pump supplied from a suitable fire hydrant, or at draft, with the net pressure maintained at 150 psi (1065 kPa). The net pressure (P), when the pump is supplied from a hydrant with positive intake pressure, is the discharge pressure (D) in psig minus the intake pressure (S) in psig.

**A-14-2.1.2** 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-14-2.3** 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 manometer (or other suitable test gauge that measures vacuum accurately) or by adding the vertical lift and the value of friction and entrance loss from Table 4-2. To be accurate, gauge readings should be corrected for the difference between the height of the gauge 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 by one of the following formulas:

(a) If intake pressure is positive, i.e., pumping from a hydrant: $P = D - S$

(b) If intake pressure is negative, i.e., pumping from draft:

$P = D + (H \times 0.5)$ or $P = D + 0.43\ (L + F)$,

where:

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

**A-14-8** There are four methods for testing a foam proportioning system for calibration accuracy.

**Test Method 1.** The foam system is operated at a given flow using water as a substitute for foam concentrate. The water is drawn from a calibrated tank instead of foam concentrate. The volume of water drawn from the calibrated tank represents the percentage of foam concentrate used by the system over a measured period of time.

**Test Method 2.** With the foam system in operation at a given flow, a solution sample is collected from each outlet and the concentration measured using a refractometer to measure the refractive index of the foam solution samples. This method might not be particularly accurate for AFFF or alcohol-resistant foam and certain other types of foam that typically exhibit very low refractive index readings. For this reason the conductivity method might be preferable where these products are used.

*Equipment Required.*

(a) Four 100-ml or larger plastic bottles with caps.
(b) One measuring pipette (l0 ml) or syringe (10 cc).
(c) One 100-ml or larger graduated cylinder.
(d) Three plastic-coated magnetic stirring bars.
(e) A refractometer.
(f) Standard graph paper.
(g) A ruler or other straight edge.

*Procedure.* 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 samples should include the nominal intended percentage of injection, the nominal percentage plus 0.3 percent, and the nominal percentage minus 0.3 percent. The water is placed in the 100-ml or larger graduate (leaving adequate space for the foam concentrate) and then the foam concentrate samples are carefully measured into the water using the pipette or syringe. Care should be used to avoid picking up air in the foam concentrate samples. Each measured foam solution is poured from the 100-ml or larger graduate into a 100-ml or larger plastic bottle. Each bottle should be marked with the percent solution it contains. A plastic stirring bar is added to the bottle, and the bottle is capped and shaken thoroughly to mix the foam solution.

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. 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.

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

**Test Method 3.** 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, the concentrate pump discharge substituting water for foam concentrate can be diverted into a calibrated container for direct measurement over a measured period of time.

**Test Method 4. Conductivity Test Method.** 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. 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. Three methods can be used to determine the percentage of foam solution by the conductivity method.

A. Direct Reading Conductivity Test Method.

*Equipment Required:*

(a) Two 100 ml or larger containers.
(b) One direct reading foam solution conductivity meter.

*Procedure.* 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 zeroed. If the direct reading foam solution conductivity meter mounts directly in a discharge line, the meter should be zeroed 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 must 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 must be used when that foam concentrate is used.

The foam proportioning system is operated and a sample of the solution produced by the system is obtained 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 from on the meter display. If the conductivity meter mounts directly in a discharge line, read the percentage of the foam solution on the meter display while foam is being discharged.

B. Conductivity Comparison Method.

*Equipment Required:*

(a) Two 100-ml or larger containers.
(b) Conductivity meter reading in µs/cm (microsiemens per centimeter).

*Procedure.* 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 determined.

The conductivity value of the water sample is subtracted from the conductivity value of the foam solution sample and the result is divided by 500 to obtain the percent of foam.

$$\frac{\text{Conductivity of foam solution} - \text{conductivity of water}}{500} = \text{\% of foam}$$

NOTE: Note: 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 hand-held conductivity meter is used to measure the conductivity of foam solutions in microsiemen units.

*Equipment Required:*

(a) Four 100 ml or larger plastic bottles with caps.

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

(c) One 100 ml or larger graduated cylinder.

(d) Three plastic-coated magnetic stirring bars.

(e) A portable temperature-compensated conductivity meter — Omega Model CDH-70, VWR Scientific Model 23198-014, or equivalent.

(f) Standard graph paper.

(g) A ruler or other straight edge.

*Procedure.* 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 samples should include the nominal intended percentage of injection, the nominal percentage plus 0.3 percent, and the nominal percentage minus 0.3 percent. The water is placed in the 100-ml or larger graduate (leaving adequate space for the foam concentrate) and then the foam concentrate samples are carefully measured into the water using the pipette or syringe. Care should be used to avoid picking up air in the foam concentrate samples. Each measured foam solution is poured from the 100-ml or larger graduate into a 100-ml or larger plastic bottle. Each bottle should be marked with the percent solution it contains. A plastic stirring bar is added to the bottle, and the bottle is capped and shaken thoroughly to mix the foam solution.

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. Protein-based foams generally produce conductivity readings in excess of 2000 µs in fresh water solutions. 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 sample references. 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. While it might not be possible to connect all three points with a straight line, they should be very close. If not, the conductivity measurements should be repeated and, if necessary, new control sample solutions should be 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.

*Sampling and Analysis.* Foam solution samples are collected from the proportioning system using care to be sure the sample is taken at an adequate distance downstream from the proportioner being tested. Using foam solution samples that are allowed to drain from expanded foam can produce misleading conductivity readings, and, therefore, this procedure is not recommended.

Once one or more samples have been collected, their conductivity is read and the corresponding percentage is determined from the base curve prepared from the control sample solutions.

**A-14-9.1.2** 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 compressed air foam systems.

**A-14-9.1.3** 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 air flow test.

**A-14-9.2** 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 compressed air foam systems.

Date ________________________________

1. Owner ________________________________
2. Address ________________________________
________________________________
3. Manufacturer ________________________________
Model ________________ Serial No. ________________
4. Chassis engine make ________________________________
Model ________________ Serial No. ________________
No. cyls. ________ Bore ________ Stroke ________ Displ. ________ Cu in.
Rate HP ______ at rpm No-load governed speed ________________
Comp. ratio ______ :1 Type ________________
5. System voltage ______ vs. Alternator output ______ Amps
6. Battery: Single or dual ______ Capacity ______ CCA
7. Battery: Make and model ________________________________
8. Chassis fuel tank capacity ______ gal Type of feed ________________
9. Transmission: Make ________ Model ________ Type ________
10. Drive to pump through transmission? ________________
11. Pump engine make ________________________________
Model ________________ Serial No. ________________
No. cyls. ________ Bore ________ Stroke ________ Displ. ________ Cu in.
Rate HP ______ at rpm No-load governed speed ________________
Comp. ratio ______ :1 Type ________________
12. Pump engine fuel tank capacity ________ gal
13. Gear ratio engine to pump ________ :1
Trans. gear ratio used ________________
14. Pump make ________ Model ________
Serial no. ________ Rated capacity ________ gmp
No. stages ________ Impeller dia. ________ in.
15. Priming device type ________________
16. Foam system type ________ Make ________ Model ________
17. Air compressor type ________ Make ________ Model ________
18. Water tank capacity ________ gal
19. Chassis make ________ Model ________
VIN ________________
20. GAWR front ________ lb Rear ________ lb
21. Tires front size ________ Rated capacity total ________ lb
22. Tires rear size ________ Rated capacity total ________ lb
23. Chassis Weight Distribution with Water and Equipment
Front ________ lb Rear ________ lb
24. Paint # ________ Paint # ________
25. Company ________________________________
26. Signed by ________________________________

**Figure A-14-11(d) Manufacturer's record of wildland fire construction details.**

## Appendix B

*This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.*

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 apparatus to be supplied. Completion of the following questionnaire by the purchaser provides the information required in the various sections of this document. The column titled "Section" indicates where in the document the requirement or recommendation is stated.

| Type of Information | Section |
|---|---|
| **General** | |
| Date of bid opening ________ | A-1-2 |
| Purchaser's name & address ________ | |
| Contact name & telephone number ________ | |
| Sealed bid envelope information, address, and identification marking ________ | |
| The bidder is to honor the bid price for ________ days. | A-1-2 |
| If an interim inspection trip(s) to the assembly plant is to be provided, indicate the number of trips and number of participants. ________ | A-1-2 |
| Where is the apparatus to be delivered? ________ | A-1-2 |
| The operation and service training is to be conducted ________ at ________ for ________ persons for ________ days. | A-1-2 |
| Specify details of any special payment plan or schedule required ________ | A-1-2 |
| Is a bid bond required? ________ What percent of the bid price? ________% | A-1-2 |
| Is a performance bond required? ________What percent of the bid price? ________% | A-1-2 |
| If an extended warranty on specific components is required, indicate which components and the length of the warranty. ________ | A-1-2 |
| Is a warranty bond required?________ In what amount? ________ | A-1-2 |
| List any special design features required on this apparatus: ________ | |
| Maximum elevation at which the apparatus will operate if over 2000 ft (610 m) ________ | 2-4.1 |
| Maximum stationary operational grade if over 20 percent ________ | 2-4.2 |
| Minimum and maximum ambient temperature the apparatus is to operate at ________ | 2-4.3 |
| Specify the apparatus road performance if it is to exceed the minimum specified in this standard ________ | 2-5.1 |
| Maximum grade that apparatus will climb at 20 mph (32 kmph) if over 6 percent ________ | 2-5.1.(c) |
| How many service and operation manuals are to be provided? ________ | 2-6.3 |